Vetiver Newsletters #3–#24 (1990–2002)

Contents by topic

Articles are grouped under the 12 topics used on vetiver.org. Within each topic they are listed alphabetically by title. Click any title to go to that article. Letters from correspondents are listed under Network news and events. The bookmarks panel lists the contents issue by issue.

Topics

Agriculture and farming	47 items
Climate change	1 item
Community and livelihoods	12 items
Disaster mitigation	5 items
Erosion and soil and water conservation	70 items
Guides, standards and publications	12 items
Network news and events	56 items
Policy, upscaling and dissemination	58 items
Pollution and wastewater	15 items
Slopes and infrastructure	32 items
The plant, planting and research	73 items
Water and hydrology	14 items

Issues

Newsletter #3 — March 1990
Newsletter #4 — November 1990
Newsletter #5 — March 1991
Newsletter #6 — June 1991
Newsletter #7 — November 1991
Newsletter #8 — June 1992
Newsletter #9 — November 1992
Newsletter #10 — October 1993
Newsletter #11 — June 1994
Newsletter #12 — July 1994
Newsletter #13 — January 1995
Newsletter #14 — September 1995
Newsletter #15 — April 1996
Newsletter #16 — November 1996
Newsletter #17 — June 1997
Newsletter #18 — December 1997
Newsletter #19 — August 1998
Newsletter #20 — April 1999
Newsletter #21 — February 2000
Newsletter #22 — November 2000
Newsletter #23 — May 2001
Newsletter #24 — July 2002

Agriculture and farming

Agricultural Uses of Vetiver (ICV-1 abstract)	NL 15 · Apr 1996
Agriworld, Vetiver in (China)	NL 20 · Apr 1999
Applications in Pineapple Farms	NL 17 · Jun 1997
Asian Grass to Lift Lambing Percentage	NL 13 · Jan 1995
China Vetiver And Agroforestry Technology Project Launched on Dabie Mountains	NL 24 · Jul 2002
Contribution of Vetiver Grass to Sustainable Agricultural Development in the Hilly Red Soil Region	NL 18 · Dec 1997
Costa Rica and Central American Growers	NL 12 · Jul 1994
Costa Rican Coffee Cooperative Benefits with Use Of Vetiver	NL 23 · May 2001
Cultural Practices for Soil Erosion Control on Cassava based Cropping Systems in Indonesia	NL 20 · Apr 1999
Ecological Effects of Planting Vetiver Grass in Citrus Groves on Sloping Red Soil Fields	NL 18 · Dec 1997
Ecuadoran Promotes Sustainable Farming Using Vetiver System	NL 22 · Nov 2000

Effect Of Grass Bunds On Erosion Loss And Yield of Rainfed Rice - Orissa, India — NL 19 · Aug 1998

Effective Mulch from Vetiver (South Africa) — NL 20 · Apr 1999

El papel del Pasto Vetiver en el sostenimiento de la productividad agricola — NL 14 · Sep 1995

Ethiopia's Tea and Coffee Plantations, Vetiver in — NL 4 · Nov 1990

Export Crops and Vetiver — NL 24 · Jul 2002

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- Cassava/Vetiver - Contour barrier; Yields per row (each row contains six plants) in kg of fresh roots and leaves and stems
- Cassava and forage productivity, soil loss and runoff data
- Cassava/Elephant Grass Contour barrier; Yields per row (each row contains six plants) in kg of fresh roots and leaves and stems
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Substitution of Contour Banks in Steep Canelands — NL 17 · Jun 1997

Swaziland Farmer Development Foundation Vetiver Demonstration Site NL 24 · Jul 2002
Tea and Vetiver - India NL 24 · Jul 2002
Use of Vetiver Grass As In Situ Mulch In Rubber Plantings NL 8 · Jun 1992
Use Of Vetiver In Sunflower Dominated Cropping System NL 13 · Jan 1995
What Vetiver Users In The Philippines Say NL 16 · Nov 1996
Zimbabwe - Commercial Farming Applications NL 12 · Jul 1994

Climate change

Noel Vietmeyer — Vetiver Grass and Greenhouse Gasses NL 20 · Apr 1999

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Aromatherapy, Vetiver in (South Africa) NL 20 · Apr 1999
Handicrafts and Vetiver NL 24 · Jul 2002
Inspiring Donor/Participant Experience In El Salvador NL 23 · May 2001
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Multiple Purpose Vetiver In Suriname NL 24 · Jul 2002
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Promotion Of Vetiver Grass Technology In The Philippines: Vetfarms Inc. Experience NL 21 · Feb 2000
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Aeolian Sands of PingTan Island: Vetiver Grass Planting and its Application NL 18 · Dec 1997
Application in Queensland NL 17 · Jun 1997
Application Of Vetiver Grass In Soil Erosion And Sediment Control On The Darling Downs NL 17 · Jun 1997
Applications in Forest Plantation NL 17 · Jun 1997
Applications of the Vetiver Grass System in Queensland and Australia NL 17 · Jun 1997
Australia - Monto Vetiver by Paul Truong NL 16 · Nov 1996

Australia Effectiveness Of The Vetiver Hedges In Soil Erosion And Sediment Control In Queensland	NL 15 · Apr 1996
Comparison of different conservation barrier treatments at Akola Maharashtra	NL 12 · Jul 1994
Comparison of the impact of three soil and water conservation systems on shallow (SS) and deep (DS) black vertisols measured as percentage incremental yield increases	NL 12 · Jul 1994
Erosion and Sediment Control in the Mackay Area with Vetiver Grass	NL 17 · Jun 1997
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Erosion Control and Land Stabilization in the Wet Tropics with Vetiver Grass	NL 17 · Jun 1997
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Vetiver vs. Bunding	
Vetiver vs. Other Vegetative Barriers	
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Fiji - Back From The Future: Do's and Don'ts After 50 years of Vetiver Utilization in Fiji	NL 15 · Apr 1996
Fiji - Where it All Started	NL 12 · Jul 1994
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Gullies and Vetiver	NL 12 · Jul 1994
Gully Stabilization	NL 17 · Jun 1997
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Figure 2. Three year total surface runoff from runoff plots in Akola, India
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China
Madagascar
St. Vincent
Nepal
U.S.A
Kenya and more
Australia - Vetiver Workshop — NL 17 · Jun 1997
Awards — NL 10 · Oct 1993
Awards Program, The Vetiver Network — NL 23 · May 2001
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Bali Hosts Vetiver Conference NL 22 · Nov 2000
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- Hu Jianye, (Red Soil Project Office of Jiangxi Province, Nanchang 330002, China)
- Mulatu Wakjira, Mettu, Ethiopia
- Mrs. B. Jiji, District Projects Officer, SAFIRE, PO Box 237, Nyanga, Zimbabwe
- Jon Hellin, Apartado Postal 791, Tegucigalpa, Honduras
- Moges Worku. Ethiopia
- Victor A. Gillespie, Engineer, P0 Box 5752, Vientiane, Lao PDR
- C.M.Gomes Tanzania
- G.van de Meeberg, Project advisor, St. Joseph's Family Farm Project, Catholic Mission Bwiam), PO. Box 165, BanjuI, The Gambia

Ethiopia - Vetiver Workshop - May 1996 - Mettu, Illubabor, Ethiopia NL 16 · Nov 1996
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First International Vetiver Workshop NL 8 · Jun 1992
Ghana. Some feed back from the November 1994 Wonder Grass Conference NL 14 · Sep 1995
Heineken Brewery Funds Training Program in Thailand NL 22 · Nov 2000
Highlights from the International Vetiver Conference – Fuzhou – China –October 21 to 26 1997 NL 18 · Dec 1997
International Vetiver Workshop Fuzhou, Fujian Province, China. October 21 - 26 1997 NL 18 · Dec 1997
Letters NL 22 · Nov 2000
- Xia Hanping - China
- Edwin Balbarino -The Philippines

Letters NL 23 · May 2001
- Indonesia Correspondence
- Madagascar
- Taiwan

Letters, Feedback, and Vetiver Chats NL 20 · Apr 1999
- Alemu Mekonnen, Ethiopia
- Joachim Boehnert, CIERs- ES, Caixa Postal 77, Nova Venecia
- Pucallpa, Peru
- Edwin Balbarino (VETINETPHIL)
- Mike Pease (Coordinator EMVN)
- Duncan Hay (Coordinator of SAVN
- Vetiver activities in the Pacific Basin
- Calvin Bey — Vetiver Network Haiti
- Ken Schlather - Honduras
- Criss Juliard (Madagascar)
- Criss Juliard - Portugal
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- Philippe Grandjean (Madagascar)
- Piet Sabbe, BOSPAS, Quito, Ecuador
- Otto M. Bundy, CEO and President, EcoGroup International Corporation, Parrish, Florida, USA
- Gueric Boucard "TEXAROME, INC."
- Ted Winston <twinston@znet.net.au> Australia
- Noah Manarang <noahvet@planet.net.ph> Philippines

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- Ken Crismier — Vietnam Vetiver Network
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- Glenn Allison, Project Manager, POPPA, Lilongwe, Malawi. (European Union funded project)
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- Rob Shelton, CARE – Papua New Guinea
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- Edwin A. Balbarino, Farmi-Visca, Baybay, Leyte,, Philippines
- Jim Smyle, Panama
- Jano Labat, Chiware Holdings Pvt Ltd. P.O. Box 14, Chiredzi, Zimbabwe
- R.P.S Ahlawat University Office: Sardarkrushinagar.385506 Banaskantha District, Maharashtra, India
- Debela Dinka, MfM, P.O. Box 120372, Addis Ababa, Ethiopia
- Xia Hanping South China Institute of Botany, Academia Sinica, Guangzhou, China

Letters to the Editor — NL 16 · Nov 1996
- Bauchi State Agricultural Development Project, Nigeria
- Medical Centers of West Africa, B.P.382, Maroua, Cameroon
- Senior Horticulturist, LandLab
- Agroforestry Programe ICRAF
- Sustainable Agriculture Program, Cerro Punta, Amisconde Project, Panama
- Coordinator of Riobamba Zone, Farmer- Forestry Development (DFC), Ecuador
- Center of Investigation and Technical Assistance and Design of the State of Jalisco, Guadalajara, México
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- Mary Noah S.J. Manarang, Philippines
- Jim Smyle and Joan Miller, Costa Rica
- Tony Tantum, South Africa
- Antonio Vasco de Mello, Portugal

Letters to the Editor — NL 17 · Jun 1997
- Australia - Bood Hickson - LandCare
- Malawi - James Biscoe - coffee
- Joachim Boehnert - Brazil
- Reneé Zalles - User - Bolivia
- Heladio Reyes Cruz - Costa Rica - Mexico

Letters to the Network — NL 14 · Sep 1995

St. Joseph's Family Farm Project, Bwiam, The Gambia
Finchaa Sugar Project
National Herbarium of Bangladesh
Shiwa N'gandu, Mpika, Zambia
Gwembe Valley, Zambia
Mettu, Ethiopia
Community Development and Welfare Society, Katmandu, Nepal
Kurunegala, Sri Lanka
Vallonia Sugar Estate, Natal. South Africa
Non-weediness of Vetiver

Network Evolves, The Vetiver — NL 22 · Nov 2000

Network News — NL 22 · Nov 2000
- TVN Adds National Networks
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Network News — NL 24 · Jul 2002
- Mexico
- Latin America Vetiver Network)
- Ecuador
- Peru
- Tanzania (TZVN)

New Networks — NL 17 · Jun 1997

News from the Networks — NL 18 · Dec 1997

Notes & Letters from Correspondents — NL 5 · Mar 1991
- Costa Rica
- Kenya
- All China Vetiver News Network Newsletters
- Alternative Technologies

Photo Gallery — NL 17 · Jun 1997

Photo Gallery — NL 20 · Apr 1999

Photo Gallery — NL 21 · Feb 2000

Photo Gallery — NL 16 · Nov 1996

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What's Happening at TVN — NL 24 · Jul 2002
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Policy, upscaling and dissemination

Accelerating Vetiver Developments In Africa — NL 14 · Sep 1995
Australia - Believe it or not — NL 12 · Jul 1994
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Central America, Vetiver in — NL 13 · Jan 1995
China (P.R.), Vetiver Grass in — NL 8 · Jun 1992
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- Background
- Study and Research
- Demonstration and Implementation

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Kenya - Slow progress — NL 12 · Jul 1994
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Malawian Initiative — NL 12 · Jul 1994
Man At Work - Alemu Mekonnen Initiates A New Vetiver Program In Northern Ethiopia – Current Activities And Hopes For The Future — NL 19 · Aug 1998
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Miscellaneous Meanderings of A Millennium Man In Southern Africa — NL 21 · Feb 2000
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Networking – A Means for The Dissemination Of Technology — NL 21 · Feb 2000
Organizing Vetiver's Next Steps To Global Acceptance — NL 16 · Nov 1996

Soil Erosion Initiative
Extreme Soil Initiative
Water Management Initiative
Pollution Control Initiative
Farmer Support Initiative
Basic Science Initiative

Pacific Rim Vetiver Network Operational Overview — NL 21 · Feb 2000
Panama Report on visit to Western Panama — NL 15 · Apr 1996
Perspectives of Vetiver Application in Southern China: A Case Study in FuJian Province — NL 18 · Dec 1997
Philippines Vetiver Network — NL 21 · Feb 2000
Pilot Programme For Promoting Vetiver Grass Implemented By The Peoples Rural Education Movement (Prem), Orissa, India.. Best Practices – Establishing a National Vetiver Diffusion Program: Example of Madagascar, A Country Eroding into the Sea — NL 21 · Feb 2000
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Research and Extension on Vetiver Grass — NL 18 · Dec 1997
Sagala, Kenya, Vetiver in — NL 24 · Jul 2002
South Africa - New Horizons — NL 12 · Jul 1994
South African Visit — NL 17 · Jun 1997
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Tour of Costa Rica — NL 16 · Nov 1996
United Kingdom, An NGO at Work — NL 12 · Jul 1994
Use of VGT in Cyprus and Gibraltar — NL 20 · Apr 1999
Viet Nam Vetiver Initiation Visit of January-February 1999 — NL 20 · Apr 1999
Visit to Southern Africa — NL 17 · Jun 1997
Where do we go Next? — NL 21 · Feb 2000
Zambia, Vetiver Development in. Alex Mundia — NL 13 · Jan 1995
Zimbabwe - The Hippo Valley Estates Magudu Vetiver Outreach Project — NL 15 · Apr 1996

Pollution and wastewater

Aquacultural Sludge Stabilization Within Created Wetlands — NL 14 · Sep 1995
Aquaculture Sludge Removal and Stabilization Within Created Wetlands — NL 16 · Nov 1996
Biotreatment of Produced Waters. Progress Report... Ray R. Hinchman, R. Gerald McNally, and M. Christina Negri — NL 13 · Jan 1995
China - “A Fix for Soil Aluminium Toxicity” — NL 12 · Jul 1994
Effects of Heavy Metals Toxicities on Vetiver Growth — NL 15 · Apr 1996

Ghana Gold Mine To Rehabilitate With Vetiver	NL 22 · Nov 2000
Miles Bentonite Mine, Queensland - Australia	NL 22 · Nov 2000
Pesticide Run-off Control Using Artificial Wetlands (Australia)	NL 20 · Apr 1999
Preliminary Experiment on Purification of Eutrophic Water with Vetiver	NL 18 · Dec 1997
Preliminary Study on Vetiver's Purification for Garbage Leachate	NL 18 · Dec 1997
Rehabilitation of Acid Sulphate Soils with Vetiver Grass	NL 16 · Nov 1996
Tolerance of Vetiver to toxic chemicals (ICV-1 abstract)	NL 15 · Apr 1996
Trapping Agro-chemicals and nutrients (Australia)	NL 20 · Apr 1999
Use of Vetiver grass in the Revegetation of Kimberlite Spoils in respect to South African Diamond Mining	NL 15 · Apr 1996
Water Eutrophication Control in Taihu Lake with Vetiver (China)	NL 20 · Apr 1999

Slopes and infrastructure

Application of the Vetiver Grass System in Land Stabilisation, Erosion and Sediment Control in Civil Construction	NL 18 · Dec 1997
Assessment Of Strength Properties Of Vetiver Grass Roots In Relation To Slope Stabilization	NL 16 · Nov 1996
Bio-engineering aspects (ICV-1 abstract)	NL 15 · Apr 1996
China - Vetiver's Application for the Prevention of Highway Slippage in South China	NL 16 · Nov 1996
China Superway Conference, Vetiver at	NL 20 · Apr 1999
East China Highway Conference, Vetiver at	NL 19 · Aug 1998
Engineering, Vetiver System for	NL 21 · Feb 2000
Engineering with Vetiver (A Biological Technique for Realizing Sustainable Development)	NL 18 · Dec 1997
First Highway Vetiver Contract Implemented In China	NL 20 · Apr 1999
Highway Stabilization: Vetiver an Authorized Grass (China)	NL 20 · Apr 1999
Hong Kong, Vetiver in. By Dr. R.D. Hill	NL 10 · Oct 1993
Important Biological Considerations In Use Of Vetiver Grass Hedgerows (VGHR) For Slope Protection And Stabilization	NL 13 · Jan 1995
Indonesia - River Bank Stabilization	NL 12 · Jul 1994
Malaysia The Wizard at Work!! Highway Stabilization	NL 12 · Jul 1994
Mine Tailing And Railroad Stabilization In Queensland Australia. Some Photos By Paul Truong	NL 19 · Aug 1998
Project For Mountain Revegetation Launched in Nanjing, China	NL 24 · Jul 2002
Recent Trials with Vetiver in Hong Kong	NL 20 · Apr 1999
Road Embankment Slope Stabilization in Nepal with Vetiver Grass	NL 17 · Jun 1997
Roads and Vetiver - China	NL 24 · Jul 2002
Shoulder Reclaimer Saves Time, Money	NL 14 · Sep 1995
Slope Stabilization: Vetiver Application from a Bio-Engineering Aspect	NL 17 · Jun 1997
Stabilising Steep and Unstable Sites with the Vetiver Grass System	NL 23 · May 2001
Stability of Slopes of Vetiver Protected Irrigation Channels By Dr. Sahu, et al	NL 10 · Oct 1993
Stabilization of Highway Roadcuts with Vetiver By Mr. A. Tantum	NL 10 · Oct 1993
Stabilization of Structures in Flooded River	NL 17 · Jun 1997
Stabilizing Homes On Steep Hillsides In Southern California	NL 21 · Feb 2000

Steep Slope Stabilisation NL 17 · Jun 1997
Studies on Protecting Highway Slopes with Vetiver Hedgerows NL 18 · Dec 1997
Use of Vetiver Grass for Engineering Purposes in Malaysia with Particular Reference to Slope Stabilization and Erosion Control NL 17 · Jun 1997
Uses of Vetiver Grass in the Land Rehabilitation and Maintenance of Military Installations NL 13 · Jan 1995
Vegetation for Slopes Stability and Erosion Control NL 17 · Jun 1997
Zimbabwe Rural Roads: Protection with Vetiver Grass NL 19 · Aug 1998

The plant, planting and research

Achnatherum splendens – A Potential Conservation Hedge Grass For Extreme Cold Winter Climates NL 19 · Aug 1998
Acquiring planting material NL 3 · Mar 1990
Agronomy of Vetiver (ICV-1 abstract) NL 15 · Apr 1996
Australian Universities, Vetiver Research at NL 17 · Jun 1997
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Commercial Source For Vetiver Planting Material NL 10 · Oct 1993
Comparative Measurements of Vetiver and Miscanthus By Mr. M. Materne and Ms. C. Schexnayder NL 10 · Oct 1993
Comprehensive Study. Bangladesh National Herbarium NL 16 · Nov 1996
Continuing Studies of Overwintering Success Rates of Vetiver by the US Army Construction and Engineering Research Laboratories at USACERL, Champaign, Illinois NL 14 · Sep 1995
Degraded Saline Land: Potential of Vetiver Grass for Stabilization and Rehabilitation. P.N.V. Truong NL 13 · Jan 1995
DNA Fingerprints (RRAPDS) Of The Pantropical Grass Vetiver, Vetiveria Zizanioides (L.) Nash (Gramineae), Reveal A Single Clone "Sunshine", Is Widely Utilized For Erosion Control NL 18 · Dec 1997
Effect of fertilizer and spacing on vetiver - interclump gaps NL 8 · Jun 1992
Effect of fertilizer and spacing on vetiver - Tops (gm, dry wt.) per 10m of hedgerow NL 8 · Jun 1992
Effect of Nitrogen Fertilization on Growth and Root Yield of Vetiver Grass (Vetiveria nigratana) in Nigeria (Preliminary Study) NL 16 · Nov 1996
Effects of Applying Fertilizer to Vetiver Grass for Erosion Control NL 17 · Jun 1997
Effects of Fertilizer on Vetiver Grass for Soil Erosion Control NL 18 · Dec 1997
Effects of Soil Salinity on The Establishment and Growth of Vetiveria Zizanioides (L.) NL 6 · Jun 1991
Experiments And Popularization Of Vetiver Grass, Nanping Prefecture, Fujian Province, China NL 6 · Jun 1991
- Vetiver root development under different manure treatments
- Treatment effects on aboveground biomass
- Research
- Benefits Of Vetiver Planting

Fungal Endophytes of Vetiver NL 16 · Nov 1996
Hedge establishment and management NL 3 · Mar 1990
Hedgerow Establishment - Plant spacing & density NL 5 · Mar 1991

Effect of Plant Spacing and Density on Survival
Effect of Plant Spacing and Density on Hedge Closure
Hedgerow Establishment - Plant Spacings (Under Semi-Arid Conditions) NL 17 · Jun 1997
Herbicides and rates of application for control of some weed species in vetiver hedgerows NL 8 · Jun 1992
Herbicides for Vetiver Grass Control NL 8 · Jun 1992
How Much Vetiver Do We Need? NL 24 · Jul 2002
How to Use Existing Barriers as Sources of Planting Material NL 16 · Nov 1996
Identification Program for Vetiver: General Information and Research Update NL 16 · Nov 1996
Influence Of Accession Variability And Fertilization On The Establishment And Growth of Vetiver Grass In A Field Nursery NL 7 · Nov 1991
Insects On Vetiver Hedges NL 23 · May 2001
Insects on Vetiver Hedges (China) NL 20 · Apr 1999
Investigations Of Jiji Grass As An Alternative To Vetiver Grass For North China NL 24 · Jul 2002
Know Your Hedge Vetiver: Environmental Concerns About Vetiveria zizanioides NL 16 · Nov 1996
Laboratory Tests Of Water Absorbing Gel For Vetiver Planting NL 22 · Nov 2000
Look See At Vetiver In Malaysia A Second Progress Report By Dr. P.K. Yoon NL 10 · Oct 1993
Production of Quality Planting Materials
Effect of Unorthodox Rooting- Media on Vetiver Growth
Establishment and Management of Quality Vetiver Hedgerows
Effect of Spacing cum Fertilizer on Growth Of Vetiver Hedgerows
Use of Selective Herbicides To Maintain Quality Vetiver Hedgerows
Use of Vetiver Grass as In Situ Mulch In Rubber Plantings
Observations To Show Special Characteristics of Vetiver Hedgerows
Look-See At Vetiver Grass In Malaysia - First Progress Report NL 6 · Jun 1991
Multiplication Of Vetiver
Growth Of Vetiver
Effect Of Vetiver On Soil Erosion
Diseases
Adaptive Use Of Vetiver By End-Users
Ad Hoc Notes
LSU AgCenter Researcher, Louisiana Businessman Team Up to Develop New Termite Control Material NL 22 · Nov 2000
Management Practices for Establishment of Vetiver Slips NL 18 · Dec 1997
Mycorrhiza and Vetiver - Rehabilitating Degraded Lands NL 7 · Nov 1991
Mycorrhizal fungi (Australia) NL 20 · Apr 1999
Native Pig Damage in Papua New Guinea, Vetiver's Resistance to NL 14 · Sep 1995
Natural Vetiver Communities Distributed in China NL 18 · Dec 1997
New Nursery For Finca Cristina - Costa Rica NL 21 · Feb 2000
Nursery Information NL 12 · Jul 1994
Nursery management NL 3 · Mar 1990
Observations and Experiments on the Multiplication, Cultivation and Management of Vetiver Grass Conducted in China in the 1950's NL 18 · Dec 1997
Observations and Experiments on the Multiplication, Cultivation, and Management of Vetiver Grass Conducted in China in the l95 NL 18 · Dec 1997
Observations on the Formation and Character of Vetiver Tillers NL 22 · Nov 2000

Observations on Vetiver In The Mediterranean Region — NL 24 · Jul 2002
Pests and diseases of Vetiver — NL 3 · Mar 1990
Pests/Diseases and Vetiver — NL 24 · Jul 2002
Planting Machine — NL 17 · Jun 1997
Planting Materials used for Various Look-See Trials — NL 16 · Nov 1996
Planting Techniques for Vetiver Slips in Rainfed Vertisols — NL 18 · Dec 1997
Preliminary Results of an Experiment Introducing Vetiver — NL 18 · Dec 1997
Preliminary Study On Vetiver (Vetiveria Zizanioides) For Utilization In The Fight Against Erosion — NL 6 · Jun 1991
- Cold tolerance
- Tissue culture
- Field Testing
- Effect of vegetative hedging (by species) on soil moisture (%) - 1989/90

Propagation of Vetiver - Better Than Cow Tea, Faster Than A Speeding Bullet — NL 24 · Jul 2002
Proposed Strategies To Meet Propagation Needs — NL 9 · Nov 1992
- Obtaining Vetiver For The Nursery
- Using Native Populations Of - Vetiver
- Nursery Management
- Low Input Nurseries and Low Cost Production
- Nurserying In Raised Soil Beds
- Containerized Nursery Stock
- Mechanised Nurserying of Vetiver For Large-Scale Production
- Alternative Propagation Methods

Rajasthan - the Driest Region of India - Vetiver's Limit? — NL 12 · Jul 1994
Regenerating vetiver hedge — NL 12 · Jul 1994
Report On Mortality In Vetiver Hedgerows In India — NL 10 · Oct 1993
Report On The Potential Weed Problem Of Vetiver Grass And Its Effectiveness In Soil Erosion Control In Fiji — NL 13 · Jan 1995
Resistance Of Vetiver Grass To Infection By Root-Knot Nematodes (Meloidogyne spp.) — NL 15 · Apr 1996
Resistance Of Vetiver Grass To Infection By Root-Knot Nematodes (Meloidogyne spp.) (Australia) — NL 20 · Apr 1999
Salt Tolerance of Vetiver — NL 8 · Jun 1992
Scale Insects On Vetiver In Guam — NL 23 · May 2001
Sodic Land Reclamation with Vetiver — NL 14 · Sep 1995
Soil Salinity Tolerance of Vetiver Grass Species Compared with Two Native Australian Species By Mr. G. Cook — NL 10 · Oct 1993
Stemborers In Vetiver Grass - Chinese Research Results — NL 5 · Mar 1991
Study of the Ecotype Comparison of Vetiver Grass — NL 17 · Jun 1997
Study On Ecological Characteristics Of Vetiveria Zizanioides (China) — NL 20 · Apr 1999
Technical issues, observations and recommendations — NL 12 · Jul 1994
Termites: Vetiver Grass a Useful Tool Against Formosan Subterranean Termites — NL 22 · Nov 2000
Thailand and China, Vetiver in / Other Species With Potential — NL 6 · Jun 1991
There are two immediate problems effecting the use of vetiver grass barriers — NL 12 · Jul 1994

Water and hydrology

Beach Erosion Protection in Bali with Vetiver	NL 24 · Jul 2002
Challenges and Problems in the Use of Vetiver for Watershed Management in the Sub-Mountain and Scarcity Zones of Nashik District (Maharashtra, India)	NL 18 · Dec 1997
Flood Plains, Vetiver Grass Trialled on	NL 14 · Sep 1995
Hydraulic Characteristics of Vetiver Hedges: An Engineering Design Approach to Flood Mitigation on a Cropped Flood Plain	NL 14 · Sep 1995
In-situ Rainwater Management on Arable, Non-arable and Wet Lands with Contour Vetiver Hedges. G.M. Bharad, Maharashtra, India	NL 13 · Jan 1995
Integrated watershed Development (Plains Project)	NL 14 · Sep 1995
Irrigation Systems: Vetiver Grass as a Preventative Maintenance Measure	NL 13 · Jan 1995
Large Scale Mechanized Runoff Water Harvesting: Prospects For Future R&D Activities	NL 14 · Sep 1995
Lowering Water Table in Saline Lands	NL 17 · Jun 1997
Prospect And Problems In Use Of Vetiver For Watershed Management In Sub Mountain And Scarcity Zones. (Maharashtra, India)	NL 19 · Aug 1998
Streamside Buffer Strips Improve Water Quality and Provide Wildlife Habitat	NL 16 · Nov 1996
Water and Vetiver - An Enhanced Perspective	NL 21 · Feb 2000
Wave Erosion Control	NL 17 · Jun 1997
Zimbabwe An initiative to save the Save	NL 17 · Jun 1997

Acquisition of planting material.....2
Nursery management.....3
Hedge establishment and maintenance.....4
Pests and diseases.....5
Research results.....6
Vetiver around the world.....9
Vetiver catalogue.....10
Vetiver users listing.....20

Photo courtesy of MASDAR

VETIVER NEWSLETTER

Newsletter of the Vetiver Information Network, ASTAG*, World Bank, Number 3, March 1990

LETTER FROM THE PUBLISHER

This is our first Vetiver Network letter using our new MacIntosh Pagemaker software. I hope it's more readable. Since the last letter in July 1989 much progress has been made. There are now about 900 interested people on this network and many more who get the information second hand. Recently the Bank's Environmental Department Director - Ken Piddington - kindly gave us some funds to hire Jim Smyle who has since October been coordinating the network on my behalf, and who recently made an extensive visit to India and Nepal and consequently collected a lot of information relating to Vetiver management which is described in this publication. And we can thank him for this interesting letter.

The demonstration and use of Vetiver as a biological barrier to reduce soil and rainfall losses is being tried in many countries particularly in Asia and Africa. Notably the States of Karnataka and Andhra Pradesh in India, the Provinces of Jiangxi and Fujian in China, some of the northern states of Nigeria and in Madagascar. In addition good work is being done in the Philippines, Indonesia, Nepal, Sri Lanka and Tanzania. It is reported that New Zealand has imported some tissue cultured

(continued on page 11)

FOR NEW READERS : WHAT IS A VEGETATIVE BARRIER ?

The idea of using plants to protect the land is anything but new; people have been replacing plant cover or leaving plant cover undisturbed to ensure the integrity of their land and its benefits for thousands of years. Over 5,000 years ago a Sumerian king codified the protection of vegetative cover for irrigation works and water supply protection. We have also known for thousands of years that replacing or leaving a complete vegetative cover is not always an option. Land is cleared for many purposes, and where it is improperly used following clearing, it becomes barren and infertile. In cleared areas, one very

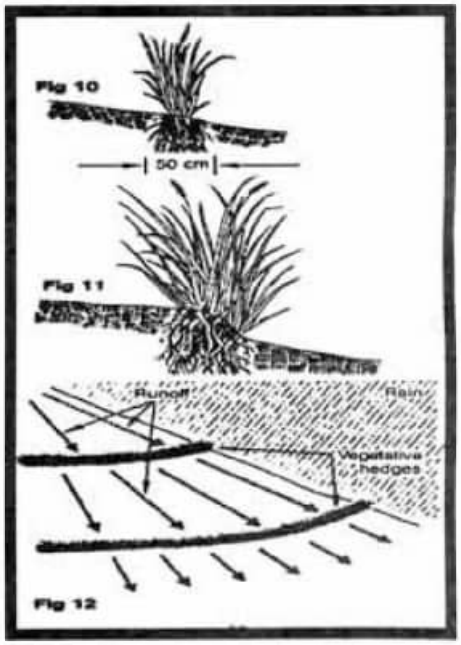

Illustration from Vetiver Handbook showing how the grass functions to trap silt and spread runoff

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effective practice that people concerned with good stewardship have been using is the creation of vegetative strips; for example the hedgerows of Britain that have been protecting the agriculture there for hundreds of years. These same hedgerows are now being removed and increased soil loss is becoming a problem. Vegetative strips, whether of grass, shrub, or tree species can form effective barriers when they are densely planted and well maintained. But the purpose for which the hedge is to be planted must decide the species which is to be used. If, as is our concern, you wish to create a barrier to the loss of soil and loss of moisture or if you wish to stabilize eroding areas such as streambanks and gully headcuts, then you will have to select a species that creates a dense barrier **at the ground surface**. That will preclude trees and most shrubs - unless you wait long enough for sufficient material (e.g. branches and leaves) to accumulate and create mechanical barriers. To slow down and spread surface runoff from rainfall, you need the same characteristic of density at the ground surface. To stabilize active water cutting areas you need something that establishes quickly, has a strong, deep root system and does not create undue turbulence in the water flow so as to cause more cutting around it. Grasses provide these characteristics, and among the grasses ***Vetiveria zizaniodes*** provides these and many other characteristics that make it a good vegetative barrier; not only the physical, but social and economic as well. For these reason this newsletter is promoting the use of vetiver grass. If your interests lie in natural resources or agriculture, please read on. • • • • • • • • • • • • • • • • •

ACQUIRING PLANTING MATERIAL

The acquisition of ***Vetiveria zizaniodes*** for planting material has been covered in previous newsletters so we will just give a quick synopsis of the information and an update on work with different cultivars of vetiver in India.

Planting material, if vetiver is unknown in your area, may be

Indian farmer from area of Mysore District where vetiver is a traditional field boundary planting and used as fodder. This hedge was planted by the man's father, at mid-field, for soil conservation. Note the elevation differences on either side.

tracked down through your local Herbarium (in a University, Botanical Garden, Agricultural Department, etc.). If they have a specimen, the specimen sheet should specify a location from where it was collected. The sheet should also specify the local names of the plant. If the plant is unknown, check either with the Vetiver Information Network, the Royal Botanical Gardens at Kew in London, or with a World Bank agricultural staff member to locate material.

When collecting material it would be well to bear in mind that there may be more than one cultivar of *Vetiveria zizaniodes* available to you. In India, the Operational Research Project component of the Kabbalnala Watershed Development Project in Karnataka is carrying out trials on cultivars of vetiver from six provenances : 1 from a coastal zone (Coondapore, Karnataka), 2 from a dry zone (Jhansi, Uttar Pradesh and Chikkabalapur, Karnataka), 2 from a transitional zone (Gundalpet and Hassan, Karnataka), and 1 from a humid zone (Koppa, Karnataka). Differences in growth rates and timing of flowering are already apparent in these trials; physiological differences in degree of leaf erectness, of leaf toughness, leaf blade width, strength of leaf margin and midrib serrations, and presence or absence of a slight reddish cast to the leaf margin are also evident. One cultivar, the local one from Gundalpet, has been selected for by farmers over time (50 to 200 years or more) for use as a fodder species. It is a softer, more palatable grass that grows well, forms excellent hedges, and the individual clumps produce less dry matter during the dry season

Stem and root cuttings of vetiver reportedly will sprout and it has been suggested that planting them in well watered soils under slightly raised plastic sheets (a mist chamber) might provide an inexpensive way to multiply vetiver.

(perhaps evidence of superior drought resistance), which results in fewer white ants (termites) in the hedges. Also, intensive breeding work has been carried out on vetiver by the National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi. In a March 1987 article in *Indian Farming* , Dr. K.L. Sethi, *et al* reported that a new variety of vetiver had been bred, Hybrid 8, that produces an average of about 50% more root then the local varieties to which it was compared in 5 locations. Hybrid 8 is a cross between two distinct types of *Vetiveria zizaniodes* : the northern India stock (representing wild populations possessing better quality oil) and the southern Indian type (representing cultivated material found in Kerala, Karnataka and Tamil Nadu). This hybrid is reported to produce a greater root mass (of "medium length roots") due to its profuse tillering. Requests for clonal material may be made to the Director, National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012. The article also recognizes different varieties of *Vetiveria zizaniodes* from Indonesia, Haiti, and Bourbon. Another interesting note in the article is the report that all the tested vetiver varieties showed diminished root production in alkaline soils; this is in light of statements found within some of the older manuals of grasses stating that the natural distribution of *Vetiveria zizaniodes* is only within areas of alkaline soils.

For soil and soil moisture conservation projects it would be wise to attempt trials in your area on as many different provenances of vetiver as possible. This is not to say that a start cannot be made with the planting materials on hand, rather that for long term promotion of vetiver as a conservation species it would be prudent to ensure having the best material possible for your area and conditions.

Finally, when collecting material, care should be taken to avoid taking tillers from source material parts that have flowered or seeded. Once having flowered and gone to seed there is diminished vigor in vegetative production in plants, generally. For a good return from investment in a nursery, young and vigorous tillers should be selected for planting. The lack of selection may explain the conflicting field reports that have been received indicating that vetiver stock from nurseries establishes better than wild vetiver planted on the main field and concurrently, that wild vetiver stock establishes better than nursery stock (in all cases the nursery stock was derived from the wild stock to which it was compared). Better establishment from wild stock was attributed to its being hardier from exposure to moisture stress, trampling, and **grazing**. Constant grazing would have ensured flowering did not take place, thus preserving vigor in the grazed versus ungrazed (or unpruned) stock. • • • • • • •

NURSERY MANAGEMENT

Nursery establishment should take place at least 6 months before the desired outplanting dates or 1 year in advance if the purpose is to supply material for other nurseries; this will ensure a good return of planting stock in exchange for the nursery establishment costs. Once you have a source of planting material for your nursery it should be planted into an area that has been prepared as if for any field crop - plowed, cultivated, weeded, manured, and clods broken up. Sandier textured soils are preferred for greater ease of lifting at harvest, however some balance between adequate water holding capacity for good growth and easy lifting is necessary.

In south India, current practice is to apply 1.5 kg/ha of Atrazine (a weedicide), 25 tons/ha farm yard manure, a basal dose of 250 kgs/ha di-ammonium phosphate, and 25 kg/ha of 10% BHC for soil grub and white ant (termite) control. Concerning the application of BHC, there exists confusion over whether or not white ants are a problem on vetiver grass; some indications exist that the white ants only remove the

dried material and do not hurt the plant. In a regularly irrigated nursery, where vigorous, green plants are maintained, white ants should not be a problem. Prior to planting, plots are well irrigated and slips with 2-3 tillers each are planted in a plowed furrow that is 15-20 cm deep. A spacing of 40 cm x 40 cm between and within furrows has been recommended though some Indian nurseries are now using a spacing of 20 cm x 40 cm and plan to try spacings of 20 cm x 30 cm and 15 cm x 40 cm. Urea is also applied in three split doses of 50-125 kg/ha each at 45, 75, and 105 days after planting. Irrigations are given every 4 to 5 days for the first two months and about every 7 days thereafter. After 35-45 days any plants which have not established are replaced. In addition, intercultural operations are carried out 3 times over the 6 month nursery cycle to control weeds. Unweeded nurseries in Andhra Pradesh, India were reported to produce 60% less tillers than weeded nurseries. Once established and growing vigorously, the vetiver should be kept pruned back to 30 cm-50 cm. If the nursery is unirrigated, pruning should only be carried out while the soil moisture status is good. Enhanced tillering as a result of pruning has been reported from China, India, Nepal, and Madagascar among a few, it has also been demonstrated by controlled experiments at ICRISAT in Hyderabad, India. Beside enhanced tillering, pruning will stop the loss of vigor in production of vegetative material associated with flowering, and provide mulch for the nursery to conserve moisture and cut down on weeds. In following these practices an average of 50 tillers/plant is expected in the semi-arid zones of south India at the end of 6 months.

Alternative methods of vetiver propagation also exist :

- Stem and root cuttings of vetiver reportedly will sprout and

(continued on page 13)

Tillers should be pruned before transport to the field and outplanting

HEDGE ESTABLISHMENT AND MAINTENANCE

Outplanting of nursery stock should take place as soon after the onset of the rains as possible, this means contour lines should be laid out earlier in the year. It is extremely important that the vetiver is planted along the contour, or if the contour is so tortuous as to make cultivation unacceptably difficult for the farmer, an "averaged" contour. The importance of contour farming cannot be understated here. One function of the vetiver is to provide the farmer a "keyline" so that his operations will take place along the contour. Contour farming is one of the few no cost practices available to poor farmers that has the potential of showing immediate and widespread benefits. Studies have shown that farmers do not do well when they lay out contours by eye, commonly missing by 20% or more. For this reason it is strongly recommended that contours be laid out with at least a hand level. Many types of hand levels have been tried and the easiest to use, as well as one of the least expensive, is a small plastic level that costs around US$ 10.00. It is made by David White Instruments of Menomenee Falls, Wisconsin, 53051, U.S.A and is available through their International Department.

As long as the soils are wet when vetiver is planted it will withstand long periods without rainfall; it has been suggested that in dry areas a minimum of 1.5 cm of soil water should be available at time of first planting (pers. comm. Dr. A.P. Raju). Experience related by field personnel in the dry areas of Maharashtra, Andhra Pradesh, and Bangalore in India indicated that survival rates began to decline if no rainfall occurred within 15 - 25 days after planting, declining to anywhere between 45% (in shallow, sandy Alfisols) and 70% (in Vertisols). Planting early on in the rainy season will avoid this problem during most years as once the roots establish vetiver is, as experience has shown, drought tolerant.

Planting is carried out by opening a 15 cm-30 cm deep furrow along the contour (or if too tortuous, an averaged contour) and the pruned slips with 10 cm-30 cm of tops and 10 cm of roots are

A 2 year old hedge of vetiver grass, the "farmer selected" cultivar, GKVK University farm, Bangalore, India

placed in the furrow. If roots are longer, care must be taken that the slips are not J-rooted, that is, planted so that the roots do not go straight down, rather curve back up or to the side. One technique to avoid this problem is to plant the slip slightly deeper, place the feet on both of the slip and pull it up slightly. Slips for planting should be selected for a maximum amount of succulent material; slips from older parts of the plants with a lot of dried material or from plants that have been allowed to flower in the nursery will not give as good establishment. When planting the soil **must** be well compacted back around the slip to ensure good soil contact for the roots. Reports of poor establishment of vetiver have often been traced to poor planting practices.

The number of tillers per planting spot and the spacing between planting spots will be dependant on the amount of planting material available, the soil, the climate, and the amount of time

(continued on page 14)

PESTS AND DISEASES OF VETIVER

Common reports of vetiver's resistance to insects and disease and its repellant properties towards rats and insects have been widely reported both from the tropics and temperate zones. These reports span at least 30 years of experience. At the same time it is inconceivable that a biological entity could be pest and disease free. Perhaps the best explanation that will reconcile 30 years of experience with common sense is that vetiver has not yet been found to have pest and disease problems that are of practical or economic importance to the farmer. The recent worldwide increase of interest in vetiver has led to closer inspection of the plant over the range in which it is used. This inspection has generated some information on vetiver and pests and diseases :

- **Termite** (white ant) nests have commonly been observed in vetiver hedges in the semi-arid zones of south India, except in the Black Cotton soils (Vertisols). Casual observations have resulted in the tentative conclusions that termite nests are not any more likely to be located in a vetiver hedge than in any other part of the field where a food source is available, i.e. vetiver hedges do not attract termites *per se*. In areas with termite populations the dry material in the hedges is an ideal food for the nests and nests are common. Whether or not the termites create damage or mortality (and gaps) is a subject under debate. It is certain that where nests have covered over entire leaves or clumps so that light is cut off, that leaf or clump has died, but that occurrence is rare. At present insufficient evidence exists to conclude if termites are a practically significant problem to hedge establishment and maintenance. If the evidence should come down on the side of termites as a problem, there already exists a good start at a biological solution. A comparison of the Gundalpet, India (farmer selected) cultivar with other cultivars has shown that the Gundalpet cultivar remains green almost through the entire dry season and produces very little dry material relative to other vetiver cultivars that dry out earlier and produce significant amounts of dry material. Termite nests have not been observed to be as common on the Gundalpet cultivar as they are on the other cultivars.

- **White grub** (Eupledia spp.) attack on the roots of vetiver has been reported as "severe" in one case in Zimbabwe by Mr. A.G.

Allison, the director of agriculture for Management, Agricultural Services, Development and Research (U.K.) Ltd. Mr. Allison states that in Zimbabwe "the white grub is a serious pest of sugar cane and napier grass", but that he does "not expect this to occur very widely but it is well to know about it."

- **Stemborers** have been observed in the culms and midribs of leaves of vetiver plants in south China and the Terai in Nepal. Currently unidentified, the stemborer larvae seemed to have been suffering a high mortality rate and no pupae could be found in either of the countries. Identification of the borer is being carried out and further information will be forthcoming.

- ***Holotrichia serrata***, an insect, has been found in the roots of vetiver.

- **Insect herbivory** has been observed on leaf margins of vetiver in the Terai of Nepal. No insect(-s) was identified as being responsible and the level of damage was not significant.

- **Rat** burrows have been found in the GKVK University farm in Bangalore, India existing under established vetiver hedges, but only where the hedges were planted on old bunds with what were most likely pre-existing rat burrows. Rats are also reported in vetiver in Madagascar. Concurrently, the rat repellant properties of vetiver have been reported from sufficient and diverse sources to lend credence to those reports. The conflicting reports are probably the result of the repellant properties being a function of the oil content (and therefore odor strength) of the root. The oil content varies widely between cultivars and possibly within cultivars and between sites. On the GKVK farm it may be that the oil content was sufficient to discourage rats from chewing through the roots to create new burrows, but insufficient to repel the rats whose burrows already existed. This same oil content and rats hypothesis has been put forward in Madagascar as well (pers. comm. Thomas Bredero). From the same source in Madagascar has come the report that farmers there are not terribly concerned about the rat repellency of vetiver as they normally burn their fields to rid them of rats, it is for that reason they prefer vetiver to other hedge plants because it survives the burning and grows back rapidly.

- **A "Brown Spot" disease** of vetiver has been reported from several countries. The "spot" disease in Andhra Pradesh, India has been identified by the Agricultural University as Curvularia trifolii, endemic to that area, this fungus is neither considered to be an economic problem of crop plants nor to have any significant impact on the vetiver. The fungus causes a dieback from the tip of the vetiver leaves. Another "Brown Spot" of vetiver, identified as *Gloecercospora sorghi*, has been reported.

- ***Fusarium spp.*** (a rust), particularly during the rainy season, has been found on vetiver.

- **Two smuts** have been found growing on vetiver in the GKVK University farm in Bangalore. The smuts are being identified, but meanwhile it has been reported (pers. comm. Dr. P. Ramanagowda, Operational Research Project) that attempts in the laboratory to cross-infect sorghum, maize and millet (the areas major cereal crops) failed and early indications are that the smuts may be host specific. • • • • • • • • • • •

RESEARCH RESULTS

Preliminary research results recently obtained from India show some interesting patterns in the impacts of vetiver grass. In particular, a set of data from the work of Dr. G.M. Bharad in Akola, Maharashtra provides some insight. Dr. Bharad has been carrying out small plot experiments, collecting surface runoff and soil loss data. The plots, which average 0.35 ha in size, represent Black Cotton soils (Vertisols) in a low rainfall area (mean annual precipitation = 861 mm). The plot slopes are less than 2% and the treatments are across slope cultivation (i.e. cultivation parallel to the major slope), and contour cultivation (i.e. cultivation parallel to all slopes) with contour hedges of leucaena, with contour bunding, and with contour hedges of vetiver grass. The vetiver and leucaena hedges were about one year old at the start of data collection. A 1 meter vertical interval was used for the layout of the hedges and bunds. Combining the data from two sets of experiments carried out in proximity to each other on two different crops (pearl millet and sorghum), simple linear re-

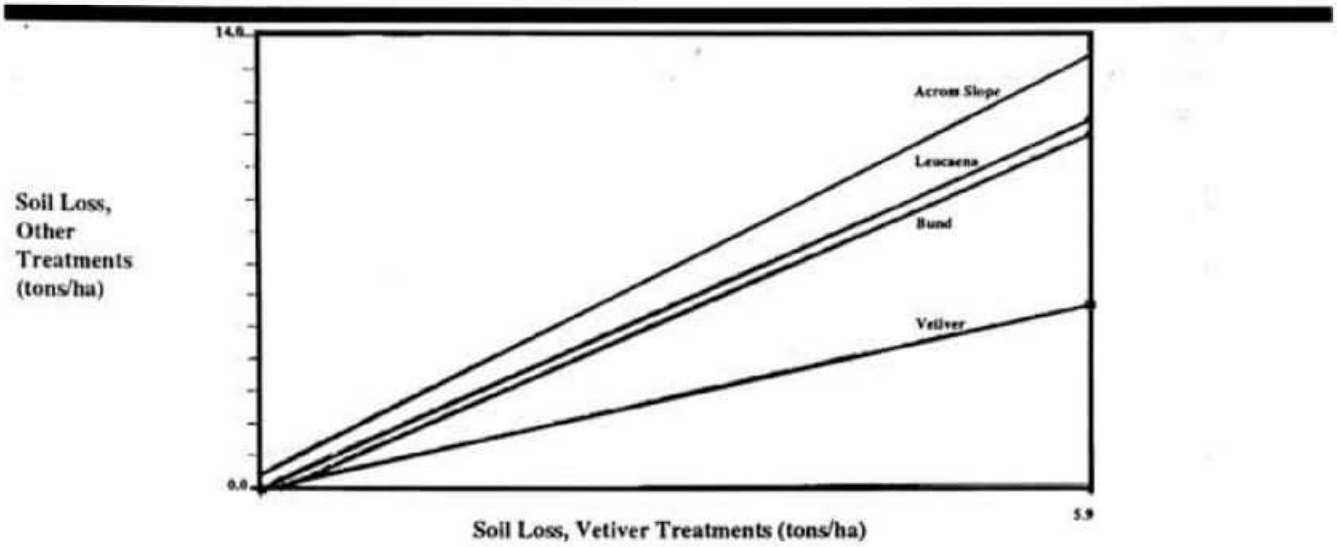


Figure 1. The Effects of Contour Planted Vetiver On Soil Losses Versus Other Treatments.

gression models were made to estimate the relationship between surface runoff and soil loss from the vetiver plots versus the "other" treatment plots. The regression equations, based on 49 rainfall-event observations (excepting contour soil bunding for which only 10 observations were available), were of the form :

$$Y_i = f(X) + E \qquad (1)$$

where, X = soil loss or runoff from the vetiver treatment plots, Y_i = soil loss or runoff from one of the other treatment plots, and E = some error term. Figures 1, 2, and 3 show the regression lines comparing soil loss, surface runoff, and peak runoff from vetiver and the other treatments, respectively. The lines on the graphs labelled "vetiver" are the vetiver : vetiver comparison lines; the deviations from those lines shows the difference between vetiver and the other plots. The r^2 for the regression lines ranged from 0.92 to 0.97 for soil loss, 0.94 to 0.96 for surface runoff, and 0.64 to 0.72 for peak flows.

In Figure 1, the patterns of soil loss from the across slope, leucaena, and bunded plots are very similar. The data from the leucaena plots is more usefully thought of as data from contour cultivated plots as the leucaena hedges were uniformly sparse and probably not very effective.

Relative to the other treatments, the vetiver plots showed a lower soil loss on a per storm basis. Using the assumption that the effects of the leucaena hedges was minimal at this stage of the experiments, the slopes of the regression lines show :

- **a 12% decrease** in average per storm soil loss from the contour cultivated (leucaena) plots versus the across slope cultivated plots;
- **little or no difference** in the average per storm soil loss from the contour cultivated plots and the contour cultivated with soil bunding plots;
- **a 56% decrease, a 51% decrease, and a 50% decrease** in the average per storm soil loss from the vetiver plots versus the across slope, contour cultivated, and contour cultivated with contour bunding plots, respectively.

The implications from these data being that contour cultivation by itself reduced soil losses from each runoff producing storm by an average of 12%, adding contour bunds to the contour cultivated system made no difference in soil losses, adding contour hedges of vetiver grass to the contour cultivated system reduced soil losses, on the average, an additional 51%.

The average total soil loss over the cropping season from the plots was 25.5 t/ha (s.d. = 13 t/ha), 16.9 t/ha (s.d. = 1.7 t/ha) and 7.6 t/ha (s.d. = 1.0 t/ha) for across slope cultivation, contour cultivation with a contour hedge of leucaena, and contour cultivation with a contour hedge of vetiver, respectively. Data on the contour cultivated plot with contour bunding was not available for the entire period of study, but during the time over which data is available, the contour bunded plot showed a soil loss of 13.5 t/ha to the vetiver plot's 8.0 t/ha.

An indication of the

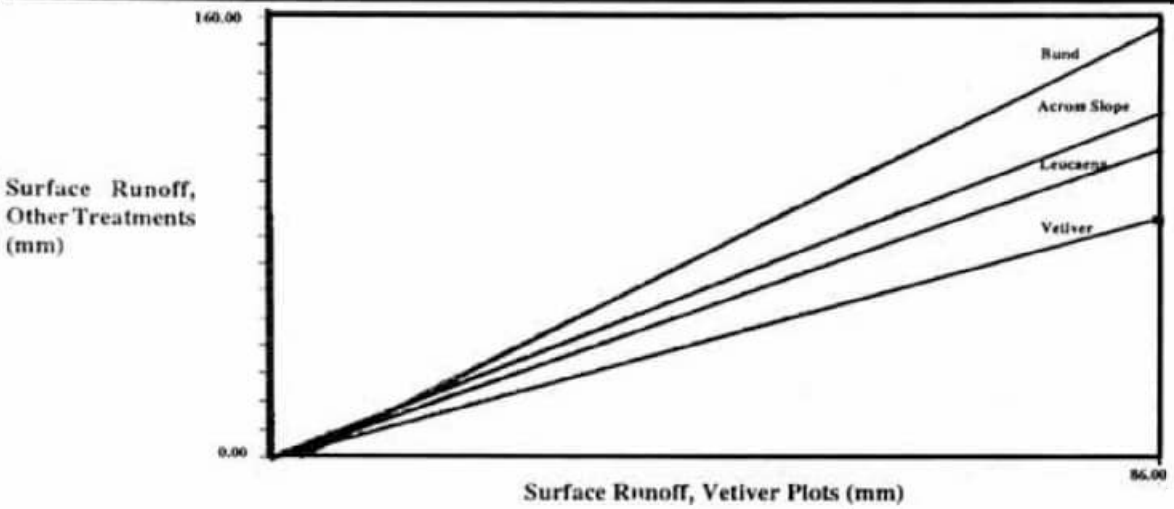


Figure 2. Effects of Contour Planted Vetiver On Runoff Versus Other Treatments

"buffering" effect against soil loss conferred by the different treatments is obtained from the distribution of soil loss from the plots over the entire cropping season. In the across slope cultivated plots, 90% of the season's soil loss occurred during 50% of the seasons's runoff events. In the contour cultivated plots, with leucaena and with vetiver, 90% of the soil loss occurred during 22% of the runoff events. The significance is that the across slope plots were more likely to lose soil during any storm event that caused runoff versus the other two plots where less than half of as many runoff-producing storms generated 90% the lost soil. Assuming that the leucaena plots were more representative of contour cultivation alone, then the effect of contour cultivation by itself was to decrease the number and magnitude of soil loss events. The addition of vetiver, which plots had approximately the same soil loss distribution as the contour cultivated plots, was to decrease the magnitude of soil loss but showed no effect on the number (or distribution) of soil loss events. Both sets of plots, contour cultivated (with leucaena) and contour cultivated with vetiver, had 90% of their total soil loss within the same runoff events, but the average total soil lost as a result of these events was 6.8 t/ha for the vetiver plots and 15.2 t/ha for the contour (leucaena) plot. The difference in the magnitude of soil losses is the effect of the vetiver in retaining sediment.

Comparing the regression lines for storm event surface runoff (Figure 2), the runoff from the smaller events is fairly similar for all treatments; this is as much an artifact of runoff sampling from small plots as it is a result of treatment. In smaller runoff events the main source of runoff water is from the area immediately upslope of the collector; in these experiments the vegetative hedges and bunds are at some distance upslope. Storm events which generate greater than (about) 15mm of runoff begin to show greater differences between treatments. It is the larger runoff events that are of the greatest interest as these are the events, occurring during the times of higher antecedent soil moisture conditions from storms of greater depth, duration and intensity, in which a large percentage of the annual precipitation occurs and is lost as runoff. The opportunity to recharge soil moisture storage is greatest during these events. Also, these represent those events causing the greatest soil loss; providing for the off-site transport of eroded soil particles. In the larger runoff events the difference in stormflow between vetiver and the other treatments is obvious; compared to the other treatments, the vetiver plots showed less surface runoff on a per storm basis. The bunded plot responded with the greatest amounts of runoff in the larger storms; in keeping with the function of the bund to channel water off of the field. Assuming that the effects of the leucaena hedges were minimal at this stage of the experiments, the slopes of the regression lines show :

- **a 10% decrease** in the average per storm surface runoff from

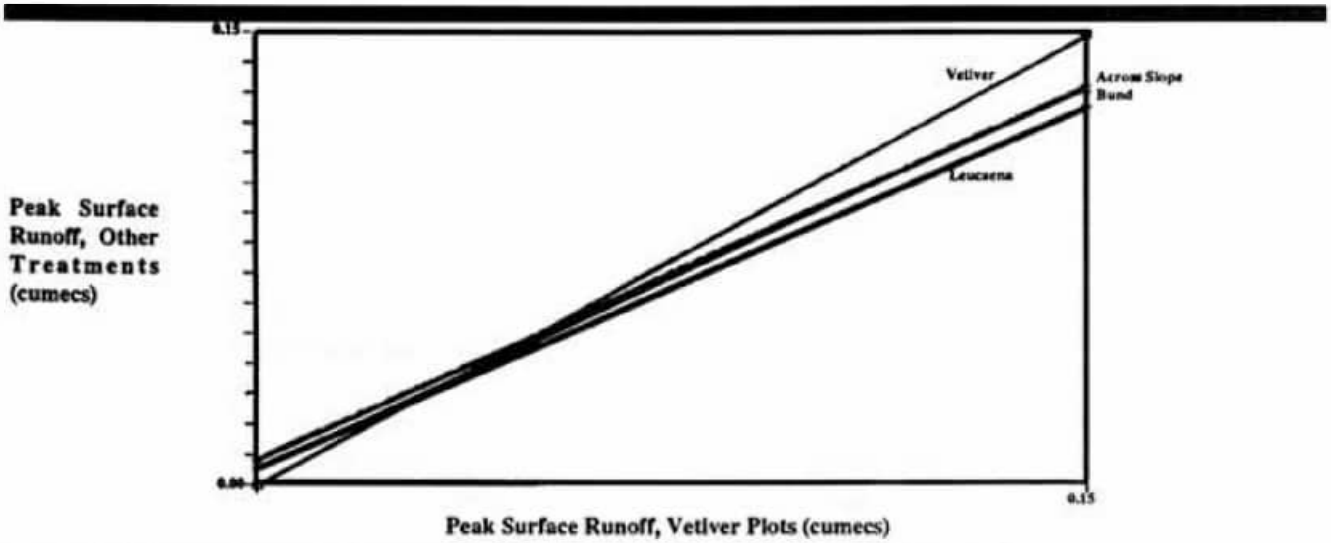


Figure 3. Effects of Contour Planted vetiver On Peak Surface Runoff Versus Other Treatments

the contour cultivated plots versus the across slope cultivated plots;

- **a 31% increase** in the average per storm surface runoff from the contour cultivated with soil bunding plots versus the contour cultivated plots. The increase was due to a greater runoff response during the larger storms; in the lesser storms runoff from the bunded plots was generally less than from the contour cultivated plots;

- **a 31% decrease, a 23% decrease, and a 46% decrease** in the average per storm surface runoff from the vetiver plots versus the across slope, contour cultivated, and contour cultivated with contour bunding plots, respectively.

The average total surface runoff over the cropping season from the plots was 317 mm (s.d. = 34 mm), 261 mm (s.d. = 49 mm) and 197 mm (s.d. = 43 mm) for across slope cultivation, contour cultivation with a contour hedge of leucaena, and contour cultivation with a contour hedge of vetiver, respectively. Data on the contour cultivated plot with contour bunding was not available for the entire period of study, but during the time over which data is available, the contour bunded plot had surface runoff of 174 mm to the vetiver plot's 115 mm.

Figure 3, which compares peak runoff rates (i.e. the maximum rate at which surface runoff left the plot during a rain storm) and shows that there is very little,

(continued on page 17)

VETIVER AROUND THE WORLD

Much of the news and information on vetiver grass (as a soil and soil moisture conservation species) has come from India, but that is not to indicate that India is the only country interested in this grass. Internationally quite a bit of interest in vetiver has been generated; most recently, the Vetiver Network has learned of the use of vetiver in the following locations :

- **In China,** under the National Soil and Fertilizer Station Headquarters of the Ministry of Agriculture, various other agencies will be carrying out work with vetiver in Fujian, Jiangxi, Sichuan, Hunan, and Guizhou Provinces for soil and water conservation on tea, fruit and cultivated slopes and terraces;

- **In China,** under the Ministry of Water Resource's Department of Rural Water Conservancy and Soil Conservation is working to extend vetiver grass into the provinces of Jiangxi, Hainan, Guangdong, Fujian, Zhejiang, Shanxi, Gansu, Sichuan, and Henan. Also, the Institute of Mountain Disasters and Environment of the Chinese Academy of Sciences is proposing research on vetiver for use in mountainous areas;

- **In Madagascar** the vetiver contour hedge system has been accepted by the Project Preparation Unit of the PAE and DVA as the key element of various systems of land use aimed at conserving soil and water. Also, an extension type booklet in Malagasy and one in French will be distributed

throughout the island. Vegetative contour protection on about 250,000 ha is to be undertaken by the national extension service;

- **On the island of St. Vincent,** West Indies interest in vetiver grass is reviving amongst policy makers and others. The grass had been extensively planted by the Department of Agriculture as a contour hedge for soil conservation in the 1940s and also had been used by the people as thatching material, a composting substance, a perfumery, and a boundary marker. Over the last decades it's use had been forgotten, but recently had been reintroduced into the northeastern portion of the island in a forestry management project by the Canadian International Development Agency (CIDA);

- **In the Terai of Nepal** vetiver has been used traditionally to stabilize rice paddy bunds and irrigation field channels, as well as used as a fodder species, for weaving baskets and to make combs (from the roots) and brooms (from the flowers). A great deal of interest in vetiver has been expressed by NGOs and project personnel active in agriculture and natural resources for usage in river cutting areas, land slide stabilization, stabilization of outward sloping terraces, and agroforestry schemes;

- **In Ethiopia** vetiver has been located on several Coffee Authority farms where it had been introduced in about 1978 by some Indian Extension workers who used it as a natural barrier to the spread of *Digitaria scalorum* and *Cynodon dactylis*. Also the Ethiopian Ministry of Coffee and Tea Development intends to publish 2,000 copies of the Vetiver Handbook in Amharic;

- **In the U.S.A.** the Soil Conservation Service in cooperation with the Agricultural Research Service plan a series of trials on vetiver focusing on soil loss reduction and in-field windbreaks. The Forest Service is also reported to be interested in vetiver for forestry applications. Propagation of vetiver is being carried out in almost a dozen of the Department of Agriculture's Plant Materials Centers;

- **In Kenya** the Soil Conservation Division of the Ministry of Agriculture is carrying out performance trials on vetiver in Embu, and we have heard from Mervyn Carnnelly at Lake Nairasha that he has used vetiver for soil conservation for many years,

- **In Nigeria,** the state of Kaduna, vetiver has been found as an agricultural boundary planting, and demonstrations are now underway in Sokoto State and other localities including the Mambilla Plateau and Gongola;

- **In Northern Ghana** vetiver is proposed for use to trap silt at dam entrances;

- **In the Republic of Mali** a pilot project design has planned to incorporate vetiver hedges into a sustainable farming systems project;

- **In Tanzania** vetiver has been in use as a soil conservation grass by at least one farmer who has been growing it for about 50 years. He recalls receiving his original planting material from German colonists. He reports no spreading out of the planted lines in the entire time. Also, CIDA is testing it on their wheat project near Arusha;

- Identified **in Queensland,** the New South Wales Soil Conservation Department is carrying out experimental work on vetiver;

- Vetiver grass has been imported into **New Zealand** where, after leaving quarantine, evaluation work will be carried out on it for its applications in that country;

- **In the Philippines,** Pantabagan, vetiver is being planted to stabilize eroding hillslopes;

- **In Northern Sumatra** the Ministry of Forestry has a vetiver nursery and trial area;

- **In East Kalimantan** sufficient material has been propagated to begin outplanting next year as contour hedges;

- **In Indonesia** the usage of vetiver grass on a large scale with oil palm and rubber palm has been reported;

- **In Brazil,** a 200 ha vetiver farm is located in the State of Rio Grande do Norte. • • • • • • • • •

VETIVER CATALOGUE

ASTAG is putting together a new slide presentation on vetiver grass and its uses around the world. The slide show is appropriate for use as an information dissemination and extension tool to introduce vetiver to policy, project and field level personnel, as well as to the general project. Each set of slides will come with a script to be read along with the slide show. Sets will be available from ASTAG by April 1990 and

will cost US$ 60.00 each.

In March 1990 the World Bank will publish the 3rd edition of the Vetiver field handbook - to be titled: *Vetiver - A Hedge Against Erosion.*; a name borrowed from MASDAR, U.K.. The book will be sold worldwide and will be available at most outlets that sell Bank publications; a free copy will be sent to all members of the network. If you want to purchase extra copies ($4.95 in the U.S) you may contact the nearest World Bank Office. It is not copyrighted and we encourage translations into local languages. Also available for free are copies of the list of Vetiver Network participants.

To assist in project preparation ASTAG has compiled a microcomputer spreadsheet that calculates the direct costs of a vetiver project including nursery and hedge planting. The spreadsheet uses information provided by the user on local input costs, area to be treated and planting geometry. Based on experience with World Bank supported projects in India, the spreadsheet calculates nursery requirements, total costs, costs per 1,000 planting slips and costs per 1,000 running meters of hedge as well as per hectare treatment costs. The spreadsheet allows users to estimate the costs of a vetiver program and compare them with other technologies. Users will want to supplement the program with knowledge of local conditions. A sample of the output from the spreadsheet is given below to illustrate the impact of wage rate and slope class on per hectare costs. The spreadsheet, in (IBM) Lotus 1-2-3 or (Apple)MS-Works is available from ASTAG for US$ 5.00 (specify size, e.g. 360K, 5.25 inch). Comments and suggestions for revisions of the spreadsheet should be sent to Bill Magrath, ASTAG.

All requests and comments may be sent to ASTAG at the address found on the bottom of page 1. • • • • • • • • • • • • • • •

Table 3. Per Hectare Cost Of Land Treatment With Contour Hedges Of Vetiver Grass On A 2 Meter Vertical Interval By Percent Slope And The Cost Of Daily Labor (US$)

	PERCENT SLOPE CLASS													
DAILY LABOR RATE	0% - 1%	1% - 2%	2% - 5%	5% - 10%	10% - 15%	15% - 20%	20% - 30%	30% - 40%	40% - 50%	50% - 60%	60% - 70%	70% - 80%	80% - 90%	90% - 100%
US$ 0.50	2.43	7.29	17.02	36.46	60.77	85.08	121.54	170.15	218.77	267.38	316.00	364.61	413.22	461.84
US$ 1.00	3.44	10.32	24.08	51.60	86.00	120.40	172.01	240.81	309.61	378.41	447.22	516.02	584.82	653.62
US$ 1.50	4.45	13.35	31.15	66.74	111.24	155.73	222.48	311.47	400.46	489.45	578.44	667.43	756.42	845.41
US$ 2.00	5.46	16.38	38.21	81.88	136.47	191.06	272.95	382.12	491.30	600.48	709.66	818.84	928.02	1037.19
US$ 2.50	6.47	19.40	45.28	97.02	161.71	226.39	323.42	452.78	582.15	711.51	840.88	970.25	1099.61	1228.98
US$ 3.00	7.48	22.43	52.34	112.17	186.94	261.72	373.89	523.64	673.99	822.55	972.10	1121.66	1271.21	1420.77

LETTER FROM THE PUBLISHER (continued)

plantlets! The latter must be the influence of John Greenfield now retired at the Bay of Islands, New Zealand.

In India, Jim Alexander at the World Bank and Dr. Seth of the Ministry of Agriculture, both located in New Delhi, are the Vetiver anchormen for India, with some exceptional good field work and research being done in Karnataka by Drs. Shastri and Hegde; and similar teams at PKV University in Akola, Maharashtra working under Dr. G.M. Bharad on the black vertisols, at Andhra Pradesh Agricultural University working under Dr. A. Padme Raju, and at R.A.K. College at Sehore under Dr. Raghu previously, now under Dr. Saran. In China, Mr. Zhang Xiubao of the Institute of Mountain Disasters and Environment, located at Chengdu-Sichuan Province, coordinates a China Vetiver Network that was established last October following a joint workshop sponsored by the Ministries of Agriculture and Water Resources; in Nigeria Mr. Sreekantiah, responsible for extension at the World Bank's Lagos office, is our key link for Vetiver in that country. Tom Bredero working for the Bank in Madagascar where

he is developing Vetiver fast would be an important contact. There are many others (see attached network participant list). Ed Coloma of the National Irrigation Authority in the Philippines has good experience with the technology, and Mr. P.K. Yoon of the Malaysia Rubber Research Institute at Kuala Lumpur is busily finding ways to propagate the planting material at a faster rate (inside of seven months he was able to produce over 16,000 plantlets from an original clump of 57 !). And so the interest grows in this age old technology.

With any technology, it is the user who keeps the new users and policy makers informed about the usefulness of the technology, as well as the best ways to manage it to get the full benefits. So far we have the example of the researchers and field people mentioned above who have been kind enough to share their experiences and research information with us. We ask that you share with us and then by extension with the hundreds of others worldwide, your findings on vetiver. We even want to hear of your preliminary results and tentative conclusions because those are still the best information we have available to us as we wait for the complete picture to evolve. A lot of work is going on now and will soon be started without the benefits of your experience if you do not let us know.

In March the Bank will formally publish the 3rd edition of the Vetiver field handbook - to be titled: Vetiver - A Hedge Against Erosion. We can thank MASDAR, U.K. for this name. The book will be sold worldwide and will be available at most outlets that sell Bank publications; a free copy will be sent to all members of the network. . We must thank Jim Feather, Director of Publications, for his support, and Vicky Lee who worked on John Greenfield's update to produce a very readable new edition. It is not copyrighted and we encourage translations into local languages. The second edition has been translated by Jiangxi Province Agricultural Development Corporation into Chinese. Uttar Pradesh Irrigation Department has translated it into Hindi (good for the Irrigation engineers!), and the Land Development Corporation - Gujarat into Gujarati. Other pamphlets have been produced in Sri Lanka and Nepal. A French translation is available in North Africa.

As the technology spreads and more people use it and study it, of course problems emerge that have to be dealt with through management practices specific to the location. However it is reassuring that to date we can still not find any really serious biological or physical problem with the technology; in fact because one is always comparing it with traditional conservation systems and other grasses, problems relating to these tend to surface more often. Two aspects are emerging: First, users will be disappointed in the technology when applied incorrectly. Correctly means planting on the contour (or average contour) at 10 to 20 cm within line spacing. Secondly, we are finding large differences in planting material. In Karnataka at least six cultivars have been identified. One of them known as the "local" cultivar selected by farmers over many years appears superior over others for hedging ability and for fodder. I would urge serious Vetiver users to start identifying different cultivars and testing them out, and importing those that they don't have for testing.

Readers who are with NGOs (Non-Governmental Organizations) or who work with NGOs might be interested in an excellent report by the Asian Development Bank entitled "Cooperation With NGOs in Agriculture and Rural Development". The report confirms the need to introduce very low cost, simple technology to the weaker (poverty) section; technologies that have minimal investment requirements for the assetless poor. The vetiver hedge technology meets these requirements after initial introduction of planting material. Particularly as it has minimal dependence on government institutions. We are sending this newsletter to all the major NGO groups identified by the ADB that work in the Asian countries that it reviewed. Writing about the poor, an example comes to mind of a village in the Achlow Project Block of the Kabbalnala project in Karnataka. The village was comprised of the poorest migrants from the neighboring state of Andhra Pradesh who had taken up residence on what was the the area's worst agricultural soils. After once convinced through demonstration of the vetiver hedge technology, the

whole village population was self-mobilized and in less than one day planted and protected their farm lands with vetiver. The project provided the planting materials and the villagers did the rest at no cost.

A technology such as "Vetiver hedges" is a wonderful way of concentrating the mind, and I for one have started paying a lot more attention to soil and moisture conservation issues and their relationship to other agricultural, water and land resources issues that are often bundled together under the environmental label. Finding low cost and effective solutions for wide scale application of soil and moisture conservation techniques are essential if we are going to come to grips with declining soil fertility issues, depleting ground water, and the widening and more perverse effects of increased flooding and reduced dry season river flows. Preliminary research results from India are now supporting our visual field observations and the farmer's experience is now showing that Vetiver hedges are significantly superior to other systems that were tested. That's why it's so exciting.

For those of you working in drought prone areas such as South India or Subsaharan Africa (average annual rainfall areas of 500 - 800 mm), vetiver grass hedges or their equivalent may be the key to retaining sufficiently high soil moisture levels and thereby reducing drought risks. Technologies, such as vegetative barriers, which are aimed at enhancing soil moisture and increasing crop security in rainfed agriculture need to be given high priority by farmers and researchers. By enhancing moisture levels we capture a greater portion of the genetic potential of improved crop varieties and make greater use of other farm inputs (such as fertilizer) that otherwise would not be used because of risk of crop failure and related economic losses.

Vetiver hedges may be one of a number of key technologies to provide a practical and low cost solution to current environmental challenges, and we should not forget that in the heat of the debate on the environment that the part dealing with land based natural resources can mainly be resolved through good agricultural practices and management.

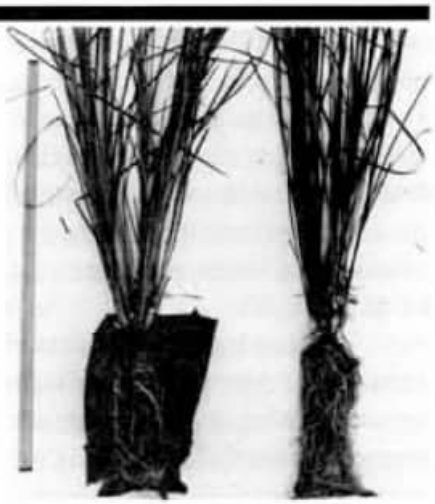
Please let us hear from you regarding your knowledge and experience with not just vetiver, but any vegetative barrier systems which you have found to serve the dual purposes of soil and soil moisture conservation. And don't forget to send in your Vetiver Network Information forms so that we might stay in contact with you.

Dick Grimshaw • • • • • • • •

NURSERY MANAGEMENT (continued)

it has been suggested that planting them in well watered soils under slightly raised plastic sheets (a mist chamber) might provide an inexpensive way to multiply vetiver.

- In West Malaysia Dr. P.K. Yoon reports that after finding one clump of 57 tillers he proceeded to plant them one each in polybags



Vetiver propagation in polybags. (photo courtesy of Dr. P.K. Yoon)

under irrigation and, using slow release fertilizers, multiplied his 57 bags to more than 16,000 bags in about 7 months. At four months he averaged 17 tillers/plant in 7"x15" polybags and 26 tillers/plant in 10"x20" polybags.

- Gullies are suggested for informal nurseries as they have higher soil moisture levels and can produce material while stabilizing the gully. Obviously all the planting material would not be uprooted, clumps can be split and tillers removed from the downslope side.

- MASDAR in the U.K. and GKVK University in Bangalore have both tissue cultured vetiver.

Lifting operations can be carried out after six months . Thoroughly soak the nursery and have two man teams with a strong fork, pick, or bar carry out the lifting. While one man levers the plant out of the soil, the other pulls the plant over toward him exposing the roots. When 20 cm of roots or more are exposed the man with the lever can cut the clump loose. The clump can then be broken up into pieces for transport to the field.

Two or three tillers can be left in the ground from each clump to provide material for the next nursery; as these 'secondary' nurseries have plants with already established root systems they can be expected to be better producers on the next rotation.

Following lifting, the plants should be pruned for outplanting. This can be done before transport to the field to avoid carrying the extra weight and to provide mulch to the nursery. Tops should be pruned to 10 cm to 30 cm to cut down on transpiration losses. Experience in India (pers. comm. Mr. G.V. Nagraj Naidu, Maheshwaram project) has shown that with 10 cm tops there is less likelihood of the slips being kicked over by the farmer or grazing animals prior to root establishment. Roots should also be pruned to about 10 cm. Preliminary experimental data (Dr. A.P. Raju, Andhra Pradesh Ag. Univ.) showed that over the first 70 days after transplanting, slips with 10 cm roots had about 40% better establishment rates after 25 days and about 18% better growth after 70 days than slips with roots pruned to 5 cm (often recommended). Longer roots are not recommended to avoid J-rooting caused by careless transplanting. Transport to the field is simple as vetiver can withstand rough handling and can be left (in the shade) unattended for long periods. Reports of good establishment rates achieved with vetiver that was transplanted 10-30 days after uprooting have been received. Preliminary results from one experiment (Dr. A.M. Krishnappa, Operational Research Project, Kabbalnala) showed no difference in establishment rates between vetiver transplanted the day of uprooting and vetiver transplanted at 2, 4, and 6 days after uprooting when left with no water in the shade. Best practice, however, would still be to plan for transplanting as soon after lifting as possible.

The abovementioned nursery practices are those that have been found suitable for local conditions in four areas of south India. Best management practices under other climates and soils may differ and require adjustments. In general, a good start will be achieved if : planting material is selected to avoid taking tillers from source material parts that have flowered or seeded; well prepared beds are made in soils that are neither excessively drained or poorly drained (sands and clays) to avoid moisture and lifting problems; some fertilizers are applied (organic or inorganic); weed infestation is avoided; and regular irrigations are carried out. If irrigation is not possible, nurseries can be planted at the beginning of the rainy season for lifting early in the next year's rainy season after green shoots begin to appear. If fertilizer is not available, the vetiver will still establish and grow well without it though tillering will be reduced to some extent. Preliminary information from one set of fertilization trials carried out on vetiver grass (Dr. A.P. Raju, Andhra Pradesh Ag. Univ.) showed no difference in growth response between fertilized (40 kg/ha N and 40 kg/ha P) and unfertilized vetiver in one plot (at 70 days) and no response until about week 8 in a second plot. Vetiver has also been reported by the same source to establish well in soils that are characterized as phosphorous deficient; this observation is supported by the experience from China in the acidic, phosphorous deficient soils of Jiangxi and Fujian Provinces. • • • • • • • • • • • • •

HEDGE ESTABLISHMENT AND MAINTENANCE (continued)

that you wish to wait for hedge establishment. In the long term, if amount of planting material is a problem, it would be best to be less conservative and strive to establish good hedges over smaller areas (to ensure farmer acceptance) while more nurseries are being established. Plantings that are too widely spaced will not provide any benefits for many years. Ideally the number of tillers per slip and their planting densities should be based on the desire to minimize, or avoid all together, the necessity to come back and carry out gapfilling in the hedges at the end of the first, second, and possibly, third years and to achieve an effective hedge in the minimum amount of time possible. The practice in the semi-arid dry zone of India on sandy soils has been to plant 3-4 tillers per slip every 10 cm-15 cm and on clayey soils to plant 2-3 tillers per slip every 10 cm. In the humid areas of China and Madagascar the practice has been to plant 2-3 tillers per slip every 15 cm-20 cm.

Photo Courtesy of MASDAR

A well established and maintained vetiver hedge planted to control sediment and runoff from a dirt road in Africa.

In controlled experiments (Dr. A.P. Raju, Andhra Pradesh Ag. Univ.) found that over the first 10 weeks that 4 tillers per slip planted every 7.5 cm had a significantly greater mean daily growth increment (2.8 cm/day) than 4 tillers per slip planted at 15 cm (1.6 cm/day) or 2 tillers per slip planted at 7.5 cm (1.9 cm/day) and 15 cm (1.4 cm/day). Also, 4 tillers per slip per planting spot had a greater establishment percentage than 2 tillers per slip per planting spot, 74% versus 57%, respectively. Fertilization does not appear to have any effect on plant survival and while it may increase the rate of growth, it will also increase weed competition within the hedge. In establishing a hedge, individual plant survival is not as important as the spatial variability and distribution of mortality within the hedge. If a vigorous plant can be established every 20 cm-25 cm in poor soils and every 30 cm in good soils, then an established hedge can be achieved in 3-4 years (pers. comm. Dr. A.P. Raju). If an established hedge is desired more quickly than that then planting densities will have to be modified to achieve this goal. Current experience suggests that in good soils within a humid zone, hedges of vetiver can be established in 1 year based on selection of good planting material and good planting practices with 2-3 tillers per slip every 10 cm-15 cm; in good soils in the semi-arid zone within 2-3 years with 3-4 tillers per slip every 10 cm; in poor soils in the semi-arid zone in 3 years with 3-4 tillers per slip every 7.5 cm.

In areas of moisture stress (which includes disturbed lands in humid areas) one of three supporting practices for vetiver hedge establishment are recommended. When plowing the furrow for the planting of vetiver, a small ridge immediately downslope of the vetiver furrow can be created using some of the soil from the furrow, or after the vetiver has established (about 30 days after planting) a furrow can be plowed adjacent to the vetiver on the downslope side, or the planting furrow for the vetiver can be plowed to 30 cm and only partially refilled after planting. Any one of these three practices will enhance infiltration and soil moisture along the vetiver line for optimal establishment and growth through the first season. In drier areas and/or in severely eroded areas it would probably be beneficial to carry out one of these three practices in the second season as well. If mean annual rainfall is below 300 mm per year a more specialized treatment is required to establish vetiver. A two meter wide and (about) 30 cm deep "V" ditch having a 160° inside angle should be constructed along the contour with a small ridge formed on the downslope side. The ditch will harvest water to aid in the initial establishment of the vetiver; after establishment the vetiver will continue the function of increasing on-site soil moisture long after the "V" ditch has become non-functional.

Establishment and growth of vetiver grass in shaded areas is not as good as it is in unshaded areas. Where vetiver has been planted for the first time along with crops such as sorghum or pigeon pea (Cajanus cajan) it has been suppressed due to a lack of sufficient sunlight. Once established the grass has no problem with shading by trees or crops, but in the early months after planting optimal management would be to allow it to have sufficient light to get a good start. If possible, adjust the planting programs to have the on-farm vetiver plantings coincide with the low growing component of the crop rotation. If this is not possible, leave about 75 cm-100

cm of unplanted space on the south side of vetiver lines that run more east and west and leave about 50 cm unplanted on both sides of the line if the rows run more north and south. Alternatively, mixed cropping could be carried out with a low growing crop along the vetiver line. If none of the above are feasible, the vetiver can still be planted, but expect reduced establishment and slower growth.

Though a semi-aquatic species, establishment of vetiver may be a problem in saturated soils. Observations in India have shown that where vetiver has been planted into waterlogged areas at the toe of improperly laid out soil bunds, establishment has been poor. The same observations have been made in low lying spots of poorly drained fields. These observation are only pertinent to the establishment phase, i.e. when the newly planted slip is placed in the ground. Once the root system establishes vetiver can survive waterlogged conditions; in India vetiver has survived weeks underwater in gullies. Growth rates of vetiver under waterlogged conditions were, as reported from Jiangxi Province in south China, lower than growth rates of vetiver growing slightly higher up next to a duck pond. The vetiver in the waterlogged soil was about two-thirds the height and had one-half the number of tillers as the same age plants that were a bit higher up on the bank.

Tillering will be increased and hedge establishment time reduced if the newly established vetiver hedges are kept pruned back to 30 cm-50 cm. This will provide not only large amounts of fodder, but material for animal bedding and mulching. According to rough estimates from Jiangxi Province in south China, 500-1,000 kg of leaf (green weight) was harvested in the first year from a 200 meter long vetiver hedge; greater production can be expected in succeeding years. From the same report, tillering of vetiver was shown to decrease following regular pruning of the hedge during the dry season when moisture is limiting; growth rates of the leaves, however averaged 4.5 cm/day during the second month of the dry season. When moisture is not limited during the wetter times of the year, pruning should increase tillering. Pruning of the hedges is not strictly necessary, but trimmed hedges are more effective, especially on crop lands, and reduce shading of crops.

Gapfilling is part of a good management system for the establishment of vetiver hedges and should be carried out at the beginning of the next rainy season following the initial planting. As stated before, planting should be carried out with the intent of minimizing or avoiding gapfilling altogether, but with any biological system there will be mortality. To the extent that mortality is associated with late planting, poor slip selection, careless planting techniques, or inappropriate planting locations (e.g. on the top or downslope toe of bunds versus the upslope toe), it can be avoided. To the extent that it is caused by slips being kicked out prior to root establishment, farm implements not being lifted over the hedge, vertic cracking running through the newly planted hedge or some other cause, gapfilling must be carried out. Many reports of difficulty in replanting gaps have been received. Slip growth in gaps is reported to be very slow and mortality high. Several suggestions have also been received on how to overcome this problem. First, gapfilling should be carried out as a priority item very early in the rainy season. Prune the plants on either side of the gap to ground level and save the cuttings to mulch the newly planted slips. Cultivate the gap to 20 cm-30 cm to break up any feeder roots from the adjacent plants and plant a clump of vetiver rather than just a few tillers. Planting material may be removed from vigorously growing plants in the hedge but remember to select tillers from parts that have not flowered or seeded. Another suggestion which has great potential for solving gapfilling problems came from a commercial nurseryman, Mr. M.Z. Hussain, in Hyderabad, India. Mr. Hussain reports that vetiver can easily be layered and suggests that if the plants on either side of the gap are allowed to flower, then the culm (the shoot on which the flower is located) can be bent over and buried in the gap, mulched (with vetiver leaves) to conserve moisture and a rock placed on top to hold it all in place. The culm, which remains attached to the plant, will then sprout from the nodes. At least 2 or 3 nodes should be buried in the gap.

Some effect on soil loss from hedges that have yet to

achieve closure has been noted. Silt deposition behind established clumps has been widely observed, and incidences of scour/soil loss within the gaps between clumps has only been noted in one isolated case on a Vertisol in one area where less than 10% of the gaps showed scouring. More commonly there have been observations of reduced soil loss in the gaps caused by subsurface root grafts that bridge the gaps and hold the soil in place.

Concern about the harvesting of vetiver roots for their oil and the resulting damage has been expressed by several sources. While some vetiver may be harvested to meet local demand, widespread damage from harvesting is not likely. This is the conclusion from L.J. van Veen's 1989 paper for the International Agriculture Center entitled *Notes on the Production and Marketing of Vetiver Oil.* Mr. van Veen reviewed both the historic and current demand for vetiver oil worldwide and concluded that " Because of this (declining demand and current production levels) it seems very unlikely that vetiver hedges planted for soil and moisture conservation will be uprooted by its users in a later stage for production of vetiver oil. Hence in the opinion of this author this aspect does not pose a serious constraint on the continued introduction of vetiver grass for vegetative soil and moisture conservation". This conclusion is supported in a 1986 publication entitled *Essential Oils and Oleoresins* from the International Trade Center UNCTAD/GATT. "The prospects for new producers (of vetiver oil) can only be described as poor, the existing producers being more than capable of meeting any likely level of demand in the foreseeable future".

	OTHER TREATMENT	TOTAL RUNOFF (sowing to harvest)	TOTAL RUNOFF (first 4 weeks)	MAXIMUM 7 DAY RUNOFF	MAXIMUM 24 HOUR RUNOFF
1	ALONG SLOPE CULTIVATION	-45% (+/- 15%)	-52% (+/- 20%)	-35% (+/- 12%)	-24% (+/- 1%)
2	ACROSS SLOPE CULTIVATION	-40% (+/- 7%)	-39% (+/- 7%)	-42% (+/- 13%)	-37% (+/- 15%)
3	CONTOUR CULTIVATION	-20% (+/- 9%)	-11% (+/- 1%)	-10% (+/- 2%)	-13% (+/- 1%)
4	CONTOUR CULTIVATION WITH LEUCAENA KEYLINE	-24% (+/- 10%)	-24% (+/- 21%)	-32% (+/- 15%)	-33% (+/- 16%)
5	CONTOUR CULTIVATION WITH GRADED BUND	-54%	-40% (+/- 3%)	-36% (+/- 3%)	-48%

Note : All experimental data is derived from plots where the vetiver and leucaena plantings were in their second rainy season, i.e. 1 year old, excepting data from # 3 where the plantings were in their first rainy season.

Table 1. Percent Differences In Surface Runoff With Vetiver Grass Versus Other Treatments.

Local demand for vetiver may best be met by a few small producers managing specifically for oil or roots. Site damage could be minimized by leaving contour lines of vetiver intact after harvest; concurrently, if 10 cm or so of root were left on each clump after harvest, the clumps could be broken up for planting material to be sold to soil and soil moisture conservation projects.

RESEARCH RESULTS (continued)

if any difference between any of the treatments. This observation is not surprising. In large storms when soils saturate even a forest area will respond very similarly, for a short period, to a poorly vegetated area. In agronomic situations, this will be even more obvious as there is less soil and little or no surface residue storage available to dampen peak flows.

Table 1, contains data that has been abstracted from research carried out not only in Akola, but also in Andhra Pradesh and Karnataka (see Acknowledgement at the end of this section). It shows the difference in surface runoff as measured from areas treated with contour hedges of vetiver versus other types of treatments. The percentages given shows the difference between them, e.g. total runoff from the vetiver treated areas was measured to be an average of 45% less than surface runoff from the areas treated with along the slope cultivation. The percentage in brackets below the 45% shows that the range of the observations, i.e. surface runoff was observed to be between 30% and 60% less in the vetiver treated areas. The re-

	OTHER TREATMENT	LOSS OVER ENTIRE CROPPING SEASON	LOSS OVER FIRST 30 DAYS AFTER PLANTING	MAXIMUM 1 DAY LOSS
1	ACROSS SLOPE CULTIVATION	-73% (+/- 4%)	-65% (+/- 10%)	-59% (+/- 0%)
2	CONTOUR CULTIVATION WITH LEUCAENA KEYLINE	-56% (+/- 1%)	-59% (+/- 2%)	-52% (+/- 14%)
3	CONTOUR CULTIVATION WITH GRADED BUND	-38%	-47%	-50%

Note : All experimental data is derived from plots where the vetiver and leucaena plantings were in their second rainy season, i.e. plantings were 1 year old.

Table 2. Percent Differences In Soil Loss From Vetiver Versus Other Treatments.

sults presented here (and other tables) are from across soil types (Vertisols and Alfisols) and crop types on slopes less than 5% in the semi-arid zones of south India. In all cases the vetiver treatments were either in their first rainy or second season since outplanting. The data comes from a small number of samples and represents preliminary results from ongoing experiment. In the data comparing vetiver with leucaena hedges, it would be more useful to use it as a comparison of contour cultivation as the Leucaena hedges were uniformly sparse and probably not effective. From Table 1 the most interesting information on surface runoff is :

- In all cases decreases in runoff are consistently seen. The greatest difference occurs in the comparison with contour bunding; underscoring the bund function of concentrating runoff and channelling it off the field.

- The relationship between vetiver and the other treatments holds constant over the different time scales represented in Table 1, with the only exception being the large difference in runoff from the bunded plot during the maximum 24 hour runoff event. The significance is that the differences remain consistent between when the soils are at or near saturation (maximum 24 hour runoff and maximum 7 day runoff), to when there is little or no crop cover to protect soil and stop surface sealing as a result of raindrop impact (runoff first 4 weeks), and over the entire cropping season.

Table 2, drawn from the same sources as Figure 1, shows the difference in total soil loss over one cropping season. The figures are percentages comparing vetiver to the other treatments. For example, over the entire cropping season 73% less soil was lost from the vetiver plots than from the plots cultivated across the slope. Again, the vetiver plots consistently showed less soil loss in comparison to all treatments. The maximum 1 day soil loss figure is important as it is the extreme events which cause the greatest damage; the differences between the vetiver plots and the other treatments is still apparent.

The conclusions that can be drawn from the preliminary data provided by Dr. Bharad and the other researchers (see Acknowledgements) are that the greatest value of vetiver, on these plots, for soil loss protection was the protection provided during the larger storm (or runoff) events. Even though peak flows were similar (and soil loss is generally well correlated with peak flows), soil losses from events that produced higher flows averaged about 50% less from the vetiver plots, while soil losses were similar between the other treatment plots. The average per storm surface runoff from the vetiver plots was about 26% less than that from the leucaena and across slope plots and 46% less than that from the bunded plot. The average total runoff for the cropping season showed the greatest differences were between vetiver and the graded bund plots, next was the along and across slope cultivated plots (which were similar), and last was the contour cultivated and leucaena plots (also similar). The data support the hypothesis that vetiver hedges, by slowing down surface runoff and spreading it evenly over the slope, create greater infiltration opportunity both in space and time which results in greater infiltration of rainfall. The data also raise the question of the impact of soil bunding

on soil moisture. Though the sample for contour bunded plots is too small to be significant, the magnitude of the plot runoff from large storm events have implications worth exploring in regards to increased moisture stress.

Greater infiltration should translate into increased soil moisture and plant available moisture. A few observations from India lend support to the hypothesis that such increases may be expected following treatment with contour hedges of vetiver. The observations comprise :

- Drs. S. Subramanian and S. Senthhil, Tamil Nadu Agricultural University, monitored soil moisture over 18 weeks on similar plots with and without vetiver hedging on a Vertisol with 1.2% slopes in Coimbatore, India. Over the 18 weeks, which began on October 27, 1988, the vetiver plot had an average of 13.4% greater soil moisture (s.d. = 10.7%) with a maximum difference of 33%.

- Dr. A.M. Krishnappa of the Operational Research Project in Karnataka reports that based on field measurements, 12 to 15 days more moisture was crop available on plots treated with contour cultivation and vetiver hedges than on the untreated control. Data obtained from gravimetric sampling showed the vetiver plots to have 50% greater volumetric soil moisture than the control 3 hours after a rainfall event (24% and 16%, respectively); 212% greater volumetric soil moisture after 7 days (12.8% and 4.1%, respectively). Wilting point for the soil (sandy, red Alfisols) was about 4% volumetric moisture content; this was reached on day 7 in the control and day 22 in the contour cultivation and vetiver treatment.

- Dr. Bharad, PKV University, Maharashtra carried out a series of water balance studies comparing treatment plots with vetiver to various other treatments under different crop types, he reports : A) under pearl millet, the vetiver treatment's estimated total soil moisture recharge was 14% greater versus across slope cultivation and 6% greater versus contour cultivation with leucaena hedges; B) under sorghum, the vetiver treatment's estimated total soil moisture recharge was 16% greater versus across slope cultivation and 9% greater versus contour cultivation with leucaena hedges; C) under pearl millet, the vetiver treatment's estimated total soil moisture recharge was 81% greater versus along (up and down slope) cultivation.

- Spot readings of soil moisture taken with a KEL Soil Moisture meter outside the village of Achlu-thotahalli, Karnataka, recorded an average 38% greater reading of soil moisture in the top 10 cm of a contour cultivated field with vetiver hedges versus a traditionally cultivated plot.

There still remains quite a bit of research to be done to spell out the impacts and expected benefits from vegetative barriers of vetiver, particularly in uplands on hillside agriculture. However, every day research is going on with vetiver in thousands of farmers field and in dozens of projects worldwide. This is the research that is carried out by doing and the results are either convincing farmers, extensionists and other grass roots workers or they are not. We need to benefit from everyone's experiences. Please pass on your comments, observations and data, we will publish them here. Send any information on vetiver or any other species you have found useful to the address given on page 1 in this newsletter. • • • • • • • • •

ACKNOWLEDGEMENTS

The research results presented in this newsletter were given to the Vetiver Information Network by the following individuals and institutions :

- Figures 1, 2 and 3; Table 1, Nos. 1, 2, 4, and 5; and Table 2 : Dr. Bharad, PKV University, Akola, Maharashtra, India.

- Table 1, No. 3 : Dr. A. Padme Raju, Andhra Pradesh Agricultural University, Pahadisharif, A.P., India.

We would also like to thank the project personnel of the **Kabbalnala Watershed Management Project, the Maheshwaram Watershed Mangement Project, the Manoli Watershed Management Project, and the Parvanala Watershed Management Project** for having supplied much of the management information which comprises this newsletter. • • • • • • • • • • • • • • • • •

The findings, interpretations and conclusions expressed here are entirely those of the authors and should not be attributed in any manner to the World Bank.

ERRATA

A) Please note the inclusion of a corrected Table 3 and ignore the copy of the table on pages 20 and 21 of the Newsletter.

B) Another table (Table 4.) has also been added since the Newsletter went to the Print Shop; this table details the area of nursery needed (hectares) to treat 1,000 hectares of land with vetiver grass, based on slope class. In reading the table you should bear in mind that the figures were derived assuming hedge establishment at 1 meter vertical intervals. This was done mostly for convenience in adjusting the figures to the vertical intervals desired for a particular management situation. In general, therefore, the table exaggerates the nursery requirements. This is especially true for higher slopes when actual vertical intervals used will result in nursery areas at least 70% smaller than those given in the table.

C) Also note the inclusion of the description of a home made hand level that can be put together simply from a piece of clear plastic tubing. The original design comes from MASDAR in the U.K. and the simplification of the design by the tying together of the tubes is owed to Brian Albinson, ASTAG. As carrying out of all agricultural operations along the contour is the basis for conservation farming, we encourage extensionists to either obtain for themselves a commercial hand level or , better, avail themselves of easy to make and use technologies such as this one, demonstrate it to farmers and then place it in their hands for use.

• • • •

ii) it has a strong, fibrous root system that penetrates and binds the soil to a sufficient depth and that can withstand the effects of soil cracking and tunneling;

iii) it is perennial and requires minimal maintenance;

iv) under the conditions found in farmer's fields (rainfed or irrigated) its seed does not germinate, nor does it spread by stolons or rhizomes to become a pest;

v) its crown is below the surface, thus protecting the plant against fire and overgrazing;

vi) it does not attract or harbor populations of rodents, snakes and other pests when planted as a hedge;

vii) its leaves and roots have a demonstrated resistance to most diseases, and is not an alternative host for any diseases of economic importance;

viii) once established it cannot be grazed out or have its function as a barrier destroyed by grazing;

ix) it will not compete with the crop plants it is used to protect;

x) it is inexpensive and easy to establish as a hedge;

xi) it grows under both xeric and aquic soil conditions;

xii) it tolerates a wide range of soil conditions (low fertility, acidity/alkalinity, salinity, excessively drained/poorly drained soils, shales, gravels, unfavorable properties such as high aluminum content);

xiii) it grows across a wide climatic range (0 degrees C to 45 degrees C and mean annual rainfall of 300mm to 6,000mm).

In the event that a species which meets this criteria is not found, an additional eight US$ 500 awards shall be made in the management and research category for vetiver grass.

The awards for management innovations and research results that lead to better defining the benefits of vetiver grass will be judged based on their importance toward :

i) lowering the costs of vetiver grass propagation (nursery costs), outplanting, hedge establishment and maintenance;

ii) providing proven low cost, low technology innovations suitable for small farmers working with vetiver grass or for off-farm land stabilization;

iii) providing valid information on the on- or off-farm impacts of vetiver hedges on any of the following : soil loss, soil moisture, surface runoff, shallow groundwater recharge, or crop yields relative to traditional or improved practices (for example, contour cultivation with and without vetiver);

iv) providing information comparing growth and morphological charecteristics of different cultivars, provenances, or varieties of vetiver grass;

v) providing the information in iv (above) across temperature and moisture gradients;

vi) providing information on economically important alternative uses of vetiver (for example, fodder value and yield of fodder per unit area of hedge).

Within this category, any management-based innovations must also include a detailing of the costs.

Evidence of findings should attempt to include photographic evidence and names and addresses of individuals or agencies that can corroborate the findings. For further information on documentation of findings contact the Vetiver Information Network at the address given on page 1 of the Newsletter.

Table 3. Vetiver Network Participants Who Are Currently Using Vetiver Or Who Are Aware Of Local Sources For Vetiver.

VET USER	NAME	TITLE	COMPANY NAME	STREET ADDRESS	TOWN	STATE	COUNTRY
Y	Garrard		NSW Soil Conservation Service	P.O. Box 198	Chatswood	New South Wales	Australia
Y	Hessel	Managing Director	Hessel Associates		Canberra	ACT	Australia
Y	Truong	Dr. (PhD)	Soil Cons. Res. Branch-Dept. of Primary Indust.	Meiers Road, Indooroopilly	Brisbane	Queensland	Australia
Y	Ding Zemin	Director	Dept. of Rural Water Conservancy and Soil Cons.	P.O. Box 2905	Beijing		China
	Wang Xiuhao	General Manager	Jiangxi Agricultural Development Corporation	No. 75, Hongdu Street	Nanchang	Jiangxi	China
	Wang Xue-ming	Deputy Director	Jiangxi Prov. Bur. of Ag., Animal Husb. & Fisheries	Beijing Road	Nanchang	Jiangxi	China
	Wang Zi Song	Director	Ag. Foreign Capital Ofc. of Jian Yang Area Fujian Prov.	Huang Hua Shan	Tanchen	Fujian Province	China
Y	Yang Xing Zhong	Senior Agronomist	Jiangxi Provincial Red Soil Research Institute		Nanchang		China
	Zhang Feng-yu	Vice-Governor	Jiangxi Provincial People's Government	Beijing Road	Nanchang	Jiangxi	China
	Zhang Guang-ming	Agro-Economist	China Red Soils Development Project Joint Office	7 Building Bei Li-Beijie Zhuang	Beijing		China
Y	Zhang Xinbao	Associate Professor	Dir. Erosion Div.-Inst. of Mntn. Disaster&Environ.		Chengdu		China
	Laing	Deputy Director General	CIAT	AA6T-13	Cali	Valle	Colombia
Y	Shimelis	Technical Manager	Coffee Plant. Dev. Corp., Min. of Coffee&Tea Dev.	P.O. Box 6	Gimira	Keffa	Ethiopia
Y	Alexander	Agriculturist	World Bank Ree. Mission	P.O. Box 416	New Delhi		India
Y	Bharad	Professor of Agronomy	PKV Agricultural University	PKV Agricultural University	Akola	Maharashtra	India
Y	des Bouvrie		World Bank Resident Mission	Po Box 416	New Delhi		India
Y	Fonseca	Village Animator	Delhi Jesuit Society, St. Xavier's	4, Raj Niwas Marg	New Delhi	Delhi	India
Y	Gopalakrishna	Joint Director of Agriculture	Dept. of Agriculture, Karnataka Government	1668, 9th Main Road, Wai III Stage	Bangalore	Karnataka	India
Y	Hegde	Professor Agronomy	Univ. of Agr. Sciences, College of Agr.	Univ. of Agr. Sciences, Hebbal	Bangalore		India
Y	Hussain		Andhra Seeds Corporation	P.O. Box 135	Hyderguda	Hyderabad	India
Y	Hussain		Plants Land	6-3 1104 Samajiguda, Raj Bhavan	Hyderabad		India
	Jha			L/46, Road No. 20, Srikrishna Nagar	Patna	Bihar	India
	Kandaswamy	Dir., Water Technology Centre	Dir., Water Tech. Centre, Tamil Nadu Ag. Univ.		Coimbatore	Tamil Nadu	India
Y	Krishneppa	Professor, ORP	University of Agricultural Sciences, GKVK	Univ. of Agr. Sciences, Hebbal	Bangalore	Karnataka	India
Y	Meshady	Divisional Forest Officer	Meshesheswaram Project		Vidyanagar	Hyderabad	India
Y	Mutreja	Superintending Engineer	Civil Construction Circle	P.O. Box 16	Dehradun	Uttar Pradesh	India
Y	Naidu	Asst. Director of Agriculture	Maheswaram Watershed Development Project	Tukkuguda-I-Maheswaram Taluk	Rangareddi Dist.	Andhra Pradesh	India
	Naik			Water Works Road	Dist. Puri	Orissa	India
Y	Nigam	Team Leader	Govt. of Madhya Pradesh	Parvanala Watershed Dev. Proj.	Bhopal	Madhya Pradesh	India
Y	Patil	Manoli Watershed Team Leader	Rainfed Watershed, Project, Govt. of Maharashtra	Opp. Bank of Baharashtra	Jattar Peth	Akola	India
Y	Pereira			79 Carter Road	Bandra	Bombay	India
Y	Prasad			No. 24-84/56 Indiranagar Col. Lothmunta	Tirumalgiri-Secunderabad	Andra Pradesh	India
Y	Raju	Sr.Scientist, Maheshwaram Proj.	.	Andhra Pradesh Agricultural University	Pahadisharif	Andhra Pradesh	India
Y	Runeborg	Senior Programme Officer	SIDA , Swedish Embassy	Nyaya Marg, Chanakyapuri	New Delhi		India
Y	Sachdev	Additional Director (Rainfed)	Agriculture, Govt. of MP	Vindhyachal Bhavan	Bhopal		India
Y	Saran	Chief Scientist	R.A.K. College of Agriculture	R.A.K. College of Agriculture	Sehore	Madhya Pradesh	India
Y	Sastry	Act.State Coord.Watershed Dev.	Govt. of Karnataka, Podium Block	Visvesvaraya Centre, Dr. Ambedkar Rd.	Bangalore		India
Y	Shastri	Team Leader, Watershed Proj.	Government of Andhra Pradesh	2-3-1130/19-5 Vidyanagar	Hyderabad	Andhra Pradesh	India
	Shrotriya	Dry Manager (Agric. Services)	Indian Farmers Fertiliser Cooperative Limited	53-54 - Nehru Place	New Delhi		India
Y	Swindell	Director General	ICRISAT		Patancheru P.O.	Andhra Pradesh	India
Y	Verma	Chief Project Director	Govt. of Uttar Pradesh	151 Vasant Vihar-Indiranagar Forest Col.	Dehradun	Uttar Pradesh	India
Y	Yule	Principal Soil Scientist	ICRISAT		Patancheru P.O.	Andhra Pradesh	India
Y	Branschold	Irrigation Engineer	Investment Center, FAO		Rome		Italy
	Carnelley		Fisherman's Camp	P.O. Box 79	Naivasha		Kenya
Y	Gibberd	E.M.I. Soil & Water Cons. Proj.	Min. of Ag., Provincial Agric. HQ, Eastern Prov.	P.O. Box 1199	Embu		Kenya
Y	Rao	Experimental Agronomist	ICRAF	P.O. Box 30677	Nairobi		Kenya
Y	Bredero	Senior Agriculturist	World Bank	Boite Postale 4140	Tananarive		Madagascar
Y	Kan	Group Leader, Weed Control	CIBA-GEIGY Agric. Experiment-Station Malaysia	Locked Bag, 71309 Rembau	Rembau	Negri Sembilan	Malaysia
Y	Kong	Head-Plant Science Division	Rubber Research Institute of Malaysia	Experiment Station-47000 Sungei Buloh	Kuala Lumpur	Selangor	Malaysia
Y	Arena	South Asia Representative	World Neighbors	P.O. Box 918	Kathmandu		Nepal
Y	Deo	Senior Agric. Officer	Bhairawa Lumbini Groundwater Project	Amchalpur	Bhairawa	Lumbini Zone	Nepal

Table 3. (cont.) Vetiver Network Participants Who Are Currently Using Vetiver Or Who Are Aware Of Local Sources For Vetiver.

VET USER	NAME	TITLE	COMPANY NAME	STREET ADDRESS	TOWN	STATE	COUNTRY
Y	Mishra	Associate Program Officer	World Bank	Kantipath	Kathmandu		Nepal
Y	Muller	Project Co-Manager	Bagmati Watershed Proj.-IDC, Ekanta Kuna, Jawalakhel	P.O. Box 730	Kathmandu		Nepal
Y	Roberts	Resident Representative-AS1NE	World Bank Resident Mission	Kantipath	Kathmandu		Nepal
Y	Sharma	Agricultural Advisor	Bhairawa Lumbini Groundwater Project	Amchaipur	Taulihawa	Lumbini Zone	Nepal
Y	Shrestha	Consultant	World Bank	Kantipath	Kathmandu	Nepal	Nepal
Y	Douglas	Scientist	DSRI Grasslands	Private Bag	Palmerston, North		New Zealand
	Kang	Director General	International Institute of Tropical Agriculture (IITA)	Oyo Road, PMB 5320	Ibadan		Nigeria
	Nwadialo	Lecturer-Dept. of Social Sci.	University of Nigeria		Nsukka	Anambra State	Nigeria
Y		Head	Federal Agric. Co-ordinating Unit-Reg. Office	Ungwar Munchi, Kinshasha Rd U/Rima	Kaduna	Kaduna State	Nigeria
		Ag. Research Coordinator	Federal Agricultural Co-ordinating Unit	PMB 2277	Kanuna	Kaduna State	Nigeria
Y	Coloma	Project Manager-B	Watershed Mang. & Erosion Control Project	NIA Campaita	Pantabangan	Nueva Ceija	Philippines
	Dy	Head-Agribusiness Unit	Center for Research and Communication	Pearl Drive Ortigas Complex	Pasig	Metro Manila	Philippines
	Mariano			650 Mayor Street	Quezon City		Philippines
	Tabago	Professor (Agric. Eng.)	Central Luzon State University		Munoz	Nueva Ecija	Philippines
	Angen	Soil Conservation Advisor	Selian Agr. Research Center	Box 6160	Arusha		Tanzania
Y	Allison	Agricultural Director	MASDAR	141 Nine Mile Ride	Finchampstead	Berks	United Kingdom
Y	Rosenthal	Agricultural Engineer	Ed Rosenthal	45 Hyde Road Sanderstead	South Croydon	Surrey	United Kingdom
Y	Boutwell	Botanist	U.S. Bureau of Reclamation, Res. & Lab Serv. Div.	P.O. Box 25007, D-3742	Denver	Colorado	USA
	Fitz	Writer		Stage Road	S. Pomfret	Vermont	USA
	Gliessman	Director-Agroecology Program	Agroecology Program	University of California	Santa Cruz	California	USA
Y	Johnson			Route 3, Box 486	Somerville	Alabama	USA
Y	La Blanc Sr.			Rt. 2, Box 643	Sunshine	Louisiana	USA
Y	Miyamoto	Professor	Texas A&M University, Agr. Res. Ctr. El Paso	1380 A & M Circle	El Paso	Texas	USA
	Peterson	National Botanist	USDA, SCS, National Plant Materials Center	Bldg. 509, BARC-East	Beltsville	Maryland	USA
	Vonk	Dir. - Ag. and Nat. Resources	CARE	660 First Avenue	New York	NY	USA
	Scott			Chipinga Farm	Chipinga		Zimbabwe
	Wilson	Co-ordinator	Fambidzanai Training Centre	Po.Box 8515 - Causeway	Harare		Zimbabwe

Table 4. Hectares Of Nursery Required Per 1,000 Ha Of Land To Be Treated With Contour Hedges Of Vetiver Grass On A One Meter Vertical Interval By Number Of Tillers Per Slip And Slope Class.

SLIP SPACING	SLOPE CLASS (%)													
	0 - 1	1 - 2	2 - 5	5 - 10	10 - 15	15 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100
5 cm	1.00	2.90	6.70	14.40	24.00	33.60	48.00	67.20	86.40	105.60	124.80	144.00	163.20	182.40
7.5 cm	0.67	1.93	4.47	9.60	16.00	22.40	32.00	44.80	57.60	70.40	83.20	96.00	108.80	121.60
10 cm	0.50	1.45	3.35	7.20	12.00	16.80	24.00	33.60	43.20	52.80	62.40	72.00	81.60	91.20

NOTES ON TABLE :

Assumptions :

62,500 plants per hectare of nursery;
50 tillers per plant at uprooting;
3 tillers per each slip outplanted for hedge establishment;
0% mortality.

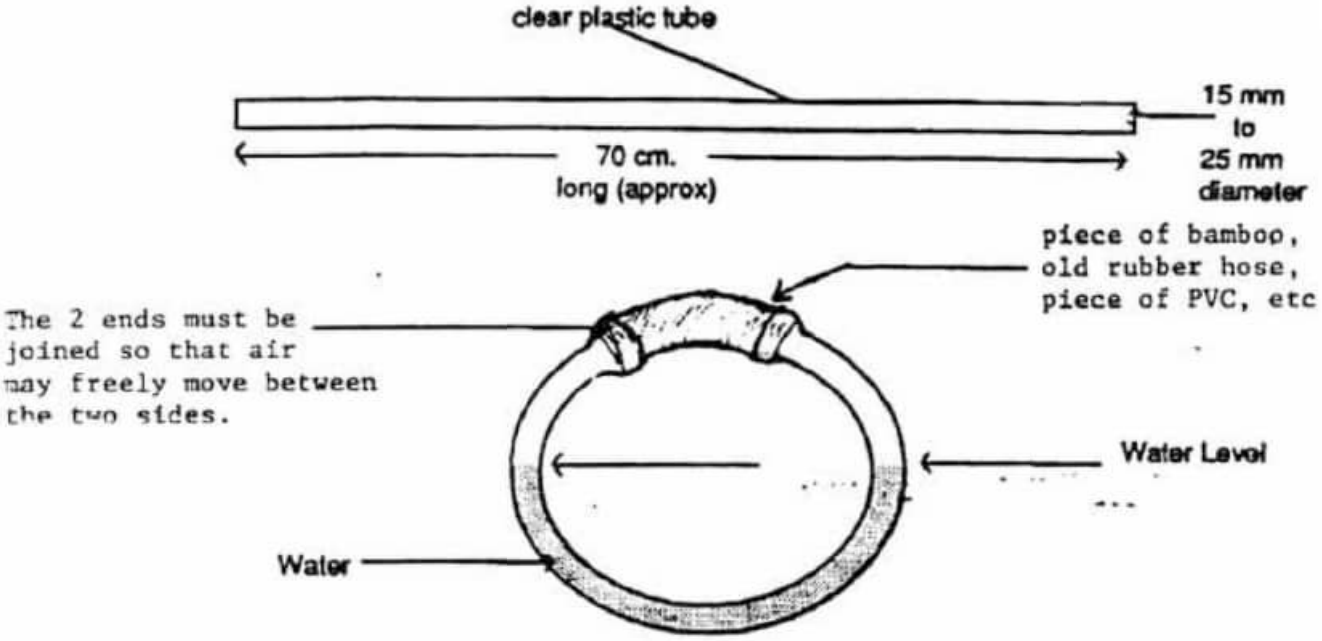
Varying Vertical Intervals :

The number of hectares of nursery given in Table 4 (above) is based on planting at a vertical interval of 1 meter. Dependant on site conditions and slope this interval will require adjustment; particularly for higher slope classes where the vertical interval will be much greater than 1 meter. The number of hectares of nursery required for a vertical interval other than 1 meter may be obtained by dividing the pertinent figure from Table 4 by the vertical interval desired. Example : On a slope of 100% where the desired vertical interval is 6 meters with an initial spacing of the slips at 7.5 cm, the number of hectares of nursery required is : (121.6 / 6) = 20.27 hectares.

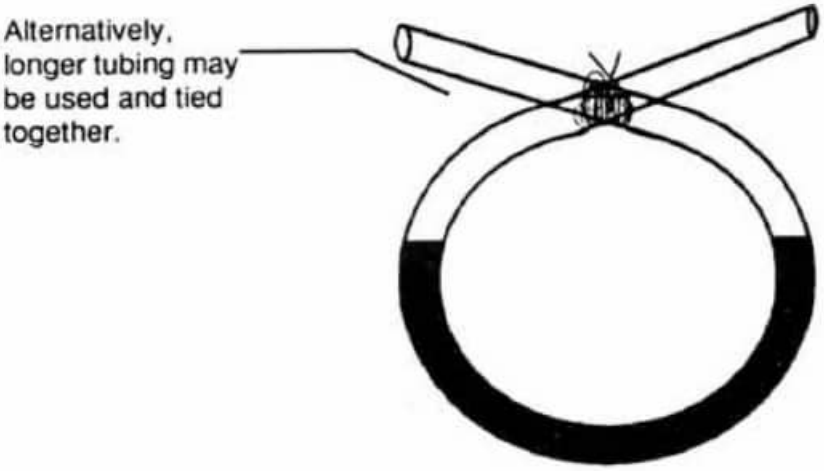
Varying The Number Tillers Per Slip Planted :

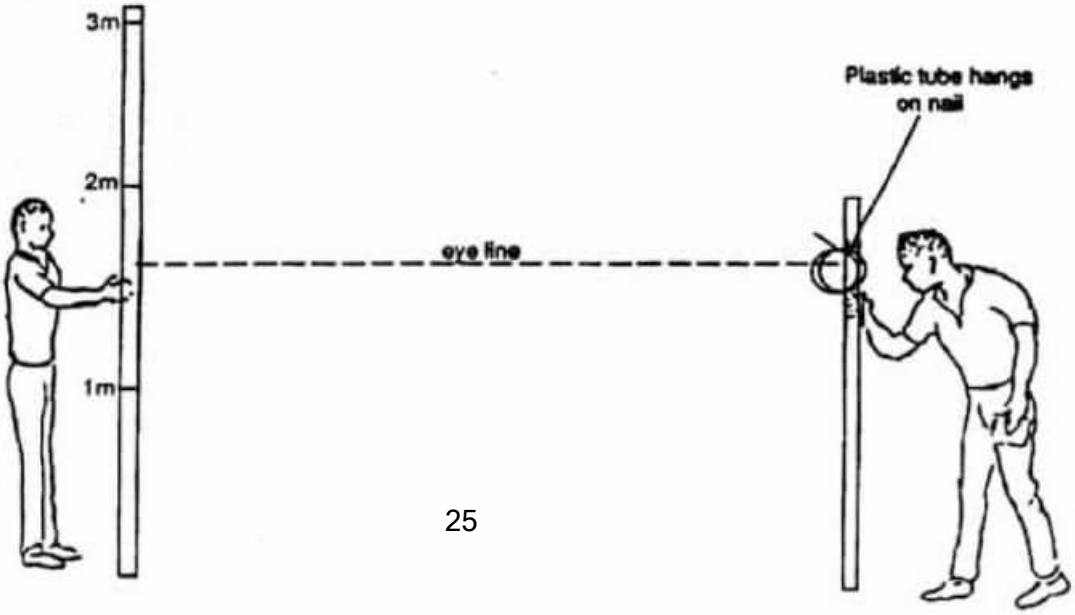
The number of hectares of nursery given in Table 4 is based on using 3 tillers at each planting spot (3 tillers/slip). Dependant on site conditions this number of tillers/slip will require adjustment; particularly in poor soils in semi-arid areas where a larger number of tillers/slip is necessary. The number of hectares of nursery required for a number of tillers/slip other than 3 may be obtained by multiplying the pertinent figure from Table 4 by the product of the desired number of tillers per slip divided by 3. Example : On a slope of 3% it is desired to plant 5 tillers per slip at a vertical interval of 1 meter with an initial spacing of the slips at 10 cm, the number of hectares of nursery required is : 3.35 x (5/3) = 5.58 hectares of nursery.

HOME MADE HAND LEVEL



The tube is bent into a ring
and half-filled with water





VETIVER NEWSLETTER

Newsletter of the Vetiver Information Network, ASTAG , *World Bank, Number 4, November 1990

TABLE OF CONTENTS

Vetiver Grass Seminars	62
Vetiver Grass Awards	62
BOSTID Vetiver Grass Study	63
Vetiver Grass Literature	63
Ethiopian Soil Conservation	64
Spacing of Hedgerows	65
Fodder Value of Vetiver	66
Research Update	66
Current Uses of Vetiver	68
Letters To The Network	68
World Bank Publication	69
Vetiver Bibliography	69

Letter From Dick Grimshaw

In October 1988 the vetiver hedgerow technology was introduced to China. Two years later, China now has its own vigorous network supporting a large number of participants. We would urge that other countries establish their own networks. A lot of letters continue to come in from private organizations and farmers. One I received recently came from a group of 30 "organic" farmers in Karnataka, India. They had read about vetiver in a copy of one of our previous newsletters that had found its way to them through the hands of a number of people. Open to the potential of the vetiver technology, they went out and found the grass and are now trying it out. A good effort.

Re: Vetiver Handbook. The 3rd Edition has been published (in Chinese) by China's Red Soils Project and the World Bank is to publish this 3rd Edition in both Spanish and Portuguese within the near future. If you, or anyone you know, would benefit from having a translated copy, let us know.

Vetiver planting material is being sent to a United Nations Development Program (UNDP) watershed project in Iran - and the 'forage' or 'farmer selected' cultivar sent from Karnataka to China is said to be doing well. I am convinced that nitrogen-fixing mycorrhiza grow in association with some cultivars of vetiver. I would be interested to hear confirmation of this from researchers participating in this program.

ASTAG has just presented a paper "Vetiver Grass - A Hedge Against Erosion" at the annual meetings of the American Society of Agronomy in their International Agronomy section. The theme of the session was 'Developing Sustainable Agriculture". We gather that it was well received and a copy is included with this Newsletter. It is a useful paper as an introduction to the vetiver technology. If you like it, please copy and distribute it widely.

As we will mention in this Newsletter again, please send us any information you might have on vetiver - we are particularly interested in the observations from this last rainy season (1990), including any runoff or sediment data. Information on next year's programs with vetiver would also be of interest. We wish you well for the New Year and the next Vetiver season.

— Dick Grimshaw

The Newsletter

This is the fourth Newsletter put out by the Vetiver Information Network. Since March 1990, when the last Newsletter was mailed, there has a been a great deal of information collected on vetiver grass and an expansion of interest both on the part of government and nongovernmental associations (NGO). Here in the United States, the Board of Science and Technology for International Development (BOSTID), National Academy of Sciences has been busy locating available literature and research data on vetiver grass. The results have been surprising as it turns out that an extensive body of studies exist, particularly cytological studies, on the grass. BOSTID has reported that "vetiver grass may turn out to be the best known "unknown" plant with which they have worked. Included with this Newsletter is a partial bibliography of research or other information on vetiver grass that might be of interest. Among them, one article in particular is a useful review: Virmani, O.P. and S.C. Datta. 1975. *Vetiveria zizanioides* (Linn.) Nash. Indian Perfumer 19:35-73.

The June 1990 edition of New African *contained this photograph of Prince Charles planting vetiver grass while on a recent trip to Nigeria. The Prince visited a joint British Council/Anambra State Project on erosion control. Mr. A. Chigbo, the Secretary and Project Engineer told the magazine that the Prince "brought prestige to the project...we knew the grass could work, but the problem had been to convince the average person. they believe that things are good only when they are costly."*

The Vetiver Information Network itself is continually growing. There are now more than 1,500 participants; in China, interested researchers and vetiver users have started their own network. Still, the Network relies heavily on its readers to keep us up-to-date on activities, experiences and opinions. At present, we try respond to many requests for country specific information, often times there are Network participants in that country of whom we know nothing except that they have expressed an interest in locating and trying vetiver grass. Any information that we receive can be valuable in sav-

ing someone else a great deal of time and effort. Please keep us informed.

Vetiver Grass Seminars and Training

A number of soil conservation seminars and training sessions, involving vetiver grass have taken place in recent months. In April, the Watershed Management Directorate in Dehradun, India organized a colloquium on "Use of Vetiver in Sediment Control" in which a number of papers were presented that detailed both research and management experiences with vetiver grass in India. In June a "Vetiver Grass Workshop" was held at the Commercial Farmers' Union in Harare, Zimbabwe in which both a research and implementation agenda was discussed to facilitate the extension and use of vetiver hedgerows in Zimbabwe. Also in June, the "First Training Course on Vetiver Grass" was conducted in Bhairawa, Nepal. The course attracted over 40 participants, mostly from nongovernmental organizations. At this time there are over 19 new nurseries and 32 new trials as a result. In July, a seminar on "Vegetative Approaches to Soil Conservation" was hosted by Ethiopia's Ministry of Agriculture. Mr. Meseret Wondimu presented a paper entitled "The Prospect of Vetiver Grass in Coffee Culture - The Experience of the Ministry of Coffee and Tea Development" in which he summarized almost two decades of Ethiopian experience with vetiver grass. Also, in recent months, training was organized through the World Bank for NGOs in Sokoto, Nigeria to establish vetiver grass nurseries from which the NGOs will be able to establish their own trials. In Guatemala, Mr. Mark Wilson, with World SHARE/Guatemala, has formed a group of organizations and individuals who are interested in vetiver grass. The group, which consists of two government agencies, four NGOs, coffee producers and some other interested individuals, is to test and promote vetiver as well as act as a focal point for decision-making concerning the best methods of promotion. The United States Department of Agriculture's Soil Conservation Service (USDA/SCS) will be holding a grass hedge conference at the end of November. One of the main purposes of the conference will be to evaluate vetiver grass and other grass hedges. The USDA/SCS has been carrying out a number of trials with vetiver grass.

Vetiver Awards

In our last Newsletter we made the announcement that we received a sum of money to use as incentives for: i) obtaining information on other plant species (not vetiver grass) that will perform the same soil and soil moisture conservation function over as wide a climatic and geographic range as will vetiver grass; ii) obtaining information on management innovations and research results from users of vetiver grass. An award of US$ 2,000 will be given to any individual or agency that can show us another specie or species as useful as vetiver grass and we will also award the seven top management and/or research results provided to us with US$3,000, US$2,000, US$1,000 and four awards of US$500, respectively. Letters detailing your suggestions and findings will be accepted until March 15, 1991. At that time an independent, external panel will choose the awardees; all awards will be made by May 1, 1991. All valid information received on management, research and other species will be incorporated into a Newsletter for publication by June 1991.

Since that time we have received notification from only one research group regarding other species with as wide a potential as vetiver grass. The notification has come from Dr. B.R. Hegde, Chief Scientist for the All India Coordinated Research Project for Dryland Agriculture in Bangalore, India. Dr. Hedge and his fellow researchers have been working with both vetiver grass and with a local species of grass, *Pennisetum hohenackeri*. They report that so far the*Pennisetum* shows promise, forming a good hedgerow under conditions on the research farm. Their research is continuing and will be presented to the independant panel that will be judging the Vetiver Awards.

If you or your organization wishes to participate, please keep in mind the March 15, 1991 deadline for presentation of your work. At present we are uncertain of the number of people who will competing for these awards. It would be helpful if you could send a note notifying us of your intentions with

Table I. Countries in which Vetiveria zizanioides is currently known to exist.

AFRICA	ASIA	LATIN AMERICA	CARIBBEAN	PACIFIC	MISC.
Algiers	Bangladesh	Argentina	Antigua	Fiji	France
Angola	Burma	Brazil	Barabados	New Caledonia	Italy
Burundi	China	Colombia	Cuba	New Guinea	Russia
Comoro	India	Costa Rica	Dom. Repub.	New Zealand	Spain
C. Afr. Republic	Indonesia	Guatemala	Haiti	Samoa	USA
Ethiopia	Japan	Guyana	Jamaica	Tonga	
Gabon	Malaysia	Honduras	Martinique		
Ghana	Nepal	Paraguay	Puerto Rico		
Kenya	Pakistan	Suriname	St. Lucia		
Madagascar	Philippines		St. Vincent		
Malawi	Singapore		Trinidad		
Mauritius	Sri Lanka				
Nigeria	Thailand				
Rwanda					
Reunion					
Seychelles					
Somalia					
S. Africa					
Tanzania					
Tunisia					
Uganda					
Zaire					
Zambia					
Zimbabwe					

a short description of your work.

Your Input is Needed by The Board On Science and Technology for International Development's (BOSTID) Study on Vetiver Grass

The National Research Council of the United States National Academy of Sciences is conducting a scientific audit of the effectiveness of vetiver grass for erosion control, to culminate in a report that will be widely disseminated. They will be assessing the knowledge, promise, and limitations of using vetiver grass hedgerows for soil and soil moisture conservation. The Academy feels that vetiver grass may potentially be utilized across vast areas of the world's watersheds, forests and farms; therefore it is essential that the information necessary to introduce vetiver grass rationally and safely — without undue environmental risk — be collected early on.

BOSTID is gathering information and commentary from anyone who may have relevant information, not only on vetiver grass, but other analogous species that may provide a broader range of suitable biological material for vegetative barriers. In addition to observations and insights, BOSTID is looking for your comments, concerns, and caveats. BOSTID assures us that nothing formal is required, send any scribbled notes or photos to :

Noel Vietmeyer
Attn : Vetiver Grass
National Academy of Sciences
2101 Constitution Avenue, NW
Washington, D.C. 20418, USA

They may also be reached by phone: 202-334-2692; by fax: 202-334-2660; or by BITNET: MDAFFORN@NAS.BITNET.

Contributors of relevant information will receive a complimentary copy of the final publication on vetiver grass.

References To Vetiver Grass

A surprisingly large body of information is turning up as part of the work to gather data on *Vetiveria zizanioides* (Linn.) Nash. The Newsletter would like to acknowledge Mr. F. Cook at the Kew Royal Botanic Gardens in the U.K. and Mr. M. Dafforn at the Board of Science and Technology for International Development, National Academy of Sciences in Washington, D.C. for providing much of the following.

A number of sources make reference to vetiver grass and its role as a soil conservation species and as a hedge plant; some of these observations, which span this century, are given below. Also, from the literature and our Vetiver Information Network, Tables I and II have been compiled to detail the currently known distribution and some of the (non-oil) traditional uses of vetiver grass.

- "Commonly cultivated in the West Indies as a hedge plant." (Hitchcock and Chase. 1917)
- "Introduced into tropical and subtropical Tunisia by the Europeans, and is sometimes planted along tracks to conserve the soils." (Trochain, 1940)
- "It was introduced to Fiji in 1907. . . it is common in most parts of the colony and (is)...probably the most important soil-binding grass in Fiji... commonly used on rice bunds for contour lines and for other soil conservation practices." (Parham, 1955)
- "Cultivated as a border plant to pre-

REGION	LOCATION	STABILIZING: CANALS/DITCHES/ EMBANKMENTS	STABILIZING: ROADS/ PATHS	FIELD/ BOUNDARY HEDGE	MISCELLANEOUS
Africa					
	Burundi	X			
	C. Afr. Rep.				Mattresses
	Ethiopia	X	X		Weed barrier/ mulch/mattresses/thatch
	Gabon	X	X	X	
	Ghana			X	
	Kenya			X	
	Madagascar			X	
	Malawi			X	
	Mauritius			X	
	Rwanda	X			
	S. Africa	X	X	X	
	Tanzania			X	Fodder
	Tunisia		X		
	Zaire	X			
	Zambia			X	
	Zimbabwe			X	
Asia					
	Burma	X			
	China			X	
	India	X		X	Fodder/weed barrier/paper/ mats/thatch/ medicinal
	Malaysia			X	
	Nepal	X			
	Pakistan			X	
	Sri Lanka	X			
	Thailand	X			
Pacific					
	Fiji	X		X	
	New Guinea				Repel insects
	Samoa				Weed barrier
Latin America					
	Costa Rica		X	X	
	Guatemala				Animal bedding
Caribbean					
	Barbados			X	
	Haiti		X	X	
	St. Lucia		X	X	
	St. Vincent		X		
	Trinidad		X	X	
	Martinique			X	
North America					
	USA				Sachet/repel insects/ ornamental

Table 2. Traditional (non-oil) uses of Vetiveria zizanioides, by location, for soil conservation and/or other purposes as reported in the literature and from correspondents to the Vetiver Information Network.

vent erosion in Barbados." (Allan, 1957).
- "In Gabon it is planted along ditches and roadsides to conserve the soil, delimit field boundaries, etc." (Raponda-Walker and Sillans, 1961)
- "Vetiver is introduced to New Guinea ....the plant itself is a useful soil binder." (Henty, 1969)
- "The plant in Malaya is a good soil binder." (Gilliland, 1971)
- "The grass is widely used throughout the tropics for planting on the contour as an anti-erosion measure, for protective partitions in terraced fields, and as a border for roads and gardens."(Purseglove, 1972)
- "Frequently cultivated in tropical America for hedges." (Hitchcock, 1980)
- "To prevent soil erosion, plants are often planted on the dikes of rice paddies, river banks, and similar places." (Lazarides, 1980)
- "Commonly used as a hedge plant in the Meseta Central of Costa Rica, planted along the top of road embankments in a continuous row, to prevent erosion". (Pohl, 1980.)
- "Special mention may be made of vetiver, which has the exceptional ability to withstand high pH and waterlogging. It is one of the very few suitable candidate species [for bringing "hard barren black alkali land" into cultivation]. Growing this species is least expensive as no amendments or fertilizers are needed for its establishment...this was one of the preferred species as a "First-Aid" to reclaim the soil." (Khoshoo, 1987).
- "A common hedge plant in Ghana." (Kew Herbarium Collection: Akpable, G.K. 565)
- "Cultivated as a border hedge in Tanzania." (Kew Herbarium Collection: Wingfield, R. 3394)
- "Contour plant in Tanzania." (Kew Herbarium Collection: Hill, W.G. 5901)
- "Cultivated extensively by Indians in Natal, South Africa as a hedge plant." (Kew Herbarium Collection: Pole-Evans, I.B. s.n. Natal)
- "Planted to avoid soil wash and invasion of weeds in Barbados." (Kew Herbarium Collection: McIntosh, A.G.S. and J.A. Allan 440)

SECONDARY USES OF VETIVER

Aside from information on vetiver's use as a hedgerow and soil conservation species, there are also a number of references to its other uses (aside from oil extraction). Some of these observations are given below.
- "Commonly cultivated in the West Indies ...(it) preserves clothes from moths." (Hitchcock and Chase, 1917)
- "In West Africa it is used as a border for roads, gardens, and cultivated fields to the prevent the extension of Dub grass (Desmostachya bipinnata). The leaves are odorless and can be used in their young state as cattle fodder." (Dalziel, 1937)
- "In India screens, fans, and other articles are made from the roots; when wetted with water they not only cool the air but also make it fragrant. The stem and leaves are used for making ropes, hats, and double mats. Suitable as pulp for paper production. The roots are used for brush manufacture. When young this plant is much liked by cattle, especially buffaloes. In folk medicine it is used to induce sweating and as a stimulating agent." (Roshevits, R.Yu. 1937).
- "Hot weather tatties, chicks, mats and fans" (Ramanujam and Kumarl 1963).
- "Vetiver is introduced to New Guinea ...the roots may be packed with clothes to repel insects". (Henty, 1969)
- "In Malaya the roots are used to provide an important curry- stuff." (Gilliland, 1971)
- "The young leaves are browsed by cattle and sheep". (CSIR 1976).
- "The pulp is suitable for making strawboards...(and) pilot- the grass yields a chemical pulp that can be used for making writing and printing papers." (CSIR, 1976)
- "The aromatic roots are ...also woven into fragrant mats, baskets, fans, clothing sachets, and ornaments. The foliage is used for thatch and can be processed for the making of coarse paper-pulp. The species is an important medicinal plant." (Lazarides, 1980)
- "Used for stuffing mattresses in the Central African Republic." (Kew Herbarium Collection: Fay, J.M. 4494)
- "Cattle fodder in Tanzania." (Kew Herbarium Collection: Hill, W.G. 5901)
- "Vetiver is used to cover the ground around taro to choke out weeds in Samoa." (Kew Herbarium Collection: Whistler, A. W 3271)
- "Planted to avoid invasion of weeds in Barbados." (Kew Herbarium Collection: McIntosh, A.G.S. and J.A. Allan 440)

SEMINAR ON SOIL CONSERVATION IN ETHIOPIA : Vetiver Grass in Use For More Than a Decade On Ministry of Coffee and Tea Plantations

On July 6,1990, a seminar on vegetative approaches to soil conservation was held in Addis Ababa, Ethio-

Hedgerows of vetiver grass have been in use for soil conservation and as a source of mulch for more than a decade in Ethiopia's coffee plantations.

64

pia. The seminar, sponsored by the Ministry of Agriculture, included a joint paper by the Ministries of Coffee and Tea Development (MCTD) and the Peasant Coffee Development and Project Implementation Department (PCDPID). The paper was presented by Mr. Meseret Wondimu, Head of Adaptive Research/PCDPID and detailed the experience of the MCTD with vetiver grass since its introduction at the Jimma Research Station in the early 1970's.

Some points of interest from the paper where :

1) Over the last two decades no negative effects of vetiver on coffee plants or coffee production have been noted.

2) Weed Control : Vetiver grass boundary hedges stop the encroachment of couch grass (*Digitaria spp*.) and star grass (*Cynadon spp*.) into the plantations from roadsides and surroundings. This has reduced labor and herbicide costs. In the Illubador region smallholders are also following this practice.

3) Mulch : Mulching is a standard practice on the lower altitude plantations to suppress weeds and conserve moisture. Vetiver mulch, unlike *Pennisetum spp*. mulch, does not have to be dried down to avoid its establishing and becoming a weed. The vetiver leaf mulch lasts longer than other grass mulches.

4) Conservation : On slopes over 25% in Kossa, Sheko, Virgachefe, Haru, Nole Kaba, Gumer, and Gumero vetiver hedges have proven effective in minimizing soil loss, the transport of fertilizer off site, and in reducing costs associated with ridging and canal maintenance.

5) Secondary Uses : (i) Vetiver grass has replaced the traditional thatching grass ("Beta") in some areas as it lasts longer and makes a more rainproof roof; (ii) vetiver grass is a primary material for mattress stuffing; (iii) vetiver hedges are planted along streams and around ponds to filter coffee pulp from the runoff and minimize water pollution.

Table III. A comparison of the fodder value of Vetiveria zizanioides - managed for fodder - with the fodder value of some other hedgerow grasses and major sources of ruminant forage.

NAME	CRUDE PROTEIN (%)	ETHER EXTRACT. (%)	CRUDE FIBER (%)	TOTAL ASH (%)	CALCIUM (%)	PHOSPHORUS (%)
Vetiveria zizanioides /1 (fresh,young leaves)	6.1-6.7	1.1-2.1	38-42	5.3-9.0	0.28-0.31	0.05-0.60
Zea mays Indentata /2 (Maize; stover)	6.60	1.3	34	7.2	0.49	0.08
Sorghum bicolor (Sorghum; stover)	5.20	1.7	34	11.0	0.52	0.13
Pennisetum purpureum (Napier; fresh, late bloom)	7.80	1.1	39	5.3	0.44	0.35
Paspalum notatum (Bahia; fresh)	8.90	1.6	30	11.1	0.46	0.22
Pasture /3 (grass dominant)		5.10			0.17	0.07
Maize (cobs maturing)		3.20			0.17	0.07
Millet		3.00			0.10	0.05
Sorghum (heading)		2.50			0.11	0.05

/1 Council of Scientific and Industrial Research (CSIR). 1976. Vetiveria. p. 451-457. In: The Wealth of India, Vol.X. Publications and Information Directorate, CSIR, New Delhi.
/2 National Academy of Sciences. 1982. United States-Canadian Tables of Feed Composition. National Academy Press, Washington, D.C. USA.
/3 Cochrane, M., Bartsch, B. and S. Valentine. 1983. Feed Composition Tables. Department of Agriculture, South Australia. Fact Sheet No. 29/83.

How Far Apart Should Hedges Be Planted ?

The spacing of hedgerows to provide adequate control of soil loss and control of surface runoff is a question which is often answered simply by a "rule of thumb". Such rules, however, come from the system of engineered soil conservation works. Their purpose is to space the works such that runoff is controlled by diverting it safely to drainageways and then off the field. With vetiver grass hedgerows we are not interested in diverting surface runoff, only in stopping its concentration. Runoff is allowed to move safely downslope over the soil surface, being spread out and kept from concentrating each time it encounters a hedgerow.

The most common rule for hedgerow spacing is to use a 1 to 2 meter vertical interval, dependant on slope. On lower slopes (less than 15%) the smaller interval is used; on higher slopes the larger. Whether this approach

is adequate or not, it is well to think ahead to the final results of the hedgerow's spacing. After some years, levelling will occur between the terraces. The greater the degree of slope, the more rapidly levelling will occur. The so-called "induced" or "controlled erosion" terraces that will be formed should be wide enough to accommodate the desired cropping and cultivation practices, if possible. For example, plowing with animals will require some minimum width to allow turning.

Terrace width will be dictated by the depth of the workable soil and the degree of slope. Hurni (1986) suggests that a one meter vertical interval be used on all slopes below 15% and that a vertical interval that is 2.5 times the soil depth be used for all slopes above 15% - providing sufficient soil to allow levelling.

Other approaches to spacing might take into account the interaction between erosion, the slope and the slope's length (Universal Soil Loss Equation's topographic factor 'LS') or a spacing to maintain runoff below some maximum permissible velocity (erosion threshold) given slope, soil texture and crop roughness factor.

From a technical viewpoint, hedgerow spacings are an area that would benefit from research; particularly on the effects of spacing on soil moisture recharge. Simple measurements that look at soil moisture distribution as a function of distance downslope from the hedgerow would be helpful.

From an implementation viewpoint, what is important is to make a start. For most small farmers, the question of spacing may initially be unimportant. In small fields a good approach might be to place a border hedgerow completely around the field. This would demarcate the farmer's boundaries, provide a hedge to aid in the control of runoff from upslope and one to stop soil loss at the foot of the field. If the farmer finds utility in these hedgerows, then the question of mid-field hedgerows may be addressed. Though it may be considered desirable to treat the entire area at once, an incremental approach that allows the individual farmers to demonstrate to their own satisfaction the usefulness of hedgerows may be more successful in the long term.

FODDER VALUE OF VETIVER GRASS

Information on the fodder value of vetiver grass was obtained and compared with published values of two other grass species which are often promoted as useful hedgerow/fodder plants and with other important sources of ruminant forage. From the values seen in Table III, the young leaves of vetiver grass can be a useful source of ruminant forage. This is confirmed by recent work in Nepal by Dr. S.B. Panday of the Central Animal Nutrition Division in Khumaltar, Nepal.

Dr. Panday carried out a chemical analysis on the north India-type of vetiver, the wild type which is believed to be less palatable than the farmer-selected types from south India. Based on analysis of 10 accessions of vetiver grass, harvested four times at 15 and 25 day intervals, it was concluded :

Dick Grimshaw introduced the Chinese to vetiver grass in 1988 under "The Red Soils Project". Even on these acidic, low fertility soils, vetiver grows very well.

"*Vetiver grass has relatively higher structural carbohydrates as compared to native grasses and rice straw. On the other hand, it also had optimal levels of CP (crude protein), considered to be enough to maximize intake and digestion of the forage (vetiver grass). From the results obtained it can be pointed out that vetiver grass may be used as ruminants' feed if it is mixed with other good quality feeds and forages.*"

Vetiver grass is known to planted and managed specifically as a fodder grass in the state of Karnataka in south India. Planted along the field boundaries, the grass is cut every two weeks or less. This practice is carried on long into the dry season. Dr. B.R. Hegde, Chief Scientist at the AICRP for Dryland Agriculture, GKVK University, Bangalore, Karnataka, India reports that they have 2 cultivars of vetiver grass on their research farm, one of which is the locally improved or "farmer selected" cultivar. As a routine they have cut them at about 30 cm, 3 or 4 times per year. After the last cutting in June of this year, following which there were no rains, it was noticed that the farmer selected cultivar did not develop large amounts of dried material in the center as did the other cultivar. This, and other evidence, suggests that the Karnataka farmer-selected cultivar of vetiver grass may be not only superior fodder, but capable of producing fodder longer into the dry season.

A recent letter from China to the Vetiver information network reported that workers in a vetiver nursery, upon discovery that cows liked the grass, sold about 1,000 kg to a local dairy at about US$ 0.21/kg (green weight). Past information from China indicated that in the first year following planting, 200 meters of (single line) hedgerow produced from 500 kg to 1,000 kg of prunings (green weight).

RESEARCH UPDATE

More data has been received from Drs. G.M. Bharad (Professor of Agronomy and Director of Research, PKV University, Akola, Maharashtra, India) and A.M. Krishnappa (Operational Research Project, Kabbalnala Watershed Project). Since 1987 a number of research station and farmer's field trials have been carried out to compare the impacts of vetiver hedgerows on surface runoff, soil losses and crop yields. In total the information given below represent 27 plot years of data from two areas (Akola and Kabbalnala) and two soil groups (Vertisols and Alfisols). The data is as yet preliminary,

Table IV. Synopsis of research data on crop yield, soil loss, and surface runoff from 1987 to 1990.

LOCATION	YR	SLOPE	CROP	TREATMENT	Pt (mm)	YIELD (kg/ha)	SOIL LOSS (t/ha)	RUNOFF (mm)
Andhra Pradesh	89	<5%	Castor	Up-and-down	347	1030		64.5
				Contour		1350		51.0
	»			Vetiver /1		1460		45.5
				Vetiver with ridge & furrow		1600		28.9
Andhra Pradesh	88	<5%	Castor	Up-and-down	509	1150		78.7
				Contour		1520		71.2
				Vetiver /2		1560		56.9
				Vetiver with ridge & furrow		1660		
Dehra Dun	89	<5%	Runoff Plot	Cult, fallow			41.0	
				Contour			22.9	
				Bench terrace			2.3	
				Contour bund			4.8	
				Graded bund			5.6	
				Panicum			8.1	
				Eulaliopsis			10.5	
				Vetiver /2			8.7	
Karnataka	87	<5%	Millet	Up-and-down	505	1860	11.0	
				Trad, bund		1930	7.4	
				Graded bund		2412	3.7	
				Contour bund		2425	1.3	
				Vetiver /2		2475	2.5	
Karnataka	87	<5%	Millet	Trad, bund	787	2550		
				Graded bund		2690		
				Vetiver /2		2710		
Karnataka	87	<5%	Millet	Trad, bund	288	1440		64.8
				Graded bund		1520		46.9
				Vetiver /2		1530		41.5
Maharashtra	87-90	<5%	Various	Across	872	1523	11.4	133.9
				Leaucaena		1696	6.2	97.7
				Vetiver/3		1957	3.3	74.4
Maharashtra	/5 88-90	<5%	Various	Across		3375		
				Leaucaena		3684		
				Vetiver /4		3854		

/1 - Vetiver hedgerows in second rainy season (12 thru 17 months since planting).
/2 - Vetiver hedgerows in first rainy season (0 thru 5 months since planting).
/3 - Vetiver hedgerows in first thru third rainy seasons (0 thru 29 months).
/4 - Vetiver hedgerows in second thru third rainy seasons (12 thru 29 months).
/5 - The data from Maharashtra represents an average of all years.

Sources : Drs. A. Padmaraju and M. Singa Rao, Andhra Pradesh Agricultural University, Pahadi Sharif, Rangareddy District, India.; Drs. G. Singh, G. Sastry, and S.P. Bhardwaj, Central Soil and Water Conservation Research and Training Inst., Dehra Dun, India; Dr K.T. Krishnegowda, GKVK University of Agricultural Sciences, Bangalore, India; Dr. A.M. Krishnappa, Operational Research Project, Kabbanala, Karnataka, India; and Drs. G.M. Bharad and B.C. Bathkal, PKV University, Akola, Maharashtra, India.

and is not statistically significant. Table IV provides a summary of all the available research data on surface runoff, soil losses and crop yields from India between the years of 1987 - 1990.

Surface Runoff

On slopes under 5%, contour hedgerows of *V. zizanioides*, planted at one meter vertical intervals, have reduced surface runoff an average of 30% (± 23%) / and 47% (± 9%) compared to conventional practices of graded bunds and across slope cultivation. Compared to Leucaena spp. hedgerows, they have reduced surface runoff an average of 24% (± 14%).

Sediment Yields

Plots and fields with vetiver hedgerows have shown a reduction in sediment yields on an average of 74% (± 5%) compared to across slope cultivation and 43% (± 19%) compared to graded bunds. Compared to hedgerows of Leucaena spp., vetiver hedgerows have reduced sediment yields an average of 54% (± 4%).

Crop Yields

Crop yield data comparing conventional practices of graded bunds and across slope cultivation with contour hedgerows of vetiver grass shows that yields averaged 6% (± 10%) and 26% (± 20%) higher from the areas with the vetiver hedgerows, respectively. Compared to Leucaena spp. hedgerows, yields with V. zizanioides averaged 10% higher (± 9%).

Crop Competition Effects

Information on competition effects between vetiver hedgerows and crop plants have been provided by a number of researchers. The information below comes from work carried out by Drs. G.M. Bharad and B.C. Bathkal, PKV University, Akola, Maharashtra, India;. Dr K.T. Krishnegowda, GKVK University of Agricultural Sciences, Bangalore, India; Dr. A.M. Krishnappa, Operational Research Project, Kabbanala, Karnataka, India; and Drs. A. Padmaraju and M. Singa Rao, Andhra Pradesh Agricultural University, Pahadi Sharif, Rangareddy District, India.

Preliminary research data from acidic and slightly alkaline, drought prone soils show no yield reduction in either finger millet (*Eleusine coracana* (L.) Gaertn.), castor bean *(Ricinus communis* L.) or peanuts (*Arachis hypogaea* L.) when planted next to vetiver hedgerows. Under the same conditions, maize *(Zea mays* L.) yield reductions were noted in the two rows closest to the hedge. Results on non-acidic soils under semi-arid conditions show no yield reductions in green gram (*Phaseolus mungo* L.), pearl millet (*Pennisetum typhoideum* Rich.), sorghum (*Sorghum vulgare* Pers. 'R-73') or safflower (*Carthamus tinctoria* L.). Aside from these crops, interviews with farmers have supported that competition effects are minor or unnoticeable in cotton, rice, and pigeon pea (*Cajanus cajan* (L.) Millsp.). It is hypothesized that the minimal competition effects are a function of root morphology - the extensive root system tends to move vertically rather than horizontally; improved moisture and nutrient status near the hedgerow and the low nutrient requirements of the grass.

The Known Range of Current Use of *Vetiveria zizanioides* (Linn) Nash.

The following information has, primarily, been abstracted from the Vetiver Network's database :

As a hedgerow species, the usefulness of vetiver grass has been established in the tropics and subtropics from sea level to 2,000 m in Uttar Pradesh, India; over a temperature range from 38 degrees C mean dry season temperature/45 degrees C maximum in Andhra Pradesh, India to a 5 degrees C mean winter temperature/ minus 9 degrees C minimum and 10 frost days in Cantalice, Italy; in soils with pH ranging from 4.5 in Ethiopia and China to 10.5 in India; across rainfall zones of 600 mm/yr with a 8 to 9 month dry season in Andhra Pradesh, India to about 6,000 mm/yr in Sri Lanka; and on slopes ranging from 30% to 40% in China. The notable exceptions to vetiver's usefulness are in areas of low temperatures — though the extent of the grass's cold tolerance is not yet established; and in saline soil — the literature classifies *V. zizanioides* as a glycophyte and 75% reductions in growth rates have been reported at electrical conductivities (EC) of 4.0 (unpublished data from Dr. S. Miyamoto, Texas Agricultural Experiment Station, El Paso, Tx., USA). Other potential problem areas for *V. zizanioides* may be in areas with rainfall much less than 600 mm/yr and/or dry seasons longer than 9 or 10 months.

Letters From Correspondents

India

- The Peoples Research Organization for Grass Root Environmental Scientific Service in Hyderabad has been utilizing vetiver and other local grasses as hedgerows for erosion control in their work with small and marginal farmers. They report that their experience has encouraged them to bring large areas under vetiver.
- A 0.16 ha vetiver nursery was constructed by students of the Government Junior College, Kadur in Chikkamangalur district of Karnataka. The nursery produced 400,000 slips over a 7 month period; enough material to establish a hedgerow about 13 km long (under their semiarid conditions). The material was sold to the state's Watershed Development Team and the students utilized the proceeds to obtain a television set and library furniture for the school.

China

- Mr. Wang Zhisong, Deputy Director of the China Red Soils Project in Fujian reports that their work with vetiver grass began during the winter of 1988. Less than two years later, the project had established more than 100 km of vetiver hedgerows in tea and citrus gardens.
- The Ministry of Agriculture is carrying out research/demonstrations in the provinces of Fujian, Guizhou, Hunan, Jiangxi, and Sichuan with contour hedgerows of vetiver on cultivated slopes and terraces and with tea and fruit. The research component is focusing on the biological characteristics of vetiver; hedge establishment and maintenance; hedgerow impacts on fertility,

moisture, crop yield, and soil losses; as well as other indirect biological and economic benefits. Each of the provinces established about 13 ha of nursery this year, with 33 ha and 67 ha of nursery planned for 1991 and 1992.

Philippines

- Mr. Ly Tung, Program Coordinator of the Farm and Resource Management Institute (FARMI), Visayas State College of Agriculture reports that vetiver grass is fairly common throughout the lowland rice areas of Leyte. Deciding to give it a try, FARMI planted a trial at the beginning of this year on "very poor and acid upland soil (pH<5). Observation to date shows that it grows very well..."

Sri Lanka

- Mr. Keerthi Rajapakse, a retired Assistant Conservator of Forests, has been instrumental in establishing vetiver nurseries in the Kandy District. The purpose of the nurseries is to supply planting material to farmers, especially tobacco farmers, as soil loss rates from hillside cultivation of this crop are considered to be a major problem. Mr. Rajapakse reports that "the most encouraging acceptance of this vegetative contour method is from the tobacco cultivators."

Malaysia

- Mr. Teoh Cheng Hai of the Golden Plantations Berhad Research and Development Department reports that their vetiver plantings, in soils with a pH of 4.7, continued to tiller satisfactorily despite a prolonged drought.

Japan

- The Vetiver Newsletter # 3 has been translated into Japanese, or so we have heard from the World Bank's office in Japan. A consultant had contacted the office there requesting information on how to subscribe to the Japanese language edition. The Network would like to commend the effort of those who translated it, and we would certainly like to hear from them as well.

Watershed Development in Asia - A new technical publication from the World Bank.

The Asia Technical Department has recently completed a review of watershed development issues entitled "Watershed Development in Asia - Strategies and Technologies" (J.B. Doolette and W.B. Magrath, eds.).

The review arose from the realization that a number of current and planned World Bank-supported projects in the Asia region deal with the linkages between upland productivity and environmental conditions and are, in various ways, motivated by concern with downstream impacts such as flooding and sedimentation. The review focused on deepening the Bank's understanding of watershed development. High priority was given to identifying discrete operational problems that could be better understood from review of existing data and analysis. In addition, the review was to provide overall guidance to the Bank's dialogue with borrowers on strategies for resource management. Working papers on six issues of direct operational concern were initiated, to be conducted by World Bank staff and consultants in the context of ongoing operations.

Watersheds as hydrologic units provide appropriate units for conceptualizing and implementing development investments. They comprise combinations of arable and nonarable land and drainage lines and are utilized by permanent and transient populations with varying degrees of skill and commitment to long term resource husbandry. The range of issues relevant to watershed management is enormous and includes environmental issues, crop and livestock production, a whole range of social and cultural concerns, infrastructure planning and entire questions of governance and control. The volume presents the results of a highly selective program of research and consultation.

In an introductory chapter the editors present a discussion of the major watershed development problems of the Asia region. Taking a policy and development perspective, the chapter tries to sort out what can and cannot management efforts. While not minimizing the importance of the linkages between upstream landuse and downstream environmental quality, the authors suggest that there are severe limits to our ability to manage these linkages in a cost effective manner. However, they observe a wide range of technological opportunities for intensifying productive activities in the uplands that, in addition to being privately profitable, will ultimately have positive impacts on downstream areas. In light of this they conclude by proposing an overall approach to watershed development that focuses on small farm development and common property management.

Additional chapters : i) examine the fundamental building blocks of watershed development through a review of the impacts of a broad range of land management technologies and illustrates the potential and constraints facing projects that attempt to influence erosion, runoff and productivity (J.B. Doolette and J.W. Smyle); ii) deal with the economic analysis of on- and off-farm conservation measures (W.B. Magrath); iii) revegetation of degraded land (A.K. Bannerjee); iv) land tenure (A. Molnar) and ; v) planning, monitoring and evaluation (G.S. Morgan and R.C. Ng).

Watershed Management in Asia - Strategies and Technologies" is available through the World Bank's Publications Department for US$ 13.95.

Vetiver Bibliography - A listing of some of the literature

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The findings, interpretations and conclusions expressed here are entirely those of the authors and should not be attributed in any manner to the World Bank.

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER INFORMATION NETWORK, ASTAG*, WORLD BANK, NUMBER 5, MARCH 1991

TABLE OF CONTENTS

Vetiver Research, Akola, India	72
Vetiver Research, Philippines	73
Vetiver Research, Malaysia	74
Planting Density & Spacing	75
Vetiver Reseach, Tamil Nadu, India	76
Stemborers In Vetiver Grass	76
USA, Vetiver Workshop	77
Letters To The Network	77
All China Newsletter	79
Funds For NGOs	80
Geographic Distribution	81
Research Institutions	81
NGOs/World Bank	81
Alternative Technologies	82

THE NEWSLETTER

This is the fifth Newsletter put out by the Vetiver Information Network. Since the last Newsletter (#4) was sent out the rate at which we have been receiving examples of research and information on the usage and impacts of vetiver grass hedges has increased dramatically. As these results come in, a more coherent picture of the function of the hedgerows has begun to emerge. For example, information on vetiver hedge interactions with associated crop plants is beginning to show that some yield reduction may be observed in the rows nearest the hedges in certain crops (e.g. maize) in certain soils. Whether these reductions result in an overall decrease in yield is not yet clear — that is, yield gains in the other rows may offset losses in the nearest row and the spacing between hedges will effect the total number of "effected" versus "non-effected". Also, to a great extent, the information available comes from non-replicated plot studies where the results can only be treated as indicative; in single plot studies the differences caused by between plot variation (such as soils, slope position, crop management, etc.) cannot be ruled out as causes of yield differences. This Newsletter contains two examples where preliminary results have shown some competition effects (maize) and another showing no such effects (rice and mungbean). In the next Newsletter we will summarize all the current data on vetiver hedge and crop interactions.

VETIVER AWARDS

The March 15 deadline for the Vetiver Research Incentive Awards has passed and the Network has received some excellent reports from countries such as Australia, China, India, and Malaysia. The Network wishes to thank all of the contributors and to let them know that their work will be going to the independent review panel and the awards announced to them prior to the next Newsletter in June.

In this edition of the Newsletter we would like to give the readers a preview of some of the reports that we received and that will be synopsized for the June Newsletter. The first is a report by Dr. P.K. Yoon, Malaysia. In only two years Dr. Yoon has produced an impressive amount of research. In his own words : *"My knowledge of Vetiver grass starts from 12/4/1989, when I first saw a clump of rather undistinguished-looking grass collected by my colleague, Encik Ahmad Azly, at my request. It looked so ordinary and so frighteningly similar to the horrible "Lalang" !* (Ed. Note - Imperata cylindrica) *However, I had been stimulated by the Handbook: "Vetiver Grass - The Hedge Against Erosion" and, having spent more than 30 years visiting rubber plantings and having seen massive erosion problems especially on steep hills, I was prepared to have a look-see at any economic method. 1989 was the time to get to know the plant and to multiply it for distribution. 1990 was the main period for distribution, start some ad hoc trials and set the stage for 'proper' trials in co-operating estates. This report summarizes mainly efforts of 1989 and 1990. 1991 should see better progress."*

"Research and Development must be well targeted and take cognizance of local situation. Whereas, Vetiver is promoted by the World Bank as a low-cost hedgerow system for controlling soil-loss and improving soil moisture, this may be true only for the poorer developing countries. Malaysia is well developed agriculturally and

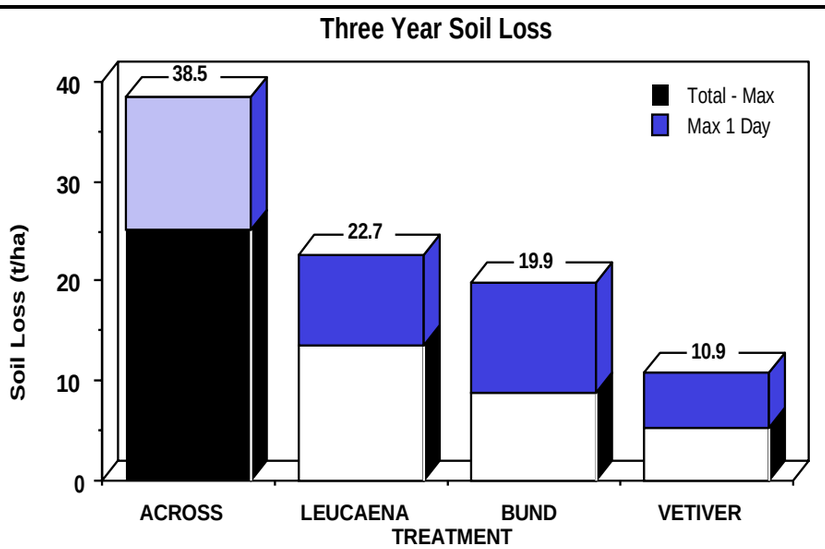


Figure 1. Three year total soil loss from runoff plots in Akola, India. Treatments are Across slope cultivation, contour hedges of Leucaena, graded earthen bund (0.2% slope) and contour hedges of Vetiver grass. Numbers on top are total soil loss (t/ha), lighter areas represent the maximum one day soil loss.

money is readily available for any cost-effective technologies. My research targets assess the potential values of Vetiver from both ends of the economic spectrum and, therefore, the early results and discussions presented could be easily adapted to suit different input requirements."

"The report presented here covers work done over a short period of less than 2 years. Even so, the results clearly show the vast potentials of Vetiver which are too tempting for any one not to look further into it! The future is being written..... "

Dr. Yoon's report provides information on:

Vegetative Multiplication : (i) By tillers; (ii) By culm-branches; (iii) By culm-cuttings.

Growth Rates : (i) Effect of shade; (ii) Effect of soil types; (iii) Effect of bag sizes; (iv) Effect of fertilizer ; (v) Effect of spacing cum fertilizer; (vi) Effect of different starting materials on variability of tiller formation and growth rates; (vii) Study of the root systems.

Effect of Vetiver On Soil Erosion : (i) Demonstration of effectiveness against top-soil loss; (ii) Growth of vetiver and its effect on filled earth; (iii) Growth of vetiver and its effect on cut-earth

Diseases

Adaptive Use Of Vetiver By End-Users : (i) Production of planting materials; (ii) Ponding; (iii) Erosion control in irrigation piping; (iv) To protect terracing; (v) Erosion control and moisture conservation.

Ad Hoc Notes : (i) Different cultivars; (ii) Labor; (iii) Weather conditions; (iv) Fodder production; (v) Mulch; (vi) Tolerance to contact weedicide spray drift; (vii) Competition with rubber; (viii) Competition against other weeds.

Another excellent piece of work received by the Network was carried out by Drs. P. N. Truong, L.J. Gordon & M.G. McDowell of the Land Management Research Branch Queensland Department of Primary Industries Brisbane, Australia on the "Effects Of Soil Salinity On The Establishment And Growth Of *Vetiveria zizanioides* (L.) Nash". In the introduction to the paper, the authors write :

"Vetiver grass [Vetiveria zizanioides (L.) Nash] is believed to have been first introduced into Queensland, Australia in the 1930s as a potential crop for its essential oil. In Queensland, its role in soil and water conservation was not realized until 1986 when it was promoted by the World Bank as a natural, effective and low cost method of soil and water conservation. Vetiver grass is presently being evaluated as a means of gully stabilization in grazing lands."

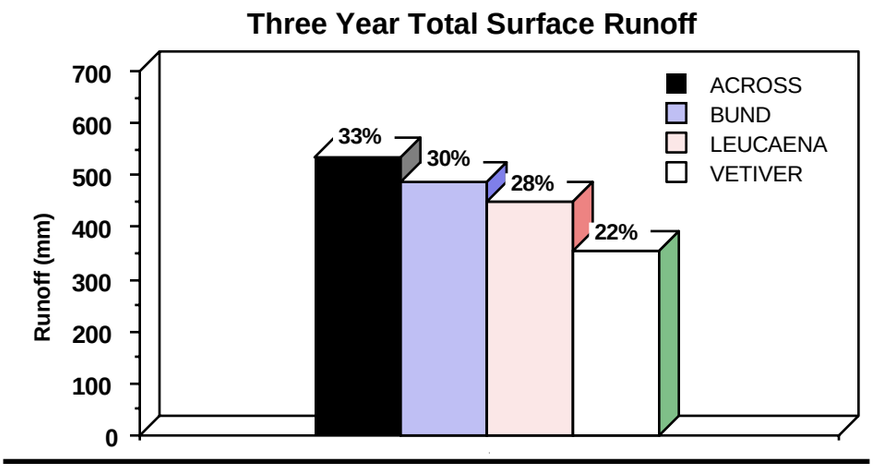


Figure 2. Three year total surface runoff from runoff plots in Akola, India. Percentages on top express total runoff as a percentage of rainfall occurring in those storm events which resulted in surface runoff. The difference between the Vetiver and the Across slope cultivated plots amounts to almost 200 mm of rainfall, or about one-quarter of the average annual rainfall of that area.

"One of the characteristics of the soils in the semi arid regions of sub tropical eastern Australia is the presence of soluble salts and exchangeable sodium in amounts likely to affect plant growth. Solodic soils frequently contain high levels of exchangeable sodium and magnesium and low levels of exchangeable calcium (Isbell 1957)."

"In Queensland, most grazing land degradation (sheet and gully erosion) in semi arid regions is often associated with saline - sodic soils and to be effective in stabilizing gullies on these soils, Vetiver needs to be moderately salt tolerant. There are practically no references in the literature on the salt tolerance level of Vetiver grass. Only one reference is listed in the comprehensive bibliography, Plant Response to Salinity (Francois and Mass, 1978) but this does not give any details on the soil salinity level where Vetiver was evaluated for its essential oil production (Chandra et al, 1968). As a result, a series of glasshouse and field experiments were conducted to determine the salt tolerance of Vetiver grass. The objectives of these trials were:

(i) To determine the salt tolerance of Vetiver grass in comparison with some well known pasture grasses; (ii)To determine the effects of shallow saline groundwater on Vetiver growth and; (iii) To determine the soil salinity level and plant chloride content of Vetiver grass at which toxic symptoms appear and describe these symptoms."

UPDATE ON VETIVER RESEARCH IN AKOLA, INDIA - SYNOPSIS OF THREE YEARS DATA

Drs. G.M. Bharad and B.C. Bathkal from PKV University in Akola, Maharashtra, India have provided the Network with another season's data on the impacts of vetiver grass hedgerows on soil loss and surface runoff. Figures 1 and 2 show the soil loss (total and maximum one day soil losses) and surface runoff from the plots over three years and Figure 3 compares these rates to the control plot (ACROSS) from the top 10% largest storms over the three years. The individual treatments are : ACROSS = across slope cultivation only; BUND = a graded (0.2%) earthen bund at a 1 meter vertical interval with contour cultivation; LEUCAENA = Leucaena leucocephala contour hedgerows at a 1 meter vertical interval with contour cultivation; and VETIVER = Vetiveria zizanioides contour hedgerows at a 1 meter vertical interval with contour cultivation. Plots are approxi-

mately 0.35 ha, slopes are less than 2%, soils are vertisols, climate is semi-arid.

Referring to Figure 1, in all plots the majority of the soil loss occurred in year 1 (68% - 79% of the totals) with a substantial proportion of that loss coming from one storm event; year 1 was an unusually wet year. The numbers on top of the histograms are the total three year soil losses and the lighter areas represent the soil lost in the one major storm event in year 1. As illustrated here, the adequacy of a soil conservation treatment must be judged not on the "average" event but on performance during exceptions to the average.

Figure 2 shows the total amount of surface runoff from all treatments. The numbers on the top of the histograms are surface runoff as a percent of the rainfall from storm events which caused surface runoff. The difference between vetiver and the across slope treatments represents almost 200 mm of rainfall. In year 2, a droughty year, surface runoff from the vetiver plot was 55%, 35% and 41% less than from the across slope, leucaena, and bunded treatments, respectively.

Figure 3 is a followup on the comment made above regarding performance of conservation treatments during the extreme events. This figure represents the data from the top 10% largest storms over the three years. These storms also represent the events which resulted in the greatest volumes of surface runoff. The figure shows soil losses and surface runoff from the leucaena, bunded and vetiver plots as a percentage of losses from the across-slope "control" plot; the absolute amounts of soil loss and surface runoff for each treatment are given on top of the histograms. Across all three treatments, it was in this 10 percentile of storm events that one-half to two-thirds of the three year total soil loss occurred and about 50% of the total volume of surface runoff.

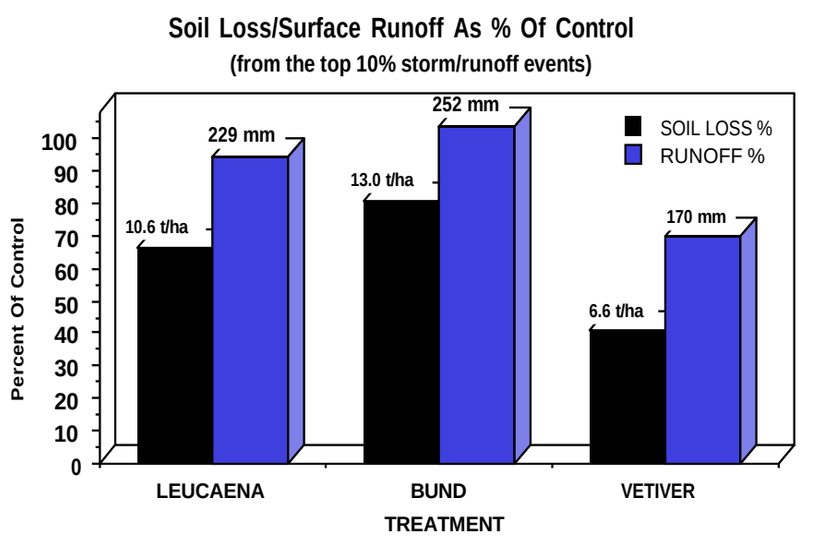


Figure 3. Soilloss and surface runoff from the largest 10 percentile of storm events occurring over the three years of observation on runoff plots in Akola, India. The great majority of soil losses and runoff damages are incurred during the "non-average" storm events; conservation treatments must be effective during these extreme events if long term losses are to be minimized. In all plots, 68% to 79% of the total three year soil losses occurred in one storm event in Year 1, prior to the Vetiver and Leucaena hedges becoming fully functional.

ON-CONTOUR VETIVER GRASS HEDGE FOR CONSERVING SOIL AND WATER, AND ENHANCING CROP PRODUCTIVITY ON SLOPING LANDS

The Network recently received the following preliminary report by Drs.T. Woodhead and T.N. Chaudhaly at the International Rice Research Institute, Los Baños, Philippines on their work with Vetiver grass :

"On sloping lands, barriers are established across the flow path of running water to reduce its flow volume and velocity, and thereby to conserve soil and water which is associated with enhancement in crop productivity. The traditionally advocated earthen embankment barrier/contour bund is not attractive to farmers because of constructional flaws and poor economics on small land holdings. An alternative is the vegetative barrier in the form of grass, shrub or tree hedges and among them, the one which creates a dense barrier at the ground surface without a long establishment period and does not interfere with crop production process by way of inconvenience in farming, crop shading and competition for water and nutrients can be preferred. Keeping these parameters in view, a field study was designed to evaluate the effectiveness of on-contour Vetiver hedge in conserving soil and water, and enhancing crop productivity on gently sloping land (about 2% slope; south-east aspect) at the IRRI farm. The study site has medium deep soil of silty clay texture and receives mean annual rainfall of about 2500 mm."

"Single-line hedges (slips spaced 8 cm apart) were planted at 0.25 and 0.50 m vertical intervals (V.I.) on 18 June 1990. The test crops of rice (IAC - 25) and mungbean (M79-13-60) were planted in the intervening alleys on 19 June and 3 July, respectively. Six treatment combinations involving rice and mungbean crops with hedges at 0.25 and 0.50 m V.I., and a non-hedged control were established in plots of 4.3 m width and varying length (26-41 m) with three replicates in RCBD."

"Observations on depth of soil accumulation, soil water content in the crop root-zone, and crop growth and yield were recorded in the upper and the lower parts of each alley."

"The hedges planted almost concurrently with the test crops took time in establishment but became continuous in the latter part of the crop growing season. They allowed thereafter substantial accumulation of eroded soil on their upslope sides that otherwise would have been transported further downslope compared to the non-hedged control where only the crop rows allowed some retention of the eroded soil. Since the hedges were not

Table 1. Seasonal soil accumulation, soil water content (0 - 60 cm depth) and crop production averaged over upper and lower alleys and across blocks under various treatments. (IRRI Data)

Treatment (Hedge)	Soil accumulation depth (mm)		Soil water content (mm)		Crop production (t/ha)	
	Rice	Mungbean	Rice	Mungbean	Rice	Mungbean
0.25 m V.I.[a]	25±3	28±2	319±8	324±8	1.42±0.12	0.81±0.05
0.50 m V.I.[a]	16±3	18±4	308±10	314±12	1.29±0.11	0.72±0.03
Non-hedged control	8±2	15±2	314±10	317±14	1.25±0.10	0.73±0.03

[a]Vertical Interval

fully established during the major part of the crops' active growth phase, a distinct advantage in respect of soil water regime and productivity of the concurrently grown crops was not realized during this first season. However, the hedges established at a shorter VI of 0.25 m gave marginal increases in crop available soil water retained within the rootzone and in rice and mungbean grain yields (Table 1). The mungbean crop (grown without fertilizers) gave grain yields of higher economic value than the rice crop (grown with fertilizers). Comparison of grain yields of the crop rows adjacent to and away from the hedges suggested no shading/competitive effect of the hedges on the growth of adjacent crop rows."

CONCLUSIONS

"The preliminary results suggest that a fully established on-contour Vetiver hedge can provide adequate protection against soil erosion on sloping lands. It should be acceptable to farmers since the hedge occupies a narrow land strip, the cost of hedge establishment is low as the farmers can use their own labor in hedge planting and there is no maintenance expenditure after it gets established. A greater efficacy can be expected by establishing the hedge at a relatively shorter than a longer V.I., and this may be realistic as well since it can serve as a more appropriate guideline for cultivation and crop planting."

"The effectiveness of more fully established hedges in conserving soil and water and in enhancing crop production as also the competitive effect of the hedges on the growth of adjacent crop rows needs to be further evaluated. With availability of more data, it may be feasible to assess relative productivity/profitability of rice and mungbean as alternative wet-season crops for uplands."

VETIVER RESEARCH IN MALAYSIA - SOME PRELIMINARY RESULTS ON SOIL LOSS, RUNOFF AND YIELD

Drs. K.F. Kon and F.W. Lim have begun trials with Vetiver grass hedges at the CIBA-GEIGY Agricultural Experiment Station in Negeri Rembau, Malaysia. They have sent a copy of preliminary research results to the Network detailing the following :

"We planted single tillers of vetiver grass (source: MARDI, Serdang) in rows at 4 m apart in plots on an Ultisol in our station. The plots were 8 m long by 1.5m wide; three hedges were planted on each at the bottom, middle and top of the plot. Within the hedge tillers were 10 cm apart within rows and they established quickly and, within 6 months, the gaps between tillers were closed. Plots of 1.5 m by 8 m were established for observational purposes as we did not have enough vetiver tillers to initiate a replicated trial. The vetiver plot was compared with a bare-soil plot for run-off, soil erosion and growth of maize."

"From June 13, 1990 to January 22, 1991, we took 19 measurements of rainfall, run-off and soil erosion. Over this period of time, the total run-off was 73% less in the vetiver plot than in bare soil and the total eroded soil was 93% less (Table 2). The maize crop was sown late and we did not take

Table 2. Conservation of soil and water with Vetiver grass on an Ultisol with a 4% slope at Rembau (CIBA-GEIGY Data)

Treatment	Rainfall[A] (mm)	Run-off (l/12 m^2)	Eroded soil (g/12 m^2)	Dry matter of maize (kg/12 m^2)
Bare soil	851	28.00	277	2.02
Vetiver grass	851	7.51	20	1.83

A - There were 63 raindays from June 13, 1990 to January 22, 1991.

it to grain yield. However, dry matter production indicated that vetiver grass competed with maize, and yield reduction was about 10% (Table 2)" .

CONCLUSIONS

"The preliminary results are interesting. We conclude that vetiver grass hedges reduce run-off and erosion considerably as was claimed in reports that have been published elsewhere. The disadvantage is that it competes with crops for nutrients at a planting distance of 4 m apart. We presume competition can be reduced by spacing the vetiver rows further apart, say 6 m or 8 m."

"The vetiver grass on our station appears to be drought tolerant. Leaves remained green and plants grew despite the dry weather. It attracted a lot of white flies that fed on its leaves. Other than this, we have not observed other pests or diseases" .

Editors Note: In a followup to the authors, the Network requested further information regarding competition effects. The authors responded :

"*Yes, we could see competitive effects on the maize plants. The nearest two rows to the hedgerow were affected. The distance between the first rows to the hedgerows varied from 15 cm to 60 cm, there was 70 cm between the rows of maize; the maize on the downslope side of the hedgerows was more affected. Each hedgerow grew to about 10 cm width at the base (3.8% of the plot) with the aerial parts at 50 cm height about 40 to 50 cm wide (17% of the plot."* The Network wishes to point out that the authors state that the planting distance of 4m apart may be the main factor here. For this slope class (4%) hedges would probably be spaced 15m to 25m apart in a farmer's field.

Hedgerow Establishment - Plant spacing & density

Information received by the Network on planting practices for vetiver grass is presented below.

- RAK College of Agriculture, Sehore, India (soils are heavy black clay (Vertisols); high moisture holding capacity; climate is semi-arid) — 3 slips at 5 cm intervals gave the best survival (86%).
- University of Agricultural Sciences, Bangalore, India (soils are reddish sandy loam to sandy clay loam (Alfisols); moderate moisture holding capacity; climate is semi-arid) — 3 slips at 5 cm intervals gave very good survival and rapid hedge closure.
- Andhra Pradesh Agricultural University, Pahadi Sharif, Andhra Pradesh, India (soils are reddish sandy loams to loamy sands (Alfisols); poor to moderate moisture holding capacity; climate is semi-arid) — 4 slips at 15 cm intervals is reported to give the best results.
- Nanping Prefecture, Fujian, China (climate is temperate) — 5 to 7 slips at 15 cm intervals for poor soils and 3 to 5 slips at 20 cm intervals for good soils.

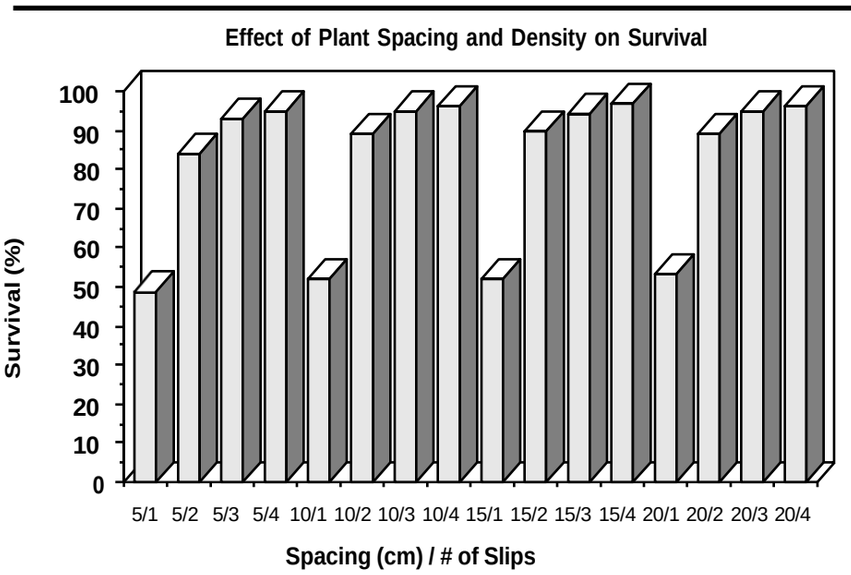
The differences between these recommendations probably results from differences in the planting materials, the soils, the climate and to a lesser extent, the planting techniques. What this shows is that the question of optimal practice for hedgerow establishment in a given location is going to be a location specific answer. This data can only be used to suggest general guidelines for management in other locations with other planting materials. It should be recognized, though, that the optimal solution is not strictly necessary or always practical. This can be illustrated from the trial data presented by the Operational Research Project in Kabbalanala, Karnataka, India. The project researchers planted vetiver at densities of 1 to 4 slips at intervals of 5, 10, 15, and 20 cm (16 treatments — 4 planting densities X 4 spacings) and obtained the following results :

Survival. Percentage survival was about 90% to 95% at six months for all plantings with 2 or more slips at all planting intervals; practically there was little difference in survival (under trial conditions) as long as at least 2 slips were planted. The data is shown in Figure 4 where the horizontal axis along the bottom (X-axis) shows the plant spacing and the planting density, for example, "5/1" means that every 5 cm there was 1 slip planted.

Average Gap Size. Researchers also measured the average gap size at six months (the end of the growing season) for each of the 16 treatments (Figure 5). The best results, in terms of hedge closure came from planting 4 slips at 5 cm intervals.

Looking at Figures 4 & 5 it can be seen that while there is an "optimal" approach, the majority of the other approaches are quite successful as well. As such, the data shows that there was a good deal of insensitivity to the approach taken. So even without access to location specific research one could feel fairly confident that within that region, by planting 2 or more slips at each spot and providing some management inputs (gapfilling, occasional pruning), a hedge will eventually result. Generally then, the worse the site the more slips one might wish to plant; the faster one wishes to form a hedgerow, the

Figure 4. Percentage survival at six months of Vetiver grass plantings at various spacings and planting densities. The horizontal (X-axis) is read : "5/1" = each 5cm 1 slip was planted.



closer together one should plant the slips.

From the survival data it can be seen that planting only 1 slip probably is not a good idea, and this is confirmed by looking at the data on the average gap sizes. It appears that planting 4 slips every 5 cm is the best way to go. However, this would require a large amount of planting material and more time for planting so that establishment costs would be higher and perhaps a smaller area would then be treated. What is needed in addition is an estimate of how long it will take to form a functional, closed hedge so that the tradeoffs between costs, time and area to be planted can be explored and an informed decision on how much material to use and how to space the plantings can be made.

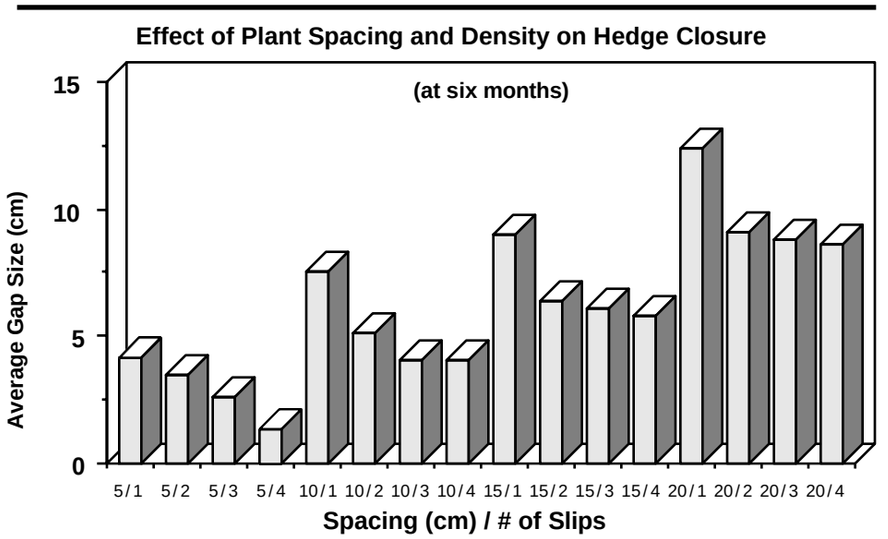
Estimated Rate of Closure. Using Figures 4 & 5, there are four possible approaches : every 5 cm planting 4 slips; every 10 cm planting 3 slips; every 15 cm planting 2 slips; and every 20 cm planting 2 slips. Comparing the 4 planting strategies, we could calculate that hedgerow closure with:

- 4 slips at 5 cm would be about 80% to 120% faster than with the other 3 strategies;
- 3 slips at 10 cm would be about 10% to 20% faster than with the other 2 strategies;
- 2 slips at 15 cm would be about 10% faster than with the other strategy; and
- 2 slips at 20 cm would be the slowest.

The location specific conclusion from this data would be that the last three strategies do not involve great differences in time to hedgerow closure (except if the growing season is very short, for example only 2 or three months each year). Unless rapid protection is required (for example in gully stabilization or protection of high value infrastructure such as road cuts & fills) the extra costs associated with planting 4 slips every 5 cm can be foregone. Depending on existing planting material and labor costs, one of the other three strategies could be chosen.

At present, there are a considerable number of countries, soils, and climates where various planting material-types of vetiver have been planted. If you know of the location of some hedgerows, why not go out and take a few measurements (original spacing, % survival over 3 to 5 randomly selected sections of 100 meters each, average gap size over 10 or so randomly selected sections of 10 meters each) and send the information to the Network where we can compile it and pass it on to practitioners in that area. Do not forget to let us know something about the soils, the rainfall, the slope of the land and anything you think of that might be of interest (is the vetiver freely grazed ?, has it been pruned or managed ?, etc.).

Figure 5. Average size of a gap, at 6 months, in Vetiver grass hedgerows as a result of the initial spacing and planting density.



RESEARCH ON VEGETATIVE HEDGES AT REGIONAL RESEARCH STATION IN TAMIL NADU

Dr. S. Subramanian, presented a paper entitled "Vetiver Vegetative Hedge - Experience At Regional Research Station, Aruppukkotai" (he is the Head of the Station) at a seminar on Vetiver Grass for Soil and Water Conservation. The seminar was sponsored by the Indo-Swedish Forestry Program. In his paper Dr. Subramanian reported that his work began in 1987 with the planting of Vetiver grass and 1988 with, Kolukattai grass (*Cenchrus glaucus*), hedge lucerne (*Desmanthus virgatus*), and subabul (*Leucaena leucocephala*). According to his paper, the establishment and growth of Vetiver and Cenchrus into hedges was encouraging, whereas Desmanthus and Leucaena *"experienced difficulty in establishing as a hedge"*. He attributed this, in part, to the latter being established from seed and the former vegetatively. Soil moisture was monitored, comparing an unhedged control to the other treatments. Results showed greater levels of soil moisture in the hedged plots with the Vetiver plot having the highest percentage soil moisture of all treatments at all stages of crop growth, followed by the Cenchrus treatment. During the 1989-90 period (September through February), the Vetiver treatment averaged 26% higher soil moisture than the control and 3%, 9% and 7% greater soil moisture than the Cenchrus, Leucaena, and Desmanthus treatments, respectively. Dr. Subramanian reported that he intends to expand his research to compare Vetiver and Cenchrus grasses within paired 8 ha watersheds. Research on this scale should provide very useful data.

STEMBORERS IN VETIVER GRASS - CHINESE RESEARCH RESULTS

In 1989 Mr. Hu Jianye from the Jiangxi Agricultural Development Corporation reported that an unidentified stemborer was in about 8% of the vetiver plantings over a 200 ha area. In result,

a field survey of stemborer damage was carried out and some larvae were collected for observation. Damage to the vetiver was caused by the borers entering the new tillers from the leaf sheathes and bases of stems to feed on the inner parts and fibrovascular bundles. Feeding activity resulted in wilting of the effected stems and leaves.

The borer was identified as a Grass Webworm (*Chilo spp.* , Lepidoptera, Pyralidae) by Professor Zhang Shimei of the Jiangxi Agricultural University. Only vetiver was found to be a host in that area; the other surrounding vegetation (tea, sweet potatoes, peanuts, citrus, napier grass, watermelon, various vegetables and paddy rice) was unaffected. At present, the recommended control method is to trim the hedges to about 3 cm above ground at the end of the growing season (end of Autumn) and the prunings used for pig or cattle bedding, as fodder or as fertilizer mixed with farm yard manure and allowed to sit for a couple of months. Prunings should not be piled up until the next spring.

UNITED STATES DEPARTMENT OF AGRICULTURE'S SOIL CONSERVATION SERVICE WORKSHOP ON THE USE OF GRASS HEDGES FOR EROSION CONTROL

In November of 1990 a workshop was held to report, in part, on work that had been carried out on vetiver grass by various Department of Agriculture agencies in the United States. One of the main issues was cold tolerance with reports that vetiver grass had : (i) "considerable" survival through the cold spell of December 1989 in Americus, Georgia — about 34° North; (ii) that in north Texas vetiver was killed when temperatures dropped as low as - 16° to -18° C over a three day period; (iii) that a two year old, 38 cm diameter clump of vetiver in Griffin, Georgia was mostly killed (the clump regrew from surviving material on the perimeter) when temperatures dropped to as low as -13° and -15° C over a two day period; (iv) in Coffeeville, Mississippi vetiver plants that had survived a frost in March of the year were killed when temperatures dropped down to - 16° C in December; (v) reports that Mr. Eugene LeBlanc, whose family has grown vetiver in Sunshine, Louisiana for over 100 years, says that when temperatures drop below - 13° C that the vetiver is damaged.

"The farmers believe that the Vetiver grass is more resistant, requires less care and as it grows erect it interferes less with cleaning practices...If you see the Vetiver rows, regular and compact, erect, there is no comparison with Lemon grass with its irregular rows, lots of blanks, and leaves in all directions."

Other information of interest on vetiver was regarding a trial in Louisiana with vetiver planted across several small gullies in a military tank testing facility where vegetation has not grown for many years and erosion is a severe problem. The vetiver was reported to have grown rapidly, and even in the early stages before hedge closure it caused a significant stoppage of sediment. It was also reported that native vegetation began to establish soon after the vetiver lines began to stabilize the area. This supposedly was the first time in any ones memory at the facility that vegetation had grown on this severely disturbed site. Also, an herbicide trial with vetiver grass showed that there was no retardation of growth with use of atrazine or metachlor. In fact, growth was better with the use of herbicides as other weed competition was reduced.

The workshop suggested that a criteria be designed for evaluating the potential for grasses as contour vegetative barriers. Some suggested criteria were : tiller density (number/unit area); tiller diameter; rate of growth (increase in clump diameter, circumference, number of tillers); whether or not individual clumps will grow together into a hedge; whether the grass is killed or damaged by sediment accumulation in its crown; whether the grass can survive extended periods of submergence; whether the grass can establish and grow in deeply eroded and other harsh soil environments with the help of fertilization or organic soil amendments.

NOTES & LETTERS FROM CORRESPONDENTS

AUSTRALIA

- The Department of Dairy Husbandry and Breeding in Queensland is testing Vetiver to control ersoion on its farm near Brisbane. After 9 months the grass was looking quite good, according to Mr. Chuck Antholt who was there on a recent visit from ASTAG/World Bank. The Network looks forward to receiving some good information from Mr. Pat Thorbon who is conducting this trial.

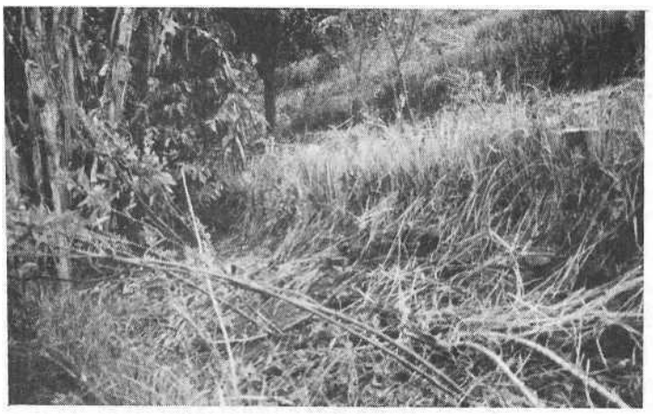
CHINA

- Mr. Zhang Guangming of the Agricultural Development Corporation in Jiangxi writes :

"*By the end of last December 7,800 copies of the Chinese version of the Vetiver handbooks had been distributed free of charge to agriculture and natural resource agencies in the provinces of Guangxi, Hunan, Jiangxi, Fujian and Zhejiang; copies had also been distributed through the China Vetiver Network in Sichuan. The rest will be sent to to agencies of research and extension, key farmers and anyone else who needs it." He also writes that the demand for vetiver planting material is so high that it may be difficult to meet demands.*

COSTA RICA

- Dr. Jorge León, a botanist and one of the world's foremost experts on Andean agriculture, reported in a letter to the US National Academy of Science that plantings of Vetiver grass hedges are increasing in an area of mixed agriculture (small farms) to the southwest of San José as borders to prevent erosion. He states that for this purpose farmers consider it to be superior to Lemon grass (*Cymbopogon citratus*) which had been the preferred species previously. The farmers believe that the Vetiver grass is more resistant, requires less care and as it grows erect it interferes less with cleaning practices.



Photos 1 and 2. The farm of Mr. and Mrs. Santa Anna in Central Luzon, Philippines. The Santa Anna's began planting contour vegetative barriers of Vetiver grass two years ago. From their experience, they believe that the Vetiver hedges will allow them to farm the same fields each year, rather than being forced to be shifting cultivators.

They say the disadvantage is that it is more difficult to separate requiring more labor, but as a whole it is preferred. The farmers also say that they never see it flower, but they explain that this is due to the fact that they cut the plants twice a year. Mr. León reports that the Vetiver sample in the national Herbarium flowers in October. In closing, he writes : "*If you see the Vetiver rows, regular and compact, erect, there is no comparison with Lemon grass with its irregular rows, lots of blanks, and leaves in all directions. It is more resistant to stemborers than Lemon grass and it lasts longer; Lemon grass has to be replanted in the rows every 4 to 5 years.*"

HONG KONG

- Mr. Ronald Hill, Reader in Geography at the University of Hong Kong reports that he obtained vetiver grass from south China last year and has begun multiplying it for eventual use on landslide areas. Mr. Hill reorts that he is "*currently multiplying* (vetiver) *on artificial terraces which are cut into the subsoil and weathered rock with a mixture of sawdust and pig manure to 20 cm depth. This hinders deep root penetration and allows easy removal of slips. We have had excellent growth with divisions at 4 month intervals.*"

KENYA

- Mr. V. Gibberd of the Ministry of Agriculture's E.M.I. Soil & Water Conservation Project writes that trial work has begun on vetiver grass in the more arid (< 800 mm/yr) zones of Kenya. So far early trial results indicate that the vetiver grass is out-performing the other species in their trials (*Panicum maximum* ,*Sehima nervosum*, and the officially recommended *Panicum makarikariense*) — " *It certainly established better and puts on far more impressive vegetative growth*". The trials were started in an attempt to find an alternative for fanyaa juu terracing as its adoption is reported to be constrained by its high labor requirements for construction and maintenance, shortage of tools to construct them, that the preferred season for construction work is the dry season when soils are hard, construction costs are relatively high, loss of land from production, and that the terraces require precision design and checking by competent people to assure that there are no low spots.

Mr. Gibberd also reports that he has found vetiver established on terraces in coffee country in the Machakos District where it was probably planted in the early 1960's, and even earlier than that (date unknown) are splits of vetiver that are thought to have been brought from the United States and used to protect a dam wall on a farm near Thika. He says they "*are still effectively protecting (the) dam wall*".

LAO, PDR

- Mr. J.P.Evenson, Chief Technical Adviser UNDP/DTCD, Nabong Agriculture School Project writes that his school is interested in vetiver for soil conservation in orchards and upland cropping areas. He discovered that the Lao he spoke with were very familiar with its common name (*Faek* or *Faek hom*); vetiver is reported to have medicinal uses in Lao PDR. As part of the school's program for making students aware of the importance and diversity of useful native plants they will launch a search for it in the vicinity of the school. Mr. Evenson also carried out a literature search where he found a reference in Vidal's 1960 publication on "The Vegetation of Laos" where it states that vetiver is :

Found in periodically inundated marshlands which are characterized by having a woody overstory and a perennial herbaceous layer (number of grass species limited to three). Places observed: Houey Kao Canal, near Vientiane.; Nong Bo Canal, north of Vientiane draining to the Mekhong via the Nam Pak Sa; Nong Thevada close to Vientiane and bordering the Mekhong; Nong Na Seng close to Thadeua, east of Vientiane; Than Tha Ngon some 28km to the north of Vientiane; Nam Khem north of Vientiane; Marshes around Pakse;Shallow pools near Paklung close to Louang Prabang.

- Mr. Somphong Pradichit from the Northern Regional Office of Environmental Protection, Ministry of Agriculture and Forestry, Luang Prabang writes that the Vetiver Handbook has been translated into Lao and the script for the Vetiver Slide Show is currently being translated. Also, a vetiver nursery has been established in Xieng Moak where some local varieties of vetiver are being compared with an Indian variety. He reports that the local varieties seem to be doing better at this time.

PHILIPPINES

- From Richard Grimshaw, Chief

of Asia Technical Department, Agriculture Division, World Bank:

"Recently I visited the farm of Mr. and Mrs. Santa Anna located near the Pantabagan Dam in Central Luzon, Philippines (see Photos 1 & 2). They established Vetiver hedges in August 1988, and now have effective hedges. The land is steep, slopes up to 50%, and highly erodible. Normally it would be subject to a cut and burn rotation and planted to cassava. Over two years the hedges on the Santa Anna's farm have become well formed and because of frequent cutting - at least every six weeks - the hedges are kept low (20 cm) and show little sign of having negative impact on adjacent crops. Erosion has been reduced significantly and already small terraces with risers of up to 50 cm high have been formed. The hedges also grow fairly well under partial shade. The Santa Anna's reactions include: hedges should be spaced no less than three meters apart; a clear recognition of reduction in soil loss and fertility decline; there is no competition with other crops; that it is too early to assess positive impact on yields. They believe that the Vetiver hedges will result in a stable form of cultivation (as against slash and burn); and that they intend planting Vetiver on a new farm they hope to soon have. Alex Coloma of the National Irrigation Authority was responsible for encouraging the Santa Anna's to use Vetiver, and he has promised to monitor its impact more closely now that the hedges are well established. One last point from Mr. Santa Anna : "If Vetiver hedges are to be properly established they must be managed and not neglected."

- Dr. Paul S. Teng, Plant Pathologist and Coordinator of IPM at IRRI, in a letter to the Unites States National Academy of Sciences writes : *During December 1990 I did pay a visit to a place called Guba which is approximately 25 km west of Cebu City on the island of Cebu, in the middle of the Philippines. Vetiver has been used for erosion here by an NGO group for several years and I saw stands on contours that were about a 0.75 m tall. Three points may be of interest to you:* ***(1)*** *There was quite a proportion of fertile seeds on panicles in at least a third of the clumps. I guess this may upset the view that the plant is sterile. However, I did not see any evidence of Vetiver establishment in areas outside where it was originally planted with cuttings.* ***(2)*** *The farmer leader I spoke to told me that Vetiver was not popular as the holdings in this sloping land topography were generally very small - < 0.5 ha - and farmers felt that the grass took up to much valuable land. He also noted that rainfall was not a limiting factor at this site, and that further north, where rainfall is limiting, there was some preference for Vetiver over other hedgerow species.* ***(3)*** *I must have examined some 50 Vetiver clumps and was "disappointed" to find no disease or insect infestations. I also now have a small colony of Vetiver growing at home, in pots, in the IRRI Housing compound for further observations" .*

Editor's Note : The Network has collected considerable information over the last two years on fertility in vetiver. There are no conclusions yet but we feel confident in stating that vetiver grass is not known to exhibit invasive behavior; based on empirical evidence from years to decades of observations in dozens of countries. Under the conditions found in farmer's fields (rainfed or irrigated), vetiver will not spread from seed and become a weed.

USA

- Mr. John Boutwell of the US Bureau of Land Reclamation carried out an investigation for his agency entitled "Evaluation of Vetiver Grass as a Biological Agent to be Used in Preventing Soil Erosion (Revegetation)". Figure 6, taken from his report, is a map of the United States with shading to depict areas that are potentially suitable in terms of temperature (30 days or less of mean annual minimum temperatures of 0° C and below) and rainfall (a normal annual precipitation of 255 mm or more) for Vetiver grass hedgerows.

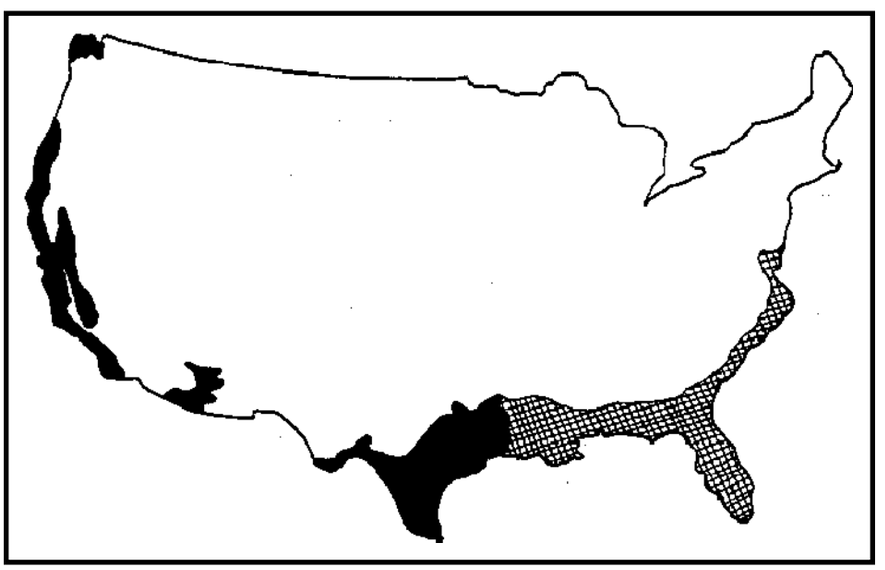


Figure 6. Shaded areas represent those parts of the United States where Vetiver grass may potentially be planted for soil and soil moisture conservation.

EXCERPTS FROM THE ALL CHINA VETIVER NEWS NETWORK NEWSLETTERS

The Chinese Vetiver Network, which was initiated in October 1989, has supplied this Network with copies of their 4th and 5th Newsletters. The following are some excerpts of interest from these:

SURVIVAL

"At the end of March this year, the Soil and Moisture Conservation Office of Sichuan Province and the Hilly Area Development Office of Chengdu introduced 12 tons of Vetiver slips from the Jingyang Prefecture of Fujian Province. These slips have been planted experimentally. Since June, some of the experimental locations have sent

us growth condition reports and observation records. According to the Pingshan SM Office: Vetiver was planted on March 29, established itself in 25 days, survival rate was 90%. At the nursery of Chiyang Village, Central Deyang Municipality, vetiver was planted on March 28, the slips recovered in 13 days, with a survival rate of 80%. In the Kuokinguo Reservoir area of Fanjihua Municipality, vetiver was planted on April 21, recovered in 13 days, survival rate was 36%. According to observation at the SM Experimental Station of Dujiangkin Municipality, the survival rate was about 40%. Vetiver planted in the garden of the Chengdu Hilly Area Development Office had a survival rate of about 60%."

GROWTH

"According to the present condition of growth in different areas, the growth prospects are mixed, and in most places, the growth has not been satisfactory. The main reason for this has to do with weather conditions and management. In Sichuan this year, the drought between Spring and Summer had been more serious than normal, in most places, no rain has fallen since April. This caused serious water stress to the young vetiver seedlings which, if not irrigated in time, would die in large quantities. In sharp contrast to this, last years' plantings suffered less drought and have been growing well. According to the Chengdu Hilly Area Development Office, the hills planted last year sprouted this spring and maintained very rapid growth, the rate of growth was twice as high as any that was planted elsewhere last year (in Sichuan). From this we can deduce that vetiver in itself is drought resistent, but those introduced from Fujian need a period of transition and adaptation."

VETIVER FOR SOIL AND MOISTURE CONSERVATION

"Since its introduction last year, vetiver cultivation in Pingnan Prefecture of Fujian has achieved very good results. In our Prefecture, there has been a history of Vetiver cultivation of some years now, but only the roots were used for extracting fragrance.... After a year of experimentation, it proved to be a good plant for soil and moisture conservation: it has wide adaptability, rapid growth, low cost and significant benefits in soil and moisture conservation. This year's new plantings are not only extensive in area, but also of significant scale."

AN INSECT PEST ON VETIVER

"According to a letter from Weili County of Sichuan, a small number of "Sticky Worm" activities were discovered in their nursery on June 26. By July 4, "sticky worms" were found on every vetiver clump, ranging from 2 to 13 worms each. The large worm is about 5 cm long and 1 cm in diameter. There are red dots on the head. They are commonly seen in paddy and maize fields. In the nursery, the worms concentrate on attacking vetiver leaves and have left other weeds and grasses alone. From the experience of Weili County, the pesticide "Rifulene" is more effective and has already stopped the attack. We hope colleagues will pay close attention to the presence of pests and diseases on vetiver and inform us in a timely manner so that various experimental units could be notified and adopt their preventive measures."

POTENTIAL AVAILABILITY OF FUNDS FOR NGO TRIAL/DEMONSTRATION WORK WITH VETIVER GRASS

Last year the Vetiver Network/ ASTAG was able to offer funding to a few NGOs (nongovernmental organizations) in Ethiopia, Nigeria, Guatemala, Philippines and Nepal. The funds provided startup costs for small vetiver grass nurseries to grow material for trial/demonstration work in cooperation with the farmers with whom the NGOs were currently working and to provide funds to the NGOs to pay the expenses (not salararies) for monitoring the vetiver grass that is planted (e.g. mortality rates, growth rates, silt buildup, crop yield, any other field observations pertinent to nursery management, and hedge establishment or maintenance) for the first two to three years. This information, as well as information on farmer and extension worker attitudes toward the use of the vetiver grass system was to be shared with the World Bank and any interested government agencies, organizations or individuals. Now, almost one year later, in each of these countries there are a few NGO groups who have started producing planting material and will be establishing their first trials with this coming rainy season.

This next year, there is a good possibility that the Vetiver Network/ ASTAG will have another grant with which it will be able to repeat the funding of another four or five NGOs in each of four or five countries. We would be

Photo 3. Vetiver grass thatching in South Africa (PC: Anthony Tantum)

interested to hear from any NGO groups who are currently involved with agriculture/natural resource management cooperatively with small farmers and who are willing to and interested in trying vetiver grass hedgerows for soil and moisture conservation. If interested, write to the Network at the address given on the last page of the Newsletter. Tell us about your group, the work you are currently carrying out and something about where vegetative contour barriers fit within the needs and farming systems of your client farmers. To a large extent the countries selected will be dependant on the responses that the Network receives.

WHERE VETIVER GRASS IS NOT KNOWN TO BE

As the search for vetiver grass around the world expanded it eventually arrived at the point where it was no longer so pertinent to ask where vetiver is so much as where it is not. The Network recently contacted Mr. Mark Dafforn, who is studying the geographic distribution of vetiver grass for the Board of Science and Technology for International Development, National Academy of Science of the United States, to obtain the latest information on this subject.

Mr. Dafforn informed the Network that *Vetiveria zizanioides* can be considered pan-tropical. The breaks in Vetiver distribution are more likely information gaps rather than physical gaps. At present they have no reports or documentation on vetiver in the Andean Region (Bolivia, Peru, Ecuador or Uruguay), North Africa (Mauritania, Morocco, Libya, Egypt), or the Middle East (from between Israel and Turkey on the west to Pakistan on the east). Also, they have no reports of vetiver from : Benin, Cameroon, Ecuatorial Guinea, The Gambia, Guinea Bissau, Namibia, Swaziland, Togo; The Azores, The Canaries, Cape Verde, Principe or Sao Tome; Portugal or Greece. Mr. Dafforn explains however, that there are a number of reasons to expect that vetiver will be found in most of these countries — for, example countries surrounded by others where it does exist or historical use in the Mediterranean — he is confident that it will eventually be found in the majority of these countries. If so, vetiver would then exist throughout all the political divisions of the tropics, subtropics, and Mediterranean.

If you are aware of the existence of vetiver grass in any of these countries, please contact the Network at the address given on the last page of this Newsletter.

INSTITUTIONS CURRENTLY CARRYING OUT RESEARCH ON VETIVER GRASS FOR SOIL/SOIL MOISTURE CONSERVATION

The following is a listing of research institutions and organizations (of which we have information) that are pursuing research on one or more of the following topics : propagation, establishment, management or impacts of vetiver grass for soil and soil moisture conservation; the biology, ecology or pathology of the species *Vetiveria zizanioides* . If you are aware of any others, please contact the Network and let us know.

Australia
Dept. of Primary Industries, Agriculture Research Branch, Soil Conservation Research Lab., Queensland

China
Institute of Mountain Disasters and the Environment, Chengdu, Sichuan
Kunming Institute of Ecology, Kunming
Ministry of Agriculture (Fujian, Jiangxi, Sichuan, Hunan, Guizhou)
Red Soils Research Institute, Jiangxi
South China Inst. of Botany, Guangzhou
South China Soil and Water Conservation Technology Experimental Station, Guangzhou

Fiji
University of the South Pacific, Suva

France
French Institute of Agricultural and Environmental Engineering Research, St-Martin d' Hères

India
Andhra Pradesh Agricultural University, Rajendernagar, Hyderabad, AP
Central Soil and Water Conservation Research and Training Institute, Dehra Dun, UP
GBUAT, Pantnagar, UP
ICRISAT, Hyderabad, AP
Operational Research Project, Karnataka
PKV Agricultuaral University, Akola, Maharashtra
RAK College of Agriculture, Sehore
Tamil Nadu Agricultural University, Coimbatore
University of Agricultural Sciences, Bangalore
Watershed Management Directorate, Dehra Dun, UP

Malaysia
CIBA-GEIGYAgricultural Experiment Station, Negeri Rembau, Malaysia
Dr. P.K. Yoon, Head Plant Science Division, Agri-Bio Corp., West Malaysia

Nepal
Central Animal Nutrition Division, Khumaltar

Nigeria
IITA, Ibadan, Nigeria

Papua New Guinea
Lowlands Agricultural Experimentation Station

Philippines
IRRI, Los Baños

South Africa
King Williamstown College

United States
Alabama A&M, Normal, Ala.
National Academy of Sciences, Washington, D.C.
Ohio State University, Dept. of Agronomy (in Costa Rica, C.A.)
University of Georgia Experimental Farm, Griffin, Ga.
University of Texas, El Paso, Tx.
USDA-ARS National Sedimentation Laboratory, Oxford, Miss.
USDA-ARS Plant Introduction Center, Griffin, Ga.
USDA-ARS-NPS, Beltsville, Md.
USDA-SCS Plant Materials Center, Baton Rouge, La.
USDA-SCS Plant Materials Center, Beltsville, Md.
USDA-SCS Plant Materials Center, Jackson/Coffeville, Miss.
USDA-SCS Research Laboratory, Ft. Worth, Tx.
USDA-SCS Research Laboratory, Lincoln, Nebraska

NON-GOVERNMENTAL ORGANIZATIONS INVOLVEMENT WITH WORLD BANK

To further NGO involvement in project design, the World Bank has for the last two years regularly updated a "List of World Bank-financed Projects with Potential for NGO Involvement" to inform NGOs about upcoming possibilities for collaboration. The Bank has

also been mailing worldwide its "Monthly Operational Summary" to NGOs that request it. For further information or to order these items contact :

MR. CHRIS HENNIN OR MR. ART THOMAS EXTIE/WORLD BANK NGO INFORMATION SERVICE; ROOM T8102, 1818 H ST., NW; WASHINGTON, D.C. USA 20433.

THE VETIVER INFORMATION NETWORK

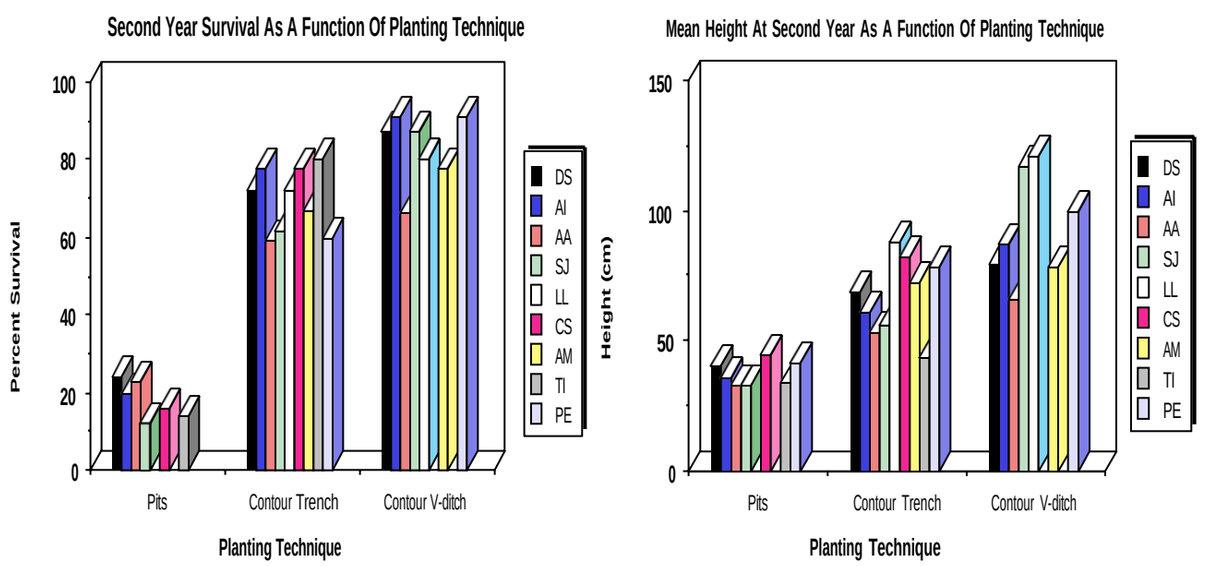
The purpose of the Network is to provide a central point where information on the use of contour vegetative barriers of Vetiver grass may be compiled and disseminated to all interested individuals free of charge. If you wish to join the Network, request further information or supply information to other users, please write to :

VETIVER INFORMATION NETWORK; c/o MR. J. SMYLE, ASTAG; RM. F 3027; 1818 H ST. NW, WASHINGTON, D.C., 20433; USA; TEL. (202) 458-2274; FAX (202) 477-1865

ALTERNATIVE TECHNOLOGIES

With this Newsletter we would like to begin providing the members of the Network with examples of other, simple low-cost technologies that can have a significant impact on how natural resources are managed. This first example comes from the State of Karnataka in south India. The histograms below show how by simply changing tree planting techniques the survival and growth rates are improved tremendously. Though this data is from a semi-arid zone, moisture stress is a major cause of mortality and poor growth rates even in humid zones, especially on hillslopes and where soil crusting is a problem. Tree planting in contour V-ditches optimizes the soil moisture regime for the individual plant to the maximum extent possible short of sub-soiling.

IMPACT OF PLANTING TECHNIQUE ON SURVIVAL AND HEIGHT GROWTH IN SECOND YEAR AFTER PLANTING



The data contained in the graphs above was collected in the State of Karnataka by the Kabbanala Watershed Operational l Research team in 1989. The three planting techniques utilized were : (i) pit planting excavation of individual holes tor each seedling, pits were approximately 50 cm square by 30 cm deep; (ii) contour trenches in cross-section the trenches are approximately 50 cm by 50 cm and are dug along the contour at 1 m vertical interval; (iii) contour V-ditches - in cross-section are approximately 50 cm deep at their deepest point and 1 m or more in width across the top. They are dug along the contour at 1 m vertical intervals.

LEGEND •

DS - Dalbergia sissoo. AI - Azadiraca indica. AA – ACACIA AURICULLFORMIS. SJ – SYZIKUM JAMBALANA
LL - Leucaena leucocephala CS - Cassia siamea AM - Aeola marmetos TI - Tamarindis indica PE - Phvlanthus embilica

The findings, interpretations and conclusions expressed here are entirely those of the authors and should not be attributed in any manner to the World Bank.

SPECIAL ISSUE

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER INFORMATION NETWORK, ASTAG *, WORLD BANK, NUMBER 6, JUNE 1991

This Newsletter issue presents the works selected to receive the Vetiver Incentive Awards. The Awards are in recognition both of the author's personal initiative and of the significant contribution they have made to the wider use and better management of contour vegetative barriers of vetiver grass.

THE NEWSLETTER

Vetiver Awards

This is the sixth Newsletter to be put out by the Vetiver Information Network. The focus of this Newsletter is on presenting some of the information that the Network has received as a result of the Vetiver Research Incentive Awards. In this issue we have tried to faithfully present the major work that was sent in by a number of individuals; unfortunately, given the length of some of the pieces some heavy editing was necessary. As a result many of the tables, figures and photographs that came in the reports have not been reproduced here. The Vetiver Information Network can, however, supply photocopies of the complete reports.

Reader Participation

Over the last 3 years the Network has received a constant stream of requests for information about vetiver grass; during the last year the Network has been receiving a slow but steady flow of information from people in the field. But we still are missing feedback from the hundreds of people who have indicated that they wish to locate vetiver and give it a try. We hope that some of you are now carrying out some work with vetiver, please keep us informed — your experience in testing and promoting vetiver can save others both time and false starts. And this is true not just for vetiver, but for the larger question of introduction and extension of resource conservation systems. We now know that, as much as anything else, "sustainable agriculture" is an information revolution and overcoming many of the critical constraints to the realization of a sustainable, productive agriculture will depend on those who are working in the field to disseminate their knowledge. We have all heard the years of complaints regarding insufficient net working and access to information in any field or endeavor in natural resource management/ conservation — well, here is a chance to do something about it, write ! And when you do, let us know what other types of information would be useful to you in the Newsletter.

Table Of Contents

The Vetiver Awards	84
Vetiver Grass In Malaysia By Dr. P.K. Yoon	86
Role of Vetiver Grass By Drs. Bharad and Bathkal	97
Soil Salinity and Vetiver By Dr. P. Troung et al	99
Vetiver In Fujian Province By Mr. Wang Zisong	105
All China Vetiver Newsletter	108
Vetiver Against Erosion By Dr. F. Dinger	110
Vetiver Hedge Research By Dr. S. Subramanian	111

Vetiver In Thailand and China/ Other Species With Potential - A Letter From Dick Grimshaw

On a recent visit to East Asia I had the opportunity to visit Thailand and China. There is a growing interest in Thailand in the use of Vetiver hedges. Vetiver

Photo 1. "There is much more soil erosion in the control estate plot." One of Dr. P.K. Yoon's vetiver trials in Malaysia.

* ASIA TECHNICAL DEPARTMENT AGRICULTURE DIVISION

Achnatherum splendens...like Vetiver ... it grows vigorously ...is not considered invasive...is strongly rooted...local people recognize its soil binding properties

(known in Thai as *Yaa Faeghom* or *Yaa Khom Faeg*) has been found in its "wild" state in waterlogged areas in Eastern Thailand. Mr. Pitsanu Attaviroj of the Land Development Department is demonstrating its use. Also the Thai-German Land Development Project near Maehong Soen in North-East Thailand is test planting it. We also found it being used for medicinal purposes by Karen tribes people near Mae Sa-reaing (the Karen call Vetiver *Posiakhi*). Taking account of what we know about Vetiver and in particular Dr. P.K. Yoon's work on Vetiver in Malaysia I am in no doubt that Vetiver will do extremely well in all South-East Asian countries.

In China I visited two year old plantings in Chongren County of Jiangxi Province. The grass has grown very well and is making excellent hedges. It is also producing a large amount of biomass which is being used to mulch citrus and other fruit trees. I would guess that Vetiver, with its very deep rooting system, when used as a mulch on these heavily leached red soils, is doing an excellent job in recycling leached nutrients. Farmers are convinced of its utility, and expansion appears to be limited to the supply of seedlings. I was pleased to see on a yet to be developed 150 ha catchment area that Jiangxi officials have planted Vetiver on the contour in preparation for the following years' land clearing. Thus, this next year when the land is opened up for cropping the Vetiver hedges will be in place to protect the newly exposed soils.

I also spent some time in the Loess Plateau Region of China and visited one area where erosion losses were reputed to be the highest in the world - 60,000 tonnes/km^2 ! The winters are too cold for Vetiver in this region. However we found another grass that has great possibilities. Its name is *Achnatherum splendens* (Jiji grass). The grass has very similar features to *Vetiveria zizanioides* except that it is confined to areas of high ph (7.5+). It is a clump grass, looks very much like Vetiver, grows to two meters high, and is found naturally in saline swampy areas where it spreads through seeds. Like Vetiver, when taken out of this environment it grows more vigorously and will only grow from vegetative slips. It is not considered invasive. It is very strongly rooted and the local people recognize it for its soil binding properties. Livestock will only eat the young leaves, and like Vetiver is not destroyed by sheep and goats. The grass will not grow in acid conditions. We do not know how it behaves when planted closely to form a hedge, and it will be test planted as a hedge in this season. Assuming it grows into a good hedge (i.e., the clumps join together) we will have an excellent grass for these regions of Asia with very cold winters. Other biological barriers measures that have potential in these northern areas for nonarable land protection include Caragana (a small leguminous tree) and *Hippophae rhamnoides* (sea buckthorn, a shrub). The trick is to manage them as a hedge, i.e., dense line seeding.

-Dick Grimshaw

THE VETIVER AWARDS

Last month a panel of two judges from the Board of Science and Technology For International Development at the (United States) National Academy of Science reviewed the reports and information received by the Vetiver Information Network over the last year on management or research associated with the utilization of vetiver grass as a contour vegetative barrier. The judges chose amongst the entries based on two equally weighted factors — (i) the contribution made toward providing significant information about some aspect of vetiver as a species and/or its utilization and/or its impacts and (ii) the degree of personal initiative displayed in carrying out the work or providing the information. This latter criteria was very important as the resources available to the participants varied greatly.

The Awardees, selected by the panel, are :

First Place (US$ 3000) - **Dr. P.K. Yoon** of the Rubber Research Institute in Malaysia for his comprehensive report on his (almost) two years of research work on the management and utilization of vetiver grass. In his report Dr. Yoon has made a rigorous study of each and every aspect associated with his work with vetiver and provided practical guidelines for utilization and management based on his findings.

Second Place (US$ 2000) -

Dr. G.M. Bharad from PKV University in Akola, Maharashtra, India for the consistently excellent research work he has carried out over the last four years on measuring the on-farm impacts of contour vegetative barriers of vetiver grass and leucaena, of graded earthen bunds and of farming with no conservation measures. Dr. Bharad was one of the people who early on grasped the importance of vetiver grass and the opportunities it opened up in conservation farming;

Third Place (US$ 1000) - **Drs. P.N. Truong, I.J. Gordon and M.G. McDowell** from the Land Management Research Branch of the Queensland Department of Primary Industries, Brisbane, Australia for their work on the effects of salinity on vetiver grass. Prior to this work indications from both the literature and other sources had led to the unchallenged belief that vetiver grass was highly sensitive to saline conditions; this work arrives at different conclusions and potentially opens up tens of thousands of hectares of degrading saline lands worldwide as sites where contour vegetative barriers of vetiver grass may be utilized to halt and reverse land degradation. Dr. Troung has also been active in introducing and spreading the word about the vetiver system in Australia.

The Panel also chose four recipients to receive US$ 500 awards for their work. The awardees are : **Dr. Zhang Xinbao** of the Institute of Mountain Disaster and Environment in Chengdu, China; this award is given for the All China Vetiver Information Network of which Dr. Zhang is the head. The role of the network in popularizing and providing practical information on vetiver within China is invaluable and represents the best of local initiative and innovation in extending technologies for sustaining agriculture. **Mr. Wang Zisong**, Deputy Director of the China Red Soils Project; this award is given to further the excellent work of those in Fujian Province who over the last two years have been working to define management systems, carry out trials and demonstrate the usage of vetiver grass while working with farmers to extend the vetiver technology. **Dr. S. Subramanian**, Professor and Head, Regional Research Station, Aruppukkotai, Tamil Nadu, India for his work on effects of contour vegetative barriers on soil moisture which compared vetiver, leucaena, desmanthus and cenchrus hedgerows. Dr. Subramanian's work has also included the management of vetiver. **Dr. Françoise Dinger** of the French Institute of Agricultural Engineering Research, Grenoble Regional Centre, Natural Hazards and Upland Erosion Control Division, St-Martin d'Hères, France for his work on multiplication (vegetative and tissue culture) and adaptability to sub-humid mediterranean climatic conditions in nutrient poor, eroded sites. Dr. Dinger's work could potentially introduce vetiver grass into a zone in which erosion rates (as a result of removal of native vegetation) are very high and, for climatic reasons, revegetation is extremely difficult.

The Network also had offered a US$ 2000 award for any other plant species that would be at least as suitable as vetiver for creating contour vegetative barriers. A number of individuals expressed interest in presenting alternative species, however, in the end only three people did. The review panel felt that while the information presented was interesting, none of the three submissions presented sufficient information for judging and/or they presented information on species which are known not to meet the criteria of, at a minimum, being as suited as vetiver as a contour vegetative barrier. The Network would like to thank these individuals : **Mr. N.B. Hiremath** of Karnataka, India (Subabul -*Leucaena leucocephala*), **Mr. Gao Weisin** of Chengdu, China (Napier grass -*Pennisetum pupureum*), and **Messrs. Wang Jing, Su Zhongren, and Liu Zhengjie** (Bhabar grass - *Eulaliopsis binata*). As the US$2000 was not awarded, the Network has utilized these funds to print copies of Dr. P.K. Yoon's excellent report; the copies are being disseminated to a number of individuals and institutions around the world who are active in farming systems and natural resource conservation concerns. One copy each will also be sent to those who submitted alternative species. The Network can have copies of Dr. Yoon's report printed for interested individuals, though the printing costs are US$ 35/ copy as the report contains quite a number of color photographs. An unbound black and white copy may be had for free through the Network — as can any other report featured in this or other Newsletters .

The Network would like to thank all of those who took the initiative to participate in the Vetiver Awards and to congratulate those whose work was singled

out by the panel for awards. For those whose work was not awarded, a special thanks is in order and please be assured that the Network values the information that you provided and intends to disseminate it widely.

Extracts From *A Look-See At Vetiver Grass In Malaysia - First Progress Report* By Dr. P.K. Yoon

My knowledge of Vetiver grass starts from 12/4/1989, when I first saw a clump of rather undistinguished-looking grass collected by my colleague, Encik Ahmad Azly, at my request. It looked so ordinary and so frighteningly similar to the horrible "Lalang" ! (ed. note :*Imperata cylindrica*). However, I have been stimulated by the Handbook: Vetiver Grass - The Hedge Against Erosion and, having spent more than 30 years visiting rubber plantings and having seen massive erosion problems especially on steep hills, I was prepared to have a look-see at any economic method.

1989 was the time to get to know the plant and to multiply it for distribution. 1990 was the main period for distribution, start some ad hoc trials and set the stage for 'proper' trials in co-operating estates. This report summarizes mainly efforts of 1989 and 1990 . 1991 should see better progress. Whereas, Vetiver is promoted by the World Bank as a low-cost hedgerow system for controlling soil-loss and improving soil moisture, this may be true only for the poorer developing countries. Malaysia is well developed agriculturally and money is readily available for any cost-effective technologies. My research targets assess the potential values of Vetiver from both ends of the economic spectrum and, therefore, the early results and discussions presented could be easily adapted to suit different input requirements.

On recognizing the potential value of Vetiver, after reading the handbook published by The World Bank, considerable time was spent before we managed to locate a clump of 57 tillers in Taiping, Perak, on 12 April 1989. After that, the first priority was to multiply the plant rapidly before we could do any observation and distribution to interested parties.

A. Multiplication Of Vetiver

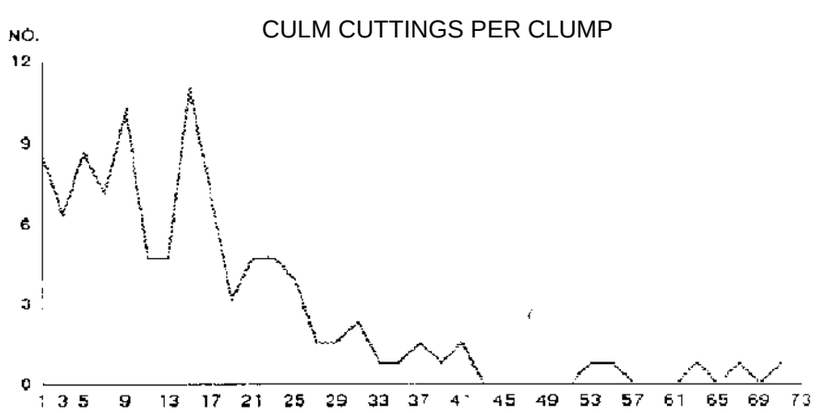
I. Multiplication using tillers

(1) Planting in polybags: Initially, all tillers were planted in polybags with sizes of 7" x 15" and 10" x 20". One six gram nugget of Kokei (N, P,K,Mg) slow release fertilizer was introduced into each bag and (a drip-type) irrigation system was used. Plants were divided as soon as they were observed to be bag-bound. At 4 months the smaller bags had 17.1± 1.1 tillers/plant and the larger bags 25.5 ± 1.6 tillers/plant.

(2) Planting in soil beds: (a) 2 rows of tillers were planted with in-between distances of 6" and irrigated system and one nugget of Kokei (6 gm) fertilizer per tiller were used Harvesting could be done at 5 months, yielding (on 2 occasions) 486 clumps with an average of 21.1 ± 0.6 tillers/clump and 185 clumps with an average of 20.6 ± 0.6 tillers/clump. (b) 6 rows of plants were established with in-between distances of 6" and irrigated. Fertilizer application was dried chicken dung. Growth up to 3 months was satisfactory but, thereafter, the plants in the central rows tend to grow and multiply slower because of shade-effect. This system should be used only if there were land constraint; otherwise, the 2-row system is much better.

(3) Planting in soil : A large block of approximately 20,000 sq. feet was ploughed and rotovated. Tillers were directly planted with a planting distance of 6" x 6". One round of dried chicken dung was applied at one week after planting. This approach ensures low establishment cost. There was little maintenance cost; with plant-

Figure 1. The number of culm cuttings obtained from vetiver



ing in the normal rainy season. watering was not needed. Also, there was no weeding nor any pest and disease control measures. Sampling of 100 clumps at 4 months showed average of 11 tillers per clumps (farmer's report). This rate of production was considered satisfactory because of the low input.

In Malaysia, labor cost is high. Therefore, the following system has been developed :

Fertilizer : use of one nugget of Kokei (6 gm) slow release fertilizer per plant. This is sufficient for 3 months. For longer periods of up to 6 months,a second nugget is required. Dried chicken dung is also very effective.

Watering : The Sumisansui (drip type)irrigation system is cheap to install and ensures good and uniform watering. Timing the planting to coincide with the rainy season minimizes the need to water.

Topping: The regular monthly topping to 40 cm to encourage tiller formation using a mechanized grass-cutter (bush wacker) which is readily available in all estates and most smallholdings.

With the above system, the cost of production is reduced to a minimum.

II. Multiplication by culm-branches

When Vetiver clumps are repeatedly topped at 40 cm and when they are more than 3 months old, the cut-culms produced many branches at the internode. These branches can be detached for planting. A trial was set up to study the multiplication and growth of these culm- branches which were separated into various types as follows: A - most vigorous with young shoots (with roots); B - less vigorous with young shoots (with roots); C - most vigorous (with roots) - single plant; D - less vigorous (with roots) - single plant; E - least vigorous (without roots) - single plant; F - Terminal shoots; G - Young shoots plants that were growing horizontally (with small roots/without roots). All types produced good root system under mist and transplanting success into polybags was nearly 100% for all types (lowest 99.6% for type E). The multiplication and growth of the various branch types will be discussed later.

"Vetiver is easyto multiply at low cost. Under normal conditions, multiplication by planting with tillers will give satisfactory results."

Dr. P.K.Yoon

III. Multiplication by culm-cuttings

It is recommended that clumps of Vetiver be cut-back to 30-50 cm to encourage tillering. Early observations suggest that too short cut-backs result in die-back of many culms under Malaysian conditions. An ad hoc trial testing 30, 40, 50 and 60 cm cut-back height suggested 40 cm to be the best with least set-back to growth, minimum die-back and good tillering.

The tops are normally discarded after cut-back at 40 cm height. However, if the Vetiver clumps are 3 months or older, the cut-tops include many culms. Each culm has varying numbers of internodal buds which can be induced to sprout and produce new plantlets under mist. Three methods of rooting under mist were tested :

(l) Layering of culms. The whole stem was buried in sand-bed with the following results after 5 weeks: (a) With leaf-sheath intact - 23.2% rooted; (b) With leaf-sheath removed - 28.4% rooted; (c) With leaf-sheath slit - 35.7% rooted.

(2) Rooting of individual node with leaf-sheath intact - at 5 weeks 5.1% rooted; at 9 weeks 14.6% rooted.

(3) Rooting of individual node with leaf-sheath slit - at 5 weeks 31.4% rooted; at 6 weeks 52,7% rooted and; at 8 weeks 76.3% rooted.

Treatment (3) of rooting each nodal culm cutting with the leaf-sheath slit was the most promising.

An assessment of 5-month old clumps in the ground yielded 16.4 ± 1.4 cuttings. The number of cuttings from each clump was highly variable as shown in Figure 1. Note that the above work was done under mist. However, based on experience with other crops, similar results would likely be obtained if materials are rooted in sand-bed under polythene sheet to keep the atmosphere moist; this has not been specifically tested because of time constraint.

Conclusion

Vetiver is easy to multiply at low cost. Under normal conditions, multiplication by planting with tillers will give satisfactory results. However, refined methods of vegetative propagation by culm branches and culm cuttings may be considered from two view

points: (1) They will be of little value in mass vegetative propagation because they may not be commercially cost-effective (2) They will be of value in the following scenarios: (a) Initial stage of multiplication of a newly found cultivar. (b) Initial stage of multiplication of a newly imported cultivar. (c) Where base cultivars are imported at high cost from other countries. Certainly these methods are much cheaper than the tissue culture method. However, once the base source for multiplication is established, the normal method of splitting the tillers should suffice. In the early phase of my work, all methods using all plant parts are used. This accounts for the large amount of materials that I have produced and distributed.

B. Growth Of Vetiver

I. Effect of shade on growth of vetiver

To be able to use a plant as for any extended period under perennial crops, such as rubber or oil palm, dictates that the plant must be shade-tolerant under the canopy of the main crop. Three trials were started to test such effect.

(i) Trial 1

Plants raised in polybags for 6 weeks, were put under shade (80%) of rubber plants at nursery spacing of 6' x 6' and in the full sun. At 3 months after treatment, sample of leaves were taken from two levels of the leaves to determine specific leaf areas.

Results

Shading significantly increases the specific leaf area (Table 1) suggesting significant response of the plant.

At 3 and 4 months after treatments, 10 polybags each were sampled and the soil washed off. Results showed that shading significantly reduces: (i) tiller formation; (ii) plant weight; (iii) shoot weight; (iv) root weight but did not modify the % root/shoot ratio significantly. Therefore, we can conclude that Vetiver (at least the cultivar I have been working with) is not shade tolerant. It is, however, not expected to be since most grasses are likely to be climax plants. The good feature is that the % root/shoot stayed rather constant and we should be able to modify agricultural methods to make the best use of this point.

(ii). Trial 2

The plants from Trial 1 were used in this trial. Half the plants grown under shade were shifted to the open, while the reverse approach was applied to plants grown in the full sun. After 3 months, 15 polybag plants were harvested They showed the following: (i) Plants from the open performed poorly under shade; (ii) Plants in shade condition continued to grow poorly with poor tillering under continuous shade; (iii) Plants from shade condition performed well once they are exposed to the open. The conclusion is: "Vetiver is not shade-tolerant" but can survive under shade (intensity ?) for a period (?) and could be easily rejuvenated if the shading canopy is removed.

In effect, such information allows us to plan the following: (i) Plant the Vetiver before or at the same time as the planting of the main perennial crop of oil palm or rubber; (ii) Leave the Vetiver along the terracing to grow or sustain itself; (iii) When the main crops of oil palm or rubber have grown over, the rows of Vetiver can either perish as in oil palm area or periodically re-established as in rubber during wintering. In either case, the Vetiver would have done its job of reducing soil erosion.

(iii). Trial 3

This trial studied the growth of plants under very intense shade of (87%) of rubber nursery and also examined 3 possible methods of establishing plants in the field. The 3 planting methods are: (i) polybag completely removed exposing the core of soil and roots; (ii) base removed and with 4 slits cut with 10 cm clearance from top and bottom; (iii) base of polybag removed. All 3 methods of planting had no influence on the intense shade effect, viz. all plants under rubber performed badly at 2 months compared with those in

Table 1. Specific leaf area (leaf area/leaf weight; cm^2/gm) as effected by available sunlight

	20-40cm		40-60cm	
	Shade	Sun	Shade	Sun
Mean	157	140	151	142
s.e.(±)	4.0	2.1	4.0	2.6
n	10	10	10	10
t-test	***		P< 0. 1	

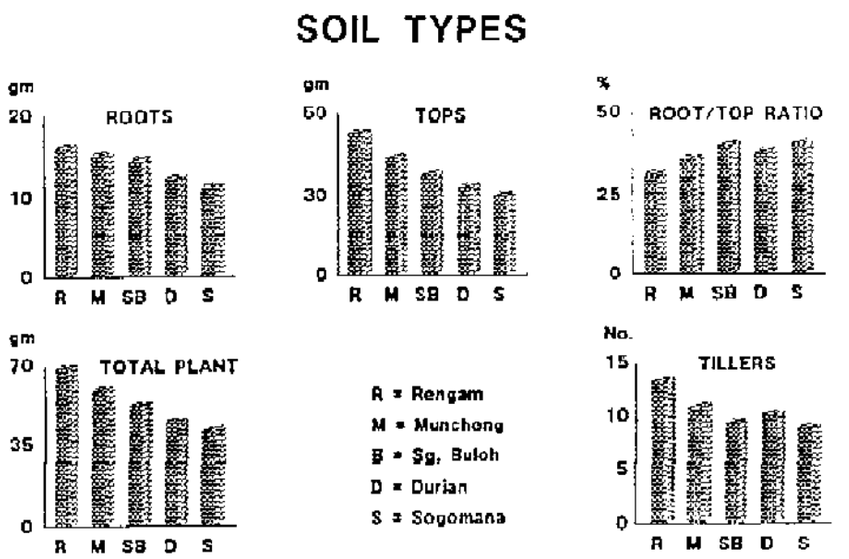


Figure 2. Effect of soil types on the growth of vetiver.

the open, then eventually, all the plants under the intense shade died off. The following points are of note: (i) Normally, the % shade under mature rubber is not so intense; (ii) The attempt to raise polybag plants to establish under established shade has to be re-examined. Direct planting *in situ* in the ground before shading by the main crop may modify the response.

Conclusion

The following points should be noted:

(i) Very intense shade was used. This is of value to study shade tolerance at the preliminary stage; but normal shade in rubber is not so intense.

(ii) Because of (i), it is important to study response to various intensity of shading. This is easy to do, using available plastic nets but we have delayed this to combine with studies of different cultivars for more meaningful results.

(iii) Polybag materials were established under existing shade. The root system at establishment was confined within the bag and therefore may not be best expressed. Would the planting "*in situ*" before canopy closure have performed the same?

(iv) Nevertheless, all evidences point to Vetiver being shade-sensitive. At what level of shade would tolerance be possible?

(v) However, because of (i), the possible value of Vetiver may be manipulated in the following manner : Because of the shade sensitivity and the possible competitive effectiveness of Vetiver against perennial crops as rubber. oil-palm. fruit trees, etc. vetiver should be used for: early function for soil and moisture conservation; allow the Vetiver plants to fade out because of shading so as to remove any possible competitive effect with the main crops;

(vi) Trial 2 showed that plants poorly grown under shade were rapidly revived upon exposure to light. This suggests shade survival may be dependent on the degree of shading, and with the periodic dose of more light as during winter period in rubber.

(vii) Vetiver will not be shaded out in crops which do not produce dense canopies or are relatively short. Examples are cocoa, tea, etc.

II. Effect of soil types on growth of vetiver

Plants were grown in polybags filled with 5 soil types (Keys to Soil Taxonomy, 4th Edition, 1990. SMSS Technical Monograph No. 6., Blacksburg, Virginia, USA) :

(1) Munchong (Typic Hapludox); (2) Rengam (Typic Kandiudults); (3) Durian (Typic Kanhapludults); (4) Sg. Buloh (Typic Quartzipsamments); (5) Sogomana (Typic Tropaquepts). A uniform fertilizer application of 1 Kokei (6 gm) nugget was used for all treatments. The results, shown in Figure 2 and summarized in Table 2 show that :

(i) Rengam soil produces the biggest number of tillers; the other 4 types of soil have similar production.

(ii) Rengam gave the best dry matter production followed by Munchong. Sogomana is clearly the worst soil type (ed. note : this is a very wet soil).

This trial shows that while there is soil type effect on tillering and dry matter production, Vetiver performs fairly well even in the worst soil type. It should be noted that the trial is on polybags with filled soil; future work on soil *in situ* may show different results. Effect of nil fertilizer and different levels of fertilizer would be of interest to show whether difficult physical characteristics may be ameliorated by additional input.

Soil	Tillers No.	Dry weight (gm) Shoot	Roots	Total Plant	Root / Shoot
Sogomana	8.8 b	29.9 c	11.2 c	41.2 c	40.2a
Durian	10.1 b	32.9 c	12.1 bc	45.0 c	37.6ab
Sg. Buloh	9.3 b	37.4 bc	14.3ab	51.7 bc	39.6a
Munchong	10.7 b	43.3 b	15.0a	58.3ab	35.4 b
Rengam	13.2a	52.6a	16.0a	68.6a	31.0 c
se (±)	0.11	3.22	0.98	4.12	1.38
LSD (P<0.05)	0.3	9.0	2.8	11.6	3.9

Table 2. Effect of soil types on multiplication and growth of vetiver.

III. Effect of bag sizes on growth of vetiver hedgerows

While it would be cheapest to plant Vetiver slips directly, such approach invariably results in: requirements for replacement of dead plants, filling of gaps of less vigorous growing slips, slower establishment and less uniform establishment. Under certain conditions as highway embankments, steep slopes in housing estates, etc., it would be more advantageous and possibly more cost-effective to use polybag plants. This ensures virtually 100% survival, fast establishment and good uniformity; producing the best hedgerows in the shortest time. The cost of establishing hedgerows using polybag plants will be affected by cost of: bags, filling the bags, digging the trench and planting the polybag plants. A trial was therefore started to assess the maximum reduction in bag sizes possible without compromising the quality and speed of hedge formation.

Five bag sizes were used that ranged in size from 4" x 6" to 6" x 13" (5 bag sizes x 4 reps x 20 plants/treatment) and a fertilizer application of 1 Kokei/bag was carried out at the time of planting. The planting distance was kept at a constant 6" between clumps. The time for digging the trench and for planting were taken. Timing studies show that only the larger sized bags of 6" x 13" take significantly longer time to be planted and for the deeper trench to be dug. All other plants in the smaller sized bags have similar time requirements. To assess growth rates, two measurements were taken at monthly intervals by : (i) the tops above 40 cm were cut and weighed (dry wt.) — other than in the first month, the amount of dry matter production was similar for plants originating from all bag sizes and ; (ii) gap measurements show that the original larger polybag sizes produce smaller gaps, however, the gaps diminish with time and the differences between the different treatments also narrowed. Tentative conclusion at this stage suggests that the smaller sized bags of 4" x 6" could be the most economical size for fast and good establishment of Vetiver hedgerow. The experiment continues.

IV. Effect of fertilizer on growth of vetiver

Whereas it is generally claimed that Vetiver will grow under nutrient-stressed condition and whereas it is also generally expected not to fertilize Vetiver hedgerows under normal practice, it is critical to know the response of Vetiver to fertilizer. This is especially so under special condition where Vetiver hedgerows need to be established very rapidly. Examples are highways, dams, waterway constructions and housing areas in humid tropics with intense rainfalls. The different requirements of cut-earth and filled-earth are entirely different and have to be assessed. Maximizing production at economic cost is also important in relation to possible production of fodder.

(i) Trial 1

This trial compared (5 treatments x 4 reps) the use of differing amounts of slow release fertilizer; which is conditioned by 2 factors: easy to control at application and therefore would not confound results and economical to use in Malaysian context where labor is expensive. Treatments were : no fertilizer - NIL; 1 nugget (6 gram) of Nursery Ace - N; 1 nugget (6 gram) of Kokei - K1; 2 nuggets (12 gram) of Kokei - K2; 4 nuggets (24 gram) of Kokei - K3. Response to fertilizer application was measured by the dry weight of cut-off tops at 40 cm at 3 months and 4 months after application and the number of tillers produced

at 4 months. The results, which are illustrated in Figure 3 and summarized in Table 3 show that : (i) Fertilizer aids in dry matter production and tiller production; (ii) even without fertilizer application, the plants grow and multiply; (iii) increasing fertilizer application rates did not increase growth and multiplication rates significantly, suggesting that the cheapest application rate of one Kokei nugget is sufficient.

(ii) Trial 2

This trial tests 3 treatments: one Kokei nugget at beginning of trial - K1 + 0; one Kokei nugget at beginning of trial followed by another nugget after 2 months - K1 + K1; and one Kokei nugget at beginning followed by 2 nuggets after 2 months - K1 + K2. The main results were : (i) Kl + K2 increases the rate of height growth; while there was no difference between Kl + 0 and K1 + K1; (ii) dry weight of tops at 3 and 4 months were improved by a second round of fertilizer, but the 2 rates of application do not produce different dry matter production; (iii) Tiller production was not affected by fertilizer treatment; (iv) dry weight of shoots and whole plant was increased by the second round of fertilizer application; (v) Root production and % root/shoot were not affected by fertilizer application; (vi) In general, increased fertilizer application resulted in higher nutrient value of the leaves and roots.

Conclusion

These 2 trials show that fertilizer improves the growth and tiller production. However, increasing the amount of fertilizer application does not result in corresponding increase in productivity. Therefore, a minimum amount of fertilizer application of 1 Kokei nugget is sufficient for polybag plants raised to 3 months. Only for longer periods is another nugget necessary.

V. Effect of spacing cum fertilizer on growth of vetiver hedgerows

On any terrain and soil condition, producing a good hedgerow is dependent on 3 factors: (1) The quality of plant materials used; (2) The distances of planting between clumps; (3) The amount of fertilizer used. A trial was set up to test this using 3 spacing distances and 3 rates of fertilizer applications; 3- month-old polybag plants, selected for uniformity, were used for all treatments.

The preliminary data suggests that dry matter production per clump is not significant where between clump competition has not arisen and that fertilizer plays a bigger part in field planting than previously experienced in polybag planting. The experiment continues.

VI. Effect of different starting materials on variability of tiller formation and growth rates of vetiver.

Vetiver plants can be grown from tillers, culm-branches and culm-cuttings; within each group there are differences mainly due to physiological age. This Chapter looks into the effects of different planting materials on subsequent multiplication and growth rates.

(i) Different tiller types

Preliminary observations have suggested that each clump of Vetiver produces different types of tillers; thus their growth and tiller formation would be quite different. This would lead to high variations in response of experimental treatments where assessment is by tiller formation and dry matter production. This could be one of the causes of non-significant effect of fertilizer, soil types, etc. previously reported. The experimental error may be higher than the treatment effect. To overcome this, the tiller types must be sorted out and the within-population studied before planning any experiment. The starting material must be the same tiller type and

Table 3. Effect of fertilizer on multiplication and growth of vetiver

	Dry weight (gm) of tops at 40 cm height		Tillers No.
	1st cutback (3 mths)	2nd cutback (> 4 mths)	
Nil	20.2 c	11.7 b	24.9 c
Nursery Ace	25.2 bc	18.3a	34.0 b
Kokei (1 nugget)	32.7ab	18.5a	32.4 b
Kokei (2 nuggets)	33.6ab	17.5a	35.8 b
Kokei (4 nuggets)	37.2a	19.1a	42.3a
se (±)	3.01	1.52	0.137
LSD (P<0.05)	9.3	4.7	0.4

fine-tuned to minimize experimental errors. The 4 major types are :

Type A - the most mature and multiplies fast. The culm produces a variable number of culm-branches; dry matter production is thus highly influenced. This type is not good for experimentation;

Types B & C - mature tillers but with no culm formation. Suitable for raising plants for experimental purposes.

Type D - youngest tillers. Tend to give variable growth.

(ii) Different culm-branches

Previous work (reported here) shows that different types of culm-branches can be rooted easily under mist and then transplanted easily into the soil. The rate of tiller production was studied and the results showed significant differences of tiller production by the various culm-branch types which also lead to differences in dry matter production. For experimental purpose the different types of culm-branches should be grouped separately.

D. Effect Of Vetiver On Soil Erosion

I. Demonstration of the effectiveness of vetiver against top-soil loss

A simple demonstration site was set up in a nursery land. The terrain was gently undulating (4°-5° slope) and planting was across an existing small gully. After 3 months the Vetiver hedgerows had trapped the (eroded) top soil and the gully had disappeared; in fact the slope has become platforms between the hedgerows. This demonstration site continues to exist for showing to interested parties. Invariably all visitors, to-date, were impressed enough to want to use Vetiver on their land.

II. Growth of vetiver and its effect on filled earth

It is a statutory requirement of the Department of Environment that all latex concentrate factories must discharge their effluents into a designed effluent pond system. The construction of a new factory in a co-operating estate necessitate the ponding to be done with bunds of filled earth. This gave us a good opportunity to test the value of Vetiver to control soil erosion. Three attempts were made to plant vetiver grass: (1) Demonstration plot set up on 24/7/1990; (2) Trial 1 set up on 31/7/1990; (3) Trial 2 set up on 3/9/1990. The plants established very well , but heavy rainfall over 4 consecutive days in October caused the bunds (on which the vetiver was planted) to collapse. Despite the collapse the row alignments of vetiver plantings were barely out.

(i) Trial 1

This trial was initiated to have more detailed measurements of surface water run-off, soil wash, etc. Experimental plots were demarcated by zinc-sheet boundaries to measure surface water run-off and soil-wash into the drums. At each level, there were 3 marked wooden pegs to measure top-soil loss. Measurements were conducted for a few days but with the heavy rains in October the drums were washed away and the zinc boundaries collapsed leading to extensive leakage. It was not possible to repair this and the trial had to be abandoned. However, visual evidence indicated the better effect of Vetiver to reduce top-soil erosion when compared with estate practice (See Photo 1).

(ii) Trial 2

This trial was on bunds where filled earth had been in

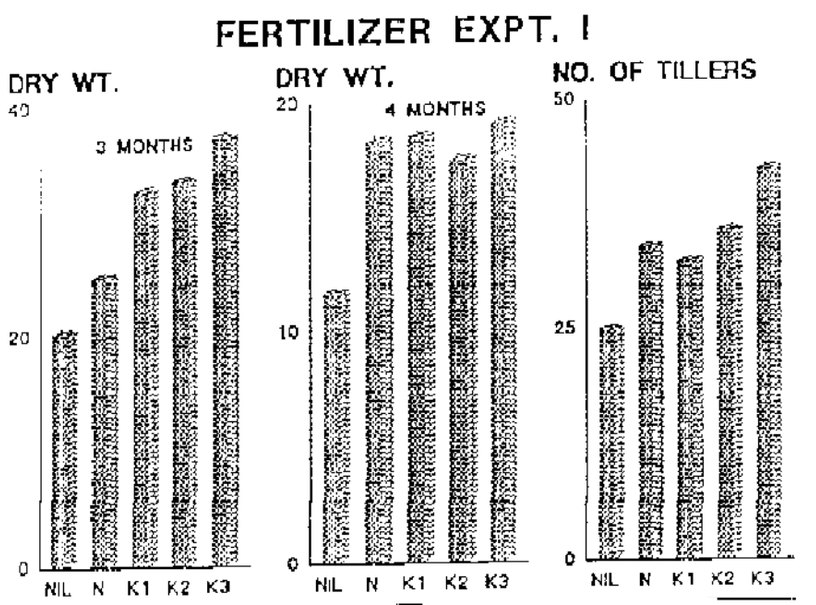


Figure 3. Effect of fertilizer on multiplication and growth of vetiver.

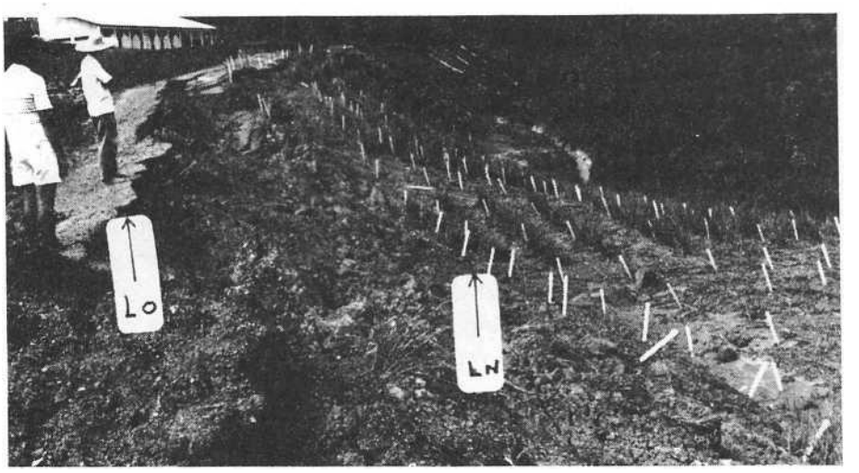


Photo 2. The subsoil has collapsed. The Vetiver plots had slipped 4 to 5 meters from the original level (L_O) to the new lower level (L_N).

place for about a month prior to the filled earth bunds being planted with vetiver immediately upon construction.

The details of the trial are : two treatments (Estate practice, Vetiver hedges @ 1m V.I.) with 10 reps. After the collapse in October the interesting phenomenon was that the alignment of Vetiver planting held very well though the whole top area of soil in the plots had slipped down (Photo 2). In the plot with the latest constructed bund, the plants have been dropped more than 4-5 meters. Examination of the various plots showed that the Vetiver planted on the oldest filled soil held well and continued to do so. Such observations confirm that the root system of Vetiver established most rapidly and penetrated and held approximately one foot of soil. This trial was abandoned but the earliest planted block continues to show the better value of Vetiver to reduce soil erosion, as compared to normal practice of using cow grass and New Guinea grass.

Conclusion

A large effort, in terms of labor and finance, was expanded on the demonstration plot and the 2 trials. The collapse of the filled-earth bunds was a big disappointment to us. However, rather than showing the failures of the Vetiver system, it tended to show its intrinsic strength. This is best illustrated in the overall picture --Photo 3 of the general view of the two trials and Photo 4 showing the collapse of the bund. Because of the great height and steep slope of the bunds, we were too optimistic not to have taken care of the sub-soil and the poor physical structure by piling. A combination of some structural work and planting of Vetiver may have overcome the collapse of the bund. The main conclusions were: (i) the top 1 foot of soil was held together by Vetiver though the whole area slid down (ed. note : at the time of the collapse the vetiver plantings were less than 3 months old); (ii) earlier plantings before the onset of heavy rain would have allowed longer time for the Vetiver to establish further and may have helped; (iii) Very deep soil fill will still need structural/ physical engineering work. Nevertheless, the results are so encouraging that the owner intends to repeat and expand the use of Vetiver and has offered additional and increased amount of funds for my future observations.

III. Growth of vetiver and its effect on cut-earth.

The value of Vetiver on cut-earth of highway embankments, etc. are of interest. An experiment is being carried out on a co-operating estate using an area of 150 meters width. The main study tests 2 densities of planting on: (i) the growth of Vetiver and formation of hedgerows; (ii) surface soil erosion as measured by wooden pegs. Early observations suggest that plants grown on the top terrace with some top soil are much more vigorous when compared to those with only sub-soil. In the later cases, while the plants established successfully, their growth is slow and stunted. This experiment is continuing.

E. Diseases

For any introduction and expanded planting of a new plant species or even a new cultivar, it is important that the introduction is not an alterative host for any disease of economic importance to major crops in the country. We, therefore, pay special attention to any pest and disease affecting Vetiver.

Results

In the period under observation, fungal attack was observed and identified as: *Nigrospora spp., Curvularia spp., Helminthosporium spp.* With the help of a

mycologist, we isolated the inocula involved. We then tried to inoculate new emergent leaves. Our first two attempts failed to produce similar symptoms despite using all known information available to us for such actions. It was only recently (February 1991) at the third attempt using cut leaves in inoculation chamber that we were able to inoculate and develop symptoms using *Helminthosporium spp*. spores. *Nigrospora spp.* and *Curvularia spp*. were only pathogenic on detached leaves which had been subjected to wounding.

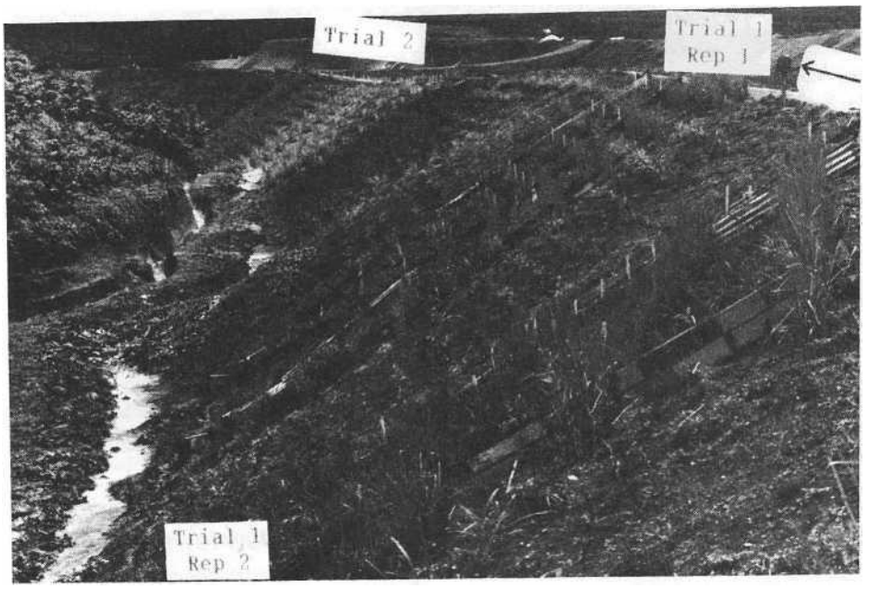


Photo 3. General view of the experimental sites

Conclusion

Of the many areas planted, only 2 sites experienced such fungal attacks and these are in the crowded nurseries of RRIM Experiment Station, Sungei Buloh; after the plants in the affected plots were topped at 40 cm growth continued as normal. Also, as there were difficulties in inoculating with the isolated inocula suggest the fungal attacks to be non-virulent. However, on examining the check-list of hosts and pests in Malaysia, we spot certain potential hosts of economic importance :

Elaeis guineensis (oil palm): *Curvularia lunata* (leaf spot); *Curvularia maculans* (leaf spot); *Helminthosporium halodes* (leaf spot); *Helminthosporium incurvatum* (leaf spot); *Helminthosporium rostratum* (leaf spot);

Cocos nucifera (coconut) - *Helminthosporium incurvatum* (leaf spot);

Zea mays (maize) - *Helminthosporium maydis, Helminthosporium turcicum* (leaf blight);

Saccharum officinarum (sugar cane) - *Helminthosporium sacchari* (sugar cane eye spot), *Helminthosporium stenospilum* (brown stripe).

It is important to identify the correct species (and cultivar) of the various fungi attacking Vetiver albeit on a small scale. Such knowledge is not available in Malaysia and we therefore plan to send our inocula to the British Mycology Institute for identification.

F. Adaptive Use Of Vetiver By End-Users

Vetiver plants have been given to many end-users. For illustration, this Chapter discusses the uses of the grass by one recipient. This is a privately-owned estate of about 700 acres planted with rubber and oil palm. As returns from these 2 crops are low, the owner wanted to convert to growing fruit trees. However, the estate is sited in an area with a distinct dry spell. A good water source is therefore essential. In addition, because the land are fairly steep, soil erosion and moisture control becomes critical.

The main targeted uses for Vetiver in this estate are: (i) Center for production and distribution of materials for interested smallholders around the area; (ii). Ponding; (iii) Erosion control in irrigation piping; (iv) Modify nursery land topography; (v) Erosion control and moisture conservation.

<u>I. Production of planting materials.</u>

Based on early experience gained, 2 methods were used:

(1) Polybag nursery producing about 30,000 bags of 6" x 9" polybag plants under a Sumisansui irrigation (drip-type) system and fertilizer applied at 1 Kokei (6 gm) per bag. The polybag plants were ready for use in 2-3 months.

(2) Ground nursery. Raised beds were prepared mechanically; each bed was 3 ½ feet x 50 meters with 3 feet spacing in-between. Planting distance of the tillers were 6" x 6" with each bed producing 1800 clumps. At the initial phase, 6 beds were planted to produce 10,800 clumps. With

Photo 4. The collapse at the top of the bund. Note how the vetiver lines have remained intact.

the Sumisansui irrigation system and liberal use of dried chicken dung, the plants were ready for use in the field after 2 months. However, for multiplication, the plants were left to grow longer. It was estimated that these beds produced more than 150,000 tillers after the first 3 months. Currently (October 1990), the estate has 12 such beds.

II. Ponding

For conversion into any orchard, abundant water is essential. Because there is no river in or near the estate, ponds have to be dug. A series of ponds occupying a total of 50 feet width x 1750 feet length was excavated and the embankments of filled earth and cut-earth were planted with Vetiver. Slips with about 5 tillers of Vetiver from the ground nursery were used. The Vetiver established very well and the embankments stabilized very fast to hold 10-11 feet of water. An interesting observation was that the Vetiver survived more than a month of being partly or fully submerged under water during the rainy weather. Another side benefit is that Chinese carp loves the cut-leaves and now these ponds are also used to rear fish. The owner is so pleased with this set of ponds produced at such relatively low cost that he is producing more! Also, this attempt has stimulated the neighboring smallholders who are introducing fish-rearing into their farms.

III. Erosion control in irrigation piping

With the abundance of water available, a complete automatic irrigation system for the whole estate was being attempted. Three hills were already fitted with drip irrigation. To minimize cost, the main supply pipe for each hill must travel from the pond to the top of the hill in the shortest distance, i.e. at a steep gradient. Such arrangement normally creates severe erosion. Vetiver planting has effectively eliminated this problem. (ed. note. irrigation pipe was laid in a shallow ditch which ran straight up the slope)

IV. To protect terracing

A large nursery is essential for the estate to propagate fruit trees. A level nursery facilitated operation and will reduce costs in the long run. This estate has mainly undulating to rather steep land. To create the 1500 sq. feet nursery, the land was bull-dozed and made into 3 terraces, each with a drop of 1-1 1/2 meters. The embankments were well protected by Vetiver hedgerows.

V. Erosion control and moisture conservation.

Oil palm and rubber fields will be cleared for replanting with fruit trees. Vetiver plants are being prepared to be planted on the terraces to reduce soil erosion and to conserve moisture.

G. Ad Hoc Notes

I. Labor

Labor cost in the agricultural sector in Malaysia is relatively higher compared with other developing countries. Therefore, cost of multiplication and establishment must be looked into. Consequently, we use slow release fertilizer and irrigation systems. These are all established and proven practices introduced to the Industry by me and my coworkers. Use of polybags is an accepted practice and may be more cost-effective. Mechanized topping is obviously more cost effective. A worker can cut a 50m bed of 6 rows of plants at 6" square planting, in 5 minutes, i.e. topping of 1,800 clumps.

II. Weather conditions

The high intensity rainfall in Malaysia dictates that the hedgerows must be established fast in order to be effective. For

highway construction, the contract of establishment of cover on embankment to control erosion runs into $100 millions and therefore cost of establishment is not prohibitive. What is expensive is the following "repair" work, if there were any failure. Therefore, the main target is to establish the good uniformed hedgerows fast. The same also applies to land fills in ponding, irrigation canals, housing estates, etc.

III. Fodder production

Vetiver hedgerows purposely grown in the normal path that sheep travel from their pen to young rubber grazing fields were not eaten by them. It seems that sheep do not prefer this grass if they have other food. The farmer-selected variety from India will be tried as soon as sufficient materials have been multiplied. Meanwhile it was noted that the tops of Vetiver, cut at monthly intervals at 40 cm height, were found to be readily consumed by sheep and Chinese grass carp. Therefore, the rate of dry matter production was studied under the following conditions in the ad hoc experiments: (1) Fertilizer effect, (2) Spacing, (3) Soil types. The fodder value of Vetiver reported in Vetiver Newsletter No. 4 is most welcome. Those smallholders who use Vetiver for protection of erosion in fish pond will be most encouraged to top the Vetiver and feed the fish. Likewise, those using Vetiver for soil erosion would be encouraged to cut the tops for fodder. Such repeated topping would make the hedgerows dense and neat.

IV. Vetiver as a mulch

The effect of mulches on establishment and growth of crops, soil erosion and soil water conservation is well documented. In Malaysia, use of lalang (*Imperata cylindrica*) as a mulch is an accepted practice, though in recent years it has been superceded by oil palm empty fruit branches where available. A preliminary observation comparing Vetiver cut tops with lalang has shown that it was longer-lasting and without the adverse effect of seeding. Analysis also show considerable available nutrient (N, P. K, Mg). Therefore, in addition to usage as erosion and soil moisture control, Vetiver planting in agricultural crops would also contribute in terms of a ready and repeated supply of quality mulch.

...the results clearly show the vast potentials of Vetiver which are too tempting for any one not to look further into it!

Dr. P.K. Yoon

V. Tolerance to contact weedicide spray drift

Weedicide spray drift is at times, unavoidable. An incident occurred in one Vetiver multiplication nursery next to a rubber seedling nursery. The weedicide used was Paracol; a contact weedicide. Only the tops of the plants were affected and there was good recovery after $2^1/_2$ months.

VI. Effect of vetiver on growth of Hevea

A colleague is looking into possible competitive effect of Vetiver on growth of Hevea. This compares with effect of other common weed species. Briefly, there are 4 trials: (1) In pots, (2) In large polybags buried in the ground, (3) Next to newly planted rubber buddings, and (4) Next to 9-month old rubber buddings. The effect on rubber as measured by height and girth will be studied.

VII. Competition with other weeds

In a commercial ground nursery, no weeding was carried out. The Vetiver plants in rows grows well in competition with the weed *Borreria spp*. and some sedges. However, it should be noted that *Borreria spp*. is normally regarded as a weak weed. The ability of Vetiver to compete with weeds is important because any need for weeding will increase the cost of multiplication, establishment and maintenance of Vetiver nurseries and hedgerows.

H. Trials Being Initiated

Vetiver plants are being multiplied in many commercial nurseries of end-users. They are to be used in cooperative trials where all funds will be supplied by the interested parties. The following summarizes those in advanced stage of being set up.

Trials 1 & 2: To study the effect of Vetiver on growth of rubber; two different estates.

Trial 3: To study the effect of Vetiver to prevent soil erosion on steep terrain.

Trial 4: To study the effect of Vetiver growth on the stability of highway embankments.

I. The future of vetiver in Malaysia

The report presented here covers work done over a short period of less than 2 years. Even so, the results clearly show the

vast potentials of Vetiver which are too tempting for any one not to look further into it! The future is being written .

Extracts From *Role Of Vetiver Grass In Soil and Moisture Conservation* By Drs. G.M.Bharad and B.C Bathkal

Around 90 percent of the area in Vidarbha, a part of semi-arid tropics, are put to rainfed agriculture. Rainfall in these areas is seasonal, limited and uncertain creating dry spell situations which result in high between-year annual variances in yield. Improvement in agro-ecosystems (productivity, stability, sustainability and equitability) in these areas is a priority. Rain water management for improved in-situ conservation of natural resources (viz.water and soil) has been identified as a main concern for this rainfed agriculture.

Very recently the watershed has become accepted as basic unit for the management of organic and biophysical resources. However, in India, unlike some other countries, the land holdings owned by farmers are very small and are often divided along (up and down) the slope; the farmers have a very strong sense of possession for their land. Taking mechanical (structural) measures to control erosion and runoff from these fields is often not feasible in these areas. The cost of structures also act as an inhibitory factor.

Greenfield (1987) introduced the concept of vegetative hedges (Vetiver) on the contour for in-situ conservation of soil and water in rainfed areas under the World Bank-aided Manoli Watershed Development Project. Punjabrao Krishi Vidyapeeth University was given the task of carrying out the research and training component of this project. Comperhensive on-station and on-farm research was formulated and is being executed with continuous refinement since the 1987 kharif season.

Materials and Methods

The on-station research programme was located in a model watershed (25 ha) developed in 1987 with the central objective of dealing with planning for development, execution and monitoring of watershed management activities. Along with the development of various systems, a monitoring block with seven large runoff plots (128m x 28m) was established with the required equipment to look at crop productivity, surface runoff and soil loss. The average main and lateral slopes are 1.6% and 0.7%, respectively. Three plots have a shallow soil with a sandy loam texture and the other four are medium-deep soils with a clay loam texture. The treatments on the shallow soil plots consist of : i) across the slope cultivation; II) contour cultivation along a Leucaena keyline and; iii) contour cultivation along a Vetiver keyline. In the medium-deep soils a fourth treatment was added - cultivation along a graded bund (0.2% grade). On-farm trials were initiated in the 1988-89 season on farmer's fields in the Chambhai micro-watershed (very shallow soil) where the average slope is less than 2%. The treatments are : i) along the slope sowing; ii) contour sowing along a vetiver keyline; iii) untreated nonarable lands and; iv) nonarable land with continuous contour trenches.

Results and Discussion

1. Productivity

1.1 Shallow Soils (Model Watershed,University farm)

Mean productivity of crops viz.green gram + Pigeon Pea-Saffower (1987-88), Pearlmillet-Safflower (1988-89) and pearlmillet (1989-90) grown on shallow soils was seen to be favorably influenced by contour cultivation. The average productivity recorded by contour cultivation was highest for contour cultivation along vetiver, followed by leucaena and across the slope

Table 4. Effect of conservation measures on crop productivity (Q/ha) on Shallow Soils in Model Watershed

Treatment	1987-88	1988-89	1989-90	Total	Mean	% (+) increase (-) decrease
Across Slope Cultivation (T_1)	11.05	20.91	13.72	45.68	15.23	
Contour Cultivation Along Leucaena (T_2)	14.21	21.76	14.91	50.88	16.96	+ 11.35
Contour Cultivation Along Vetiver (T_3)	17.34	22.88	18.50	58.72	19.57	+ 28.50

(Table 4)

1.2 Medium Deep Soils (Model Watershed, University farm)

Productivity of sorghum hybrid CS11-9 (1988-89) with contour cultivation along vetiver key line was highest. Grain yield of hybrid Sorghum was seen to be reduced with the graded bund system when compared with across the slop sowing during a season with very high rainfall (1356 mm.). During the year 1989-90 the increase recorded in yield of sorghum R-73 by contour cultivation along vetiver was again the highest. (Table 5).

1.3 Very Shallow Soils (Manoli Project Area)

On farmers field in the Chambhai micro-watershed, contour cultivation along a vetiver keyline increased yields 45% in 1988-89 (rainfall = 1109mm) and 25% in 1989-90 (rainfall = 669mm) compared to along the slope cultivation.

2. Surface Runoff

2.1 Shallow Soils (Model Watershed, University Farm)

Contour cultivation along vetiver keylines resulted in lower total runoff over the three seasons. Runoff from the contour cultivation along Leucaena keylines was lowest in year one; Contour cultivation along vetiver keylines was lowest in the second and third years (Table 6).

2.2 Medium Deep Soils (Model Watershed, University farm)

The surface runoff from Sorghum was consistently less from the contour cultivation along vetiver keylines plot for all three years. The runoff from the graded bund system recorded from July to August 1989 was recorded, however, the runoff from September onwards could not be recorded due to over-topping (Table 7).

Treatment	1987-88	1988-89	Total	Mean	% (+) increase (-) decrease
Across Slope Cultivation (T_1)	29.26	38.24	67.50	33.75	
Contour Cultivation Along Leucaena (T_2)	31.80	41.88	73.68	36.84	+ 9.15
Contour Cultivation Along Vetiver (T_3)	33.28	43.80	77.08	38.54	+ 14.19
Cultivation Along Graded Bund (T_4)	27.00	42,82	69.82	34.91	+ 3.43

Table 5. Effect of conservation measures on crop productivity (Q/ha) on Medium Deep Soils in Model Watershed

2.3 Very Shallow Soils (Manoli Project Area)

The rainfall recorded at the Chambhai micro-watershed during 1988 and 1989 seasons was about 1778 mm (1109mm first season and 669 mm the second). Total runoff from along the slope sowing, contour sowing along a vetiver keyline, untreated nonarable lands and nonarable land with continuous contour trenches was 445mm,171mm, 378mm, and 87mm, respectively.

3. Soil Loss

3.1 Shallow Soil (Model Watershed, University Farm)

Maximum soil losses were recorded during the month of July followed by August. Soil losses were highest 1989 due to the high rainfall and increased runoff. Cumulative and average soil losses were less from the contour cultivation with vetiver keyline system than that from the other plots (Table 6).

3.2 Medium Deep Soil (Model Watershed,University Farm)

The same pattern for soil loss was observed in the Medium Deep Soils as was observed in the Shallow soils with contour cultivation with vetiver keyline system showing the least soil losses.

Conclusions

Higher productivity of crops under on-station and on-farm trials with adoption of contour cultivation was mainly due to uniform in-situ soil and moisture conservation over the entire toposequence reflected in terms of lesser surface runoff and soil loss. Similarly contour cultivation along the vetiver key line was found to be more effective in terms of arresting surface runoff and soil than with the leucaena key line. This is attributed to the formation of a dense, uniform and continuous barrier. This has also resulted in higher productivity. In case of Leucaena, during the first year the barrier was quite good. However, with age, some shoots began to dominated the adjoining seedlings resulting in open barriers adjacent to the ground surface.

The graded bund system was found to enhance runoff and soil loss and in high rainfall situations the productivity was lower

Season	Total Rainfall (mm)	Surface Runoff (mm) T_1	T_2	T_3	Soil Loss (t/ha) T_1	T_2	T_3
1987-88	639	51.1 (8.0)**	13.3 (2.1)	25.8 (4.0)	8.3	1.7	2.5
1988-89	1267	293.2 (23.2)	226.3 (17.4)	167.0 (13.2)	24.3	15.7	6.8
1989-90	577	69.1 (12.0)	53.6 (9.3)	30.4 (5.3)	1.9	1.3	0.6
Total	2482	413.5	293.2	223.2	34.5	18.7	9.9
Mean	827.3	133.9	97.7	74.4	11.4	6.2	3.3

T_1 = Across Slope Cultivation ; T_2 = Contour Cultivation Along Leucaena ; T_3 = Contour Cultivation Along Vetiver
** Figures in parenthesis indicate percent surface runoff

Table 6. Effect of conservation measures on surface runoff and soil loss on Shallow Soils in Model Watershed.

than even the across the slope sowing plots. The vetiver barriers functioned both in low and high rainfall situations and did not effect the crop in any way. In view of the above results, it could be inferred that the contour cultivation along vetiver key lines for raising crops is necessary to improve productivity and *in situ* conservation of soil and moisture in rainfed farming.

Excerpts From *Effects Of Soil Salinity On The Establishment And Growth Of Vetiveria Zizanioides (L.) Nash* By Drs. P. N. Truong, I.J. Gordon & M.G. McDowell

Introduction

Vetiver grass [*Vetiveria zizanioides* (L.) Nash] is believed to have been first introduced into Queensland, Australia in the 1930s as a potential crop for its essential oil - (P. Cameron pers. comm.). In Queensland, its role in soil and water conservation was not realized until 1986 when it was promoted by the World Bank as a natural, effective and low cost method of soil and water conservation. Vetiver grass is presently being evaluated as a means of gully stabilization in grazing lands.

One of the characteristics of the soils in the semi arid regions of sub tropical eastern Australia is the presence of soluble salts and exchangeable sodium in amounts likely to affect plant growth. Solodic soils frequently contain high levels of exchangeable sodium and magnesium and low levels of exchangeable calcium (Isbell 1957).

In Queensland, most grazing land degradation (sheet and gully erosion) in semi arid regions is often associated with saline - sodic soils and to be effective in stabilizing gullies on these soils, Vetiver needs to be moderately salt tolerant. There are practically no references in the literature on the salt tolerance level of Vetiver grass. Only one reference is listed in the comprehensive bibliography, *Plant Response to Salinity* (Francois and Mass, 1978) but this does not give any details on the soil salinity level where Vetiver was evaluated for its essential oil production (Chandra et al, 1968). As a result, a series of glasshouse and field experiments were conducted to determine the salt tolerance of Vetiver grass. The objectives of these trials were:

• To determine the salt tolerance of Vetiver grass in compari-

Table 7. Effect of conservation measures on surface runoff and soil loss on Medium Deep Soils in Model Watershed.

Season	Total Rainfall (mm)	Surface Runoff (mm) T_1	T_2	T_3	T_4	Soil Loss (t/ha) T_1	T_2	T_3	T_4
1988-89	1267 (671)*	341.7	296.6 (27.0)**	227.5 (23.4)	173.3* (18.0)	34.9 (25.9)	18.1	8.3	27.3*
1989-90	577	54.0	37.5 (9.4)	24.4 (6.5)	41.5 (4.2)	1.8 (7.2)	0.64	0.33	1.06
Total	1843 (1248)	395.6	334.2	251.9	215.2***	36.7	18.8	8.03	28.4

T_1 = Across Slope Cultivation ; T_2 = Contour Cultivation Along Leucaena ; T_3 = Contour Cultivation Along Vetiver ; T_4 = Cultivation Along Graded Bund
* Data from July & August 1989 only
** Figures in parenthesis indicate percent surface runoff
*** Not comparable with other figures, as data set not complete

son with some well known pasture grasses.

• To determine the effects of shallow saline groundwater on Vetiver growth.

• To determine the soil salinity level and plant chloride content of Vetiver grass at which toxic symptoms appear and to describe these symptoms.

grasses evaluated by Russell (1976). Experiment 2 investigated the effects of osmotic stress, caused by high soil salinity level, on mature plants of the three grasses. Experiment 3 determined the soil salinity level at which yield was reduced by 50%. The column experiment was set up to determine the effect of shallow saline watertable on Vetiver and Paspalum. A field trial was also established to correlate the results of pot and column experiments to field conditions.

Table 8. Mean EC values (1:5 and se), Chloride and Sodium levels in soils of different treatments under Vetiver, Rhodes and Paspalum grasses of Experiment 1.

Treatment Solution EC	$EC_{1:5}$*	EC_{se}**	Cl^-	Na^+
0 (Control)	0.05	0.64	21	0.07
6	1.17	15.02	1814	4.42
12	2.08	26.71	3325	8.30
18	3.34	42.89	5597	12.68

All EC in $mScm^{-1}$

Cl^- in mg/L

Na^+ (exchangeable) in mequiv/100g

* $EC_{1:5}$ (Electrical conductivity soil/water ratio)

**EC_{se} Electrical conductivity (Saturation extract)

Experimental Design

An integrated series of pot, column and field experiments were carried out to achieve the objectives mentioned above. Three pot experiments were conducted. Experiment 1 compared the salt tolerance of Vetiver with *Chloris gayana* (c.v. Pioneer) (Pioneer Rhodes grass) and *Paspalum dilatatium* (Paspalum). Rhodes was the most salt tolerant and Paspalum the second most sensitive species among the ten tropical

Methods

I. Soil salinity levels of the pot experiments

Different soil salinity levels were obtained by watering the pots with a saline solution of various salt concentrations (the treatment solution). Daily watering of the pots with the treatment solution was undertaken to maintain field capacity. Although the pots were free-draining, salt accumulation occurred in the top soil. To reduce this accumulation, the pots were flushed with 500ml of treatment solution every week. The final soil salinity levels varied with the volume and the salt concentration of the treatment solution used.

The salinity levels taken at harvest were considered as treatment levels. There were four salinity levels including the control treatment in the first pot experiment, three in the second and eight in the third.

II. Column Experiment

Four salt concentrations, similar to those used in experiment 1, were used in this experiment. For each treatment Vetiver and Paspalum plants growing in separate columns stood in a tray of 10cm depth. This tray was refilled with the treatment solution daily and the solution was replaced once a week. Again the soil salinity levels taken at harvest were considered as treatment levels.

III. Field experiment

Two rows of Vetiver plants, approximately 80m in length each, were established across a drainage line where saline seepage water flowed after rain. The composition of this seepage water is similar to that of the water used in the glasshouse experiments. The salt concentration ranged from 6 to 14 $mScm^{-1}$ depending on previous rainfall.

IV. Harvest

Six weeks after planting all glasshouse experiments were harvested by cutting all green materials at the crown level.

Treatment Solution EC	Rhodes		Vetiver		Paspalum	
	g/pot	Soil EC_{se}*	g/pot	Soil EC_{se}*	g/pot	Soil EC_{se}*
0 (Control)	21.50 (100)** *a*	0.37	13.24 (100) *a*	0.96	15.44 (100) *a*	0.64
6	13.02 (60) *b*	16.80	7.93 (60) *b*	15.79	5.98 (39) *b*	12.32
12	8.00 (37) *c*	30.56	1.55 (12) *c*	25.80	1.07 (7) *c*	23.75
18	1.52 (7) *d*	42.88	0 (0) *c*	37.36	0 (0) *c*	48.4
LSD 5%	4.17		2.97		2.61	

All EC values in $mScm^{-1}$

* Mean values for 0-12 cm depth

** Relative yield expressed as percentage of yield from control treatment.

a,b,c,d - Treatments with similar alphabet are not significant at 5% level.

Table 9. Dry matter yields of Rhodes, Vetiver and Paspalum at four soil salinity levels in Experiment 1.

Materials

I. Soils

A Udalf soil with 10% clay was used in the glasshouse experiments. This soil has very low levels of chloride and soluble salts. The field experiment was established on a Typic Agiustoll soil with 25% clay in the top 10cm and 50% at 30cm depth.

II. Saline water

Saline water used in the glasshouse experiments was collected from a seepage pond near the field trial site. This saline water was diluted with de-ionized water to the required salt concentrations for each treatment, immediately before watering every day.

III. Planting materials

Slips of Pioneer Rhodes and Paspalum grasses, comparable in size to Vetiver, were used as planting materials.

IV. Containers

Black polyethylene pots (17cm x 17cm) were used in the pot experiments and PVC pipes (11cm (dia) x 60cm (long)) were used for the column experiment. Each pot was filled with 2700g of air dry soil, and 5000g of soil was used in each column, giving the overall soil depth of 50cm (after settlement).

V. Fertilizers

To compensate for the low soil fertility level in the pot experiments, a relatively high rate of fertilizer application was needed. A complete mixture, including micro-nutrients (Zn, Cu, Mn, Mo, Fe and B) was used and the N,P,K rates were 184, 104 and 144 kg/ha, respectively.

Results And Discussion

I. Soil Salinity Levels

Electrical conductivity (EC) was determined using a 1:5, soil deionized water suspension at 25°C. To enable a more consistent comparison with published literature and to assess more fully the plant response, it was decided to convert all EC 1:5 measurements to EC_{se} (EC saturation extract). Plants respond to salinity at water contents equal to or drier than saturation. EC_{se} is the most dilute soil solution concentration that plants could be expected to encounter and has been used widely to relate plant response to soil salinity across a range of soil textures.

The relationship between EC 1:5 and EC_{se} can be calculated using a water content conversion factor. Although the chemistry of solutions is profoundly affected by water content, if the salts are essentially all Cl and there are limited levels of partially and slowly soluble salts, a reasonable conversion based on water content can be determined (Shaw et al 1987). The solutions used in this experiment were dominantly chloride salts, hence EC_{se} was calculated using the following equation:

$$EC_{se} = EC_{1:5}\,[500 + 6ADMC / SP]$$

where ADMC = air dry moisture content (g/100g) and SP = saturation percentage (g/100g).

The EC_{se} figures used throughout the text have been calculated as above, and to maintain consistency all further electrical conductivity figures will be discussed as EC_{se}.

In the pot experiments a wide range of soil EC_{se} was obtained by watering the pots with

the treatment solution as described in Section 3.1. The EC_{se} recorded for experiment 1 ranged from 0.96 to 42.89 $mScm^{-1}$, for experiment 2 from 23.88 to 73.44 $mScm^{-1}$ and for experiment 3 from 3.39 to 20.92 $mScm^{-1}$. The values for the column experiment were from 2.63 to 52.26 $mScm^{-1}$. These values cover a wide range of soil salinity levels, ranging from non toxic to highly toxic concentrations.

Both soil chloride and sodium concentrations also increased proportionally with the salinity levels of the soil (Table 8). Despite the weekly flushing, considerable amount of salt concentrated in the top 3cm of soil.

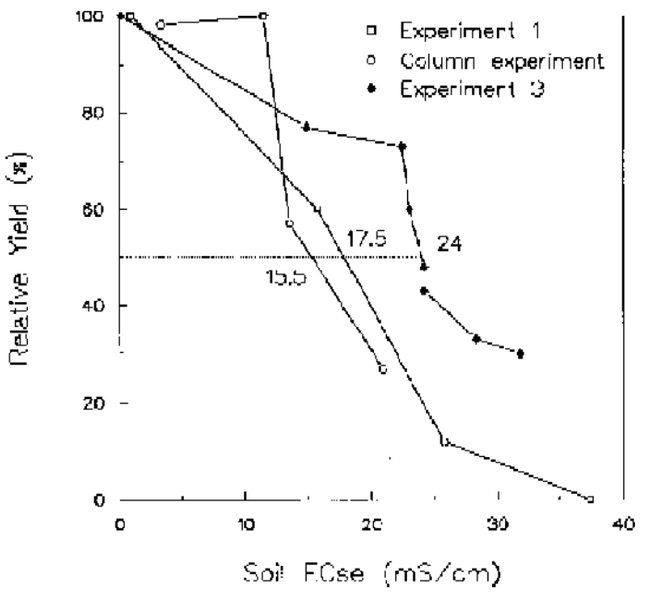


Figure 4. Soil ECse values for a 50% Vetiver yield reduction in pot and column experiments.

II. Salt tolerance of Vetiver grass

Table 9 shows that Vetiver grass has a very high salt tolerance level, much higher than Paspalum and almost comparable with Rhodes. When yield was expressed as a percentage of control treatment yield, Vetiver grasses produced as much growth as that of Rhodes (60%) with soil EC_{se} up to 16 $mScm^{-1}$. At higher salt levels (EC_{se} > 16 $mScm^{-1}$) Vetiver yield reduced more sharply than Rhodes.

Using NaCl, Russell (1976) reported that among the ten most commonly used pasture grasses in sub-tropical Australia, Pioneer Rhodes could stand the highest soil salinity level (EC_{se} = 23.2 $mScm^{-1}$) before its yield was reduced by 50%. Results from experiment 1 indicate that soil EC_{se} at approximately 17.5 $mScm^{-1}$ reduces Vetiver yield by 50% (Figure 4). This represents a very high soil salinity level and it compares very favorably with that of Rhodes in this experiment (approximately 22.5 $mScm^{-1}$). Soils with EC_{se} of 16 $mScm^{-1}$ or higher are considered to be highly saline by the United States Salinity laboratory (1954).

III. Effects of shallow saline groundwater

Saline shallow watertables are often associated with dryland salting in sub-tropical Australia. Dryland salting is one of the main causes of scald erosion in grazing lands in Queensland. Results from the column experiment indicate that Vetiver grass is much more tolerant of high saline watertables than Paspalum, particularly at higher salt levels (Table 10). This could be attributed partly to the different root distribution characteristics of the two grasses and partly to the salt profile in the soil column.

Table 11 shows a very high salt accumulation in the top 5cm of the soil column, a typical salt distribution profile under shallow saline groundwater conditions. Vetiver grass is known to be deep rooted and tends to develop roots vertically rather than laterally, thus having a better chance of escaping the high salt concentration in the top soil of this experiment. Conversely, Paspalum roots which are more evenly distributed were affected by the high salt level. Photos 5 and 6 illustrate the root distribution pattern of Vetiver and Paspalum from Experiment 2. Figure 5 indicates that 50% yield reduction occurred when soil EC_{se} reached approximately 15.6 mScm-l.

The deeper rooting characteristic of Vetiver and the typical salt distribution profile of the soil column may explain why under the same treatments, particularly at higher salt concentration, the relative yield of Vetiver growing in the columns was higher than those growing in the pots. (Tables 9 and 10). The total soil depth of the pots was only 12cm so Vetiver roots probably could not escape

from the high salt levels in the top soil.

IV. Effects of saline water on mature Vetiver

In experiment 2, well established plants, which had been grown under non-saline conditions for five weeks, were watered with saline solutions to examine the adaption of mature plants to saline water.

Results from Table 12 show that mature Vetiver, Rhodes and Paspalum plants were not adversely affected by saline water. Growth of Vetiver was not greatly affected by relatively high salinity levels which had depressed yield considerably in experiments 1 and 2, suggesting that mature Vetiver roots can tolerate considerably high salt levels in the soil solution. Therefore, once established, Vetiver can tolerate fairly high concentrations of salt over a considerably long period.

V. Effects of soil salinity on Vetiver growth under field conditions

Two rows of Vetiver grass were planted across a saline seepage depression in an attempt to stabilize a gully head 5m further downstream. Vetiver slips were planted in late summer (February 1990) and good rain fell after planting. However a very cold winter (-6°C minimum grass temperature) and a very dry spring followed (only 26mm of rain fell between July and mid December 1990). Soil on the higher part of the slope was very dry, whereas soil on the lower part was moist due to seepage. Despite the unfavourable conditions, Vetiver grass grew well and the effect of soil salinity was clearly obvious.

The difference in plant growth can be attributed to both soil salinity and soil moisture. Poor growth (40cm height) of plants grown in the lowest part was most likely due to high soil salinity level. This is supported by the high salt level of the soil (mean value of 15.49 $mScm^{-1}$ for top 50cm) and the appearance of salt toxicity symptoms. Growth of Vetiver plant grown on the higher part was also poor (40cm) and this was most likely due to moisture stress, rather than salt toxicity as soil salinity level was relatively low and there were no symptoms of salt toxicity. On the other hand, the intermediate area between the two above positions produced excellent plant growth (80cm). This can be attributed partly to better soil moisture and partly to lower soil salinity at lower depths. These results support the finding of the column experiment that the deep rooting characteristics of Vetiver could escape the high salt concentrations of the surface soil. These results also confirm that Vetiver has a high salt tolerance.

VI. Recovery after rain

Following the very dry period between July and mid December 1990. 229 mm of rain fell between mid December and early February 1991. Vetiver responded very quickly to the rain and warm weather (temperatures ranged from 20.5°C to 31.1°C in January 1991). Vetiver growth more than doubled over a five week period. Severe salt toxicity symptoms were no longer observed in new growth.

VII. Soil salinity level for 50% yield reduction

Dry matter yield of Vetiver grass from experiment 3 is much higher than that from experiment 1 over the six week period. This higher yield can be attributed largely to warmer growing condi-

Table 10. Soil ECse and dry matter yield of Vetiver and Paspalum grasses from the column experiment.

Treatment Solution EC	Vetiver		Paspalum	
	g/pt	Soil EC_{se} *	g/pot	Soil EC_{se}*
0 (control)	6.26 (98)** *a*	3.39	12.38 (100) *a*	5.91
6	6.40 (100) *a*	11.49	5.14 (42) *b*	9.53
12	3.63 (57) *b*	13.60	1.74 (14) *b*	12.70
18	1.72 (27) *c*	20.92	0.27 (2) *b*	18.87
LSD 5%	1.29		5.86	

All EC values in $mScm^{-1}$

* Mean values for 0-50 cm depth

** Relative yield expressed as percentage of highest yield

a,b,c, Treatments with similar alphabet are not significant at 5% level.

Soil Depth (cm)	Vetiver			Paspalum		
	Treatment Solution (EC)			Treatment Solution (EC)		
	6	12	18	6	12	18
	Soil EC_{se} ($mScm^{-1}$)					
0 - 5	28.37	26.96	52.26	20.03	25.16	27.60
5 - 10	8.97	11.31	16.18	6.44	11.93	14.12
10 - 20	9.24	12.62	16.05	5.34	12.20	14.12
20 - 30	10.12	12.11	14.12	5.16	10.12	14.12
30 - 40	7.70	9.51	12.08	5.78	9.91	18.36
40 - 50	4.57	9.05	12.30	2.63	7.45	12.54
Mean	**11.49**	**13.60**	**20.92**	**9.53**	**12.70**	**18.87**

All EC values in $mScm^{-1}$

Table 11. Salt distribution of soil columns of the column experiment

tions and better planting materials used in this experiment. While the temperature ranged between 12°C and 28°C (spring) for experiment 1, the range was between 22°C and 38°C (summer) for experiment 3. Faster growth and higher temperatures required more water, and led to higher soil salinity levels. As a consequence, for a 50% reduction in growth, soil EC_{se} needs to be at approximately 24 $mScm^{-1}$ (Figure 4).

Figure 4 shows that for a 50% yield reduction the soil EC_{se} ranged from 15.5 (column experiment), 17.5 (experiment 1) to 24 $mScm^{-1}$(experiment 3). For a similar yield reduction (estimate by plant height), the value of 15.6 $mScm^{-1}$ was obtained from the field trial. This value (15.6 $mScm^{-1}$) relates best with that from the column experiment and it may be explained by the fact that values from the column experiment and the field trial were mean EC_{se} of the top 50cm of soil whereas the soil of experiments 1 and 3 only reached 12cm depth.

VIII. Plant Chloride concentration

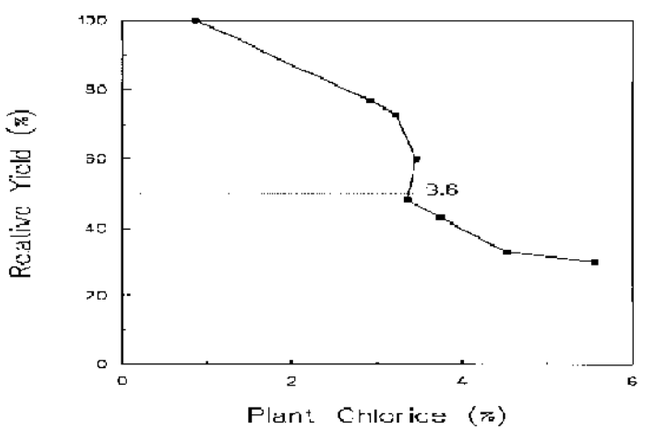
In general, the chloride concentration of Vetiver leaves increases as the soil salinity level increases. Figure 5 shows that a leaf chloride concentration of approximately 3.6%, is associated with a yield reduction of 50%. However this chloride concentration cannot be considered as the critical level, as results from the field trial showed that leaf chloride only reached 0.97% when plant growth was reduced by at least 50%.

IX. Symptoms of saline toxicity

Under glasshouse conditions, symptoms of mild salt toxicity first appeared on young shoots. The whole plants had a dull bluish green color in contrast to the bright green color of the healthy plant. Under moderate toxicity, chlorosis started from leaf tips so the lower part of the leaf remained green. As the severity of the symptoms increased, the whole leaf became chlorotic and all young emerging leaves were completely bleached. Even under the most severe toxicity, no necrotic spots were noticed, the whole leaf was chlorotic, bleached and dried up. These symptoms were more common when soil EC_{se} reached 23-24 $mScm^{-1}$.

Under field conditions, older leaves first turned light purple in color and dried up from the tip. In more severe cases the whole shoot became chlorotic and dried

Figure 5. Effects of soil salinity on Vetiver shoot chloride content



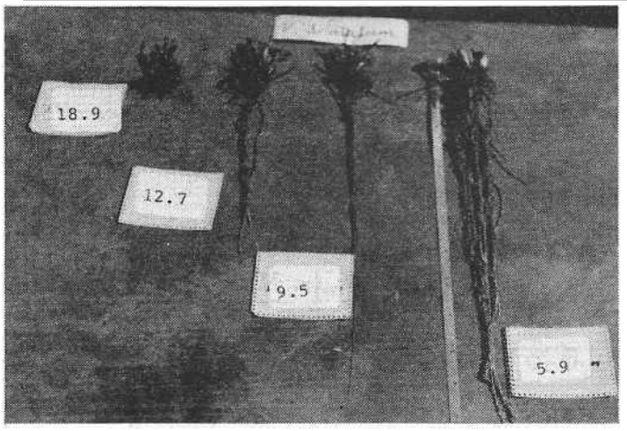


Photo 5. Root distribution pattern of Vetiver grass at varying salt concentrations

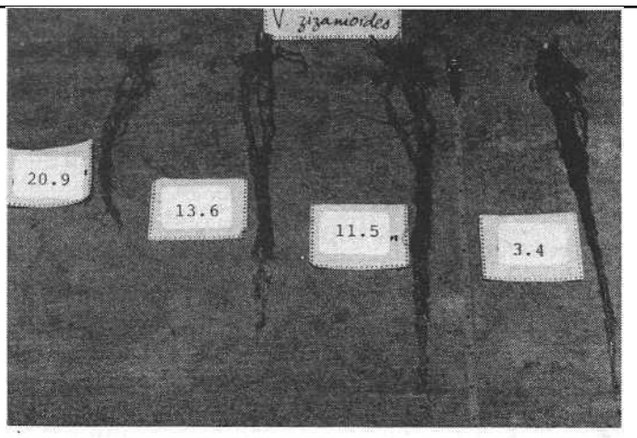


Photo 6. Root distribution pattern of Paspalum at varying salt concentrations

up. The chlorotic leaves in the field were not as bleached as those in the glasshouse.

Conclusion

This series of experiments indicate that Vetiver grass has a fairly high level of salt tolerance, especially in mature plants. Its salt tolerance is almost as high as Rhodes. Yield reduction of 50% can be expected when soil salinity (EC_{se}) of the top 50cm reaches between 15 and 24 $mScm^{-1}$ but more commonly near 16 $mScm^{-1}$. Plant chloride content is not a reliable indicator of salt toxicity in Vetiver grass.

Vetiver was found to be highly tolerant to shallow saline groundwater and could recover very quickly after rain. These attributes make Vetiver a suitable species for stabilization and reclamation of saline lands, especially in conjunction with gully stabilization.

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Excerpts From *The Experiments and Popularization of Vetiver Grass, Nanping Prefecture, Fujian Province, China*, By Mr. Wang Zisong

Three years have passed and we have achieved some success in research on propagation and utilization of vetiver grass.

Table 12. Soil ECse and dry matter yields of mature Vetiver, Rhodes and Paspalum plants after six weeks exposure to saline water (Experiment 2)

	6	8	9	10	12	15	18	LSD
Rhodes Grass								
Yield*	n.i.	n.i.	n.i.	n.i.	22.99	16.34	16.43	n.s.
Soil EC_{se}**					50.72	72.16	73.44	
Vetiver								
Yield*	13.3	16.7	n.i.	13.7	n.i.	n.i.	n.i.	n.s.
Soil EC_{se}**	23.88	30.30		37.75				
Paspalum								
Yield	8.98	n.i.	11.18	n.i.	n.i.	n.i.	n.i.	n.s.
Soil EC_{se}	20.41		28.76					

n.i. not implemented

n.s. non significant at 5% level

* Dry matter yield g/pot

** Mean values ($mScm^{-1}$) for 0-12 cm depth

Treatment	Depth of Roots (cm)	Width of Roots (cm)	Roots in 6.25m^2 profile	Number of roots at depths 0-20cm	20-40cm	40-60cm
Oil Seed Cake	55	42	165	120	30	15
Lime	35	35	41	32	9	0
CaMg Phosphate	40	40	55	28	27	0
Pig Manure	46	36	78	45	28	5
Control	50	35	50	20	20	10

Table 13. Root development under different manure treatments.

Utilizing Local Vetiver Grass

Our prefecture introduced and planted vetiver grass as an aromatic oil crop in the 1970s; later this cultivation was abandoned because of the low economic benefits. We were thus able to secure grass locally from Jianyang and Guangzhe Counties. We first did trial plantings for protecting the steep slopes of project tea farms and orchards. In 1989 we dug up 50,000 kg of the local vetiver and trial planted it on 29 farms. The planting area was 2,000 mu (133 ha) or 120 km of hedgerow. Since planting the hedges have grown well despite the cold winters, drought, flooding. Under normal conditions of water and fertilizer, survival rates are over 90%, tillering rates are 4-12 tillers/planted piece, grass height can reach 1.5m. The function of the grass for soil and water conservation is outstanding. To date, vetiver grass has now been planted on 50 project farms in our prefecture, planting over 3,500 mu (233 ha) with 195 km of hedgerow to protect 10,000 mu (666 ha) of land. Jianyang County has established about 6,100 meters of hedges.

To further experiment and popularize vetiver, a joint meeting was held between the Ministry of Agriculture and the Water Conservancy Ministry. This meeting moved the work on vetiver into a new stage in which a greater extension effort will be made.

I. Local vetiver grass growth

The climate in the prefecture is of the middle sub-tropical mountain-type. There are 1,668 to 1,972 hours of sunlight/yr; annual average temperature is 17.5^{o}C to 19.3^{o}C; in winter minimum temperature is -5.8^{o}C to -9.5^{o}C; maximum temperatures are from 39°C to 41.4^{o}C. The no frost period ranges from 254 to 305 days. Annual rainfall is 1602mm to 1890mm. Local conditions provide that the growth of vetiver follows a general pattern of : i) late March to early April established vetiver begins to grow again; ii) from late April to middle July is the period of fast growth — many cuttings of fresh, young leaves can be had during this time; iii) growth slows from early to middle July through middle October as the grass moves into the reproductive stage ; iv) from early to middle October, flowering begins and seed bearing takes place in November; v) after middle November senescence begins. More frequent pruning in May to July will make for multi-peaks in growth; cutting from October to November will delay flowering and another growth peak will appear — this can be made use of to obtain more fresh cuttings.

Nursery Establishment

In 1989 we started with a 20mu (1.3 ha) nursery and today we have six nurseries totaling 48mu (3.2 ha); the six nurseries can supply 50,000kg/yr of vetiver slips. We have also developed 70mu (4.7 ha) of deserted vetiver plantation, through weeding and management, into a nursery. We have so far supplied 80,000kg of vetiver to the Provinces of Jiangxi, Guizhou, and Sichuan and to other prefectures in our province.

Research

I. Effects of different base fertilizers

A 5 x 3 fertilizer trial (12 plants/replicate) was carried out to compare applications of oil seed cake (10 g/plant), lime (42 g/plant), calcium magnesium phosphate (17 g/plant), pig manure (42 g/plant), and no fertilizer; though quantities differ, costs for each treatment is the same. The trial was carried out in a red soil (*ed. note* : red soils = Udults; acidic; high Al saturation). Table 13 shows the results on the plant root growth. Oil seed cake promoted the best root growth followed by pig manure. Table 14 shows that oil seed cake and pig manure's effects were about the

same in aboveground biomass production. Oil seed cake manure than is the most effective for establishing vetiver grass in the marginal red soils, followed by pig manure. The effectiveness of lime and calcium magnesium phosphate was not very outstanding; though height and tillering under these treatments was better than in the control, the plants were slender and aboveground biomass reduced. This may have been a function of treatment-related change in pH and a decrease in available nitrogen.

II. Vetiver growth on barren lands

After six months, two area of vetiver planting were compared. Vetiver that was planted in good soils averaged 147 cm in height, 26.4 tillers/plant, and 136 fibrous roots whereas vetiver planted in barren, poor soils averaged 87cm in height and 5.9 tillers/plant. With fertilizer the vetiver on the barren soils would have done better but that it grew at all in the barren areas shows its resistance.

III. Cold tolerance of vetiver

In 1976 temperatures dropped to -9.5^{O}C, existing vetiver oil plantations were not killed out. These abandoned plantations still exist .

IV. Effect of varied planting densities

A 4 x 3 planting density trial was initiated in 1990; soils were red soils. Plant spacings of 15cm, 25cm, 35,cm and 45cm were tried. The 15cm and 25cm plant spacings were best, allowing a functional hedge to form within a year. Results are presented in Table 15.

V. Experiment of combining different hedge plants

Treatment	Average Number of Tillers	Height (cm)	Aboveground Biomass (kg)
Oil Seed Cake	23.7	136.3	5.0
Lime	12.0	96.7	1.7
CaMg Phosphate	17.7	104.0	2.4
Pig Manure	23.7	124.3	5.0
Control	10.0	94.0	2.6

Table 14. Treatment effects on aboveground biomass

A 5 x 3 experiment that looked at the effects of interplanting vetiver with other species (big mungbean, daylily, broadleaf barnyard grass, Japanese grass) versus vetiver by itself on hedge formation. Big mungbean was unable to survive the barren and droughty conditions but the other species did survive to form vegetative hedges in combination with vetiver grass. More work must be done in this area to see if such combinations may form more effective hedges.

VI. Experiment of different planting places

Vetiver was planted in 6 different locations (farms) in the project area. Grass height, and grass clump weight appeared to be correlated with the soil organic matter and available N. Table 16 summarizes the results.

VII. Experiment with vetiver as a contour vegetative barrier

Vetiver was planted within a chestnut plantation to see if it would form an effective vegetative barrier. Three kilometers (3 km) of vetiver hedgerow was planted in a 200 mu (13.3 ha) plantation. Planting was done at a 10m horizontal interval, with 3 slips of vetiver planted each 20cm. Within one year dense, functional hedgerows had formed; the average number of tillers/planting spot was 18.7.

VIII. Pilot experiment of vetiver contour hedges for controlling surface runoff

Two runoff plots of 100m^2 each were established side by side on a 20° slope (36%). Both areas were made completely bare of vegetation. On Plot A, 3 hedgerows of vetiver grass were established; a runoff collection pond was dug at the base of each plot. Preliminary results from a few storm events showed that the vetiver plot had lost 60% less soil (115.8kg vs 284.9kg) than the untreated plot. This study will continue long term.

IX. Stemborers

Stemborers attacked a vetiver planting in a tea plantation in 1990. Across the effected area an average of 1.5% to 6% of individual plant's tillers were killed by the borers. Control may be achieved by insecticides or with cultural practices. The borers lay their eggs (which will overwinter) in early to middle September on young and tender growth, there-

fore pruning should stop in the autumn to allow growth to harden off before the egg-laying period.

Benefits Of Vetiver Planting

I. Preventing walls and ridges of terraces from collapsing

The cost of protecting terraces with stone walls is Yuan 22,500/ha whereas protecting with vetiver costs only Yuan 1,900. Also, according to multi-site experimental data the soil and water losses in some tea farms is serious and the terrace walls collapse easily without protection with vetiver. Terracing alone reduces soil losses on the average of 63%; terraces with vetiver plantings reduce soil losses 87%.

II. Preventing drought, decreasing temperature and storing water

Cutting vetiver hedgerows three times a year and spreading the clippings as a mulch in tea plantations and fruit orchards has reduced runoff an additional 7%; temperature in the top 15cm of the soil was also decreased 5°C compared to unmulched. Using vetiver from the in-plantation hedgerows can save Yuan 450/ha/yr by replacing rice straw.

Initial Spacing	Interclump distance (cm) (Replicate Number) I	II	III	Avg
15 cm	9	8	4	7
25 cm	10	6	11	9
35 cm	23	20	20	21
45 cm	26	23	20	23

Table 15. Effects of initial plant spacing on hedge closure at six months

EXCERPTS FROM *THE ALL-CHINA VETIVER NEWSLETTER*; *NO. 6 FEBRUARY 1991.*

Vetiver Grass News from Jiangxi Province

In Spring of 1989, a company in Jiangxi introduced some young Vetiver (V-grass) to many big provinces. The Jiangxi Province tried and planted 3,500 kg V-grass among 15 special fields. The V-grass being planted were about 5,000 m long, they spread over an area of 360 mu (15 mu = 1ha). The V-grass hedges are formed and sediment buildup is occurring. The effect of soil and water conservation is very obvious. As it is proved, V-grass is an ideal plant for soil and water conservation, it is worthy of promotion.

V-grass do not produce seeds, it can only be reproduced by vegetative propagation. In India, where V-grass is very popular it is propagated mainly by splitting young shoots from the plants. On the average, such method reproduces 12 young shoots per year. This rate of reproduction is very slow, and it requires digging into the original clumps. In order to promote reproduction, and not to dig into the V-grass clumps, we tried planting from culms. Basically, we have succeed. In August 10, 1990, we did an experiment. The experiment contained 4 sets, 3 applied different treatments, and 1 acted as a control without applying external treatments. 30 culms were planted in every set of the experiment. In about 7-10 days, new buds appeared on the branches, in 10-15 days, new roots begin to emerge. By September, the number of young shoots to appear in each set of the experiment are as follows: Set A: 23 tillers, 77% success; Set B: 20 tillers, 67% success; Set C: 2 tillers, 7% success; Set D (control) : 1 tiller, 3% success. It is seen that without any external treatment, the success rate is very low. Sets A & B have

Table 16. Site effects on vetiver grass

Location	Year Planted	Org. Matter (%)	Avail. N (ppm)	Avail. P (ppm)	Avail. K (ppm)	# of Tillers	Sum of Leaf Length (cm)	Root[/1] Area (cm^2)	Weight (kg)	Weight (kg)
1	90	0.60	23.8	1.8	0.30	3.5	122	110 x 1	0.17	0.09
2	90	1.19	32.2	2.5	0.36	6	360	20 x 2	0.17	0.09
3	90	1.37	32.7	3.0	0.65	8	880	50 x 30	0.58	0.33
4	90	1.48	42.9	2.3	0.30	12	1080	50 x 35	1.28	0.68
5	89	1.60	48.1	2.6	0.26	18	1620	50 x 40	1.43	0.83
6	89	1.99	57.4	2.7	0.36	41	6150	10 x 58	5.8	3.34

[/1] Cross-sectional area occupied by the roots (vertical spread x horizontal spread)

a high percentage; planting culms has a practical value. On August 24, we tried the experiment for a second time, we repeated the experiment with Sets A & B and we obtained results which were close to the first one. Set A: planted 30 culms with 22 successfully establishing and Set B: planted 30, culms with 19 successfully establishing. Overall, planting of culms to reproduce V-grass is successful. This requires no digging, it makes use of the cut-offs of the V-grass shoots to grow the plant. This method of reproduction is very fast. This experiment was carried out during a dry and hot season which affects budding and growth of V-grass. If the experiment were carried out in a warm and humid spring weather, it is expected that V-grass would have a higher growth rate.

Vetiver Grass News from Hunan Province

The experiment site is located between the northern equator of 25" 44' to 26" 13' and eastern meridian of 113" 27' to 114" 14'. The weather here is hot and humid, the land is high above sea level and is surrounded by mountains. Over the years, it averages about 1689.6 sunny hours per year, temperature averages about 14.9 - 15.9°C. The highest temperature is 35.5° C, and the lowest is -9° C. No snow days average 240 days/yr, average annual rainfall is 1578 mm, average annual evaporation is 1323 mm.

In Winter of 1989, V-grass was planted in red and yellow soils. There was no rainfall for 57 days straight. V-grass survival rate was above 90%. After 5 months of rough management, its average yearly growth rate is 142 cm, the highest is 231 cm. Yearly tillering rate is about 15.8 young shoots, the most is 44. The root was as deep as 125 cm.

It has been observed that V-grass is very sensitive to temperature. V-grass planted in winter 89 began budding in February 90. By the middle of March, there are as yet few young shoots. During March and April, the temperature is low, avg 20.8 “C. Highest average soil temp: at 10cm deep is 14°C, at 20 cm deep is 12°C, at 30 cm deep is 10.2°C. From budding to April, some 40 days, its average growth is 17.5 cm, its average branching is 1.5. After May, average temerature is 24°C, highest average soil temp: at 10cm deep is 16.2°C, at 20 cm deep is 14.2 °C, at 30 cm deep is 12.4°C. Growth is rapid, it averages about 1.1cm/day, average branching is 2. When the weather is hot in the summer, V-grass grows even faster, it reaches 1.5cm/day and average branching is 3. Between the peak month of May and Aug, some insects affect the growth of V-grass.

	4/20	5/21	5/28	6/4	6/11	6/18	6/25
Average Height (cm)	0.12	13.5	20.5	26.5	31.5	36.8	51.4
Average Number of Tillers	1.3	2.7	3.7	4.5	5.4	7.2	10.9

Table 17. Observations on early growth of vetiver grass in Sichuan.

Vetiver Grass News from Sichuan Province

A nursery site is located in a rural area which is surrounded by rivers, it is located near N31°18’5" by E104° 23'. Planting began on March 27, 1990; 60 mu have been planted. The site is alongside a river and was used previously for growing vegetables. The land is sandy, it contains 2.5% organic matter, 0.125% nitrogen, 15 ppm active phosphorus, 125 ppm active potassium, 110 ppm potassium, pH is 7.0. Experience in the nursery has shown that when the V-grass clump has more than 20 tillers it is ready to be divided. This division can be done 4 times a year. From our experiments, if the avg temperature is above 12“C, V-grass can be transplanted. Retired roots and withered leaves would be trimmed, the branch is kept within 15-25 cm. Transplanting with soils can guarantee 100% survival rate. This procedure eliminates the period of budding, and it promotes fast tillering.

Observations on early growth (see Table 17) showed that when daily temperature averages 20°C, V-grass grows about 1cm/day and a tiller is produced every 7 days. When daily temperature averages 25°C, V-grass grows about 2 cm or above per day, and 3-4 tillers are produced every 7 days. From 12/27/90 to 3/27/91 average growth within a subsample (n=12) was 12.3 tillers/plant.

As a benefit from the management of the nursery fodder for cows is produced from the pruning of the plants.

In 1990, between August and September, there was some problem with worms. These worms penetrated into the stems of the V-grass and caused the stems and leaves to wither and die. After discovering this, on August 10, the tips of leaves and stems were cut and chemical sprays were used, but in early September, the situation got worse, chemical spray were applied again, after 3 days, all worms were dead. No diseases were during the whole growth period.

EXCERPTS FROM *A PRELIMINARY STUDY ON VETIVER (VETIVERIA ZIZANIOIDES) FOR UTILIZATION IN THE FIGHT AGAINST EROSION*, BY DR. FRANÇOISE DINGER

Propagation Of Vetiver

The objectives were to ascertain Vetiver's performance under our climatic conditions; its aptitude for vegetative multiplication (the current method for propagation); to develop *in vitro* (tissue culture) multiplication techniques and to introduce and put onto the market in the Mediterranean basin both the plant and planting techniques.

In July 1989 we received two ecotypes of vetiver from India — one from the regional research station in Paiyur and the other from a state horticultural farm in Thimmapuram; the latter type with a finer leaf so that the two types were referred to as large vetiver (LV) and small vetiver (SV). In August 1989 we received another type with a New Caledonian provenance; this type also had a finer leaf than the LV-type. We named it for its provenance as "NC". In total we had 53 plants with which to begin work.

Half of the vetiver was sent to the Centre de Formation et de Promotion Horticole (CFPH) in Ecully where they would also carry out experiments in vegetative and tissue culture propagation.

CEMAGREF Tests

I. Cold tolerance

The vetiver plants were placed in containers filled with a potting mixture (1/2 sand and 1/2 compost) on 20 July and grown until 10 October, providing material for testing. The first trials were to determine vetiver's cold tolerance, trials were carried out concurrently in Draix (Haute-Provence Alps) and in Grenoble (Isère).

"The objectives were to ascertain Vetiver's performance under our climatic conditions; its aptitude for vegetative multiplication; to develop tissue culture multiplication techniques and to introduce and put Vetiver onto the market in the Mediterranean basin ..."

Dr. Françoise Dinger

Draix is located in the mid-mountain country of the Mediterranean, soils are highly erodible black marls located between 850m to 1200m above sea level. Climate is Mediterranean with dry summers (some few, occasional storms) and most precipitation occurring in spring and fall. Winters are cold with little snow; between December and March there are an average of 90 icy days. Average annual rainfall is 900mm occurring over about 80 raindays; characteristically, rainfall events are intense and of short duration. Constraints to the development of the local vegetation in this zone are the high insolation (i.e. strong sunlight), unfavorable rainfall distribution, and low water holding capacity of the soils. For vetiver grass we considered that the lack of snow as an insulating blanket for the plants protection during freezing weather was potentially a constraint. In Grenoble, plants were placed in a greenhouse and received little sunlight, nor were they watered during the winter.

None of the plants in Draix survived the winter and in grenoble, only 3 (GV) vetiver plants survived out of the 34 planted. The survivors did not recover well, showing little vigor — by August 1990 they had only produced 3 or 4 tillers/each.

Research work was also carried out in the center at Ecully on both the Indian (LV and SV) and New Caledonian vetiver. The objective was to look at vegetative multiplication in consideration of light and temperature. Plants were placed in pots at four different dates and grown for ten weeks. Fertilization was every 15 days. Pots were placed outside to test cold tolerance and within a greenhouse where they were exposed to natural light conditions and extended (16 hours/day light using a mercury vapor lamp) light conditions. At the end of ten

weeks note was taken of the growth. Results showed that the Indian plants were very sensitive to the cold though the winter of 89/90 was not severe (min. temp. - 6° C). Tillering rate was low in the winter period and no significant influence on tillering was observed as a result of differing photoperiod length; though the plants with the greater amount of light exhibited a greater degree of homogeneity in growth rates and had better root growth. The New Caledonian plants, which were observed under greenhouse conditions only, appeared to respond to the longer photoperiod with greater tillering. We concluded that the Indian vetiver is freeze-constrained under a temperate European climate and that photoperiod seems to influence growth and rhizogenesis but this conclusion requires further confirmation.

II. Tissue culture

Based on work that had been done previously with mediums for multiplication of Alpine Bluegrass (*Poa alpina*), vetiver grass was tested in the mediums which had produced the best results. The results with the vetiver were not as good; the vetiver did less well though rooting was not a problem. Continuance of this work has now provided nearly 5,000 plants to be outplanted in tests of hedgerow formation and efficiency. No particular problems have been noted to date with either diseases or pests.

III. Conclusions

Studies covered growth, development and propagation through two work phases : (1) laboratory, where a few samples were reproduced and (2) larger scale multiplication, where tissue culture was used to provide sufficient material for further testing of vetiver for erosion control and on conditions for reproduction. Resistance to cold was also tested in areas subject to freezing conditions and the ecotypes tested did not perform well. Further work should evolve based on testing of other ecotypes (e.g. Himalayan) which may display greater cold tolerance.

A third phase of work, coming up, will study flowering and germination; tests in somatic embryogenesis to develop resistance and to look at mycorrhization for optimization of plant multiplication and growth. Major-scale testing of vetiver for erosion control, perfecting of management techniques, and marketing feasibility studies will also be carried out during this third phase.

IV. Field Testing

Six sites were chosen for testing of vetiver grass as a hedgerow species based on microclimate (so results will be transferable to arid and semi-arid Mediterranean sites); on soil (to begin work on finding a vegetative solution to controlling erosion on blue marl soils) and strategic considerations. The sites are all located on a massif where the forests have been burned off and *Calamagrostis argentea* is common. Soils on 5 of the 6 sites are blue marls and the other is a friable clay. The altitudes of the sites range from 430m to 510 m above sea level and have aspects of north, south, southeast, east, northeast and west. Slopes range from a nearly level area on one site to 35% to 70% on the others. Four of the six sites are planted with tissue cultured plants and the other two with vegetatively propagated stock. On one site the native species *Calamagrostis argentea* is being compared to the vetiver. No results are yet available at this time.

Hedge	October	November	December	January	February
Vetiver	12.8	12.3	10.4	8.6	7.6
Cenchrus	11.1	11.5	10.9	9.4	8.4
Subabul	12.9	9.2	6.7	7.2	5.2
Desmanthus	11.4	11.1	10.2	9.0	7.9

Table 18. Effect of hedging (by species) on soil moisture (%) - 1988/89

EXCERPTS FROM *VETIVER VEGETATIVE HEDGE - EXPERIENCE AT REGIONAL RESEARCH STATION ARUPPUKOTTAI* BY DR. S. SUBRAMANIA

For sustained agriculture, conservation of agricultural assets are essential. This is more true in dryland agriculture. Land and water are the two major natural resources which need efficient management to ward against degradation of the environment and of agricultural productivity. Various soil conservation measures have been attempted and con-

Hedge	September	October	November	December	January	February
Vetiver	12.6	21.2	23.0	21.0	19.5	17.3
Cenchrus	12.1	20.1	22.8	20.4	19.2	16.9
Subabul	12.1	20.6	20.4	19.3	17.7	15.3
Desmanthus	11.9	19.0	23.0	20.1	18.1	15.7
Control	12.1	17.2	17.4	16.4	15.1	13.1

Table 19. Effect of vegetative hedging (by species) on soil moisture (%) - 1989/90

tour bunding had been accepted in India on slopes up to 6%. The system is effective, however, it is not without difficulties. (In) deep vertisols, where shrinking and swelling results in cracks up to one meter in depth, contour bunds get destabilized and become ineffective. Also saturation of soils and waterlogging behind the bund result in poor crop stand and growth. Another difficulty is that landholdings in India are small and this type of bunding requires co-operative efforts to achieve safe disposal of surplus water; in practice this cooperation is only achieved in stray instances. These factors necessitate new thinking on contour bunding, especially for deep vertisols; vegetative hedges seem to offer an advantage.

Tamil Nadu Agricultural University, Regional Research Station began in 1987 experimenting with Vetiver (Vetiveria zizanioides); Kolukkattai grass (Cenchrus glauca) which had been found to be the most drought tolerant grass in this part of the country. Hedge Lucerne (Desmanthus virgatus) and Subabul (Leucaena leucocephala) were added to the trials in 1988.

The establishment growth and coverage as a hedge was quite encouraging with vetiver as well as Cenchrus grass. The establishment was quick probably due to the fact that vegetative parts; plantlets for vetiver and grass slips for cenchrus, were used . However, the seed propa- gated Desmanthus and subabul experienced difficulty in establishing as hedge.

We monitored the moisture in the hedged portion as well as in the control with no hedge. The tabulated data shows greater moisture conservation through the vegetative hedge (Tables 18 and 19). Among the hedging systems tried, the vetiver hedging system has recorded higher percentage of soil moisture at all stages of the crop, followed by cenchrus hedging system .

Based on the experience of the first two years we are now planning and also planting with Vetiver, Cenchrus and Desmanthus in two mini-watershed areas of 8 ha each to study their relative performance in conserving soil and moisture. We are also planning interbund management practices to further improve the system. Among the various hedging materials, vetiver grass is the best known plant at this time, which can be used to help prevent sheet erosion and increase moisture conservation.

As the station does not have silt measuring devices we are not able to record soil erosion. From our visual observations we used to have rills and sometimes gul lies in a field of 4.00 ha of about 1.2% during earlier years. After establishment of the Vetiver and Cenchrus vegetative hedges soil loss has been greatly reduced. We could also observe silt accumulation behind the contour vegetative hedges when we had a storm of 250 mm on a single day on 30.11.90 and 524 mm during the week 28th October to 3rd November.

THE VETIVER INFORMATION NETWORK

The purpose of the Network is to provide a central point where information on the use of contour vegetative barriers of Vetiver grass may be compiled and disseminated free of charge to all interested parties. If you wish to join the Network, request further information or supply information to other users, please write to :

Vetiver Information Network;
c/o Jim Smyle, ASTAG;;
Rm. F3067
1818 H St., NW
Washington, D.C.
20433, USA
Tel. 202-458-2274
Fax 202-477-1865

The findings, interpretations and conclusions expressed here are entirely those of the authors and should not be attributed in any manner to the World Bank

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER INFORMATION NETWORK, ASTAG *, WORLD BANK, NUMBER 7, NOVEMBER 1991

THE NEWSLETTER

This is the seventh Newsletter and also, the largest in terms of articles that have been sent in by you who are on the Network. Putting this publication together is becoming progressively easier as more and more people are getting involved with their own research, trials and use of vetiver. It is very rewarding for us to get your comments and put them together like this to send back out to others. It gives those of us who are spending too much time with paperwork a sense that we are a part of something more practical and useful. Thanks to all of you who are and have been looking for good ideas and who, more importantly, have been willing to give those ideas a try.

Please read this before you go on to read other things in this Newsletter. In this issue we had wanted to put in a special section on the propagation of vetiver grass. We could have done so, we have quite a bit of information here. But, what we do not have are your concerns, ideas, issues, knowledge, techniques, or needs, because you have not told us and we have not asked you. So now we are asking you, please turn to page 16 and fill out the form you find there on propagation; do not mistake it with the form you will find on page 15 — that one is to get your free copy of the Board of Science and Technology for International Development's (BOSTID) book on vetiver grass, to be published soon.

And on that subject, BOSTID took its expert panel consisting of Drs. **Norman Borlaug**, **Rattan Lal**, and **Hugh Popenoe** to Louisiana to view the US Soil Conservation Service's vetiver plantings. The panel (which also includes Dr. **David Pimental**) will soon be making their recommendations to BOSTID regarding vetiver. We look forward to reading their ideas and suggestions.

Photo 1. At the Agricultural Research Service's Sedimentation Laboratory in Oxford, Mississippi, USA flume studies show the structural strength of vetiver grass and its ability to control runoff when planted as a hedge. Photo courtesy of the USDA/ARS Sedimentation Laboratory, Oxford, Mississippi.

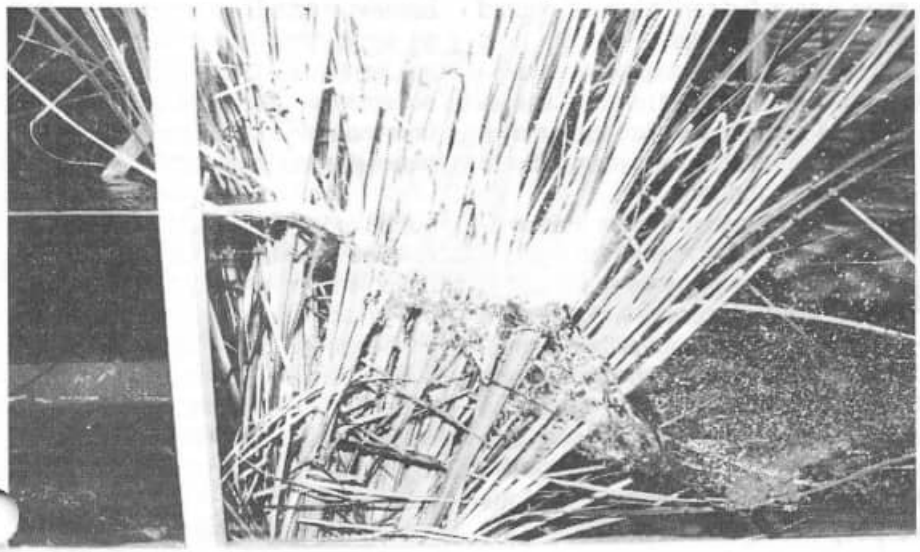


TABLE OF CONTENTS

BOSTID Publication	2
Change in Soil Conservation	2
Mycorrhiza and Vetiver	3
Fertilizer Trials	4
Indigeneous Soil Conservation	6
CIAT Trials	8
Crop Yield	9
Mulch and Termites	9
Network Letters	9
BOSTID Form	15
Propagation Questionnaire	16

One final note for all of you dog fanciers, Mr. **Richard Skolnik**, of the World Bank reports that *Dog Fancy Magazine* says vetiver can be used as a natural flea repellant.

CORRECTION ON VETIVER AWARDEES

Mr. **Wang Zisong**, the Deputy Director of the China Red Soils Project, has informed the network that the award of US$500 given to him for the work carried out in Fujian Province should not be credited to him alone. He writes that in carrying out the work (described in Vetiver Newsletter #6, June 1991) his cooperators were Mr. **Wong Changzhang**, Mr. **Liu Songting**, and Mr. **Huang Jianling**. We apologize for our oversight and congratulate Messrs. Wong, Liu and Huang on their excellent work and on their award.

UPDATE ON THE POTENTIAL AVAILABILITY OF FUNDS FOR NGOS DEMONSTRATION WORK WITH VETIVER

In our Newsletter #5 in March of 1991 we announced that there was a good possibility that we would be able to find grant funding in order to support NGO groups currently involved in agriculture/natural resource management cooperatively with small farmers and who wished to try vetiver grass hedgerows for soil and moisture conservation. Since last March we have heard from a number of interested groups and individuals who either are already start-

* - ASIA TECHNICAL DEPARTMENT AGRICULTURE DIVISION

ing work with vetiver or have a keen desire to do so. Well, it is almost 9 months later and we are still writing proposals and looking for a source to provide us with a "Technology Fund". We wish to establish this Fund, not only for vetiver grass, but also for work with other promising technologies that can improve our management of natural resources both on-farm and off. We have been receiving favorable comments on our proposals, but as yet no money. So, to all who have replied, be assured that we are keeping a special file with your requests. To those of you that have not gotten in touch with us and would like to, please do. We can make no promises, but we are trying and we are optimistic. In the meantime, keep up the good work !

Photo courtesy of Dr. S. Jayaraj, Tamil Nadu Agricultural University, India.

Photo 2. Contour vegetative barrier of vetiver grass at Tamil Nadu Agricultural University in India. This university is one of the now more than 45 institutions worldwide who are carrying out research on the use of vetiver grass for soil and soil moisture conservation.

Would You Like A Free Copy Of BOSTID's Upcoming Publication On Vetiver Grass ?

The National Academy of Sciences is preparing a report on vetiver and its potential. The final report, a book of 150 pages or so, will be published in a few months. They will make it widely available to politicians, administrators, financiers, agricultural planners, entrepreneurs, researchers in many disciplines, and field workers. It should help get vetiver better understood and appreciated.

An appendix in the book will give the addresses of vetiver researchers and users. Do you want to be listed? If so, please fill out the form found on page 15. Everyone replying will receive free copies of the report when it is published. Having your name listed in the book is likely to foster professional contacts with those who want to employ vetiver in their own programs.

Seeds Of Change In Soil Conservation

The following is abstracted from Dr. **Michael Stocking's** article of the same name in the March/April 1991 issue of *International Agricultural Development*. Dr. Stocking, a soil scientist, is currently the Dean of the School of Development Studies, University of East Anglia, Norwich, UK.

"Soil is in a perilous state. 'Textbook' conservation is not working; some argue that it should therefore be applied with redoubled vigour. But there are alternatives and this article examines some of the new initiatives being tried by conservationists."

"Conservation was built on an engineering approach. If the soil should start to move, then the response was to build a barrier to arrest further movement. It sounded sensible but it ignored a fundamental factor— namely, that the conservation measures were tackling the symptoms and not the disease. The soil had already started to move; the conservation would merely try to stop it going further."

"Fortunately there are alternatives that work with nature, strengthening preventative systems and supporting biological processes which restore soil quality. Most conservation researchers are concentrating their efforts on these alternatives. Before looking at some of the initiatives, what is the current state of soil degradation?"

"Soil erosion threatens millions of people in developed and developing countries alike. FAO estimates suggest that we are currently losing between 5 and 7 million hectares of good land a year because of degradation. This land comes primarily from the 11% of the total land area (about 1500 million ha.) which is currently suitable for agriculture. FAO's view is that soil and water conservation measures must be extended to a quarter of all farmland by year 2000."

"Networking. The sharing of experiences is one way to promote conservation. Research networks do this, so why not implementation agencies? Soil conservation cuts across disciplinary barriers erected by subjects as diverse as agriculture, economics, engineering, extension, forestry, sociology and soil science. It therefore demands input from many specialists and coordination between government departments."

"Most developing countries do not have the specialists or institutions with the expertise to tackle soil degradation and to design appropriate methods to tackle the problems. It is a major challenge for small countries where trained manpower is scarce. Even large countries such as Indonesia struggle when specialists are not used to working together. Regional networks are an answer."

"Local Knowledge. Professionals need to recognise that they are not the sole repository of knowledge. Local people have much to offer in their own

struggle to conserve soil and water resources without professional help. These efforts, frequently the result of decades of accumulated experience, were often rejected by experts as rudimentary and inefficient. But evidence is gathering that farmers will maintain and even expand such measures, while at the same time neglecting important techniques. So who is wrong?"

"**Husbandry.** Part and parcel of such changes in thinking is that far from being simply a set of techniques, soil conservation is about harmonising the views of conservationists—saving soil, preventing off-site impact, concern for society as a whole with the needs and aspirations of farmers. It is about land husbandry or how to gain an acceptable living from the land without jeopardising the future. The control of soil erosion will follow as a consequence if good husbandry is achieved. In medical analogy again, it is understanding the root cause of the problem rather than the symptoms."

"**Political Will.** Tracing back the causes often leads to failure in government policy and the institutions that government sets up to effect the policy. It is here, with sufficient political will, that the greatest advances could be made in promoting soil conservation. If governments through their policies made it worthwhile for a farmer to conserve soil, then soil degradation would be a thing of the past."

"Justifiably soil conservation has developed a bad name, especially in many developing countries where its techniques have been forced on unwilling peasantry. People have shown by their neglect of the measures that much that is sold as conservation is unworkable, impractical and sometimes even detrimental to society and the environment. Structures such as terraces and check dams were previously seen as the starting point. But the new philosophy, **Francis Shaxson** of FAO assures us, "assumes that the primary thrust is better soil management, with structures only used when they are unavoidable." This emphasis on production and making soil conservation worthwhile to the land user would seem a far wiser basis for a long-term strategy to reverse the appalling decline in the quality of our soil resources."

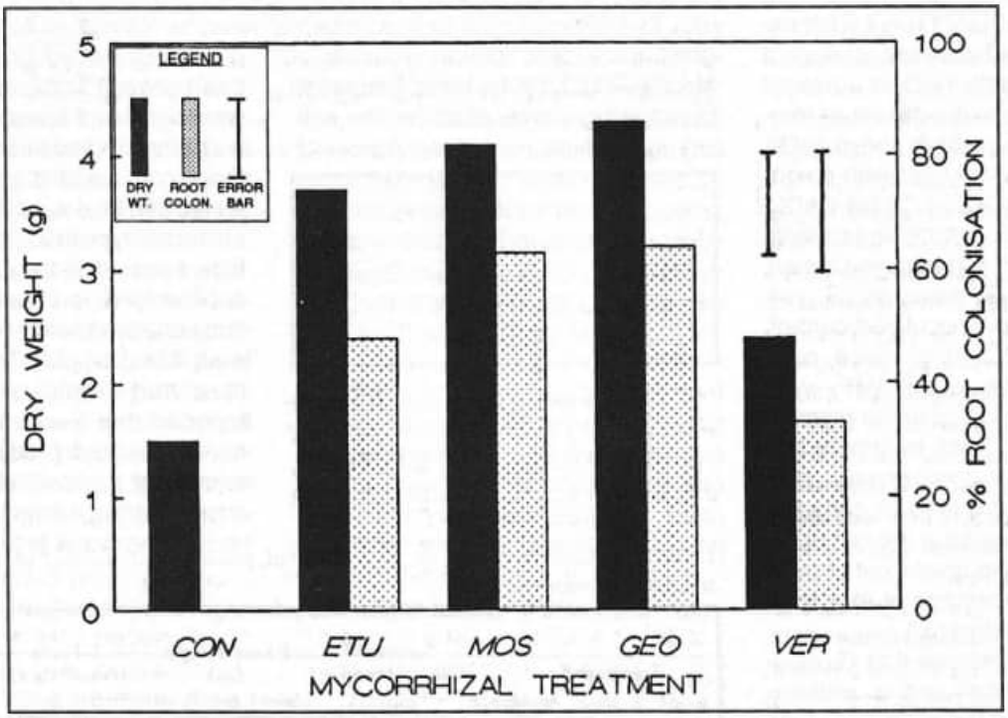


Figure 1. Inoculation of the roots of vetiver grass with mycorrhizal fungi improves growth significantly. Note that while some of the fungi were better than others in promoting biomass production, even the least successful of the fungi still improved the average biomass production by over 50% compared to the control.

Mycorrhiza and Vetiver - Rehabilitating Degraded Lands

The following preliminary results were provided by Drs. **J.C. Dodd, S. Williams** and **P. Jeffries** of the Durrell Institute of Conservation and Ecology/ Biological Laboratory at the University of Kent, Canterbury, UK in an article entitled : *The Effect of Arbuscular Mycorrhizal Fungi on the Growth of Vetiver.* The authors' work with mycorrhiza — a term for a particular association between the roots of a plant and the vegetative parts of a fungus. Mycorrhiza help plants take up nutrients and soil water more efficiently; this is very important under conditions where nutrients or moisture are limited. In their work, they found that by inoculating vetiver roots with certain fungi, early growth and establishment of vetiver was much better. The authors point out that if we establish plants with the right mycorrhiza to rehabilitate and stabilize degraded lands, then the fungi can benefit other crops that will eventually be grown there.

They write : "Mycorrhizal fungi occur in nearly all soils on earth and form a mutualistic symbiosis (an association beneficial to both) with the roots of most terrestrial plants. The arbuscular mycorrhizal fungi (AMF) occur over the widest ecological range and are commonly found in association with most of the important agricultural and horticultural crops. Most plants in natural ecosystems will also have well developed mycorrhizas. The growth of many plants can be improved when inoculated with effective strains of AMF in soils low in plant available phosphate (P), primarily as a result of more efficient uptake of this nutrient. At present, however, inoculum must be produced on the roots of a suitable host plants such as onion in temperate regions and a forage legume like *Pueraria phaseoloides* or *Sorghum spp.* in the tropics, since they cannot yet be grown on synthetic media. AMF can have other beneficial effects on plant growth including increased tolerance of water stress and helping to

bind soil particles into more stable aggregates by their extensive mycelial network outside the root. The latter could be of considerable importance in aiding the stabilization of badly eroded areas or the recuperation of soils in hilly areas along with Vetiver for example. The possibility that AMF could aid the early growth and establishment of Vetiver and allow the buildup of mycorrhizal populations, in soils where the indigenous fungi have been removed by loss of top soil, has great potential for the rehabilitation of degraded land."

"In a small experiment here in UK we evaluated the effects of four different AMF on the growth of Vetiver microplants weaned into peat and supplied by MASDAR (UK). The experiment occurred between 20 August 1990 and 25 March 1991 in a heated greenhouse where the minimum temperature was maintained above 12°C. Three-litre pots were filled with a non-sterile sand (pH 7.3 in 0.01M $CaCl_2$) and free of AMF. Five fungal treatments were established; *Glomus etunicatum, G. geosporum, G. mosseae, G. versiforme* and a non-inoculated control. 25 g of chopped roots of maize, colonized by the appropriate AMF, were placed below a plantlet in the planting hole of each pot. Each treatment had six replicates. Water was given weekly to bring pots back to field capacity. Plants were harvested at the end of the experiment and the dry weight of plant tops and the percentage of root colonized by AMF assessed."

"Figure 1 shows that *G. mosseae, G. geosporum* and *G. etunicatum* increased the dry weight yields of Vetiver compared with both the non-inoculated control and plants colonized by *G. versiforme*. Plants inoculated with the former three AMF also had the highest levels of root colonization (Fig. 1). The linear correlation between dry weight and the percentage of the root system colonized by AMF in this experiment was very positive (r = 0.814)."

"These data indicate that AMF could help the early growth and establishment of Vetiver plantlets in alkaline soils where there are no indigenous AMF, such as in badly eroded hill areas. This and other evidence infers that the recuperation of soils and soil fertility must include a regeneration of the soil microflora and especially the beneficial microorganisms such as AMF and rhizobium bacteria if the growth of legumes is envisaged. Many tropical plants (cassava, legumes and fruit trees) depend on their mycorrhizal symbiosis for efficient uptake of nutrients in poor soils. If Vetiver plantlets were inoculated with AMF, appropriate for the soils in which they were planted, then they would benefit not only from colonization of their own root system but also in aiding the buildup of inoculum for the roots of other crop species being grown in association, such as legumes. This multidisciplinary approach to the recuperation of degraded soils may bring more successful results in the long-term."

"We would like to express our gratitude to Mr. **Glenn Allison** of MASDAR LtD, UK for his collaboration in supplying Vetiver plantlets."

Influence Of Accession Variability And Fertilization On The Establishment And Growth of Vetiver Grass In A Field Nursery

The following research article was received by the Vetiver Network from Drs. **P.E. Igbokwe, S.C. Tiwari, J.L. Burton** and **R.E. Waters, Jr.** from Alcorn State University, Lorman, Mississippi, USA. Dr. Igbokwe and his colleagues carried out two field experiments to evaluate the survival and growth potentials of four different accessions (geographical sources) of vetiver grass (from India) as affected by fertilization. They found that fertilization increased the number of tillers and seedheads per plant in 1990; and increased the plant height, the number of tillers, seedheads per plant and the plant's biomass in 1991.

They also found differences between the vetiver plantings which resulted from the different plant's origins. The individual accessions showed differing plant height, number of tillers and seedhead in 1990; and differing plant height only in 1991. The interaction between fertilizer and accession was significant for seedhead in 1990 and plant regrowth in 1991. The authors concluded that the accessions tested can be established successfully on the soil type in which the experiment took place; that they respond to soil-applied NPK fertilizers; and they can survive the mild winter months in Southwest Mississippi. The authors also measured biomass production and reported that the combined root and shoot biomass productions after six months of regrowth could range from

Table 1. Treatment effects on plant survival, plant height, number of tillers and seedhead formation, 1990

Treatment	Survival[Y] (No./Accession)	Plant Height (m)	Tillers (No./Plant)	Seedhead (No./Plant)
Fertilization:				
Fertilized	6.69	1.91	9.96	4.48
Unfertilized	6.94	1.89	6.38	2.24
LSD, 5%	NS	NS	1.64	0.37
CV, %	4.23	8.05	13.58	9.87
Accession:				
196257	6.88	1.83	8.13	3.54
213902	6.63	2.02	9.92	2.57
271633	6.75	2.03	8.54	4.04
302300	7.00	1.71	6.08	3.30
LSD, 5%	NS	0.11	1.26	0.41
CV, %	6.50	5.42	14.64	11.54
Interaction:				
Fertilization X Accession	NS	NS	NS	**

Y Survival after initial transplanting of 7 plants per accession.

176,798 kg/ha for one of the accessions (lowest) to 353,596 kg/ha for another (highest); plant spacing was 20.3 cm x 20.3 cm.

Introduction. "Realizing Vetiver grass potential for becoming a hedge grass in the United States, as well as for its industrial applications, its propagation and nursery establishments are being carried out in some of the United States Department of Agriculture's Plant Material Centers, to determine its most appropriate propagation method, adaptation potential and for increasing the available plant materials already in the country. Greenfield (1989) noted that Vetiver grass grows faster in nursery and produce more tillers in shorter period of time if they are fertilized with phosphatic fertilizer in combination with some form of nitrogen. Sreedharan and Nair (1975) reported that application of 20 kg/ha each of P and K_2O increased the oil yield but not the root yield. Increasing the rate to 30 kg/ha each did not improve response, but 30 kg/ha P alone increased oil yield. In India no difference in growth response was observed between fertilized (40 kg/ha N and 40 kg/ha P) and unfertilized vetiver in one plot (at 70 days) and no response until about 8 weeks in a second plot (Vetiver Newsletter, 1990). Vetiver has also been reported by the same source to establish well in soils that are characterized as P deficient. Because of the increasing interest in vetiver, and limited information on its adaptation and fertilizer requirements in the United States, this study investigated the survival potential and fertilizer effect on the growth of four vetiver accessions in field nursery in Southwest Mississippi."

Method. "Two field experiments were used to evaluate the survival and growth potentials of both fertilized and unfertilized 196257, 213902, 271633 and 302300 (Indian) vetiver grass accessions planted in a field nursery. A split plot arrangement in a randomized complete block experimental design was used, with fertilization as main plots whereas vetiver grass accessions made up the subplots. The experiments were conducted on a Memphis silt loam (Typic Hapludalf: fine, mixed, thermic) soil at Alcorn State University, in Lorman, Mississippi. Soil extractable nutrient level was medium for Phosphorus (68.32 kg/ha), low for Potassium (216.16 kg/ha), very high for Magnesium (1130.08 kg/ha) and very high for Zinc (8.18 kg/ha). Soil pH was 5.3."

"Single tillers obtained from vegetatively propagated (root division) vetiver grass accessions from the Regional Plant Introduction Station in Griffin, Georgia were transplanted to field nursery on May 29, 1990. Each accession was spaced 20.30 cm on sub plots 1.42 m x 1.07 m and replicated 4 times. A total of 7 plants were transplanted into each subplot. Moisture was limited to the initial hand watering immediately after transplanting, plus natural rainfall. The average monthly rainfall during the first year of this study was 0.18 cm. The average monthly soil temperature at the same period was 22.44°C for the morning and 31.22°C for the afternoon. On June 5, 1990 each of the fertilized plots received 240.8 kg/ha of 13N-13P-13K. Weeds within the experimental plots were controlled by hoeing and hand pulling, whereas the surroundings were mowed as needed. Pesticides were not used in this study since pests were not observed. Plants were allowed to overwinter with the seedheads unharvested. Data were analyzed by the analysis of variance and means separated by least significant difference (LSD)."

"On April 22, 1991 the number of plant regrowths from the 1990 fertilizer field study were counted, and percent regrowth was used to estimate cold tolerance for the 4 vetiver accessions."

"After cold tolerance evaluations, missing plants were replaced for each accession on April 23, to initiate the 1991 study period. On May 8, plots were fertilized as for 1990. All production practices were as in 1990. The average monthly rainfall during this second year of this study was 0.95 cm. The average monthly soil temperature at the same period was 22.43°C for the morning and 28.72°C for the afternoon. Data were analyzed as for 1990."

Results and Discussion. "In 1990, fertilization increased the number of tillers and seedheads per plant, while accession variability influenced plant height, number of tillers and seedhead per plant (Table 1). Tillers were greater (9.96 per plant) for fertilized plants than (6.38 per plant) due to unfertilized plants. Seedheads per plant were also greater for fertilized plants (4.48) compared to 2.24 from unfertilized plants.

'The greatest plant height values of 2.03 metre occurred in accession number 271633. The number of tillers per plant was greatest (9.92) in accession 213902, and least (6.08) least in accession 302300. Seedhead per plant was significantly greater (4.04) in

Table 2. Treatment effect on plant regrowth, plant height, number of tillers, and plant biomass, 1991.

Treatment	Regrowth (%)	Plant Height (m)	Tillers (No./Plant)	Seedhead (No./Plant)	Plant Biomass Root & Shoot (Kg/Plant)
Fertilization:					
Fertilized	90.25	5.12	12.06	5.50	1.48
Unfertilized	86.75	3.93	4.26	1.66	0.51
LSD, 5%	NS	0.92	1.16	1.65	0.61
CV., %	15.69	18.10	12.68	41.03	54.24
Accession:					
196257	93.00	4.90	8.06	4.31	1.46
213902	85.88	4.20	8.56	2.44	0.73
271633	91.13	4.80	9.06	3.31	0.95
302300	84.00	4.10	6.95	4.25	0.82
LSD, 5%	NS	0.40	NS	NS	NS
CV., %	13.77	11.91	39.22	72.50	59.24
Interaction:					
Fertilization X Accession	**	NS	NS	NS	NS

I favor Mura (Vetiver) over Gliricidia since it will not give me problems when it matures. With Gliricidia its laterally growing roots interfere with land preparation, resulting in so much delay..... quote from Filippino farmer

accession 271633 and least (3.30) in accession 302300."

"The number of seedheads per plant was significantly different due to the Fertilizer x Accession interaction."

"Percent survivals were 95.57 and 99.14 for fertilized and unfertilized plants, respectively. Percent survival for plant accessions 196257, 213902, 271633 and 302300 were 98.29, 94.71, 96.43 and 100.00, respectively (not in the table).

"Vetiver grass cold tolerance was not affected by fertilization and accession variability (Table 2). However, fertilized plots had 90.25% of grass regrowth as compared to 86.75% for unfertilized plants. Cold tolerance among accessions was highest, 93.00% due to 196257, and least, 84.00% due to 302300 accession."

"Data due to Spring 1991 fertilization were significant for plant height, tillers and seedhead per plant, and fresh weight. Their respective higher value of 5.12m (height), 12.06 (tillers), 5.5 (seedheads) and 1.48 kg/plant (fresh weight) were due to fertilization as compared to their respective lower values of 3.93m, 4.26, 1.66, and 0.51 kg/plant from the unfertilized plots. Accession variability influenced plant height. The greatest plant height value of 4.9m was due to 196257 accession."

"Based on 20.30 x 20.30cm plant distance, and plant fresh weight values (Table 2), total biomass production from these 6 month old vetiver grass regrowths could range from 123,516.39 kg/ha to 358,439.72 kg/ha for unfertilized and fertilized plots, respectively. Similarly, the biomass production by vetiver accessions could range from 176,798 kg/ha to 353,596 kg/ha for accessions 213902 and 196257, respectively .

"Fertilizer x Accession interaction was significant for plant regrowth. Fertilized plants reduced within row plant spacing in the range of 77 to 88mm compared the range of 62 to 76mm due to unfertilized plants, after 4 months of regrowth. Accession 271633 had non-significantly higher value for gap reductions than other three accessions used in this study (not in the table)."

Conclusion. "Data from these studies suggest that vetiver grass accessions 196257, 213902, 271633 and 302300 can be successfully established on the Memphis silt loam soil of Southwest Mississippi if growth factors are not limiting. These accessions will respond to soil applied NPK fertilizers, however the extent of response will depend among other factors, on seasonal variations and their genetic variabilities. High coefficient of variability reported in this study could contribute to nonsignificant difference among some parameters tested. Greater number of tiller productions could lead to faster trapping of sediments on the uphill side of the rows, resulting in earlier erosion control from fertilized plots, compared to unfertilized plots. Data also indicate that when these vetiver grass accessions are grown in Southwest Mississippi, their survival potential after a mild winter season could range from 84% for 302300 accession to 93% for 196257 accession. Combined root and shoot biomass productions could range from 123,516 to 358,440 kg/ha for unfertilized and fertilized plots, respectively. The biomass productions by vetiver accessions could range from 176,798 kg/ha (accession 213902) to 353,596 kg/ha (accession 196257)."

Acknowledgment. "The authors wish to thank the United States Department of Energy, and Mississippi Department of Energy and Transportation Division, Economic and Community Development for funding this project. Special appreciations to Mr. **Doral Kemper**, and Southern Regional Plant Introduction Station, Griffin, Georgia for providing seeds and seedlings used to initiate this study. The authors also wish to thank Drs. **Samuel Donald, Johnnie Collins, Charles Tillman** and Mr. **Tom Collins** for their support and encouragements; and **Larry Russell** for assisting with planting, field maintenance and data collection; Ms. **Janice Carter** for typing the manuscript."

PHILIPPINES - THE INTRODUCTION OF VETIVER GRASS TO IMPROVE AN INDIGENOUS TECHNOLOGY FOR SOIL AND WATER CONSERVATION.

Dr. **Ly Tung** and Ms. **Fatima T. Balina** of the Farm Resource and Management (FARMI) Institute at Visayas State College of Agriculture in Leyte have provided the Network with the following piece :

".....As farm density has increased the fallow cycles are reduced to a few years at most, farm sizes decline, and fallow cycles are replaced by continuous cropping. Subsequently, many of the cereal-based farming systems in such areas are unsustainable because of soil erosion and soil nutrient depletion. One of the technical possibilities to address the problem is the de-

Table 3. Soil loss as effected by contour hedgerow vegetation, Claveria, Philippines, August 1988 to April 1990.

Hedgerow Species	Soil loss (cm)
Gliricidia and *Paspalum*	0.38
Napier grass	0.62
Gliricidia and Napier	1.38
Gliricidia alone	1.50
Open field (common/local practice)	4.20

83

velopment of contour hedgerow farming systems. Although scientists perceive many benefits of the hedgerow system technology, its adoption rate by upland farmers is disappointing."

"In January 1990, FARMI/ ViSCA started to implement a project entitled Upland Agriculture, Philippines. The project funding comes mainly from the International Development Research Center (IDRC) of Canada."

"FARMI selected a pilot research site covering five upland barangays in the municipality of Matalom, province of Leyte. Two of the selected barangays are characterized mainly by calcareous soils where corn is most widely grown. The other barangays have strongly acidic, degraded, and infertile soils where upland rice is predominant. A close study of the production systems in these barangays reveal that farmers have developed their own technique to fight soil erosion."

Learning from Farmers. "Through this project, we first noticed in the two calcareous-soil barangays the existence of natural grass strips in many sloping fields (mostly 10%-40% slope). These are narrow (0.5m - 1 m wide) contour strips left unplowed and allowed to vegetate naturally. They are put in at the time when a piece of fallow land is brought into cultivation. The distance (surface run) between strips may range from 4 m to 10 m (Ly Tung and Alcober, 1991). The above technique is locally termed as "cemento-cemento" or "kahon-kahon."

"As of April 1991, about 34 percent of the total 396 households in barangays Altavista and Templanza have adopted this technique of soil and water conservation. Ninety-six percent of farmer-adoptors have indicated that their primary reason for adopting is to check soil erosion (Balina et al, 1991). Of late (June 1991), we observed that a good number of adoptors in these barangays have expanded the technique to their other land parcels that are brought into cultivation after fallow."

"The natural vegetative filter strips are not without problem, however. As the dominant grass species are either cogon (Imperata) and/or low-statured native grasses, the strips are not strong enough to hold the soil, especially on steep slopes (more than 18%). According to farmers, heavy rains and/or animals cause broken strips."

Searching for Technological Improvement - The Mura grass. "Research on the use of natural grass strips has received very little attention to date (Garrity, et al 1991). The grass strips are simple to install and have low or no labor requirements but show an outstanding capability to reduce soil loss, a charecteristic which makes them potentially superior to the commonly recommended, introduced species (Table 3).

"An interesting grass species was first observed by the authors in August 1989 in barangay Anolon, Hindang, Leyte. The grass was found grown by some farmers along the dikes of lowland rice fields for the purpose of holding the soil. In a Visayan vernacular, farmers call it Mura. After a period of verification, it turned out that Mura in Anolon is actually Vetiver grass. Interestingly, many of the farmers thought that Mura was not adaptable to the uplands. The first trial planting of Mura (5 rows at 10m/row) to test its adaptability to an acid infertile upland area of Matalom was done by the Project in January 1990. A dry spell struck the area from February through May of the same year. When Mura survived this drought, its adaptability to the uplands and its being drought-tolerant were confirmed."

Creating Awareness Among Farmers. "Some 12 farmers from 3 barangays were invited to view a slide show on the Mura grass technology. After the slide show, they were brought to the trial planting area of Mura. Subsequently, some 10 farmer-participants signified their interest to try it in their farms. The Project provided some planting materials to interested farmers in one barangay. In the other two barangays, the farmers secured the planting materials by themselves from nearby lowland areas."

Testing and Feedback by Farmers. "Initially, one farmer planted Mura in the lowland, two planted both in the lowland and upland, and seven planted in the upland only. To date

Table 4. Number of rows and total length of Mura (Vetiver) grass planted by demonstration farmers in barangay Matalom, Leyte, Philippines.

Barangay/ Farmer		No. of rows planted Lowland	Upland	Total length (m) Lowland	Upland
A. Esperanza					
	1	4	4	48.6	50.00
	2	2	2	22.4	30.00
	3	-	5	-	72.00
	4	-	1	-	12.00
	5	-	2	-	45.00
	6	1	-	7.0	-
	7	-	1	-	20.00
Sub-Total		7	15	78.0	229.00
B. Altavista					
	1	-	1	-	26.00
	2	-	2	-	76.75
	3	-	3	-	67.00
Sub-Total		-	6	-	169.75
C. Templanza					
	1	-	1	-	84.00
	2	-	2	-	18.00
	3	-	16	-	210.00
Sub-Total		-	19	-	312.00
D. San Salvador					
	1	-	3	-	40.80
	2	-	2	-	88.00
	3	-	8	-	222.40
	4	-	3	-	62.00
Sub-Total		-	16	-	413.20
Total	17	7	56	78.00	1123.95

Photo courtesy of CIAT, Cali, Colombia

Photo 3. Cassava in an erosion control experiment with vetiver and Arachis pintoi; showing little sign of competition effects of vetiver in cassava growth.

(June 1991 the number of farmers in four barangays who have tried/expanded planting Mura has increased to 17 (Table 4). As reflected in the table, all farmers but one planted Mura in the uplands. The number of rows planted varied from farmer to farmer with a total length of 1,124 meters for the uplands."

"Farmers' feedback was taken and the following comments were gathered:

1. As hedgerows in the upland, Mura seems to be stronger than cogon because it is deep-rooted.
2. Mura does not grow tall compared to leguminous trees/ shrubs such as Gliricidia, thus pruning is not needed.
3. Less water can pass through the Mura hedgerows during heavy rains once they are already established.
4. Mura is better than cogon because its root growth is vertical while Cogon has lateral roots which produce new shoots; hence, more maintenance for cogon is needed.
5. Crops such as corn and rice planted near Mura hedgerow show better performance.
6. Mura has an expanded/dense base which can serve as a physical barrier preventing soil and water to pass through.
7. "I favor Mura over Gliricidia since it will not give me problems when it matures. With Gliricidia its laterally growing roots interfere with land preparation, resulting in so much delay."
8. "I have observed that Mura contributes much to the control of topsoil erosion. The transported soil is accumulated along the Mura hedges where it is trapped. Where there is no Mura the rate of erosion is really high and a lot of gulleys are formed. I have observed all these things after the recent (super) typhoon Ruping."
9. "I have also observed that Mura can tolerate partial shading caused by the ipil-ipil."

"As of June 1991, one farmer has already expanded the planting of Mura in another parcel of his farm and there are six who are planning to do the same when the rains come. Some of them have cited insufficient planting materials, at; present, as a constraint for expansion. The comments of farmers who have planted Mura suggest that they are optimistic about its performance as hedgerows in the uplands."

Concluding Statement.

"After a year 17 upland farmers have tested and adopted Vetiver grass for soil and water conservation. Indications are that the technology will be spread and be sustained even if the project no longer exists. A main ingredient leading to such a good adoption rate in a short period of time appears to be the following: learning from farmers first before attempting to introduce technological improvements. In the long run the simple grass (Vetiver) strips will not remain simple. They provide foundation for subsequent diversification into more labor-intensive hedgerow enterprises. This diversification is being looked into by the project."

"Based on the Project's experiences and reinforced by recent literature on the use of Vetiver grass for soil and water conservation around the world, the Project has prepared and pretested a leaflet written in Cebuano for distribution to all farmers covered by the Project. However, it should also be useful for other upland farmers in Region VIII."

From The International Center For Tropical Agriculture (CIAT)

Dr. **Douglas R. Laing**, Deputy Director General of CIAT in Cali, Colombia writes :

"I enclose for your information some photographs taken recently in Mondomo Cauca, Colombia showing vetiver with *Arachis pintoi*. I believe this is a first. The results seem to be shaping up quite well from various viewpoints. The final results at the end of the first year and particularly after 2 or 3 years will really tell. At the moment erosion is at a minimum in the vetiver plots and cassava seems to be growing well without competitive effects close to the barriers."

"The idea of the Arachis association is to provide a source of nitrogen for the system as a whole. Arachis is shade tolerant and fixes nitrogen quite well in acid soils at intermediate altitudes, i.e. where most of the erosion seems to take place in the tropics. Over time there could be a reasonable contribution of nitrogen provided from this association. The Arachis could also be cut for fodder without endangering the vetiver as a hedge against erosion. This would reduce one of the main constraints in the use of vetiver per se, i.e. its low acceptability to bovines."

"The experiment is the work of Mr. **Martin Ruppenthal** from the University of Hohenheim,working at CIAT in a collaborative project funded by the BMZ. We will keep you posted on the outcome."

An Update From Karnataka, India On The Effects of Vegetative Barriers On Crop Yield and Soil Loss

Dr. **B.R. Hedge** from the University of Agricultural Sciences in Bangalore (who has been carrying out research involving vetiver hedges for over 4 years now) has provided the Network with some information from the 90-91 Annual Report of the AICRP for Dryland Agriculture. In comparing a control plot (no hedgerows, graded bunds at top and bottom of plot), a plot with a vetiver hedgerow (in plot center, graded bunds at top and bottom of plot) and a plot with a *Pennisetum hohenackeri* hedgerow (in plot center, graded bunds at top and bottom of plot), he reports that there was no influence of the vegetative hedgerows on overall yield of millet. This is significant as the crop rows adjacent to the hedgerows exhibited some competition effects. Yields in the adjacent two or three rows (editor : these would be located within about 30cm to 50cm of the hedgerow) were reduced from, in one case 0% (row 3) upto a maximum of 52% (row 1) in another case. This suggests that yield increases in the interior rows would have had to occur in order to offset the losses due to competition at the hedge. Soil losses in the three plots during that year were very low due to rainfall charecteristics; losses were .49, .51, and .54 t/ha for the vetiver, pennisetum, and control plots, respectively.

A Preliminary Study on Vetiver Grass Mulch Effect On White Ant (Termite) Attack In Horticultural Plantings

From the **Staff of the Watershed Technology Development Center** in Solo, Central Java, Indonesia :

"The objective of the study is to determine the usefulness of vetiver leaf for preventing white ant attack of horticultural plants. The study is executed in an area of marginal and shallow soils at Gunungsari, Sub-district of Wonosegoro, Boyolali."

"Table 5 shows the number of trees observed, the intensity of the white ant attacks and the percentage of the trees killed by white ant attack. From the data it can be seen that there is a significant difference between the three mulches used — cuttings from the wild grasses, banana stems and vetiver grass cuttings. The use of banana stems or vetiver grass as mulch decreased the intensity of white ant attack and the percentage of trees killed by white ant. That vetiver is as effective as banana stems is important as it is impossible to fulfill the need for mulch with banana stems. It is suggested that further more detailed research should be carried out to test the usefulness of vetiver mulch in preventing white ant attack on horticultural plants."

No.	Combination of mulch type and horticultural plant type	Number of trees observed	Number of trees attack by white ant	Number of trees killed by white ant
1.	Mulch of wild grass manure in coconut trees	5	4 (80%)	1 (20%)
2.	Mulch of wild grass manure in mango trees	5	5 (100%)	2 (40%)
3.	Mulch of banana's stem in coconut trees	5	0 (0 %)	0 (0 %)
4.	Mulch of vetiver manure in coconut trees	5	0 (0 %)	0 (0 %)
5.	Mulch of vetiver manure in mango trees	5	0 (0 %)	0 (0 %)

Table 5. Effects of mulching with native grasses (wild grass, banana stems and vetiver grass on white ant (termite) attacks and mortality in some horticultural crops.

Letters From Vetiver Network Correspondents

Australia -

The Network has received information through Dr. **Noel Vietmeyer** at the United States National Academy of Science, that, according to Mr. **R.S. Junor**, Commissioner, Soil Conservation Service, New South Wales, the Australian Soil Conservation Service's "interest in Vetiver has been reawakened and currently we are undertaking a major project to evaluate vetiver in four states of Australia. The project is coordinated through our Plant Materials Centre and the officer responsible is Mr. **Ken Reynolds**..... Over the next three years vetiver will be evaluated at a wide range of sites, in various environments and for different uses. Throughout the duration of the project, results will be distributed through the Vetiver Newsletter."

Dr. Paul Truong, the recipient of one of the Vetiver Awards for his work on saline tolerance in vetiver, writes that he is continuing his salinity work and, in addition, hopes to set up trials to evaluate the effectiveness of vetiver in stabilising coal mine overburdens. He writes : "If this trial is successful, Vetiver will provide our mining industry with a low cost and effective means of reclaiming mine wastes."

Bhutan -

Possible First Vetiver Planting in Bhutan

Mr. **P.G. Harrison** writes from the Department of Primary Industries

Photo 4. Digging Vetiveria in the Benue Floodplain near Demsa, Nigeria

and Fisheries in Australia that he believes that, what may be the first vetiver plantings in Bhutan, have been put in at Pemagatshel this last February. Mr. Harrison informs the network that planting material was obtained through World Bank staff from Kathmandu and that they had excellent establishment with new tillers appearing only 10 days after transplanting. They planned to try and distribute vetiver to farmers this last July or August.

Bolivia

Mr. **Mathieu Kuipers**, Project Coordinator of a cooperative program between the Ministry of Agriculture and Campesinos (MACA), the Corporation for the Development of Cochabamba (CORDECO) and the United Nations informs the Network that they are beginning to develop a program to assess and utilize vetiver grass hedgerows. Mr. Kuipers has also provided us with Ing. **Alfredo Ballerstaedt's** (MACA) translation of the Vetiver Handbook as well as an introduction that Ing. Ballerstaedt has written on the vetiver system for Bolivia.

Cape Verde

Vetiver Introduced To "New" Country

Ms. **Frances Harris**, a Plant Scientist with the Henry Doubleday Research Association who is working in a collaborative project with the Instituto Nacional De Investigação Agrária on agricultural and forestry research, writes that their project has introduced vetiver to Santiago Island :

"A supply of the grass was brought out from England in February 1991 and is now growing well in a nursery. When the rains start, these plants will be divided and should provide enough material to plant a demonstration trial on a steeply sloping site. Survival and growth of vetiver grass will be monitored and its effects on soil erosion and crop yield will be observed."

"Cape Verde foresters, soil conservationists and agriculturalists are very interested in vetiver. They have been very helpful with respect to allowing it to enter the country and providing materials necessary to build an enclosed nursery. Many Cape Verdians have requested planting material and are very curious to see if it will grow successfully here. If it does, it is likely that the National Soil Conservation Service will use it regularly in their campaign to control soil erosion."

"Vetiver grass has also been introduced to the second-largest island, Santo Antao, by a Dutch agricultural project. Unfortunately, I have been unable to contact them. If any groups from Cape Verde have responded to your (Network), I would like to know of them."

Costa Rica

Six Years of Vetiver Use

Dr. **C. Bufford Briscoe** writes that he now has about six years experience with hedgerows of vetiver, lemongrass (*Cymbopogon citratus*), and citronella (*C. naudus*) on his farm in a humid zone ("Ten days without rain is rare") receiving about 2400 mm/yr rainfall. He reports that there had been no apparent differences between the hedgerows until 1990, when, more than 90% of his lemongrass (apparently) died of a root rot. Other than this, he tells us that there are no visually obvious differences in the densities of the three hedgerow types, nor has he observed any die out in the centers of any of the hedgerow species....which he suggests may be due to annual trimming. He reports that flowering in the plants is rare to nonexistent. Dr. Briscoe also states that on a consultancy to St. Vincent, West Indies this year, he found that lemongrass is considered to be an important pest...."it flowers and seeds abundantly, and has spread over considerable areas".

Hong Kong

A Perspective On "Good" vs "Bad" Fodder Grasses For Erosion Control

In the May 1991 edition of *Asia-Pacific Uplands - A Newsletter for Scientists*, Dr. **R.D. Hill** of the Department of Geography & Geology, University of Hong Kong writes about upland development in Guizhou Province, P.R.C. :

"For higher more temperate areas pampas grass (*Cortaderia argentea*) may offer possibilities and for lower more tropical areas Vetiver may be suitable for erosion control. Neither is good quality fodder. This is important since good-quality fodders are likely to be environmentally-sensitive, or require significant inputs (which no farmer can afford and would not use anyway on public-access grazing lands). More importantly, vigorous low-quality fodder is likely to suffer less cutting or grazing pressure and thus continue to be effective in erosion control, especially if planted, as recommended, in a double-row hedge along the contour."

Dr. Hill is publishing this news-

letter for the Pacific Science Association as a medium for the sharing of news and views, for the informal publication (in brief) of research reports and for documentation on management systems which are economically and environmentally sustainable for the utilization of the **Asia-Pacific uplands. If you are interested in joining this network, contact Dr. Hill at the University of Hong Kong.**

(**Editors note** : *there are two points in Dr. Hill's article on which we would like to comment. The first is to note that in some areas pampas grass is considered to be a serious weed, and the second is to state that the Network does not recommend double rows of vetiver in areas where control of sheet and rill erosion are desired. Double rows may, however, be desirable or necessary in situations where runoff is concentrated, for example, stream banks and active cutting areas in gullies.)*

Photo courtesy of R.S. Patil

Photo 5. *Mr. Patil's vetiver about 90 days after planting from single tillers.*

India

Letter From A Karnataka Farmer

Mr. **R.S. Patil** of Hombal, Gadag, Dharwad writes to the Network that :

"I am happy to give you my feedback from my last 6 months of work. During the summer I found our Forest Department's vetiver nursery and requested a supply.....I was able to make vetiver bunds (hedges) on 8 acres of Black-cotton soil land (**ed. note**. *high shrink/swell clay soils subject to deep cracking when they dry - Vertisols*). This land has been planted on all boundaries....(and) divided into two equal parts with khus (vetiver) planted across the waterway. A total of 67 acres (drains) through this land to another farmer's land. Another farm of my own has also been planted....there I have planted khus on 3 boundaries (of a) 7.5 acre land (and have) made 16 parts. Everywhere I have used single rootlets (plants)."

We are encouraging farmers to make vetiver nurseries on their own land through a small group, a farmer to farmer association called 'DHARLTRI'. Already four small nurseries have been established....We are promoting Permaculture, organic farming, vetiver importance in soil erosion and other related methods of sustainable Agri-methods in our area."

Mauritius

More Evidence That Vetiver Grass Hedges Stop Encroachment of Weeds Into Farmer's Fields

The following information was sent to the Network by Dr. Noel Vietmeyer and comes from a communication by Dr. **Jean-Claude Autrey**, Head of the Plant Pathology Division of the Mauritius Sugar Industry Research Institute.

"Any sugar cane grower in Mauritius will tell you that vetiver is used both for erosion control as well as some sort of barrier to prevent noxious weeds such as Cynodon dactylon to penetrate fields from roads. The abundant root system of vetiver is ideal for this purpose."

People's Republic of China

Plantings Expanding in Jiangxi

Mr. **Zhang Guangming**, a regular contributor to the Newsletter and one of the individuals who has been instrumental in promotion of vetiver grass in China, writes : "Under the influence of vetiver establishment in the Red Soils project area, Jiangxi is now expanding its planting area. By the end of 1990, we had established a protection area of 5,000 mu (332 ha), nurseries of 100 mu (6.7 ha) with six million planting slips. Vetiver is not only planted in the Phase I Red Soil project area. In mid-March, 1,500 county government staff and farmers were organized to plant 30,000 meters (protection area 1,000 mu) of vetiver strips with 700,000 slips in proposed phase II project area. In Xinfeng county, 100,000 slips (protection area 100 mu) have been planted at the edges of level trenches, in the soil plugs of gullies and around the slopes of hills on the contour. Priority will be continuously given to planting material and planting quality."

"Recently a training course was sponsored in Nanchang for an environmental protection forestry project. Participants from 16 provinces discussed vetiver establishment. Special funds have been allocated to Jiangxi and Guangdong provinces for trial planting. Mr. Liao Baowen, from the Tropical Forest Institute of the China Academy of Forestry came to Jiangxi ADC on April 14 for information and handbooks

on vetiver. He says that the Institute, which is near the South China Botanical Garden where three people have started research on vetiver, and the Forest Bureau of Yangxi county in Guangdong province will plant a 150 mu (10 ha) vetiver demonstration for a forestry project."

In Fujian province, the Network is informed that under the direction of the Water and Soil Conservancy, two more counties (Anxi and Jianyang) will put in vetiver trials on about 255 mu (17 ha). The trials will consist of hedges on sloping agricultural fields, in gully control, to stabilize collapsed slopes, to stabilize fruit/tea terraces, to protect ponds, and along roadsides. The trials will monitor impacts of vetiver on erosion, runoff, soil nutrients and work at enhancing management techniques.

Rates Of Tillering Significantly Increased By Pruning

According to work carried out by Mr. **Chen Cayang** and Mr. **Cheng Hong** of the Department of Water and Soil Conservation, Nanchang Water Resources and Hydropower Academy in Nanchang, Jiangxi, the rate at which tillering occurred in vetiver was definitely affected by pruning. In their trials, pruning of vetiver in late August had increased the rate of tiller formation by 71% at the end of one month and by 83% at the end of the second month; they conclude that pruning should be carried out prior to flowering, but after growth has begun to slow so as to maintain the maximum photosynthetic surface during the period of optimal growth. The authors carried out their work in six locations, between latitudes N18°10' and N36°33' (rainfall 706 to 2,000 mm/yr; lowest temperature -9°C; soil pH = 4.5 to 5.6) and make the observation that based on the first year's data, so far vetiver appears to be sufficiently adapted to this climatic range for use as a soil and water conservation species. They will continue monitoring.

In Zhejiang, Vetiver Grows In Cold Uplands

Mr. **Qiu Jiye** of Zhejiang has written to the network to inform us that vetiver grass has been planted in the Province since 1971. It has been planted as clumps, not as hedgerows, primarily for stabilizing soil, for pickling spice (from the root), and for fuel from the stalk. Mr. Qiu notes that vetiver has a large range of adaptability from acid soils (pH = 4.5) to alkaline soils (pH = 8.5) and from mountainous uplands (mean winter temp 7°C; min = -7°C; 35 frost days; 10-15 snow days) down to sea-level.

Vetiver Is A "Delicious" Spice

Mr. **Gao Weisin** of the Institute of Mountain Disasters and Environment in Chengdu informs the Network that new economic uses for vetiver grass are being found in China. He tells us that vetiver is being found useful to feed fish and also "Another use of V. grass is to be used as a spice, especially with meat. These dishes are very delicious."

Republic of South Africa

Private FirmStabilizes Difficult Sites

Mr. Anthony Tantum has been working with vetiver grass since 1966, when he first saw the Mauritians using vetiver grass hedgerows to stabilize drains on a sugar estate in the Lower Shire Valley; today he has a private company which specializes in land stabilization with vetiver grass hedgerows. In a recent letter to Dr. Noel Vietmeyer at the United States National Academy of Science, Mr. Tantum recounts the following :

"In 1990, **Neils Carsten** of the Roads Department (Cape Provincial Administration) asked (me) if vetiver could solve a serious erosion problem at the Stellenbosch flyover (Exit 22 of Hwy N2 to Cape Town). The embankment was very steep; the "soil" pure white sand. Vetiver was planted in April 1990, closely spaced and without fertilizer. Virtually all plants survived,and their growth was good. Natural terracing was already visible before the end of the year."

"In another trial in the Stellenbosch area (on the R44 road to Paarl), a steep road bank with very poor subsoil was planted. Nothing grew in the white clays with red patches until vetiver was put in April 1990. Today the grass is growing and tillering well, and the bottom hedge, for example, had built up between 70 and 100 mm of soil in just the first 7 months !

Another remarkable approach in South Africa has been achieved by the Institute of Commercial Forestry Research. Vetiver has now been accepted by the forestry industry on fire breaks; which have been a major source of erosion up until the introduction of the vetiver hedges. The insurers of this industry have accepted the concept of vetiver hedges, on fire breaks, not being a potential fire hazard. In June of each year, the hedges are herbicided with Gramoxone and burnt a week later. Within two weeks the hedges come back as green belts across the fire breaks."

Thailand

'Faek' Well-known in Thailand

The following are some excerpts from two articles passed on to the Newsletter. The first is by Dr. **Weeachai Na-nakorn**, who is the Coordinator of the recently established Thai Vetiver Network, written in response to some question arising from a seminar on Vetiver grass given in Thailand last May. The second is from **Richard Grimshaw**, Chief of the World Bank's Asia Technical Department, Agriculture Division and gives some of his impressions from his May trip to Thailand to speak at the seminar on Vetiver.

Those interested in joining the Thai Vetiver Network can contact Dr. Nanakorn at The Forest Herbarium, Royal Forest Department, Phaholyothin Road, Bangkok 10900.

"According to interviews with the Department of Biology, Faculty of Science, Chiang Mai University, and reference to the Royal Forestry Department's Directory of Plants in Thailand, vetiver grass, known in the scientific name as *Vetiveria zizanioides*, is a plant under "Faek" family in Thailand. The new generation who are not familiar with rural life may wonder as to what is Faek. "Faek" is well known among Thai people in many provinces because it can be used for house and

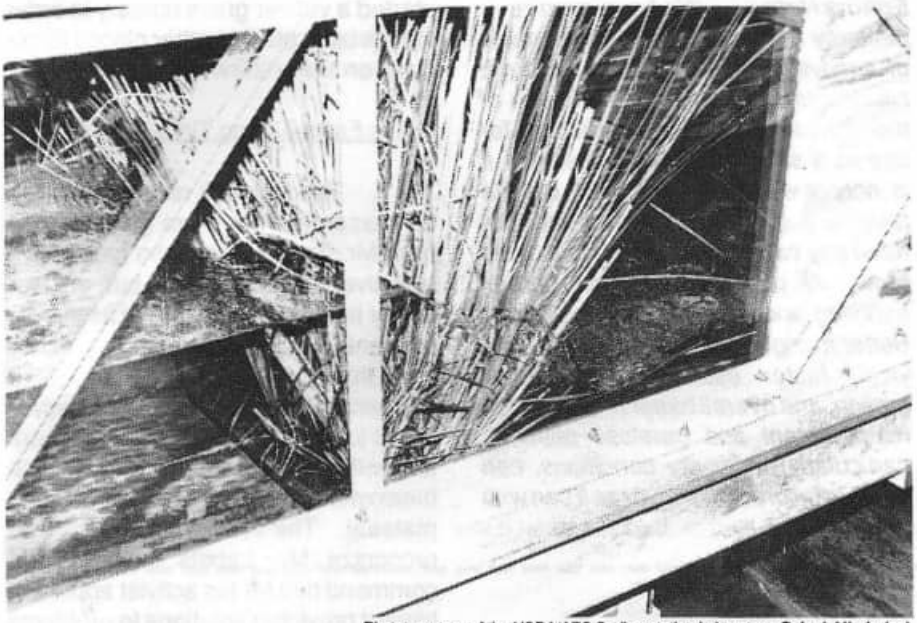


Photo courtesy of the USDA/ARS Sedimentation Laboratory, Oxford, Mississippi.

Photo 6. Water is ponded to the depth of 30 cm during a test run at the Agricultural Research Service's Sedimentation Laboratory in Oxford, Mississippi, USA.

farmhouse roofing. However, according to people in the countryside, natural Faek is now becoming scarce. People have begun using Imperata cylindrica for roofing instead. In their opinion, roofing made from Imperata cylindrica is not as effective as that made from Faek because Faek leaves, when assembled into a band, can aggregate themselves tightly due to the characteristics of the bottom end of its leaf. As a result, rain water does not hold on nor leak. Due to its more durability, its price is higher than roofing made from Imperata cylindrica."

Where Can Faek Be Found in Thailand? "Faek is commonly found in the low plateau lands of the Nakhon Sawan and Uthai Thani provinces; where it grows along the edge of swamps and roads. The specimens in the collection of the Botanical Center, Royal Forestry Department, come from areas of 250 metres MSL in Nakhon Patchasima province, 400 metres MSL in Phayao province and 800 metres MSL in Mount Phu Kradung in Loei province. Since natural Faek can be found thriving in different environments, it can be said that Faek can endure occasional floods, droughts and low-quality soil."

Faek and Soil and Moisture Conservation. "According to a World Bank report, Faek which was burnt in dry season could thrive on again during the following rainy season. This qualification means that it is likely to be suitable for use as a plant for soil and moisture conservation because there are often fires on upland crops during the dry season. It is under an experimentation as to how quick native Faek in Thailand can thrive on in time in rainy season for effective soil and moisture conservation."

From Richard Grimshaw's Trip to Thailand

"During the month of May (May 21 to May 24) I visited Mae Hong Song Province in Northern Thailand. Specifically I visited the Royal Project (near Chiang Mai) and the Thai-Australian Project at Mae Ho (near Mae Sa-reang) and the Thai-German Project at Nam Lang in Pang Ma Pha District. I was impressed by the efforts being made to help the Hill Tribes and by the indigenous farming practices by these Hill farmers. Clearly bush fallow/crop rotations are being reduced in duration and soil fertility is declining. Soil loss due to erosion is extremely high - sometimes more than 100 tons/ha per annum."

"Experimental work by the Thai-Australian, and Thai-German projects confirm that vegetative systems of soil and moisture conservation are significantly superior to engineered/structural systems. Not only are they cheaper but also require less maintenance. The two most commonly used conservation hedges were *Leuceana spp.* (a Shrub hedge) and grass strips of various species."

"Vetiver may well prove to be readily adoptable by the local farmers. Presently, they are showing increasing interest in grass strip conservation - even on the steepest slopes (over 50% slope). The main problem with the grasses being used are their spreading habits and limited longevity."

USA

Vetiver hedgerows have been established by the Soil Conservation Service in and near Baton Rouge, Louisiana under the initiative of Mr. **Mike Materne** of the SCS with the aid of Dr. **Kitty Derstine** and Ms. **Cindy Shexnayder**. In one particularly impressive trial, the SCS has planted vetiver hedges to test their ability to control gullies and arrest sediment flows in a military tank testing ground at Ft. Polk, La. Planted in May 1990, the hedgerows have established well and begun to trap sediments. During 1991, Louisiana has had record rainfall (it is their wettest year on record) and under these extreme conditions the structural integrity of the vetiver hedges in the active drainageways has not been compromised — more than 50 cm of sediments have built up behind the hedges despite their not being fully closed yet.

Vetiver Barriers Pond Water

Further evidence of the structural strength of vetiver hedgerows has been provided to the Network by Drs. **S. Dabney** and **G. Dunn** at the United States Department of Agriculture's Agricultural Research Service Sedimentation Laboratory in Oxford, Mississippi. In a flume study, water flowing at 28 liters/sec (flume width 61 cm) was ponded to a depth of about 30 cm behind a vetiver hedge; gravity head loss through the hedge was about 23 cm; it can be seen that leakage between the glass and the hedge contributes to reduced effectiveness in ponding the water. Photos 1 & 5 show that the vetiver hedge is only slightly deflected by the flow.

More On Drought and Cold Tolerance

Two areas of concern are vetiver's ability to establish under difficult, particularly drought, conditions and its ability to withstand cold. The following letter from **James E. Eagan** of Esparto, California provides the Network with some information of interest :

".....An associate of mine visited Sunshine, Louisiana and made arrangements to ship 3 square feet of Vetiver grass root to me in Woodland, California. We started propagating the Vetiver from tillers in about 200 pots in my small backyard in Woodland. During July of 1989, I was forced to separate and transplant the tillers under very hot and adverse conditions. Water was a serious problem due to Californias drought conditions. As a result irrigations were sparse and the tillers were severely stressed. Quite frankly, I expected a near zero survival rate. I was surprised that I lost less than 10% of the materials. However, due to the stress the plants were very slow to develop and averaged about one foot of height during the next six months.
In December of 1990 the hardest freeze in at least 50 years struck our area. Night time temperatures stayed between 10 and 20 Fahrenheit (-12C to -7C) for approximately 17 to 20 days. At the end of this time all of the plants were brown and wilted right to ground level. There was only a hint of green remaining on a few of the plants. I again expected nearly a 100% loss. Amazingly enough all but a few plants showed signs of new growth in about 6 or 7 weeks. The actual rate of loss was 2% or less."

"One fact that I should have mentioned earlier is that the original root stock that was obtained from Louisiana was air freighted to me in California in burlap sacks. The roots were kept moist in a wheel barrow for 2 weeks and covered with newspapers until my associate and I had time to separate and plant the tillers. (Other plants which are now growing very well) were literally started from scraps that I had discarded as meaningless during the initial planting. Obviously, I am impressed with the durability of Vetiver grass."

Editors Note: *We have seen repeatedly that vetiver grass is capable of surviving under some fairly rough conditions and handling;that is one of the reasons why it is well adapted for use as a soil conservation species. It is not, however, a very good idea to take the approach that vetiver does not need any care in order to establish and grow. All plants benefit from careful handling and good planting practices. Better mangement means greater survival, faster establishment, better growth, and overall better results. Poor management and careless planting, particularly under dry conditions, can result in failure with vetiver as it can with any plant.*

Zimbabwe

Protecting Valuable Irrigation Works

The following excerpts are from a letter written by Mr. **Alan Norton**, Project Manager of the Rupike Irrigation Scheme.

"I am currently installing the Rupike Irrigation Scheme on behalf of the Rio Tinto Foundation. My interest in Vetiver grass started because of my concern at the large areas of denuded borrow pit (approx. 15 ha) left by the contractors who constructed the dam. The borrow pits are within the immediate dam basin, largely on slopes greater than 5% and on highly erodible granite-derived soils. Already there has been much visible soil wash into the dam from the pits in addition to the considerable amounts from farther up the catchment. The installation of the dam, irrigation facilities and associated infrastructure represents a large investment and we do not want the life of the project shortened unnecessarily by siltation of the dam. We have attempted to plant Vetiver on the contour in the borrow pits in order to check the erosion. Much of the grass is on decomposing granite with thus very little soil for root development. Also the cattle and goats in this area are so desperate for food that they feed on the grass not only when it is young and palatable, but also when it is dry and/or fully grown in its coarse state. However, despite these set backs and a long dry season, the grass is surviving in most places. We have started a vetiver grass nursery in order to bulk up to plant in other places especially on the waterways in the fields."

Notes From A Long Time Vetiver User.

The Network received this letter (excerpts from it are given below) from Mr. **Jano Labat**, who has known of vetiver for some years, but, only recently had become aware of its use for soil and water conservation. Since then, through his own efforts, Mr. Labat has written a small pamphlet on vetiver grass to pass out to his fellow farmers and within which he has offered to help them with more information or planting material. The Network would like to recognize Mr. Labats initiative and commend him for his activist approach toward providing solutions to problems — in this case, the use of vetiver to control soil loss.

"I must say that, although I have been associated with Vetiver for quite a number of years, I was not aware of its many uses until February (1990, when I saw) your booklet and newsletters and (Tony Tantum from Howick, Republic of South Africa) told me of his programme. Needless to say I am an addict of Vetiver since. Recently I have been see Tony and see first hand all his work. I was most impressed."

"I have already established a nursery of 3.2 ha. on my farm. The grass was planted on 15 March 1991 under flood irrigation. You might be interested to know that to control weeds I have sprayed the Vetiver with herbicide three days after planting, at a concentration of 3 litres/ha. The herbicide used was ATRAZINE 500 FW (47% atrazine, 3% active triazines, 50% inerts). There were no ill effects to the Vetiver."

The findings, interpretations and conclusions expressed here are entirely thoseof the authors and should not be attributed in any manner to the World Bank

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER INFORMATION NETWORK, ASTAG*, WORLD BANK, NUMBER 8, JUNE 1992

TABLE OF CONTENTS

Vetiver Awards	2
First International Vetiver Workshop	4
More 'Ad hoc' Trials From Dr. Yoon	4
Vetiver In Louisiana, USA	7
An Update On Salt Tolerance	7
Vetiver In P.R. China	8
Golden Hope Plantation' Experince With Vetiver/Malaysia	11
Vetiver Trials at CIAT/Colmbia	13
Herbicides For Vetiver	15
Letters To The Network	18
Farmer's Form For Vetiver Awards	21

THE NEWSLETTER

Quite a bit has taken place in the few months since our last Newsletter, amongst which is that Dick Grimshaw, the division chief of ASTAG, has been able to raise $32,000 for this next year's **Vetiver Incentive Awards**. An article in this issue gives further information. Additionally, the first International Vetiver Technology Workshop, sponsored jointly by the Rubber Research Institute of Malaysia and the World Bank was held in Malaysia in April. Also in that month, the second Ethiopian vetiver grass workshop was held in Addis Ababa, this workshop was jointly sponsored by Ministry of Agriculture and Environmental Protection and Development (MOAEPD) and the World Bank and brought together those in Ethiopia either working with vetiver or interested in its use. Both workshops were given excellent reviews by the participants and in the Ethiopian workshop **Dr. Mesfin Abebe**, Vice Minister, MOAEPD promised the support of his Ministry in seeing the vetiver technology demonstrated and extended in that country. We have more on the Malaysian workshop in this Newsletter.

On the subject of the Vetiver Incentive Awards, the Network wishes to thank those who provided funds for the awards. In particular we would like to thank **His Majesty, The King of Thailand.** His Majesty had previously expressed a very keen interest in the vetiver technology; one of the King's special interests being the development of the tribal people in the hills of North East Thailand, where deforestation is accelerating, where soil erosion rates are very high, and where there is a need to diversify away from growing poppies. The King had been quick to see the value of Vetiver grass for soil and moisture conservation and he started a testing program in 1991. Soon after that, Dick Grimshaw was asked to meet with him and discuss the Thailand program further. During the audience The King expressed his belief that Vetiver could well be the answer to stabilizing Thailand's fast eroding lands while reducing excess runoff and the problems that excess causes. The King then gave a generous gift of US$ 10,000 to be used to promote research with vetiver through the Network's Vetiver Incentive Awards program.

Photo 1. A well-established vetiver hedge along a roadside in Malaysia not only stabilized the road's edges, but also stopped and held a boulder rolling down the slope. Photo taken at one of Dr. Yoon's demonstration areas. Photo by James Smyle

In the last Newsletter (#7) we published a questionnaire on Network participants experiences, needs and suggestions regarding the propagation of vetiver grass. Due to the unexpectedly large response, we are delaying the publication of our "Propagation Newsletter" issue to the next one after this one. As yet we have not had the time to put together all of the responses so it will be late August or early September before that issue will come out.

In the last few weeks, Dick Grimshaw returned from China

* - Asia Technical DepartmentAgriculture Division

and had a few observations to pass along to the Network :

"China's Ministry of Agriculture (MOA) is well convinced on the use of Vetiver on slopes of less than 15 degrees (30% slopes). They still have some doubts as to its effectiveness on steeper slopes, particularly where soils are very shallow. They also worry that farmers do not see any direct economic value to Vetiver — in other words it has no value for paper, etc. — making its extension difficult. My view is that there are direct economic benefits, such as forage, thatch, and mulch, but these are not immediately perceived by the farmers. MOA will be taking steps to improve its information campaign for Vetiver as well as for other promising technologies such as grain amaranth for fodder."

"Another point of interest from my trip is that I have for the first time seen quite well established 'living walls' (cattle proof hedges) in China. They (many kilometers of them) are located alongside the main road from Beijing to Mutianyu (Great Wall) some 36 km from the Great Wall Hotel, at a place called Niulanshan (Cowshed Hill). These livestock proof hedges are protecting large orchids of peaches, and consist entirely of Black Locust (Robinia pseudoacacia). With a little better planting (a double row, and closer interline spacing), and improved management (specifically the cutting and maintenance) Black Locust should make a very robust and effective hedge, as well as producing wood for fuel and poles."

"Recently, the Chinese have translated from English to Chinese the excellent report done for the GTZ by Dr. Guido Kuchelmeister entitled Hedges for Resource-poor Land Users in Developing Countries. The report, published in 1989 is a comprehensive detailing of

(Continued on page 18, see Grimshaw's Remarks)

Vetiver Awards To Be Given In June 1993
King of Thailand Contributes To Award Fund

Once again Dick Grimshaw has persevered in finding funds which can be utilized to recognize those 'jobs well done' by both individuals and groups in promoting, managing and researching the use of vetiver grass for contour vegetative barriers. This time the Network has a total of **$32,000 to award**. The Network wishes to thank His Majesty, The King of Thailand for his support and contribution to the award fund. The Network would also like to thank **Messrs. Kaji and Wood**, respectively the World Bank Vice-Presidents for East Asia & Pacific and for South Asia, **Mr. James Eagan** of the Yolo County Flood Control and Water Conservation District in California, USA, and **Mr. Reginal Pollack** of Washington, DC for their contributions to the Award fund.

Below are the categories within which the awards will be given. The Network has split the awards in order to encourage a number of different, valuable areas. Please note that "work of interest" is indicative only, we do not want these categories to limit anyone, on the contrary we encourage any useful and practical work outside these areas as well. Be assured that any one sharing information on an area not contained below will have their work treated equally with that which does fall under the categories set out below. Wherever appropriate and possible, costs or cost estimates for implementation of recommendations should be included in order to allow potential users to fully weigh the utility of the recommendation for their situations.

The Network will be accepting your 'entries' until April 15, 1993. At that time an independent, external panel will choose the awardees (with the exception of the Yolo County Award, see below); all awards will be made by June 1, 1993. All materials received should be sent with the understanding that they will not be returned and that

Photo 2. *Assistant Professor Zheng Songfa making observations on the growth of a vetiver hedge in a runoff plot where vetiver hedges are being tested for their impacts on soil loss and runoff control in eucalyptus plantations. The research is being carried out at the Research Institute of Tropical Forestry in Longdong, Guangzhou, P.R. China*

Photo courtesy of Drs. Zheng D., Zheng S. and Liao B.

they will become public information and shared with the Vetiver Network. All relevant information received will be incorporated into a Newsletter (or Newsletters if warranted) for publication by July 1993.

The Awards

The King of Thailand Vetiver Research Award.

His Majesty, The King of Thailand has offered $10,000 in awards to promote the dissemination of useful and practical information on vetiver grass. One-half of these funds ($5,000) will be awarded seperately to the individual contributing the most significant piece of research work.

Research Awards

The Plant

Work of interest on : Vetiver taxonomy , eg species/varieties/types, their identification & comparison of characteristics in : growth and/or management needs and/or palatability/non-palatability and/or applications based on differences and/or pollen, flower, seed fertility/sterility by type; effectiveness as soil/water conservation species as a function of its roots, strength of tops and hedge-forming ability; pest repellency effects by type; allelopathy; cold or drought tolerances; pests and/or diseases; mycorrhiza and vetiver; pH-related questions (eg. absolute tolerances, Al toxicity, P deficiency); and other physiological characteristics.
Awards = 1st - $2,500; 2nd - $1,500; 3rd - 1,000; 4th - 4 awards of $500 each.

Engineering Applications

Yolo County Flood Control and Water Conservation District Award for most comprehensive and/or unique viable applications for vetiver in stormwater and wastewater reclamation. The winner of this award will be determined jointly by Mr. James Eagan, General Manager of the Yolo County Flood Control and Water Conservation District and Mr. R.G. Grimshaw, Chief, ASTAG/World Bank. **Award = $2,000;**

Other work of interest on : stabilization of cuts and fills, protection of infrastructure from run-on and sedimentation, stabilization of the infrastructure:soil interface, stabilization of canals and ponds, groundwater recharge. **Awards = 1st - $2,000; 2nd - $1,500; 3rd - 1,000.**

Management

Work of interest on : pests, their importance/significance and management (insects and/or weeds); "how-to" guides for most efficient propagation and/or viable, alternative propagation methods (eg. layering); "how-to" guides for most efficient establishment of hedgerows (be specific about soils, climates and land use conditions); establishment and management system costs under varying conditions; "how-to" guides on mycorrhizal inoculation of vetiver; management of vetiver hedgerows for secondary benefits; economic analysis of the benefits of vetiver hedgerows relative to other approaches; impacts on soil loss, runoff/soil moisture and crop yields on steep slopes.
Awards = 1st - $2,500; 2nd - $1,500; 3rd - 1,000; 4th - 4 awards of $500 each.

Promotional/Extension Work and/or Materials

Best Video Awards = 1st - $1,150 and a painting contributed by Mr. Reginald Pollack, a renowned contemporary artist, 2nd - $600, 3rd - $250; please include an english-language script if there is any untranslated speech in the video. Note that while the quality of the video, editing, etc is appreciated, the content of the video will be more important. Do not worry if your video is not a 'professional' production.

Best Photograph, Poster, or Drawings. Awards = 1st - $850, 2nd - $400, 3rd - $250.

Please include any necessary descriptions, explanations or translations with the submitted material. Materials do not have to be in english, but a translation is required on a separate piece of paper.

Photo 3. Roadside stabilization with vetiver grass includes protecting culverts from scouring. Photo taken at one of Dr. Yoon's demonstration areas.

Photo by James Smyle

on a separate piece of paper.

Best Proven Approaches for Extension/Technology Transfer. Awards = 1st - $500, 2nd - $300, 3rd - $200, 4th - 5 awards of $100 each.

Tell us your story of how you have been successful in promoting and extending the use of contour barriers of vetiver grass so that we can pass it on to other extensionists. Please include photgraphic evidence and testimonials from farmers/users in your area.

Farmer Awards

These awards will be given out to farmers who are using vetiver grass hedges and have sufficient experience to be able to discuss what they are doing, tell how they work with other farmers and/or report other farmer's opinions of what they are doing, give their honest opinions of vetiver's strengths and weaknesses, and recommend to us what we should be telling other farmer to convince them to give it a try. The form provided on the back page of the Newsletter may be used and/or a voice recording of the farmers with an english translation; photographic evidence should, if at all possible, be included. **Awards = 1st - $300, 2nd - $200, 3rd - 10 awards of $100 each.**

First International Vetiver Workshop

A jointly sponsored Rubber Research Institute of Malaysia (RRIM) / World Bank workshop was held between April 13 and April 16, 1992 in Malaysia at the RRIM Experiment Station at Selangor Darul Ehsan near Kuala Lumpur. Some 85 persons from nine countries — Australia, China, India, Malaysia, New Zealand, Sri Lanka, Thailand, the USA and Viet Nam - representing government, public and private research institutions, development agencies, and field practitioners attended. Only 5 formal papers were presented at the Workshop with most of the time devoted to field visits showing the practical applications of vetiver grass for soil and moisture conservation. Dr. P.K. Yoon of RRIM, who should be familiar to Network participants as the person whose work received the first place Vetiver Award last year, personally organized the workshop.

The main presenters - **Drs. G.M. Bharad (India), M. Materne (USA), P. Truong (Australia), P.K. Yoon (Malaysia) and Zhang Xinbao (China)** - paper's are excerpted in this Newsletter where appropriate. Newsletter #6, in which the work of the recipients of the Vetiver Awards was published, contains either all or part of some of the presentations, therefore only that information not to be found in #6 is presented here.

In addition to the main presenters short talks were also given by a representative of the **Golden Hope Plantations/Malaysia**, **Mr. John Greenfield** (the initiator of the vetiver system), **Mr. Richard Grimshaw** (Chief, Asia Technical Agriculture, World Bank), and **Dr. S.L. Seth** (Additional Commissioner Watersheds/ Ministry of Agriculture, India).

Ad Hoc Trials On Vetiver - Presented at Vetiver Workshop

The following article con-

Table 1. *Effect of fertilizer and spacing on vetiver -- Tops (gm, dry wt.) per 10m of hedgerow*

Spacing (cm)	Month after treatment 1	2	3	5	6	7	8	10	12	13	15
15	176a	449a	475a	370a	745a	855a	666a	1568a	2285a	1777a	2021a
30	90b	238b	282b	312a	598b	742b	663a	1481b	1889b	1594a	1967a
60	42c	130c	180c	191b	388c	472c	438b	911b	1261c	1136b	1438b
s.e. (+)	6.93	17.5	21.7	23.5	41.7	37.3	36.7	82.0	100.6	105.9	116.8
LSD(P<0.05)	21	53	65	71	126	112	111	247	303	319	352
Fertilizer											
F1	94	221b	257b	254b	498b	622b	561a	1318a	1735a	1465a	1747a
F2	111	324a	368a	327a	656a	758a	616a	1322a	1889a	1540a	1870a
s.e. (+)	5.7	14.3	17.7	19.2	34.0	30.5	29.9	66.9	82.1	86.5	95.3
LSD(P<0.05)	-	4.3	53	58	103	92	-	-	-	-	-

Means with the same superscript alphabelts are not significantly different at P<0.05

Treatments	Gap distance (cm) 10 mths	12 mths	13 mths	Gap reduction (cm) 10-12 mths	12-13 mths
30 cm F1	16.8 b	16.2 b	15.3 b	0.6 b	0.9 b
30 cm F2	15.7 b	15.1 b	14.3 b	0.7 b	0.8 b
60 cm F1	44.3a	42.8a	41.3a	1.5a	1.5a
60 cm F2	43.6a	42.2a	40.7a	1.4a	1.5a
se (+)	0.50	0.44	0.39	0.12	0.15
LSD (P<0.05)	1.6	1.4	1.2	0.4	0.5

Means with the same superscript alphabets are not significantly different at P<0.05

Table 2. *Effect of fertilizer and spacing on vetiver - interclump gaps.*

tains excerpts from the paper presented by **Dr. P.K. Yoon** from the Rubber Research Institute of Malaysia at the recent Vetiver Conference in Malaysia. A more complete presentation of Dr. Yoon's work was printed in Vetiver Newsletter #6 in "Excerpts From A Look-See At Vetiver Grass In Malaysia - First Progress Report". The following presents only the information not found in Newsletter #6.

The Effects of Spacing Cum Fertilizer On Growth Of Vetiver Hedgerows

Treatments testing three spacings (15cm, 30cm, and 60cm) x two levels of fertilization (F1 - one 6 gm Kokei fertilizer nugget at 0, 4, and 8 months, followed by one 15 gm Field King fertilizer nugget at 12 and 15 months; F2 - same as F1 except three Kokei nuggets used at 0, 4 and 8 months and two Field King at 12 months and three Field King at 15 months). Assessments of dry matter were based on production from tops cut above 40 cm Table 1), gap measurements (Table 2) were begun at month 10 (due to staff constraints) at which point it was not possible to measure the gaps in the 15 cm treatments as the error in measurement would have been too great.

Results and Conclusions

This exercise was not designed as a proper trial and therefore the conclusions are tentative. Additional fertilizer seemed to have an effect on dry matter production in the early months, but the higher level did not produce any increase later. Spacing plays a bigger role in dry matter production; the wider spacing produces significantly higher dry matter per clump. The reverse was noted in dry matter production per linear distance reflecting the interaction of individual plant growth and the planting density. There is a time x density change which will only be apparent if the trials are carried out over a long period with time sequence studies. Time x density changes and dry matter yield will be affected by the vigour of planting materials. This information is useful in the establishment of Vetiver for : i) production of fodder and ii) production of source materials for paper pulp.

Competitive Effects of Vetiver and Other Weed Species on Rubber

In rubber plantings much effort and cost have been expended to control weeds. This study attempts to quantify the depressive effect of weeds if they were left unattended.

Trial 1

A trial was conducted on the competitive effects of vetiver and other weed species on the growth of rubber clone RRIM 901 at the Rubber Research Institute Experiment Station, Sungei Buloh, Malaysia. The rubber plants and weed species were planted in perforated polythene bags, 95 x 150 cm filled with 256 kg of Sungai Buloh series soil which is sandy in texture. Of the grasses tested, all effected both the growth (girth) and dry matter production. Reductions in girth, compared to the control, ranged from 8.2% with *Imperata cylindrica* to 26% with *Pennisetum polystachion*; vetiver reduced girth by 14.9%. Other species tested were mixes of *Eleusine indica* + *Paspalum conjugatum* (12.4% reduction) and *Ottochloa nodosa* + *Ischaemum muticum* (18.1% reduction). Dry matter reductions, compared to the control, ranged from 27.2% with *Imperata cylindrica* to 53.2% with *Pennisetum polystachion*; vetiver reduced dry matter by 37.7%%. The other species reduced dry matter by 28.5% and 44.4% for *Eleusine indica* + *Paspalum conjugatum* and *Ottochloa nodosa* + *Ischaemum muticum*, respectively. This severe reduction in growth of rubber was due to the competitive effect of the roots of weeds which were confined within the limited area of the polythene bag.

Trial 2

In the field trial at Sungei Chinoh Estate, Perak, Malaysia, vetiver was planted around 2 whorl rubber buddings of clone RRIM 937. The results showed at 6 months that vetiver reduced the girth of rubber 14.2%. This could be due to the massive roots, and the erect and tall Vetiver which shaded the rubber plants. Further recordings were taken at 14 months. During this period from 6 to 14 months, the

vetiver was slashed three times at 50 cm height and the leaves were used as mulch. At 14 months, Vetiver was less competitive and rubber girth was reduced by only 8%.

In these two experiments, the competitiveness of vetiver to rubber was more severe in the polythene bags than in the field because of the confinement of roots within the polythene bags. In the field, the rubber roots will outgrown the root zone of the Vetiver. Manuring will be difficult if the Vetiver are planted too close to the rubber plants. Slashing of Vetiver to prevent shading of young rubber and mulching will benefit the growth of rubber.

Use of Vetiver Grass As In Situ Mulch In Rubber Plantings

Trial 1

Alternate plots of (linear) plantings of vetiver hedgerows and a leguminous ground cover were planted in early 1991 on a large scale (with 3 replicates) to compare mulching with vetiver grass to normal estate practices. The vetiver was slashed twice to provide mulch, viz. July and October 1991. To date, data analysis suggests that there are no significant differences between a vetiver mulch and a leguminous ground cover on rubber growth at 5 months. At 11 months, in one of the three blocks, the mulching showed effects on average tree girth (a 9.1% increase) and tree girth increment (a 22% increase). The trial is continuing.

Trial 2

A randomized block experiment with 4 treatments x six replicates of :

T1 - Control, normal estate practice with leguminous ground covers

T2 - Vetiver hedgerow, 15cm spacing

T3 - Circular planting of vetiver around trees, 61cm radius

T4 - Circular planting of vetiver around trees, 46 cm radius

After the 6 months growth, the girth measurements of rubber showed that producing mulch from the hedgerow (linear) planting of Vetiver resulted an increase in the mean tree girth by 5.8%, 10.1% and 14.7%, respectively, compared to T1, T3 and T4. Mean girth increment was increased 14.3%, 24.4% and 30.2% by mulching from the hedgerows versus T1, T3 and T4, respectively. The 46cm radius planting seemed to be growth depressive. These results are only tentative at this early stage. This trial continues.

Table 3. *Herbicides and rates of application for control of some weed species in vetiver hedgerows.*

Weeds	Herbicides	Rates
Chromolaena odorata (Siam weed)	Ally 20 DF	150 g/ha
	2,4-D Amine	1.50 l/ha
	Starane 200	1.25 l/ha
Mikania micrantha	2,4-D Amine	1.00 l/ha
	Starane 200	0.50 l/ha
Pueraria phaseoloides	Ally 20 DF	100 g/ha
	Starane 200	0.375 l/ha
Asystasia intrusa	2,4-D Amine	0.50 and 1.50 l/ha
	Starane 200	0.3 l/ha

Diseases of Vetiver

In Newsletter #6, it was reported that a fungus, *Helminthosporium sp.*, had been found on vetiver, since then that fungus has been reclassified as a *Bipolaris sp.* or, specifically, *Bipolaris maydis* (Nisikado and Miyalce) Shoem. In Malaysia this fungus is not considered an important plant pathogen; though it is recorded on maize, which is not a major Malaysian crop. Additional observations on the (previously reported) *Curvularia sp.* and *Nigrospora sp.* (not common) infections have shown that the fungi occur only in wounded portions (cut ends, pinpricks, etc), therefore they are considered as secondary invaders.

In February 1992, the leaves of some vetiver plants in a crowded nursery were observed to be covered with dark powdery fungal colonies which could be easily peeled off. This fungus has been identified as *Meliola sp.* a fungus belonging to a group commonly known as sooty molds. Meliola species are described as common in the tropics, generally occurring in the crowded and shady conditions where the plants are found. Severe attacks can be detrimental through covering over the leaf surfaces and thus reducing photosynthesis.

Control of Noxious Weeds in Vetiver Hedgerows

Weeds grow luxuriantly under Malaysia's high rainfall, temperature and humidity, making their control necessary in situations where severe infestations would result in poor vetiver hedgerow establishment. Based on ad hoc experiments in the establishment of Vetiver hedgerow, the various herbicides and rates recommended to

control various common weeds are shown in Table 3.

Qualitative Experience With Vetiver In Louisiana - Presented at the Vetiver Workshop

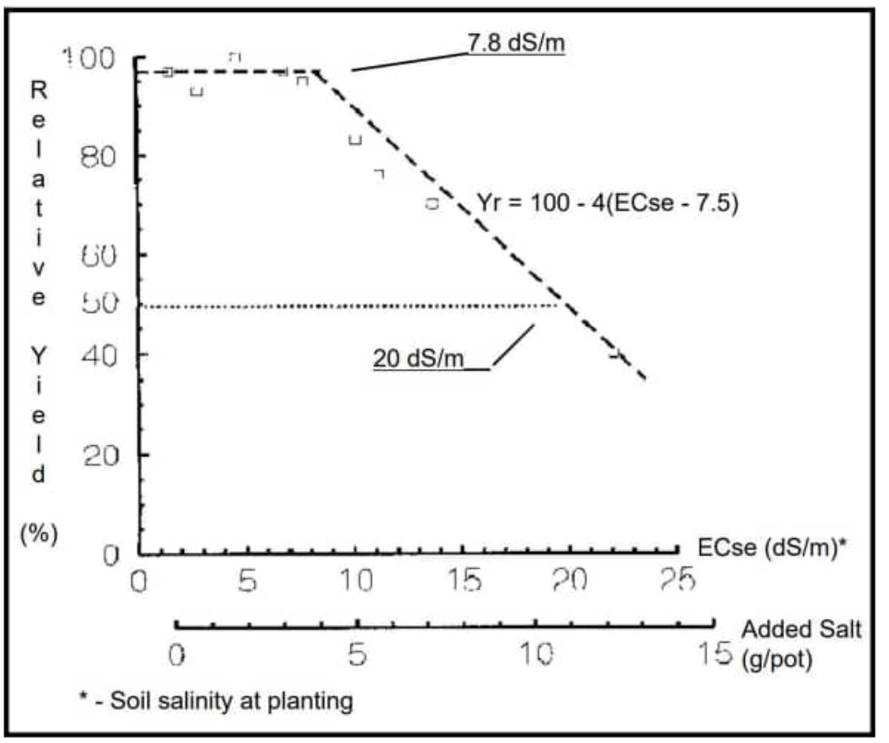
The following article is a summation of **Mr. Mike Materne's** presentation at the recent Vetiver Conference in Malaysia. Mr. Materne is with the United States Department of Agriculture's Soil Conservation Service in Baton Rouge, Louisiana.

"Though vetiver grass has been in Louisiana for over 100 years, it is just in the last 3 years that we have begun to look at it as a soil conservation species for what we refer to as "stiff grass" hedgerows. Our early field trials were conducted to look at vetiver grass' environmental tolerances — its water, nutrient and soil needs, primarily. Though we have had access to a number of vetiver accessions from India through the Soil Conservation Service's Plant Materials Centers, the accession which we have been using in our field trials is the "Sunshine" vetiver from Sunshine, Louisiana. This particular accession was obtained from **Mr. Eugene LeBlanc** whose family has grown vetiver for generations."

"Our field testing of vetiver hedgerows has been mostly carried out with the military. Vetiver hedgerows have been established by the SCS to test their ability to control gullies and arrest sediment flows in a tank testing ground at Ft. Polk, La. Planted in May 1990, the hedgerows have established well and begun to trap sediments. During 1991 we had record rainfall (wettest year on record) and under these extreme conditions the structural integrity of the vetiver hedges in the active drainageways has not been compromised — more than 50 cm of sediments have built up behind the hedges despite their not being fully closed yet. Based on our three years experience we can say that vetiver grass has performed well up to our expectations."

"We can definitely say that vetiver grass is hydrophytic, but also grows well under the extremes of dry conditions found in Louisiana. Vetiver's main drawback is that it is not sufficiently cold tolerant to be useful across Louisiana, or the majority of the United States. Based on work by **Dr. Gill Lovell** at the Agricultural Research Service, the threshold value for vetiver appears to be a soil temperature of 5°F (-15°C)."

Figure 1. *Salinity response for Vetiver grass.*



Salt Tolerance of Vetiver - Presented at the Vetiver Workshop

The following article contains excerpts from the paper presented by **Dr. Paul Truong** at the recent Vetiver Conference in Malaysia. Dr. Truong is from the Queensland, Australia's Government Department of Primary Industries. The piece below is a summary of Dr. Truong's latest efforts on the saline tolerance levels of vetiver. A presentation of his earlier work was printed in Vetiver Newsletter #6 in "Excerpts From Effects of Soil Salinity On the Establishment and Growth of Vetiveria zizanioides". The following presents only the information not found in Newsletter #6.

Background and Method

In the previous series of trials, the effects of soil salinity on Vetiver were studied under an open system where water with various saline concentrations was used to irrigate the plants and excess water was drained off. Although weekly flooding was carried out to minimize salt accumulation in the soil, there were some doubts as to the critical saline values obtained from the trials.

This series of experiments

tem to overcome those doubts. The same soil and the same saline water were used and the range of soil saline levels were obtained by adding appropriate quantities of saline water to the soil. After drying out the soil was thoroughly mixed, fertilizer added, repotted in a strong plastic bag, and brought to approximately field capacity soil moisture levels before planting. The pots were weighed and brought back to field capacity soil moisture levels daily using de-ionized water. After 12 weeks of growth, plant tops were harvested.

Results

Figure 1 shows the relationship between relative yield and soil saline level at planting. The critical level was approximately 8 dS/m and the 50% yield reduction level was at 20 dS/m which is within the range obtained by the last series (15.5 to 24 dS/m). This trial confirms the findings of the previous series and using the US Saline Laboratory standards, Vetiver can be used on moderately saline (4-8 dS/m) and very saline (8-16 dS/m) soils.

In another trial where saline water was added to fully established plants results indicate that Vetiver growth was not significantly affected within the range of soil saline levels between 4.6 and 10.5 dS/m. This again confirms the results of the last trial.

Vetiver Grass In P.R. China - Presented at the Vetiver Workshop

The following article was presented by **Dr. Zhang Xinbao** at the recent Vetiver Conference in Malaysia. Dr. Zhang, of the Chengdu Institute of Mountain Disasters and Environment of the Academica Sinica and Ministry of Water Conservancy, heads China's Vetiver Information Network.

Photo 4. *Along the North-South Highway in Malaysia, Dr. Yoon is carrying out trials on the use of vetiver hedges to stabilize road cuts. In this area high rainfall results in soil "blow outs". The control area in the foreground of the photo is rapidly degrading while the vetiver plot on the far side remains stable.*

China has 22% of the world's population, but only 7% of the world's arable land. Not only the flat Valley plains, but also many hill slopes have been exploited for cultivation in upland regions in China. The extensive cultivation brings about severe soil erosion problems; a considerable amount of cultivated slope land has been degraded into bare rock slopes. Protecting cultivated slope land has priority over other aspects of soil conservation in China and traditional terraces are still the principal practice against soil erosion. Terraces require heavy labour and are very costly to build. For steep slopes (>20°), farmers do not like to adopt terraces because the terrace walls will occupy too much land; they are anxious to seek other cheap and reliable techniques to protect cultivated slope land against soil erosion.

Many thanks to Mr. Richard Grimshaw, who introduced the Vetiver Grass hedge technique into China in 1988 and promoted the technique to farmers and officers at all levels. Since then, the technique has been spread over 8 provinces in Southern China. Here, I briefly describe the application and dissemination of the Vetiver Grass hedge technique in China.

Biological Behavior

Temperature. Vetiver Grass has been planted experimentally in 9 provinces of Southern China and in 4 provinces of Northern China. The grass grew well during the summers in both Southern and Northern China, but it could not survive the cold winters in Northern China. Observations show that the grass sprouted when mean daily temperature was >12° C, grew normally at >17° C, and grew fast at >25° C. The grass could survive slight frosts and snows, but it died out whenever the soils froze. The subtropical climate of southern China up to the Yangtze River is favourable, but the temperate climate of Northern China is not.

Soil The grass has grown normally on various soils and with pH ranges from 5.0 to 8.5 — such as red soil, yellow soil, paddy soil, alluvial soil, and lithological soils. Fertile loams and sandy soils are the most favourable. Where soils are sticky or shallow and underlain by

hard bedrock, the grass grows slowly in the first year as the root development is difficult under those conditions; but it grows much better in the second year. Soil fertility has a great effect on the grass growth. For example, after one years growth a clump of vetiver grass had 30 to 50 tillers (on a lithological soil of weathered granite in Fujian) with fertilization, but only 10 to 15 tillers without fertilization.

Moisture Vetiver grass persists well under very dry soil conditions. The grass survived dry seasons without watering during 1990 and 1991 in the dry and hot valley of Yuanmou in Yunnan Province. The annual precipitation and average temperature there are 613.0 mm and 21.9 °C, respectively, and only 14% of annual precipitation occurs during the dry season (from November to May). The grass also grew well under very wet soil conditions based on observations in a vetiver grass nursery located on very wet land and surrounded by rice fields in Dujiangyan City, Sichuan.

Pests and Diseases Paddy borers were reported in all planting places in Southern China. In the worst case, about 39% of the grass was effected by the borer. In the drier and hotter valley regions of Yuannan, the borer problem was not severe. Armyworm has been reported to occur in the humid and mild springs of Kuizhou and Sichuan. Both problems were controlled by using pesticides. A smut was found growing on vetiver this autumn in the garden of the Chengdu Institute of Mountain Disasters and Environment.

Photo by James Smyle

Photo 5. *A hillside road in Malaysia stabilized by vetiver hedges. The hedge, in controlling runoff over road's edge, has protected the entire surface to the extent that native grasses are establishing themselves evenly across the road. Photo taken at one of Dr. Yoon's demonstration areas.*

Nursery Practices

Nurseries are usually set up on fertile land of sandy soil or loam with reliable irrigation. Manure is commonly used as a base fertilizer. Slips with 2-3 tillers are planted in a ploughed furrow that is 15-20 cm deep. Planting density is 30x40 cm or 30x30 cm. One mu (.067 ha) of nursery needs about 250 kg of planting material. After the planted slips begin to turn green, human waste or nitrogenous fertilizers are used as top dressing. Survival rates varied from 45-95% in 1990, mainly depending on temperature and soil moisture conditions. Analyses of observational data from various places showed that vetiver grass should be planted when the mean daily temperatures are higher than 15° C. In 1991, the survival rates of vetiver in most nurseries was higher than 90%. In Deyang, Sichuan vetiver was split and replanted 4 times in 1990. The original 2 mu (.13 ha) nursery was enlarged to 10 mu (.67 ha) and 15 tons of planting material was produced from 250 kg. The nursery reported that, once established and growing vigorously, the grass was kept pruned back to 50 cm to promote tillering. In Chongren, Jiangxi Mr. Zhou has successfully used stem cuttings to multiply vetiver grass.

Application and Dissemination

Vetiver Grass was first introduced into Hainan Island from India as a perfume oil plant in the 1950's. It subsequently was planted in Fujian, Guangdong and Zhejiang provinces for this purpose, however, farmer interest declined as root prices were low. Since 1988 the technique of using vetiver for soil conservation has spread over the 8 provinces of Southern China, with support from the World Bank, Water Conservancy Ministry, Agriculture Ministry and local governments. The first field workshop of Vetiver Grass in China was held in Saowu, Fujian, in October 1989. In the workshop, two Ministries decided to set up a 'Vetiver Grass Network" based at the Chengdu Institute of Mountain Disasters and Environment. The Network has 150 members now, and has edited and published 9 newsletters.

Vetiver In Fujian and Jiangxi

In Fujian and Jiangxi, under the World Bank-financed Red Soils Project about 1000 hectares of arable land, mainly valuable tea and orchard terrace land, have been protected by using vetiver grass hedges; scarcity of planting material has constrained

Water (%)	Ash (%)	Raw Fat (%)	Raw Protein (%)	Raw Fibre (%)	Other (%)
78.7	1.8	0.4	3.3	7.1	8.8

***Table 4**. Nutritional analysis of vetiver grass from P.R. China.*

orchard terrace land, have been protected by using vetiver grass hedges; scarcity of planting material has constrained this effort. The grass has mainly been planted on terrace edges to strengthen earth banks. Farmers have used grass cuttings as a mulch in their orchards. Vetiver grass hedges have also been successfully used to control slope failures in weathered granite hills (a mixture of water erosion and gravitational erosion) in Xingao County, Jiangxi. Contour hedges were planted on bare slopes of the loose weathered granite as a pioneer species to provide stability. Afterward, trees were planted on the accumulated soils captured by the hedges and by year 3 the previously bare slope was totally covered with young pine trees, various shrubs and grasses.

Vetiver In Sichuan Province

In 1989 Sichuan Province received 20 kg of vetiver grass from Jiangxi. It was experimentally planted In four counties and grew well. In 1990, 12 tons of planting material obtained from Fujian was planted in 6 nurseries across the province and 200 tons of planting material were produced by spring of 1991. In April of 1991 a Vetiver Grass workshop was held in Sichuan. At the workshop, the Provincial Soil Conservation Department decided to set up twenty mu (1.33 ha) of trials in the hill and mountain areas of eastern Sichuan. Most of the vetiver grass hedges were planted on terrace edges to protect them; cuttings from trial areas are now being used to feed cows and fish. Additionally, vetiver grass hedges have been successfully used to stabilize roadsides and irrigation ditch banks.

Vetiver In Yunnan Province

In Yunnan province, vetiver grass was experimentally planted in the dry and hot valleys of Yuanmou and Dongchuan in 1990. It tolerates the dry climate well. Two nurseries of 10 mu (.67 ha) were set up in 1991 and trails on protecting cultivated slope land without terrace and of controlling severe soil erosion on bare rocky slopes in debris flow gullies will be initiated in 1992.

Vetiver In Hunan, Guizhou, Zhejiang and Guangdong Provinces

In Hunan, Guizhou, Zhejiang and Guangdong, vetiver grass has been experimentally planted and growing well since 1990. Nurseries to multiply the plant for trial plantings have also been set up in each. In Hunan, a trial was set up to use vetiver hedges to control severe soil erosion in tea oil (camellia) orchards.

Ecological & Economic Benefits

In Jianyang, Fujian two runoff plots were set up on cultivated land with a slope of 30° to test soil and water conservation benefits of vetiver grass hedges. The experiment ran from May 1990 to September 1990. The treatments were cultivation up and down slope with a sweet potato crop and the same treatment, but with three across slope vetiver hedges. Each plot was 20m in length and 5m in width. Data showed that water and soil losses decreased 56% and 95%, respectively, from the vetiver.

In Anqi, Fujian, vetiver grass hedges were planted in April 1990 on 2 ha of nearly bare slopes of weathered granite to control severe sheet and rill erosion. The vertical interval between adjacent hedges was 2 m, slopes were 10°. Two years later, comparing data from the two runoff plots (1 control plot, 1 vetiver plot) showed that water and soil losses decreased 25% and 70% from the vetiver grass plots.

Cost data from Sichuan shows that the cost of terracing cultivated slope land is about 300 Yuan per mu (about US$ 825/ha). It is only about 60 Yuan per mu (about US$ 165/ha) using vetiver grass hedges.

Direct economic benefits from Vetiver grass may the crucial factor of whether farmers adopt the grass hedge technique for soil conservation in China. Young cuttings of Vetiver grass have been used to feed cows, goats, pigs and fish in China. Nutrition analyses show that the cuttings are good livestock fodder (Table 4). In 1990, the Pinshan Soil Conservation Station, Pinshan, Sichuan, used Vetiver grass cuttings as fish fodder and produced 1396 kg of fish with 5 tons of vetiver grass and 2 tons of rye grass. In 1989, fish production of the station was 1156 with 6.5 tons of rye grass. The Vetiver grass nursery in Deyang, Sichuan sold young cuttings of vetiver grass to a milk cow farm in 1990. The price was 0.1 Yuan per kg (US$ 18.4/ton) of young cuttings. It is estimated that the vetiver grass hedges in 1 mu (.067

ha) of cultivated slope land (about 200 m in length) can produce 500 to 1000 kg of young cuttings. It means that farmers can get 50-100 Yuan per mu (US$ 9.2 to 18.4) from vetiver grass hedges. It was reported from the Red Soil Project that Vetiver grass cuttings were used as a mulch material instead of rice straw in orange orchards; this would equal a saving of about 100 Yuan material costs per mu for the orchards (US$ 275/ha) if vetiver hedges planted in the orchards supplied the mulch instead.

Discussion

From present experience, the following points can be made regarding vetiver use and adoptability by farmers. First, the problems with adoptability are that the farmers are not yet very interested in Vetiver Grass hedges in some areas because: i) vetiver grass is not a high value plant and land for cultivation is very limited; and ii) crop yield does not appear to increase in the first year, though it will apparently increase from second year.

Second, I think that without subsidies the technique would be mainly applicable to: i) protection of cultivated slope lands in remote mountain regions where cultivable land resources are not too limited; ii) to control severe soil erosion in areas too difficult for other soil conservation practices, such as the granite mountain and hill regions in Southern China and the dry and hot valley regions in southeastern China; and iii) to protect banks of canals, ditches, roads, highways and railways as a bio-engineering method.

Finally, I think that Vetiver grass hedges can be considered as part of an ecological agriculture system in the mountain and hill regions of southern China. The hedges can protect cultivation land, the young cuttings of vetiver grass and crop straws are used as livestock fodder/bedding, and the livestock manure is returned to cultivation land. I propose to set up an experimental vetiver grass eco-agriculture demonstration farm. If it succeeds, vetiver grass hedges will have a bright future for protecting cultivated slope land in most of the mountain and hill regions in China.

Golden Hope Plantation's Vetiver Experience - Malaysia - Presented at the Vetiver Workshop

The following article by **Drs. Khairudin Hashim, C.H. Teoh and Ismail Hamzah** was presented at the recent Vetiver Conference in Malaysia.

This paper reports early experiences on the utilization of vetiver for erosion control in Golden Hope plantations. Our interest in vetiver grass was aroused by the World Bank's handbook: "Vetiver Grass - The Hedge Against Erosion". Planting materials were obtained locally from Ciba-Geigy and the Malaysian Agricultural Research and Development Institute (MARDI). Slips in small polybags were obtained from Ciba-Geigy (4 slips total) in December 1989 and MARDI (12 slips total) in May 1990. These 16 pieces of materials were multiplied by conventional and micropropagation techniques for planting on our estates for erosion control. In September 1990, 2 slips of vetiver from India referred to here "India grass" were received from Mr. R.G. Grimshaw of the World Bank; they are currently under multiplication. If our work confirms vetiver to be cost-effective, commercial scale planting could be considered in estates where soil erosion is likely to be a problem

Early experience with conventional propagation revealed that vetiver from CIBA-GEIGY and MARDI multiplied at about similar rates as shown in Table 5. The materials were raised in cylindrical plastic containers 27.5 cm in diameter and 30.0 cm in height. For the low moisture regime, two holes were made at the bottom of the containers while for the high moisture regime the two holes were located on the sides at 10 cm from the bottom of the containers. The soils used were Munchong series and the vetiver plants were fertilized once with Nitrophoska Yellow (15:15:6:4) fertilizer at 5g/container two weeks after planting. There were no differences in multiplication rates of vetiver grown between different moisture regimes or the two sources. This was not unexpected as Ciba-Geigy materials supposedly originated from MARDI.

***Table 5**. Multiplication rates of vetiver from two different sources in Malaysia*

Source	Moisture Regime	No. of tillers 21 days	47 days	101 days
Ciba-Geigy	Low	3.8	11.7	32.7
	High	4.4	10.7	30.6
MARDI	Low	2.7	8.2	27.3
	High	3.3	11.2	30.3

Soil Condition	No. of tillers 5 months	8 months
Subsoil	4.8	7.6
Topsoil	4	29.1

***Table 6.** Multiplication rates of vetiver under two soil conditions.*

No direct comparison was yet been made between MARDI and India grass as the latter was acquired much later. We were more interested in multiplying them to serve as stock materials. After one year, the two slips have been multiplied to 1,134 slips and outplanted in the ground. India grass was observed to be very vigorous, it also has several different characteristics from the MARDI vetiver. Its leaves are bluish green and it readily produces culms (ed. note: culm = a stem with joints) whereas the MARDI vetiver possesses green leaves and does not produce culms as readily.

As we are using vetiver solely for erosion control we have resorted to minimum inputs in our approach to establishing vetiver hedges. A comparison of the multiplication rates of vetiver under two soil conditions viz. subsoil by the edge of a road and on a topsoil as a fence around a nursery, are recorded in Table 6.

Initial growth was slow in both soil conditions, however, the rate of tillering increased markedly at the eighth month in the vetiver grown on top soil as compared to that grown on sub-soil. It was seen that our planting of single slips at 50 cm proved too far apart to form a rapid continuous hedge. From this, it is obvious that the planting interval of 10 - 15 cm recommended by the World Bank would be more appropriate to achieve quick hedge formation. The closer planting intervals should be considered for sub-soils or poorer soils. Use of multiple sllps could ensure even more rapid closure of the hedge.

In establishlng a vetiver nursery using slips, weeds were seen to overwhelm the grass. As manual weeding is both laborious and expensive, a trial was undertaken to determine six herbicides for eradication of broadleaf weeds (*Mimosa invisa* and *Boreria latifolia*) and grasses (*Paspalum conjugatum* and *Axonopus compressus*) growing among vetiver. Herbicides were applied using a knapsack sprayer at an equivalent 400 litres of spray solution/ha. Metsulfuron-methyl provided the best control of broadleaf weeds with no effect on vetiver and grasses. Acceptable kill of *B. latifolia* was obtained with bentazon, 2,4-D amine and fluroxypyr, however, they were ineffective on *M. invisa* and grasses. Glyphosate was effective on grasses while fluazifop-butyl was only effective on *P. conjugatum*. Unfortunately, both were phytotoxic to vetiver, particularly glyphosate. It is of interest to note that in the treatments where glyphosate was applied immediately after trimming of the vetiver good control of the other grasses was achieved with minimal scorching effect on vetiver.

Using the micropropagation technique, vetiver was multiplied and supplied to 12 Golden Hope estates in peninsular Malaysia and Sabah. The significant advantage of the micropropagation technique is that large numbers of plantlets could be obtained within a short time and furthermore, production of plantlets may be regulated or programmed according to demand. Using internodal stem cuttings of matured tillers, the rate of multiplication is from 8 to 16 fold wlthin four weeks. Thus, if one begins with 1,000 shoots initially, within four weeks the total number of shoots available would he between 8,000 to 16,000 shoots. Once the base number of shoots for subculturing is available, it would be a matter of growth room space and demand that would determine the volume of production necessary for a particular month.

Although vetiver could be propagated from stem nodal cuttings by conventional means the rate of lateral shoot development is slow compared with micropropagatlon. The percentage of lateral shoots from such cuttings after four weeks is about 70%, and root formation is sparse. By the in vitro method roots are usually readily formed within two weeks after the multiple shoots have been transferred from the multiplication stage to the rooting medium. Once they are removed from the rooting medium and transferred into polybags vigorous growth occurs and the survival rate is almost 100%.

Using internodal stem cuttings of matured tillers, the rate of multiplication is from 8 to 16 fold wlthin four weeks. Thus, if one begins with 1,000 shoots initially, within four weeks the total number of shoots available would be between 8,000 to 16,000.....

For long distance transportation vetiver plantlets are sent out as bare rooted material from the production centre to the site of nursery establishment. The shoots are usually removed from the rooting medium and wrapped with moist paper towels. So far we have successfully established vetiver grass on estates in Sabah via this method. The establishment success was reported to be almost 100%.

To date, more than 14 km of vetiver hedge have been established for erosion control. Growth of vetiver has been satisfactory and they are performing as expected. The labour cost for field planting of vetiver in

small polybags into the field was about $99 per 100m of hedge (about US$40). However, using bare root slips from established stocks, the field extraction and planting costs was $47.50 per 100m of hedge (about US$19).

Acknowledgement

The authors would like to thank Golden Hope Plantations Berhad for permission to present this paper. We would like to record our appreciation to **Mr. K.H. Yeow** of World Bank for introducing us to vetiver and **Ciba-Geigy, MARDI** and **Mr. R.G. Grimshaw** (World Bank) for providing our initial vetiver stock material.

From the International Center for Tropical Agriculture (CIAT), Cali, Columbia

Dr. Douglas Laing, Deputy Director General of CIAT writes :

In Newsletter #7 of November 1991 I promised to bring the Network members up-to-date on the research conducted at CIAT on erosion control in cassava production systems. We at CIAT have been researching this subject for many years. Recently, various initiatives have come together in a series of experiments being conducted in a collaborative project between CIAT and the University of Hohenheim. The results reported here are the work of **Mr. Martin Ruppenthal** who is about to leave CIAT to finish writing his PhD thesis in Germany.

The long-term treatments at two locations involve a series of cultural options that we have developed over the years, compared two cassava treatments viz: the system used by farmers in the region (treatment #2 -planting cassava at about 10,000 plants/ha in rows 1m apart, no other cultural practices). The other treatment (#3) is cassava planted on (about) 30 cm high contour ridges; involving a considerable amount of manual labor. Treatments 4, 5 and 6 were designed to study cover species (Zornia, Centrosema and kudzu) underplanted beneath the cassava to provide not only groundcover but soil improvement possibilities. Treatment 7 is cassava planted on the flat with elephant grass (*Pennisetum purpureum*) living barrier strips where the grass occupies about 25% of the total plot area. The advantage of this system would be that elephant grass could be used for fodder.

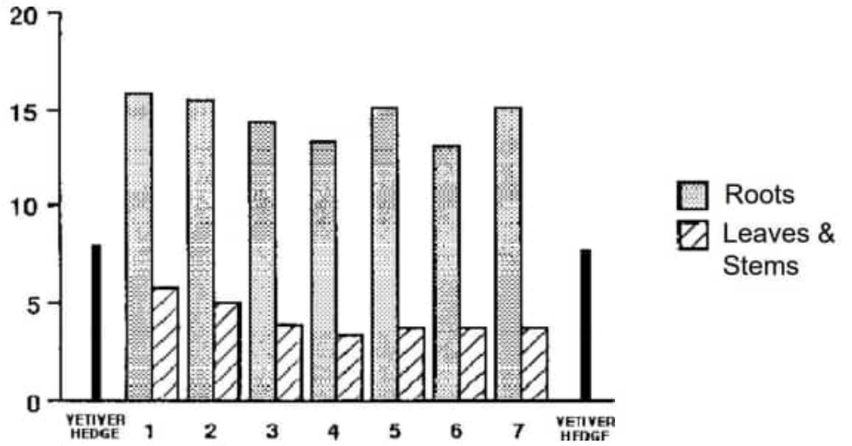
Treatment 8 is cassava planted on the flat with vetiver grass barriers occupying about 12.5% of the plot area. The vetiver grass, not the cassava, is underplanted (at the same time as the planting of the cassava) with the forage legume *Arachis pintoi*. All these treatments are compared to a clean weeded, bare fallow (treatment #1) where the soil is allowed to erode in accor-

Table 7. *Cassava and forage productivity, soil loss and runoff data for a range of cassava production systems compared to bare fallow on an Oxic Dystropept[1] at CIAT's Santander de Quilichao Station, Colombia (1,000m altitude; growing season rainfall, 10 months 1240mm)*

System	Cassava Fresh Root Yield, t/ha [2]	Forage Yield t/ha	Runoff mm (10 months)	Runoff % Rainfall	Soil Loss t/ha (11 months)
1. Bare Fallow	na	na	144.0	11.6	142.0
2. Cassava on Flat Cultivation	35.7	na	46.0	3.7	8.3
3. Cassava on Contour Ridges	35.6	na	44.0	3.5	3.1
4. Cassava Underplanted with Zornia	27.2	3.4	80.0	6.5	27.4
5. Cassava Underplanted with Centrosema acutifolium	31.8	3.4	38.0	3.1	12.8
6. Cassava underplanted with kudzu	20.7	2.9	43.0	3.5	15.4
7. Cassava on Flat with Elephant Grass Strips [3]	23.8	6.3	50.0	4.0	4.0
8. Cassava on Flat with Vetiver Grass Hedges [4]	34.0	1.1	45.0	3.6	1.3

1 - Acid soil (pH 4.2), Al saturation 50-85%, low nutrient status in shallow A horizon (15-25cm); average slope 0-15%.
2 - Cassava yields for 11 months (1990-91); Vetiver plots planted one month after other treatments thus cassava yield for treatment 8 was adjusted to an 11 month basis using growth in root yield per day data available from a similar experiment on the same station in the same year.
3 - Area occupied by elepahant grass is 25% of the plot.
4 - Area occupied by vetiver grass is 12.5% of plot area; Vetiveria zizanioides was transplanted and under planted (only under grass barrier) with Arachis pintoi at time of planting cassava.

Figure 2. Cassava/Vetiver -- Contourbarrier; Yields per row (each row contains six plants) in kg of fresh roots and leaves and stems.



dance with the rainfall received.

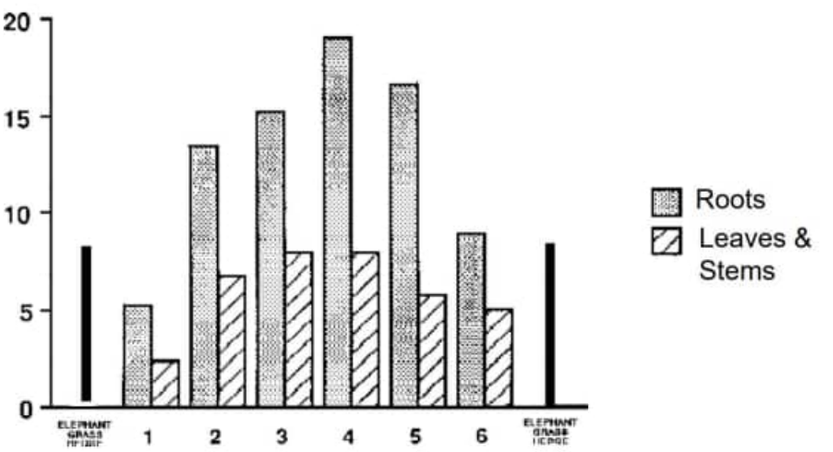
The data in Table 7 shows the final results from the first year at one site in terms of fresh cassava root yield, forage yield from the associated legume or grass species, runoff (and runoff as percentage of rainfall) and soil loss in tons of dry soil/ha over an 11-month period. The data clearly supports the view that vetiver grass is by far the best living barrier that CIAT has evaluated in the sense that the yield of cassava has not been affected, i.e. considering that 12.5% of the plot area is occupied by the grass strips, and given that the vetiver grass was only established at the same time as the cassava.

Runoff in the vetiver grass plots was extremely low representing only 3.6% of the total rainfall received and the soil loss was an insignificant 1.3 tons/ha compared with 142 tons/ha in the bare fallow plot. These results are extraordinary considering that the vetiver was only established at the same time as the cassava was planted whereas the elephant grass had been pre-established long before the planting of the cassava. The *Arachis pintoi* is now well established forming a dense mat under the vetiver grass hedge and is helping to stop erosion and presumably is providing nitrogen to the vetiver grass. As the soil and nutrients accumulate on the uphill side of the vetiver it is expected the Arachis will produce more fodder in coming years.

In Figures 2 and 3 we show the competitive effects of the two grass species on cassava in terms of per row yields at various distances from the grass strips. You can see that cassava growth was not affected by the vetiver grass whereas the elephant grass had severe competitive effects (probably root zone competition) on cassava.

We have studied the rooting pattern of the vetiver grass on an acid oxisol soil (**ed. note** - *oxisol = ferralsol in FAO taxonomy*) at the CIAT-Quilichao station. It is clear that the species has a cone-shaped root system where the major roots penetrate more or less vertically and then fan out slightly at deeper depths — in these highly aluminum toxicity-affected subsoils. Analysis of the vetiver grass roots have shown it to be extremely mycorrhizal with three fungal species identified on the same roots providing colonization levels greater than 80%. The demonstrated vigor of vetiver on very poor soils is clearly related to this phenomenon.

Figure 3. Cassava/Elephant Grass Contour barrier; Yields per row (each row contains six plants) in kg of fresh roots and leaves and stems.



The one major doubt we have with respect to vetiver is related to its palatability and digestibility for bovines. If adoption is to be successful in the region we have to find an economic use for the grass strips. We are carrying out digestibility studies (in-vitro and in-vivo) to find how vetiver grass compares with other tropical grass species in terms of some critical parameters.

Once again we have proved that there is nothing new in the world. In our on-farm research with vetiver and limoncillo we have uncovered the fact that vetiver grass (known as 'Tiva' to the local people)

"We are convinced at CIAT, both in our on-station and on-farm research with farmers in the mid-altitude acid soil tropics, that vetiver grass is probably the best living barrier one could possibly ask for in terms of its low competitivity with the associated crop and its extremely effective erosion control ....."

has been growing in the region for many years. We visited a farmer near Jamundi Valle (1000m altitude) who has planted vetiver grass around his house to stop the land from slipping away, thus stabilizing the foundation. Unfortunately, he had not planted the grass in his cassava field which is eroding very heavily nearby. Tiva has been grown in the Valle del Cauca for many years and one of the reasons it has not spread is probably because of its apparently low palatability to bovines.

In response to this we have made a small collection of some of the local vetiver grass materials that have been planted by farmers and found some variation among accessions in leaf 'softness'. Included in the above studies on digestibility is one of these 'softer' selections. If any members of the Network have comments to make on this issue we would be delighted to receive them. The accession originally obtained by CIAT for our work was found growing in the botanical garden at the National University in Palmira. CIAT now has small quantities of sexual seed of this accession if Network members are interested they should contact **Dr. M. Iwanga** (see editor's note below). Obviously we will continue to look for more such variation including material for high elevations in the tropics.

The above discussion on palatability for bovines and the possibility that there is variation within vetiver grass points to the urgent need for a breeding program devoted to this activity somewhere in the world. I would urge members of the Network to think about this and to contribute accessions from various sources to somebody who could begin a breeding program. This program would have to be associated with scientists who can measure palatability and digestibility (in-vitro and in-vivo) so that we can see if we can come up with a fodder grass which is more acceptable to animals and without losing vetiver's superb features as a hedge against erosion.

We are convinced at CIAT, both in our on-station and on-farm research with farmers in the mid-altitude acid soil tropics, that vetiver grass is probably the best living barrier one could possibly ask for in terms of its low competitivity with the associated crop and its extremely effective erosion control characteristics. Terraces are already forming behind the vetiver grass and the second year's harvest seems to be pointing toward longer term benefits. We will keep the members of the network posted on these results as they come to hand. Contacts with CIAT for the immediate future should be made through **Dr. Karl Mueller-Saaman or Dr. Mabrouk El-Sharkawy** in the Cassava Program.

Editor's Note : *The Network urges extreme caution when dealing with vetiver propagation with seed. One of the most important characteristics of vetiver grass is the fact that it can be introduced with little or no fear that it will become a weed. However, if one begins selecting for plants which are more easily established from seed, a problem may be created where one did not exist before.*

Herbicides for Vetiver Grass Control

P.E. Igbokwe, S.C. Tiwari, J.L. Burton and R.E. Waters, Jr., Alcorn State University, Larman, Mississippi.

This study investigated the efficacy of glyphosate, sethoxidim and fluazifop-p-butyl in controlling vetiver grass accession 271633 at 3 different stages of its growth in greenhouse ground-beds and in field plots.

Materials and Methods

Both greenhouse and field-experiments were used to evaluate 3 postemergence herbicides for vetiver grass control at Alcorn State University. The study investigated the effect of postemergence applications of 6.32 kg active ingredient (ai)/ha of glyphosate (N[Phosphonomethyl] glycine), 0.52 kg ai/ha Fluazifop-p-butyl ([R1-2-[4-[[5-[trifluoro- methyl]-2-pyridinyl]-oxy]phenoxyl] propanoic acid), and 1.04 kg ai/ha sethoxydim ([2]1[ethoxy-imino] butyl]-5-[2-ethylthiol propyll]-3-hydroxy-2-cyclohexen-l-one) on vetiver grass control. A completely randomized experiment design was used in this study. Herbicide treatments were either applied at one, two or three, months after the transplanting date to represent the immature, mature without seedheads, and mature with seedhead growth stages, respectively. Treatments were made with a backpack knapsack sprayer at 20 psi. Also, Ortho X-77 was used at the rate of 14.79 ml per 3.67l of

Greenhouse Experiment:

On March 25, 1991 seeds of vetiver accession 271633 were seeded in inserts containing Pro Mix BX® as a growing medium and placed on a greenhouse bench. On April 25, seedlings were transplanted into the greenhouse groundbeds with pH of 6.5. Plants, which were at 5-leaf stage with an average height of 12.7 cm, were spaced 20.3 cm within each row. Fertilization with Ca[NO3]2 was at the rate of 112.1 kg N/ha and irrigation was as needed. Visual ratings were used to determine herbicide effects on vetiver grass at one week, one month and two months after each application was made. The rating of 10 signifies complete control by herbicide,whereas 0 signifies no control.

Field Experiment

On July 29, 1991 seeds of vetiver accession 271633 were seeded as for the greenhouse study. Plots were disked, harrowed and made weed free before seedlings were transplanted one month from seeding. Transplants, which were at 5-leaf stage with an average height of 12.7 cm, were spaced 60cm x 90cm. Soil pH was 5.3. Fertilization with NH4NO3 at the rate of 293 kg/ha was based on soil test results. Moisture was limited to hand watering with can immediately after transplanting plus natural rainfall. Visual ratings were as in the greenhouse study.

Table 8. *Herbicide control of vetiver grass in the greenhouse.*

Herbicide	Rate Kg ai/ha	Weed Control Visual Rating Periods (Days From Herbicide Applications) 7[Y]	30[X]	60
Herbicides Applied One Month After Transplanting				
Control	0.00	0.0	NIL	NIL
Glyphosate	6.32	6.5	Perfect	Perfect
Fluazifop-p-butyl	0.52	2.1	Perfect	Perfect
Sethoxidim	1.04	7.9	Perfect	Perfect
LSD. 5%	--	0.5	--	--
C.V.. %	--	8.7	--	--
Herbicides Applied Two Months After Transplanting				
Control	0.00	0.0	0.0	0.0
Glyphosate	6.32	5.2	9.9	10.0
Fluazifop-p-butyl	0.52	2.2	8.7	8.9
Sethoxidim	1.04	1.4	8.4	8.7
LSD. 5%	--	0.9	0.6	0.7
C.V.. %	--	29.6	6.8	7.3
Herbicides Applied Three Months After Transplanting				
Control	0.00	0.0	0.0	0.0
Glyphosate	6.32	3.2	9.2	9.9
Fluazifop-p-butyl	0.52	0.6	2.6	2.8
Sethoxidim	1.04	1.6	2.6	2.8
LSD. 5%	--	0.7	2.4	0.8
C.V.. %	--	36.3	48.7	15.6

[X]NIL indicates no control: Perfect indicates complete control.

[Y] Based on a scale of 0 to 10. where 0 signifies no control, and 10 signifies complete control.

Results and Discussion

For the greenhouse experiment Vetiver grass control due to herbicides applied either one, two or three months from the date of transplanting is reported in Table 8. For herbicides applied one month after grass transplanting, sethoxidim had the highest initial grass control rating of 7.9 after seven days of application. A perfect [100%] control of vetiver grass was observed for all herbicide treatments after thirty days of applications. For herbicides applied two months after grass transplanting, glyphosate had the highest control rating of 5.2, 9.9 and 10.0 after seven, thirty and sixty days of application, respectively. Such values were significantly different from values due to other treatments and the control. For herbicides applied three months after grass transplanting, glyphosate had the highest control ratings of 3.2, 9.2 and 9.9 after seven, thirty and sixty days of application. The values were significantly different from values due to other treatments and the control.

For the field experiment (Table 9), herbicides applied one week after grass transplanting, sethoxidim and glyphosate had perfect control of vetiver grass after

Table 9. Herbicide control of field-grown vetiver grass.

Herbicide	Rate Kg ai/ha	Herbicides Applied One Week After Transplanting — Weed Control Visual Rating Periods (Days From Herbicide Applications) 7[Y]	30[X]	60
Control	0.00	0.0	0.0	NIL
Glyphosate	6.32	10.0	10.0	Perfect
Fluazifop-p-butyl	0.52	7.6	9.0	Perfect
Sethoxidim	1.04	10.0	10.0	Perfect
LSD. 5%	--	0.4	0.9	--
C.V.,%	--	6.8	3.3	--
		Herbicide Applied One Month After Transplanting		
Control	0.00	0.0	0.0	--[Z]
Glyphosate	6.32	10.0	10.0	--
Fluazifop-p-butyl	0.52	2.0	10.0	--
Sethoxidim	1.04	2.8	9.4	--
LSD. 5%	--	0.4	0.4	--
C.V.,%	--	6.8	3.3	--
		Herbicide Applied Two Months After Transplanting		
Control	0.00	--[Z]	--	--
Glyphosate	6.32	--	--	--
Fluazifop-p-butyl	0.52	--	--	--
Sethoxidim	1.04	--	--	--
LSD. 5%	--	--	--	--
C.V., %	--	--	--	--

[X] NIL indicates no control: Perfect indicates complete control.

[Y] Based on a scale of 0 to 10, where 0 signifies no control, and 10 signifies complete control.

Plants were killed by freezing temperature, hence no data collected.

one week of spray. These effects were significantly better than those due to fluazifop-p-butyl application and the control. However, control of vetiver after one month of application was not different for treated rows. All treated rows had perfect control due to herbicide applications after two months. For herbicides applied one month after transplanting, glyphosate had a perfect control after one week of application. This effect was significantly better than fluazifop-p-butyl, sethoxidim and control. After one month of herbicide application, grass control was also perfect for fluazifop-p-butyl and was significantly better than sethoxidim effect and the control. No data was collected two months after herbicide application since all plants were killed by freezing temperature. For the same reason, no data was reported for herbicides applied two months after transplanting, and no herbicide application was made three months after transplanting.

Conclusions

Findings suggest that glyphosate, fluazifop-p-butyl and sethoxidim will effectively control or surpress the growth of vetiver grass in greenhouse ground-beds and in field plots. Glyphosate which had a near complete control of mature vetiver grass with seedheads in the greenhouse is considered superior to fluazifop-p-butyl and sethoxidim at the rates of their applications in this study. A perfect control of vetiver grass can best be achieved by the application of these herbicides one month from grass emergence or earlier.

Acknowledgment

The authors wish to thank the **United States Department of Energy** and **Mississippi Department of Energy and Transportation Division, Economic and Community Development** for funding this project. Special appreciations to **Dr. Doral Kemper**, ARS National Program Leader, Soil Science, Beltsville, Maryland, and **Southern Regional Plant Introduction Station**, Griffin. Georgia for providing seeds and seedlings used to initiate this study; **Dr. Seth Dabney**, Agronomist, ARS Sedimentation Laboratory, Oxford, Mississippi, and **Mr. Thomas Collins**, Soil Conservationist and SCS Liaison to ASU for their valuable suggestions and assistance with materials for literature search: **Drs. Samuel Donald, Johnnie Collins**

Johnnie Collins and Charles J.D. Tilman for their encouragements: **Ms. Janice Carter** for typing the manuscript.

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Grimshaw's Remarks

(Continued from page 2)

the state of knowledge on hedgerows. The Chinese translation was done by the Middle-Reach Bureau of the Yellow River Conservancy Commission and interested individuals should contact them directly to arrange for copies."

"One last issue that I would like to bring up in this Newsletter is about where we stand today on the usage of vetiver grass. As a technology, contour barriers of vetiver grass for control of soil and runoff in farmer's fields have matured rapidly in the last few years. No longer should planners and field people who are proposing and promoting soil conservation technologies view vetiver grass as an "exception rather than a rule". Vetiver hedgerows are a proven technology that should be considered by all soil conservation ness is in the engineering areas — for example, stabilization of roadsides and ponds. With vetiver now engineers could construct effluent ponds on hillsides, something which has not been possible before. Another area of unexplored potential is the use of vetiver hedgerows to reduce non-point source pollution from agriculture and for the hedges themselves to help renovate runoff waters contaminated with agro-chemical residues. Preliminary work — such as that by ***Dr. Miyamoto*** *in Texas who found that vetiver, when planted in stormwater detention ponds, was a very efficient scavenger of the lead contained in urban runoff — points out that this remarkable plant has tremendous potential beyond that which we currently are trying to exploit. Let us get on with the needed work."*

"No longer should (people) view vetiver grass as an 'exception rather than a rule'. Vetiver hedgerows are a proven technology that should be considered by all...."

agencies and agricultural projects. Where we need to get on with busi

Letters From Vetiver Network Correspondents

HONG KONG -

Calorimetric Value of Vetiver - Dr. R.D. Hill, University of Hong Kong

From the viewpoint of farmers in developing countries, one of the objections to the use of Vetiver is that it gives limited direct return, especially from plantings for erosion control. As is well-known, vetiver is of indifferent quality as fodder for animals, fortunately so, in fact, since it proves to be remarkably persistent in the face of heavy grazing and, providing a fair stubble (20-30 cm) survives, its sediment-trapping abilities are substantially unimpaired by grazing or by cutting.

A possible alternative use of vetver is as fuel where quick heat is required, as in the traditional Chinese cooking method employing a stove fueled by dried plant materials and hemispherical iron pan (wok). Over very large areas of southern China wood, grass, fern and herbs are cut, sorted and dried for fuel; an activity that essentially maintains the vegetation as scrub and grass or fern land. In monsoonal ctimates, vetiver growth tends to slow or cease during the dry season. At this stage, when the grass becomes tough and unpalatable to animals, it is useful as a bedding material or as a mulch for crops; vetiver mulch breaks down rather slowly under dry conditions. Use as fuel is thus an alternative. This was investigated at Kadoorie Agricultural Research Centre, University of Hong Kong, employing a standard semi-micro method of analysis by bomb calorimeter. In February 1992 (dry season) samples were analysed in field condition i.e. without prior drying. The average moisture content (eight samples) was determined to be 11 per cent. Calorimetric analysis of the eight samples showed a mean gross heat of combustion of 18.6 KJ/g with a range from 19.1 to 17.8 KJ/g.

These results fall within the range of calorific values for grass, fern and herb species commonly used for fuel in southern China reported for oven-dried samples by Chen (in litt.) i.e. 21.5 to 16.5 KJ/g, with a mean of 19.3 KJ/g.

Future work will focus upon

Vetiver Variety	Water (%)	Crude Protein (%)	Crude Ash (%)	Crude Fiber (%)	Ca (%)	P (%)
Fujian	43.2	0.44	4.5	22.2	0.22	0.076
Indian	39.5	0.68	4.4	20	0.18	0.068

Table 10. *Nutrition analysis of two different accessions of (dry) vetiver in China.*

burning. It should be noted also that Vetiver may be of some value as feed for grass-eating freshwater fish such as grass carp. Trials will begin shortly at the South China Agricultural University.

Acknowledgements

Calorimetric determinations for Vetiver were made by **Ms. Dorothy Yu at the** Kadoorie Agricultural Research Centre, University of Hong Kong (**Prof. D.K.O. Chan**, Director) where also the comparative determinations were made by **Mr. Chen Rongjun.**

NIGERIA -

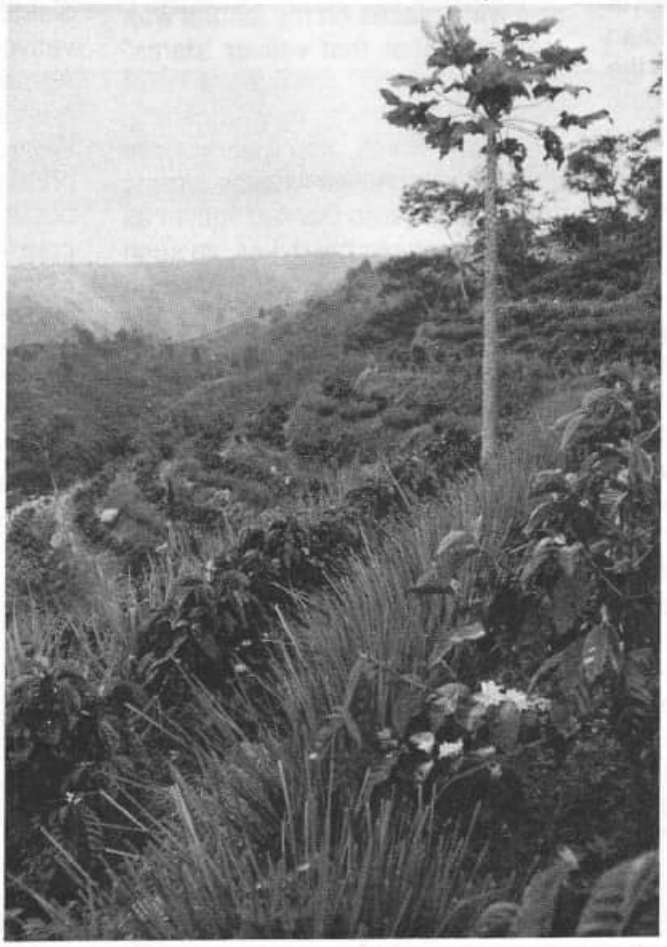
The following contribution to the Newsletter was received from **Mr. H.S. Randev**, a Forestry Specialist now living in the United States, who worked for a number of years with the Federal Agricultural Coordinating Unit (FACU) in Kaduna, Nigeria.

Vetiver Grass Technology In Nigeria

Vetiver grass, locally named 'Jemma' grass in the Northern states, grows naturally along the rivers Niger, Benue and their tributaries especially in fadama lands which are characterized by deep heavy soils with favorable moisture conditions. In its wild state the grass grows gregariously, but is localized, in the lowlands of Bauchi, Sokoto, Gongola, Borno, Kano, Plateau, Niger and Kwara states. Recognizing its usefulness and adaptability under varied savannah agro-climatic conditions, progressive farmers in Kano, Katsina, Sokoto and Bauchi states had planted Jemma grass over the decades for boundary demarcation, not realizing that it also possesses soil and moisture conservation uses. Under semiarid and sub-humid climatic conditions, clumps sprout and attain 1-2 meters height during the rainy season spanning over 3-5 months. The vegetative growth provides animal fodder either cut and carried or grazed in the open after the agricultural crops have been harvested. During the dry season green parts are relished by cattle. When protected, they flower and form panicles 15-70 cms long which are generally sterile.

Photo 6. *A coffee plantation protected by vetiver hedges in Indonesia.*

Photo Courtesy of P.C. Romkes



FACU, in cooperation with Agricultural Development Units (ADPs) initiated vetiver pilot activities in 1987. The first materials came from the Plant Introduction Bureau of the Indian Agricultural Research Institute in New Delhi. In1988, Mr. R.G. Grimshaw of the World Bank identified the local Jemma grass as *Vetiveria nigritana* which could serve equally effectively as the Indian *Vetiveria zizanioides*. During 1989 the first pilot plantings were made in farmers fields to test the effectiveness of Jemma for arresting soil erosion. To date, activities are confined to demonstrations, though farmers in the Mambilla Plateau adopted vetiver planting on a large scale. In this latter case, NGOs (mostly farmers clubs) were provided input and technical support including training in multiplication of vetiver stock for Sokoto state in 1990. As part of FACU support, information from

multiplication of vetiver stock for Sokoto state in 1990. As part of FACU support, information from the Vetiver Network was summarized in the form of technical notes and distributed to ADPs for dissemination to farmers. In addition, FACU compiled a technical note on Irrigated Nursery Techniques for Vetiver Grass Multiplication.

Vetiver grass multiplication and its use in land management forms an important component under the new National Agricultural Technology Support Project", which is currently in the negotiation stage. If funded, this project would have the capacity to provide about 24 million slips for farmers field over a 5 year period in the states of Kano, Bauchi and Sokoto.

P. R. CHINA -

Mr. Liu Zhou Lin from the Jiangxi Agricultural Development Corporation sends the Network the following information on the fodder value of vetiver grass :

"We ... collected 5 kg of leaves from each of the Indian (vetiver) variety (ed. note : this is the farmer selected variety from south India which is commonly used as a fodder grass) and the Fujian variety. We noted at the plot that the Indian vetiver is much shorter and darker green than the Fujian variety, which is tall and light green. After taking the cuttings we immediately drove to a dairy farm where we divided four dairy cows into two groups. We feed one group with the Indian and the other with the Fujian vetiver. To our surprise it seemed that the cows liked to eat it and there was no obvious difference between the cows eating of the two varieties; they ate all of both. We tried again on another farm with small amounts of vetiver given to 8 cows, only one cow refused it. I also sent samples of the two varieties to a lab for a nutrition analysis, the results are presented in Table 10."

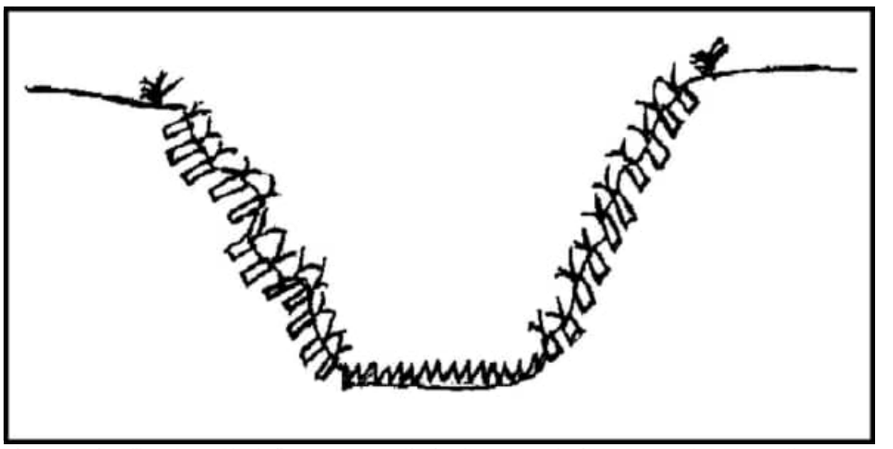


Figure 4. *Mr. Jano Labat suggests that vetiver slips be plugged in to gully banks rather than trench planted. He reports that with this method there is less chance of the slips washing out before they take root.*

SOUTH AFRICA -

Mr. Martin Bothe wrote to the Network to describe a unique application for vetiver grass, one which readers should note :

"I planted Vetiver right across the lowest spots within the low-lying places on my land. It was not long after that vetiver "dams" popped up and collected a lot of other grass, debris, mud, etcetera. The water which, after it works itself through the vetiver is now almost l00% clear. I also planted vetiver all across between my dykes. In such places it holds the water back long enough so that it soaks into the ground between the dykes. As a result, the water level rose in the boreholes which were drilled alongside the dykes. If people, governments, municipalities, mining companies, farmers etc. plant Vetiver my way then floods all over the world will be somewhat reduced and even avoided in many places."

Mr. Bothe included a hand drawing with his letter which shows his planting configuration, with the rows of vetiver planted across the low spots and up to higher ground so that flow will not bypass the hedges. He writes :

"When the lowest areas fill up, then such areas can be used to plant things such as creeping grasses."

TANZANIA -

Mr. Poul Richardt Jensen, Agriculture Adviser, HIMA-DANIDA, Iringa writes :

"We are just about to finish distributing about 50,000 splits of vetiver to farmers in the project area. Agreed, it is not very much but this is what we can handle this season. We will try to increase our nursery production to 100,000+ this year but at the same time we try to advocate the farmers own multiplication. Mostly because it seems as if the use of vetiver is ever going to reach anywhere then we will have to operate in numbers of many million splits and not just in numbers of thousands as today. And that will be difficult to manage in central nurseries."

ZIMBABWE -

Mr. Jano Labat, the Director of Vetiver Grass Stabilization (Pvt) Ltd. writes :

"...Right now we are going

through one of the worst droughts we have ever had. For the last four years we have received below 50% of normal rainfall and this year, so far, we are 20% below. We need a miracle to come through, otherwise the sugar industry will collapse."

"Another sad part of it is, that no rain means no vetiver to go out planting in the lands for another year, and another year means tons and tons of soil will be washed away with any little amount of rainfall that we might receive. I have written, I have travelled, I have shown the vetiver slides to many people; to Government officials, to farmers, to peasants. Everybody is impressed, you leave the meeting feeling good and expect a positive reaction, but in vain. I would like to send extracts from the Newsletter to our farming magazine, The Farmer, that I might reach more people. The only positive attitude I have received so far comes from G.T.Z., the German aid mission, but there again the drought is not helping."

"As a matter of interest I send you the best way that I have seen to plant vetiver in gullies : Plant the vetiver slips across the gully. When going up the banks, instead of making a trench, use an augur to drill holes at a 45 angle into which the slip is inserted. Caution must be taken that the roots do not end in a J at the bottom of the hole. To avoid J-rooting, once the slip is in the hole, ram the soil back lightly and pull the slip up slightly, and then ram the soil in firmly. By doing so the soil is hardly disturbed and remains firm in between the slips with less chance of the soil and the slips being washed away (see figure 4). If this idea is helpful to someone I will be happy.

Editors Note : *Mr. Labat's letter points out the need for not only for perseverance in introducing new technologies, such as vetiver, but also the critical need for good extension materials that can be self-explanatory, eye-catching or interest inspiring, practical and effective. Please, if you have any ideas, work on them, test them, refine them and then, let us pass them along to others. Remember to look at the article in this Newsletter on the latest round of Vetiver Awards where extension-oriented work is being emphasized.*

ADDENDUM

Just before we went to the print shop, Dr. Laing sent the Network the resullts from CIAT's second year of vetiver research (the first year's results are contained in this Newsletter). The results speak for themselves.

CIAT (International Center for Tropical Agriculture) reports on the second year's results in cassava systems with living barriers of Vetiver Grass and Elephant Grass.

Dr. Douglas Laing, Deputy Director General, writes as follows:

The results of the second harvest (1991-1992) are now available. The data on cassava yields, forage yields, soil loss and run-off are similar to the 1990-1991 cropping year (Table 11). The cassava crop in 1991-1992 was harvested at 11 months.

The data are remarkable. Cassava with vetiver barriers in 1991-1992 yielded higher than the traditional cassava system even though the vetiver grass occupied 12.5% of the plot area. The elephant grass and the other legume-based treatments reduced whole plot cassava yields significantly as was the case in 1990-1991. The yields on the actual area cropped to cassava was 26t/ha suggesting that the vetiver barriers are having a strong positive influence through factors such as soil fertility maintenance (i.e. reducing nutrient loss in run-off water or in eroded soil) or in water availability (i.e. by slowing down rate of run-off and conserving water for longer periods in the subsoil). This year the vetiver has had competitive effects on cassava yield in the first row next to the grass barrier but this was compensated for by the higher yields in the intermediate rows, i.e. giving a net positive effect on cassava yields for the whole plot area. It will be interesting to see the competitive effects of vetiver in the third cropping year which is now planted. The forage yields obtained are to be expected given the difference in plot area occupied by the elephant grass in relation to the vetiver barrier. Clearly the forage quality of elephant grass is superior to vetiver grass. The importance of breeding or selection to improve forage quality of vetiver without losing its superior qualities in soil and water conservation cannot be overemphasized.

On another matter we have had a response from **Dr. N. Vietmeyer** of the National Research Council (BOSTID) with respect to the advisability of exchanging sexual seed of vetiver grass. The concern was expressed that vetiver accessions with sexual seeding capacity could increase the potential of the species to become a weed. We at CIAT fully agree that this species is too valuable for human kind and the above outcome should be avoided at all cost. On the other hand, we feel that researchers will need fertile accessions for breeding to improve such characters as forage quality. we will definitely hold any shipments of vetiver sexual seed until this matter is clarified. It would be useful to have opinions from other members of the network. CIAT has oniy one accession which has actually produced any seed so far. The amount of seed produced is extremely low compared to most of the other tropical grasses with which we are working. Exchange of seed only between breeders could be an environmentally acceptable solution to this very real problem.

The University of Hohenheim- CIAT project has now taken vetiver and other grasses and legumes into on-farm conservation research in the Cauca Department of Colombia.

Farmer resistance to vetiver seems evident because of the lower forage quality of the species. This will be my last communication on this project. In future all enquiries should be addressed to **Dr. Karl Mueller Saemann, Dr. Mabrouk El-Sharkawy** or to **Dr. Masaru Iwanaga** (Genetic Resources Unit/ CIAT). The latter will be handling the matter of seed exchange (or not). It has been a pleasure to participate in this very exciting global effort on this excellent species.

Table 11. *Cassava and forage productivity, soil loss and runoff data for a range of cassava production systems for 1991-1992 harvest compared to bare fallow on an Oxic Dystropept [1] at CIAT's Santander de Quilichao Station in Colombia (1000m altitude, rainfall 1625 mm (11 months).*

System	Cassava Fresh Root[2] Yield, t/ha (11 months)	Forage Yield t/ha (11 months)	Run Off mm (12 months)	Run Off % Rainfall	Soil Loss t/ha (12 months)
1. Bare Fallow	-	-	195	12	210
2. Cassava on Flat Cultivation	22.7	-	81	5.1	4.6
3. Cassava on Contour Ridges	23.3	-	63	3.9	3.8
4. Cassava underplanted with Zornia	12.9	2.4	119	7.4	0.9
5. Cassava underplanted with Centrosema acutifolium	13.2	3.5	91	5.7	1.2
6. Cassava underplanted with Kudzu	16.0	1.9	91	5.7	4.0
7. Cassava on flat with Elephant grass strips[3]	16.2	4.6	93	5.8	3.5
8. Cassava on flat with Vetiver grass strips[4]	23.5	2.4	81	5.1	1.2

1 Acid soil (pH 4.2), Al saturation 50%-85%, low nutrient status in shallow A horizon (15-25cm); avg. slope 15%.
2 Cassava yields for 11 months; Vetiver barriers planted 12 months earlier.
3 Area occupied by Elephant grass is 25% of plot area.
4 Area occupied by Vetiver is 12.5% of plot area; *Vetiveria zizanioides* underplanted with *Arachis pintoi*.

The findings, interpretations and conclusions expressed here are entirely those of the authors and should not be attributed in any manner to the World Bank.

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER INFORMATION NETWORK, ASTAG*, WORLD BANK, NUMBER 9, NOVEMBER 1992

TABLE OF CONTENTS

Vetiver Seed For The Nursery	2
Using Native Populations	2
Different Cultivars	3
Nursery Management	3
Low Input Nurseries	6
Raised Bed Nurseries	7
Containerized Nurseries	8
Mechanized Nurseries	9
Alternative Propagation Methods	12
Tissue Culture	14
Commercialization	14
Vetiver Awards Reminder	15

THE NEWSLETTER

In Newsletter #7 (11/91) the Network sent out a questionnaire on the subject of the propagation of vetiver. Part of our concern in sending this out was to get at the question of how demand for vegetative material might be met on a large scale. In the questionnaire we asked for information from people and also requested them to tell us what information they needed. This Newsletter is in response to what people have told us and what they have told us they would like to know. Our intention is to provide information for each level of vetiver production from small-scale to large-scale; we also hope that this may provoke some further response on questions regarding propagation.

Questionnaire Results

In total we received 148 responses, of which 115 came from people who have vetiver. Out of those with vetiver, 89 see no problems with propagating sufficient material to meet future demand for establishing vetiver hedgerows, whereas 17 respondents did feel that there would be some problems. The rest either did not comment or were not sure. There were no apparent regional or climatic trends amongst those who responded in the negative.

Among the 17 who felt that future demand could not or would not be possible to meet, 6 reported poor nursery production rates and 3 responded that lack of funding and/or government support was the main constraint to meeting demand for planting material. The remaining individuals did not specify why they felt that future demand would not be possible to meet.

Of the 89 persons responding in the affirmative to the question about being able to propagate sufficient vetiver, nursery production rates were high for 18, moderate for 23, low for 10, and 5 relied on native grass populations; 2 respondents relied on containerized plant production using polybags. Those with high nursery production rates tended to be in tropical climates, about evenly humid and semi-arid; those with moderate rates tended to be in humid areas, and about evenly distributed between tropical and subtropical areas.

Photo 1. Vetiver's massive root system. Photo courtesy of Dr. P.K. Yoon

Proposed Strategies To Meet Propagation Needs

Those who responded to the survey generally did not seem to be concerned about meeting centralized targets or the size of areas that potentially could be covered. Their answers reflected an attitude that small-scale propagation by a large number of farmers, NGOs, locally-based projects, etc will solve the problem. Almost 80% of the respondents indicated that the long-term needs must be met through such a de-centralized approach. Other recommendations included micropropagation (tissue culture), containerized propagation, and large-scale government or commercial nurseries. Discussion of all of the above techniques are contained in this Newsletter.

Absolutely DO NOT Plant Vetiver Seed

Several respondents to the vetiver propagation questionnaire recommended using seed and this is something that we feel is an extremely dangerous idea. One of the

* - Asia Technical Department Agriculture Division

greatest advantages of vetiver is that it has not spread as a weed from seed and become a pest. The northern Indian-types of vetiver, however, which flower and seed freely do produce some seed which is viable and will germinate — usually only under a fairly narrow range of conditions such as are not normally found in agricultural areas (rainfed or irrigated). However, a program of propagation through seed would result in selection for plants with a greater potential for becoming invasive. In this fashion we could create our own weed problem. The Network requests that vetiver users take the responsibility to not begin, or, if already propagating from seed, to halt all seed-based propagation. Please be aware that it may only take one incidence of vetiver spreading from plants selected for their ability to sexually reproduce to cast suspicion on vetiver's use. We have a good technology, let us not lose it intentionally.

Obtaining Vetiver For The Nursery

Do Not Use Seeds ! The Network very strongly urges all people who are working with and selecting vetiver to avoid the use of seeds. Throughout the history of vetiver's movement around the world, up to today when it is found in almost every country on earth, we do not have any reports of vetiver's spreading as a weed from seed. Yet we know that there are accessions which flower and seed freely and whose seed can be brought to germinate. We consider that vetiver seed is not good for two reasons : 1) vetiver seed, when viable germinate under a fairly narrow range of conditions - conditions which are not normally found in agricultural areas (rainfed or irrigated). We consider this to be advantageous as then the plants do not spread and become pests and 2) plants from seed display a high degree of heterogeneity whereas clonal material is uniform; in a hedgerow a high degree of uniformity is desirable. Therefore, the Network urges extreme caution when dealing with vetiver propagation with seed. One of the most important characteristics of vetiver grass is the fact that it can be introduced with little or no fear that it will become a weed. However, if one begins selecting for plants which are more easily established from seed, a problem may potentially be created where one did not exist before. Select, collect, and use vegetative material, NOT SEED !

When collecting material bear in mind that there may be more than one cultivar of *Vetiveria zizanioides* available to you. It would be wise to put out trials in your area using as many different provenances of vetiver as possible. This is not to say that a start cannot be made with the planting materials on hand, rather that for long term promotion of vetiver as a conservation species it would be prudent to ensure having the best material possible for your area and conditions. Finally, when planting the collected material in your nursery, throw away older plant parts that have flowered or seeded. Once having flowered and gone to seed, vetiver (and all other plants) will exhibit reduced vigor and decreased growth rates. Use young, vigorous plant material both in planting the nursery and in establishing hedges.

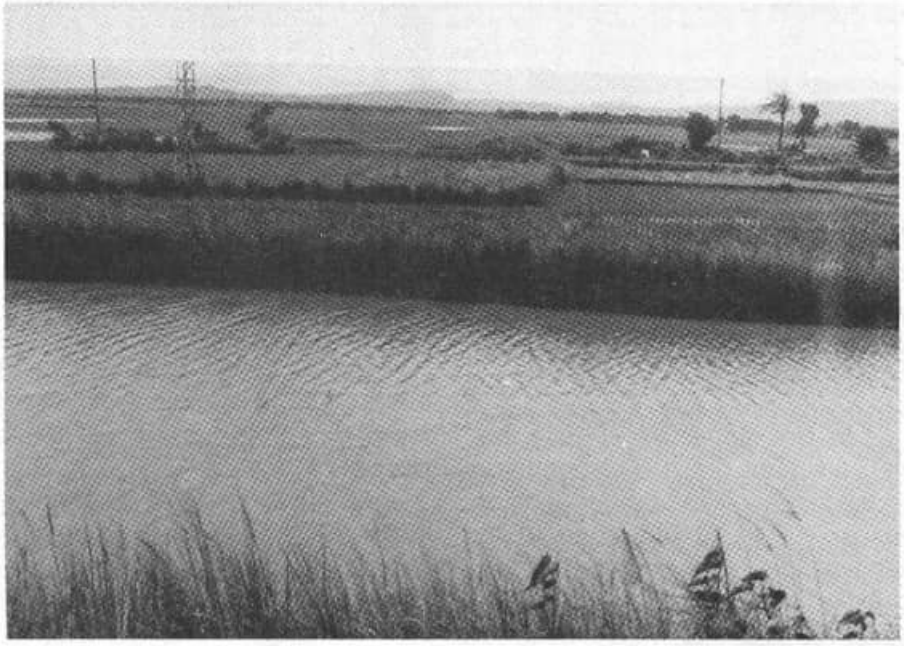


Photo courtesy of Dr. P.K. Yoon

Photo 2. Vetiver protecting a paddy field along a river in Bangladesh.

Using Native Populations Of Vetiver

The following is abstracted from a recent report by **Dr. P.K. Yoon** from Bangladesh :

With the ready availability of Vetiver growing wild in the country, the first reaction was that nurseries would be redundant. When needed, Vetiver could be collected and transported back for planting. However, the above assumption may be affected by : i) transport and collection costs and logistics; ii) adverse weather condition, e.g. the project team was supposed to collect the plant materials for planting in early July, but the collection was not carried out because of flood; iii) some of the Vetiver plants in the

field may be weakened by overgrazing.

In addition to the concerns that Dr. Yoon raises above, again, with collection from native populations there is the question of selecting types which reproduce more readily from seed. One must consider carefully the circumstances under which one finds the wild vetiver. If plants are non-uniformly spread along a waterway or within a flood plain or wetland, this would suggest that this particular type was not readily establishing from seed. If, however, there are large, uniform patches or areas of vetiver this may indicate a potentially weedy type. Even in this first case, caution is urged. Perform a few tests yourself on the germination rate of the seeds. If the seed readily germinates under controlled conditions, look for other sources of planting material where this is not a problem.

Different Cultivars of Vetiver : Their Specific Attributes and Superior Germplasm

This is an area where we are sorely lacking in information and it is becoming more and more critical. We know that there are differences between various accessions of vetiver and this is repeatedly borne out whenever comparisons are made between gross morphology and biomass production. We have strong evidence to suggest that vetiver from north India represents a different type than vetiver from south India. What we lack is specific knowledge that lends itself to improved management and plant selection. Any ideas out there how we can solve this problem? Any volunteers? This is perhaps the priority area for vetiver research at this time.

Nursery Management

How Long Should Vetiver Be Grown In The Nursery ?

Nursery establishment should take place sufficiently in advance of the optimal time for hedgerow planting in order that an adequate supply of material is assured. "Sufficiently in advance" will be determined primarily by management inputs and climate. Analysis of the information that came in on the propagation questionnaires showed no correlation between rainfall, minimum temperatures, or length of growing season and months in the nursery

Months In Nursery	Number of Slips: High Yield	Number of Slips: Average Yield
3	22	14
4	29	17
5	37	20
6	44	23
7	51	26
8	59	30
9	66	33
10	73	36
11	81	39
12	88	43
24	176	81

Table 1. Nursery production rates as estimated from information provided by respondent to the vetiver propagation questionnaire.

or yield of planting material from the nursery. Even the amount of time over which vetiver was grown in the nursery was not a particularly good measure of how much planting material might be produced. This suggests that the most important variable is the management which is put into nurserying....the better the management, the faster the plants grow and the higher the production. Good management equals good yield.

Undoubtedly climate does affect growth and even the best management cannot overcome all climatic constraints. In looking at the propagation questionnaires, the worst nursery production rates tended to be in colder locations. However, notice the word "tended", about one-third of the locations in which the best production rates occurred were colder and about one-third of the worst production rates came from nurseries in the warmer locations. Vetiver is a tropical plant. It prefers a warmer climate. It is also a C_4 plant, that means that as temperature rises, vetiver will continue to grow faster and faster as long as it is not constrained by moisture and lack of nutrients. Therefore, in areas where temperature is a constraint to nursery growth, the strategy should be to have the vetiver as well established as possible coming into the warmer months. Best estimates suggest that minimum soil temperatures above about15°C are necessary for growth to begin. Locate nurseries where soils warm the fastest in the spring, be sure that cold air drainage is good. Moist soils heat up and maintain heat better than drier soils. If possible, mulch the nursery with the vetiver cuttings going into the cold period. Produce strong plants, they resist cold better and grow faster — irrigate, fertilize and weed the nursery! Another suggestion from **Mr. Gueric Boucard** of Leakey, Texas is to burn back the vetiver if its leaves are killed by a frost. He says if you wait for it to dry out after the frost, then burn it, it will come back earlier and more rapidly in the next growing season.

In answer to "How Long Should Vetiver Be Grown In The Nursery?", we cannot answer that for you. Since it will depend on your local conditions, use your own judgement and experience ask the opinions of others who are good with plants and know your area. Manage your nursery so as to get the best production possible. What the Network can tell you is the average

Photo courtesy of Mr. R.G. Grimshaw

Photo 3. Roadside stabilization with vetiver in Malaysia. Plantings were established from vetiver nurseried in polybags.

nursery yields that were reported to us in the propagation questionnaires and they are reported to you in Table 1.

Nursery Soils

Sandier textured soils are preferred as this makes it much easier to lift the vetiver clumps at harvest. However, sandy soils are drought prone soils. It is by far the best practice to irrigate your nursery; in sandy soils it is an absolute necessity if you wish to achieve even average production rates. Network correspondents generally recommend sandy to loam soils. These types of soils can be identified by simple means. Moisten the soil and squeeze it in the hand - sands will stick together in a clump, but the clump will easily crumble when touched and handled. A sandy loam, will bear careful handling without breaking. A loam soil can be handled freely without breaking.

It is strongly recommended to avoid clayey soils for nurseries. To identify these soils, again, moisten the soil and squeeze it between your thumb and forefinger. If you can form "ribbons" with the soil it is clayey. If the ribbon breaks easily it is a clay loam. If the ribbon does not and is flexible, it is a clay. Neither of these two are recommended.

Reportedly, vetiver grows better under slightly acid soil conditions.

Nursery Preparation

Land should be prepared as would be done for any crop to provide a well-aerated rooting zone, clods broken up, etc. If available, it is always good to incorporate farm yard manure, animal manure (pig manure seems best), green manure, and/or oil seed cake during land preparation.

Planting of Vetiver

Irrigate the soils or wait until soil moisture levels are good, prior to transplanting into the nursery. Plow a shallow furrow to accomodate slips such that not more than 2 cm of the tops would be buried in the furrow. Do not worry about the amount of root on the slips, vetiver will establish without roots. Some persons with practical experience in growong vetiver report that residual roots on the slips serve no purpose at all. They contend that vetiver slips omly grow after they put out new roots. Plant 2-3 tillers every 15cm to 40cm depending on the level of inputs and time in the nursery. Nurseries where little fertilization and/or little or no irrigation is available should be spaced farther apart. Longer nurserying periods mandate wider spacings as well. Between rows, a spacing of 15cm to 40cm is also appropriate.

Fertilization

If possible, soil testing should be done to ascertain the levels of available soil nutrients and aid in deciding the nursery's fertilizer regime. Optimum levels of fertilization are not known at this time, however the benefits of fertilization to nursery production are certain. Work in the United States has shown an increase in tiller production of 56% one year and 183% the next year between unfertilized and fertilized vetiver (**Igbokwe, et al**, Vetiver Newsletter #7). This particular experiment was conducted using 241 kg/ha of 13-13-13 — 31 kg/ha total N, 14 kg/ha available P, and 25 kg/ha water soluble K — in soils with extractable nutrient levels of 68 kg/ha (moderate) and 216 kg/ha (low) of P and K, respectively. In India 250 kg/ha of di-ammonium phosphate is recommended. This is the equivalent of 53 kg/ha of N and 58/ha of P. **Mr. John Greenfield** had earlier noted that use of phosphate and nitrogen together was beneficial. It is also reported from India that split doses of urea at 45, 75, and 105 days after planting is beneficial. Doses of urea at 50-125 kg/ha — 21 kg/ha to 58 kg/ha N — were reported.

Irrigation

Irrigation is absolutely essential to good production rates in the nursery. The purpose of nurserying is to provide optimum conditions for the plant in order to maximize pro-

duction. Dryland nurserying of course can be done, but it simply will not produce the amounts of material that irrigated nurseries can. Irrigation, in combination with good management practices, can more than pay for itself by reducing the unit cost of planting material to insignificant sums. Without irrigation and management, labor costs will keep the unit cost of planting material high as production will be low. The only good alternatives to irrigation are nursery establishment in landscape positions which maintain adequate levels of soil moisture throughout the nurserying period (e.g. bottoms of gullies with watersheds over 10 to 25 ha, along stream banks, etc.).

In the semi-arid zone of India, on soils with low water-holding capacities, irrigations are given every 4 to 5 days for the first two months and about every 7 days thereafter.

Photo courtesy of Dr. P.K. Yoon

Photo 4. Attendees at the April 1992 International Vetiver Workshop inspect one of Dr. Yoon's hedges. Less than two years old, this well-formed hedge has already trapped a substantial volume of sediment.

Weeding

Nurseries should be weeded as necessary. Weed competition can affect nursery production. Unweeded nurseries in Andhra Pradesh, India were reported to produce 60% less tillers than weeded nurseries. Nurseries in Malaysia reported that vetiver grew well in competition with *Borreria sp.* and some sedges, though noted that *Borreria sp.* is a weak weed.

Establishment of nurseries in sand to loam soils will reduce labor needed for weeding. Row spacing to accommodate mechanical or animal drawn implements for inter-row cultivation may also reduce weeding costs.

While herbicides generally are cost-effective in nursery use, the Network has little information at this time on specific herbicides and their use along side of vetiver. From India, Atrazine is reported to be in nursery use and in Malaysia work is being carried out on this subject. It is reported that Roundup (glyphosate), Fusilade 2000 (fluazifop-p-butyl), and sethoxidimate will effectively kill vetiver (**Igbokwe, et al**, Vetiver Newsletter #8) and therefore are not recommended. Dr. Yoon, in Malaysia, has also reported that Paracol damaged vetiver tops when it drifted onto them unintentionally. In this case, however, the plants fully recovered within 2.5 months.

Pruning

From all accounts pruning increases tiller production; pruning on a monthly basis is suggested. Pruning below 40cm is not recommended at this time. According to our best information, pruning below this level may retard growth. Prunings can be used as mulch to reduce water losses and slow weed growth. If labor is expensive, a mechanized grass-cutter would would decrease labor input to less than 1.5 mandays/ha per cutting.

Pest Management

Fungal attacks have been reported within crowded nurseries in Malaysia (*Nigrospora sp.*, *Curvularia sp.*, and *Helminthosporium sp.*) by Dr. Yoon. Treatment consisted of topping the affected plots at 40cm and was effective.

In Weili County, Sichuan Province, P.R. China a so-called "sticky worm" — a 5cm long x 1cm in diameter worm with a red dot on its forehead — was found in their nursery and seemed to be concentrating on vetiver leaves to the exclusion of other available weeds and grasses. Control was achieved with a contact insecticide.

The Boucards in southern Texas report that they had severe damping off problems some 15 years ago when they first began planting vetiver. Control was achieved through application of fungicides. (**ed. note:** damping off, a common nursery disease, has not been reported in any other nurseries with which the Network is aware and so does not appear to be a common phenomena at this time.)

The Network has no reports of significant nursery pests or diseases.

Culling

A nursery should have the goal of producing only high quality, healthy, and vigorously growing plant material. It is only such material which makes any sense to plant, regardless of whether it is vetiver or any other plant. It is extremely foolish to waste time and resources planting poor quality material out in the field. It can cause frustration, extra labor, and even failure. To achieve the aim of providing farmers with good quality material one of the simplest things a nursery can do is just throw away any plant which does not look good. Production planning should allow for a minimum of 15% - 20% of total estimated production as being substandard. If in doubt, throw it out. Train yourself and/or your nursery workers to get rid of poor plants and poor plant parts. At harvest, throw out tillers which are not healthy and vigorous. Make sure that if you purchase vetiver, that you let it be known that you will only buy quality tillers.

Also, this is one area of nursery management on which the Network has little information. If you have a nursery, let us know what percent cull you find necessary.

Low Input Nurseries and Low Cost Production

Previous articles in this Newsletter have stressed a high input approach to vetiver nurserying; from a planning perspective this makes sense. One should never start off by asking, "How cheaply can I do this?" The correct question is "What is the best job that I can do with the resources at my disposal?" In nurserying of vetiver (and most other activities) there are economies of scale and inputs— the bigger the operation the cheaper the unit cost of production and up to some optimum the returns to production for any given input will often more than pay for themselves. That having been said, what we have presented in other articles is a mix of basic and ideal practices. It is up to you to judge the resources that you have available relative to the work you wish to accomplish and figure out what is the best job you can do in propagation. As we have said before, vetiver is a tough plant and will grow under some fairly unfavorable conditions. But it is a plant and it is tough only relative to other plants...if you do not get water to it, it will not grow; if it has no nutrients upon which to draw, it will not grow; if it is choked out by weeds or stomped on and grazed from the moment it is put in the ground, it will not grow. This is not to say that if you cannot afford irrigation, fertilizer and a lot of labor that you cannot nursery vetiver; rather if you cannot provide these things from purchased inputs, you can provide a better environment through planning. Below are some ideas.

A number of suggestions come from the Network on how to minimize inputs for vetiver production. Most of these suggestions would be appropriate for the individual user or small groups.

- no formal nurseries, just plant slips along the roadside, etc. On the coffee plantation we leave them for 2 years during which time we cut them for mulch. We get up to 250 tillers/plant. From **Mr. Shimelis Kebede** in Ethiopia, where has about 500km of vetiver hedges on the plantation where he is located.

- plant double rows of vetiver as hedges, next year uproot one row and use it to gapfill the other. Then plant another double row with the rest, repeat each year. Plant a nursery only if vetiver is scarce. From **Mr. R.S. Patil.**

- maintain a small nursery with year around production, take plants whenever you need them. Always replant what you take, when you take it. From **Mr. F.W. M'buka.**

- casual propagation of plants wherever there is space and good moisture such as paddy bunds, banks of tanks, and streams. From **Mr. Mihir Kumar Jha.**

Photo courtesy of James Smyle

Photo 5. An informal, roadside nursery in an Ethiopian coffee plantation. These plants may be left for 2 years and produce up to 250 tillers/plant before they are harvested for hedgerow plantings within the coffee fields.

- *establish local, farmer-managed nurseries in the wetter sites within each watershed — in all watersheds a spot can be found that is wet throughout the year.* From **Mr. Gunnar Jakobsen.**

- *contract with farmers to produce small amounts, give them enough material to establish about a 750 plant nursery. Buy it back at an agreed upon price.* From **Mr. P.C. Romkes.**

- *provide credit and procurement contracts to small farmers.* From **Mr. Konaje Gopalkrishna.**

- *small individual nurseries and farmer nurseries are best.* From **Mr. Ranjit Kumar Roy , Mr. M. Singa Rao, Mr. Chris Eijkemans,** and **Mr. Vaughn Redfern.**

- *take tillers from established hedges.* From **Mr. Michael Poshkus** and **Mr. Alemu Mekonnen.**

- *small nurseries, plant at the onset of the rains; good water supply makes all the difference.* From Mr. Michael Poshkus.

- *if there is no hurry, simply remove slips from your own established plants year-by-year and extend the length of the hedge.* From **Mr. C. Buford Briscoe.**

- *nursery in damp valley bottoms.* From **Mr. Robert J. Sims.**

Dr. Yoon also provides us with his recipe for a low input nursery :

A large block of approximately 0.2 ha was ploughed and rotovated. Tillers were directly planted with a planting distance of 15cm x 15cm. One round of dried chicken dung was applied at one week after planting. This approach ensures low establishment cost. There was little maintenance cost — with planting in the normal rainy season, watering was not needed. Also, there was no weeding nor any pest and disease control measures. Plants were growing well by 2.5 months and managed to compete with other weeds. Sampling of 100 clumps at 4 months showed average of 11 tillers per clump (farmer's report). This rate of production was considered satisfactory because of the low input.

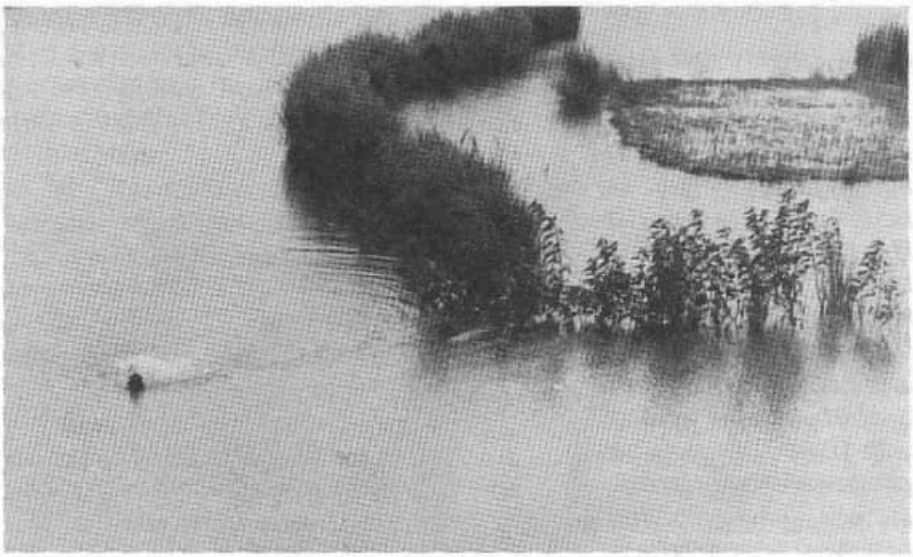


Photo courtesy of Dr. P.K. Yoon

Photo 6. Where a house once stood along this riverbank in Bangladesh, a vetiver hedge continues to protect the site long after the occupants who planted it moved away.

Production from Dr. Yoon's low input nursery, at 4 months, would provide enough material for about 40 to 60km of hedgerow. This assumes a 20% cull and 2 or 3 slips every 15cm.

Nurserying In Raised Soil Beds

Raised beds may have an advantage over planting in the ground based on reduced labor inputs for harvesting of the plants and weeding. The raised beds themselves might be formed either by hand or with a walking tractor, with the latter the less expensive of the two. In areas where labor costs especially limit nursery management options, this system may result in lower plant production costs.

The following information comes from the Network's all-around expert on vetiver, **Dr. P.K. Yoon** of Malaysia.

The width of the beds prepared should be based on the number of rows of vetiver slips which will be planted across the bed. Based on experience in Malaysia, if time in the nursery is to be more than 3 months, than ideally no more than 2 rows of vetiver should be planted in each bed. This is because growth up to 3 months has been satisfactory, but after that the plants in the central rows tend to grow and multiply more slowly as a result of the shading effect. Unless land is a constraint, or nurserying will not go past 3 months (or the time at which under your nursery conditions the plants would enter into severe light competition), then 2 rows of vetiver slips planted 15cm apart works well. If you can (or must) use more than 2 rows, then the bed width should not be any wider than what can be easily managed or about 1m.

To ensure good growth, one nugget of Kokei/plant (6 gm of 5-5-5-1(Mg)) is recommended. Dr. Yoon also recommends the Sumisansui tube irrigation system (produced by Japan) as in the polybag nurseries. In harvesting his nurseries at 5 months, on 2 occasions the average yields from the 2 plant/row system were 21.1 tillers/plant (±0.59) and 20.6 tillers/plant (±0.92),

based on counting 486 and 185 plants, respectively.

In a 6 plant/row nursery, plants were established on a 15cm x 15cm spacing, with a Sumisansui irrigation system in beds that had received a liberal application of dried chicken dung. Each bed was about 1m x 50m with 0.9m spacing in-between and had 1800 plants. In total, 6 beds were planted with 10,800 plants. The plants were ready for use in the field after 2 months; however, for multiplication, the plants were left to grow longer. It was estimated that these beds produced more than 150,000 tillers after the first 3 months.

On a per ha basis, Dr. Yoon's production is equivalent to about 189,000 plants producing about 2.63 million tillers in 3 months. This is sufficient planting material to establish about 131km to 195km of hedgerow assuming 2 or 3 slips each 15cm, without any culling of plants. In practice, it is a good idea to assume that some percentage of plants should not be utilized as there will be some older, less vigorous material. Assuming a 15% cull, this still leaves adequate material to establish 110 to 167km of hedgerow using top quality plants.

Photo courtesy of Dr. P.K. Yoon

Photo 7. A polybag nursery in Malasia.

Containerized Nursery Stock

A number of individuals on the Network are currently using polybags or other containers in which to nursery vetiver. While costs are higher using this method, it has certain advantages for particular situations. The advantages of containerized stock are : First, plants grown in containers are planted in the field with well-developed, relatively undisturbed root systems. This reduces establishment time considerably. Second, planting with containerized stock is almost equivalent to putting out a one year hedgerow immediately. At close spacing, the containerized material with its larger plants, in effect, gives an almost functional hedgerow within the time it takes for the roots to penetrate the surrounding soil and anchor the plant. Thirdly, under high stress situations, e.g. very poor and friable soil with low nutrient content, severe erosion from multiple directions, and difficult climatic conditions, the use of polybag materials with their vigorous root systems encased in a core of soil will allow early establishment and growth when transplanted. In Photo 8, it can be seen that the root system is well-developed and has bound the soil in the container effectively. Finally, polybag production should rarely result in plants which must be culled. Nursery output should be close to 100% of production.

Situations under which the increased cost may be justified would normally be those where protection of high value infrastructure is the goal. Examples of this might be for the farmer who has constructed a new house on a steep slope, for new road cuts, on any fill slopes or main irrigation canals. Literally anywhere where the cost of stabilization would be measured against the replacement costs of the infrastructure should stabilization methods fail. Containerized stock might also be found economic in stabilization of gullies. **Mr. Mike Materne**, with the U.S. Soil Conservation Service found that he could take containerized plants and, using old welding rods as pins, establish hedges right across areas where concentrated flows were causing active down-cutting. The potential use in these areas — infrastructure protection and gully control — is enormous.

According to some of the writings of Dr. P.K. Yoon, polybags (0.05mm) of 5" x 7" work well. Multiple tillers can be used instead of single tillers. This way the tillers

primarily need only to regenerate their root systems; accordingly, the time in the nursery to produce quality plants may be reduced.

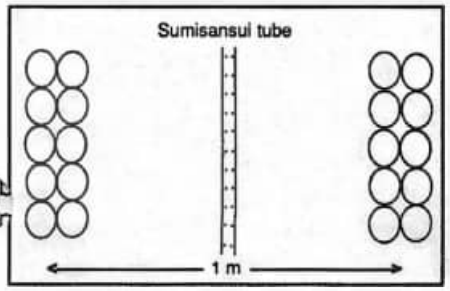
In preparing tillers for polybag planting, Dr. Yoon suggests that the tops should be cut to about 20 cm with the roots cut to 4-5cm. At planting, not more than 2cm of the tops should be buried. To ensure good growth, especially of the root system, one nugget of Kokei (6 gm of 5-5-5-1(Mg)) should be put into the polybags one week after planting.

He reminds us that vetiver is sensitive to shade and the arrangement of polybags is therefore critical. Only 2 polybags per row should be used. With more polybags per row, the plants in the centre will be shaded and thus perform poorly. For the same reason the spacing between the polybag rows should be one metre. A good arrangement is shown below in Figure 1.

Dr. Yoon prefers mechanized watering to normal watering because of better control of the quality of watering. The Sumisansui tube irrigation system (produced by Japan) is favoured in Malaysia because it is cheap to install. However, any irrigation system may be used and he has seen seen overhead sprinkler systems that appear to meet the need.

On a recent consultancy to Bangladesh, Dr. Yoon estimated the cost of the system described above. Such an arrangement, in Bangladesh, would allow production of one polybag of quality planting material (with more than 10 tillers) for US$ 0.05 ea.

Figure 1. Arrangement of polybags for a vetiver nursery.



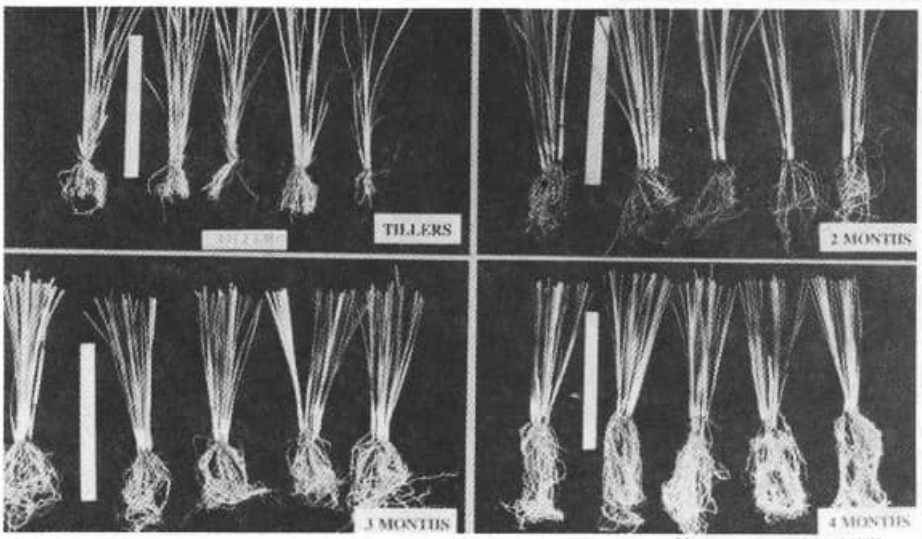


Photo courtesy of Dr. P.K. Yoon

Photo 8. A comparison of the root systems of plants raised in polybags and the roots of freshly cut tillers. The ages of the polybag plants are given. Note the active root mass after 2, 3, and 4 months.

A plan for an irrigated 10-acre polybag nursery (4 ha) in Bangladesh showed estimated nursery startup costs at US$ 3,000. The nursery would produce 1.3 million plants annually on a 4 month cycle, i.e. raise and distribute 3 lots of plants/year. This would provide enough planting material for 195 km of hedgerow/year when planted on 15cm centers. Recurrent costs would be covered under the US$ 0.05/polybag plant.

Dr. Yoon suggests regular monthly pruning to 40cm to encourage tiller formation.

Mechanized Nurserying of Vetiver For Large-Scale Production

The following article was contributed by **Mr. Gueric Boucard**, who, with his brother **Victor**, has operated the largest vetiver farm (of which we are aware) in the world. The Boucards have been involved with vetiver for more or less their entire lives as their father was an enthusiast about the plant as well. Their interest in vetiver farming in recent decades has been to produce oil from the root, however, their operations for this purpose would equally serve for mechanized nurserying and hedgerow establishment. Please note that the Boucards operation is an irrigated one, as should be any nurserying operation.

In American agriculture, "large-scale" is a relative term. ***American Vetivert Corporation*** *or AVC (ed. note : the Boucard's company) has had up to 200 acres of vetiver under cultivation in South Texas, and called it large-scale vetiver farming, primarily because of its large drain on the company's small research and development budget. On the other hand, AVC's farming partner has some 5,000 acres under the plow at any given time, and another 5,000 acres in cow pastures and idle farm land. But, certainly, the large-scale mechanized propagation of vetiver would seem to have considerable merit.*

The question that arises is, how does one propagate vetivert on a large scale? Propagating vetiver on a large scale is relatively easy, because there are only 15 or 20 mistakes and pitfalls to avoid.

Photo courtesy of Joan Miller

Photo 9. The Boucard's vetiver root digger (harvester).

Unfortunately in agriculture, it takes one full calendar year to discover the results of each mistake and correct them. Therefore, after nearly 20 years of experimentation (17 to be correct), AVC can make some basic recommendations for the large scale planting and harvesting of vetiver, to those who may wish to do so. It should be noted that certain requirements which pertain to high quality root production do not apply to the growing of vetiver for seedling harvest. For instance, vetiver will grow in sand, heavy clay, rocky soils, volcanic soils, in swamps, in saline river deltas, and just about everywhere in tropical and subtropical climates, but the good roots with high quality oil occur only in a few of the above. Once the right soil and geographical location has been selected, the main problem lies in the development of adequate farming machinery. Unfortunately, specialized vetiver farming machinery is not to be found in the catalogues of John Deere, New Holland, and International Harvester.

Needless to say, full mechanization of the vetiver crop is an absolute necessity for large-scale propagation, especially in the United States. Often however, the patient and skillful modification of existing conventional farming machineries can produce satisfactory results. One may find that a 90% mechanization of a particular agricultural operation may be commercially acceptable, while the achievement of the 100% mechanization goal may be $1 Million down the road, and bring little additional profit. It is along these lines that AVC has developed its own special machinery. It must he stressed, however, that regardless of all the special farming equipment developed by AVC, vetiver remains in the category of labor intensive crops, such as vegetable crops, fruit crops, and tobacco.

There is, however, one important distinction which separates vetiver from other labor intensive crops, and makes all the difference in the world. Fruit and vegetable crops have to be harvested within a narrow time window, and very large scale operations of several thousand acres are rarely practical. However, vetiver is a perennial grass which can he harvested at virtually any time of the year (at least in south Texas). A 3,000 acre farm, taken a day at a time, is the same as a 16 acre Mom & Pop farming operation.

Some of the specialized vetiver farming machinery developed by AVC is described below.

1. Vetiver transplanter. *The AVC transplanter is a 4 or 6 row machine for 30" to 38" rows requiring two men per row to plant 8" to 10" tall vetiver seedlings of 2" diameter, 3" deep, and 18" on the row. A mechanism allows the injection of water and fungicide, root activator, or any other chemical with each seedling. The machine is a modified tobacco transplanter which can plant 8 to 10 acres per day. (ed.*

Photo 10. Mr. Victor Boucard holds up a clump of vetiver which was harvested with their root digger.

Photo courtesy of Joan Miller

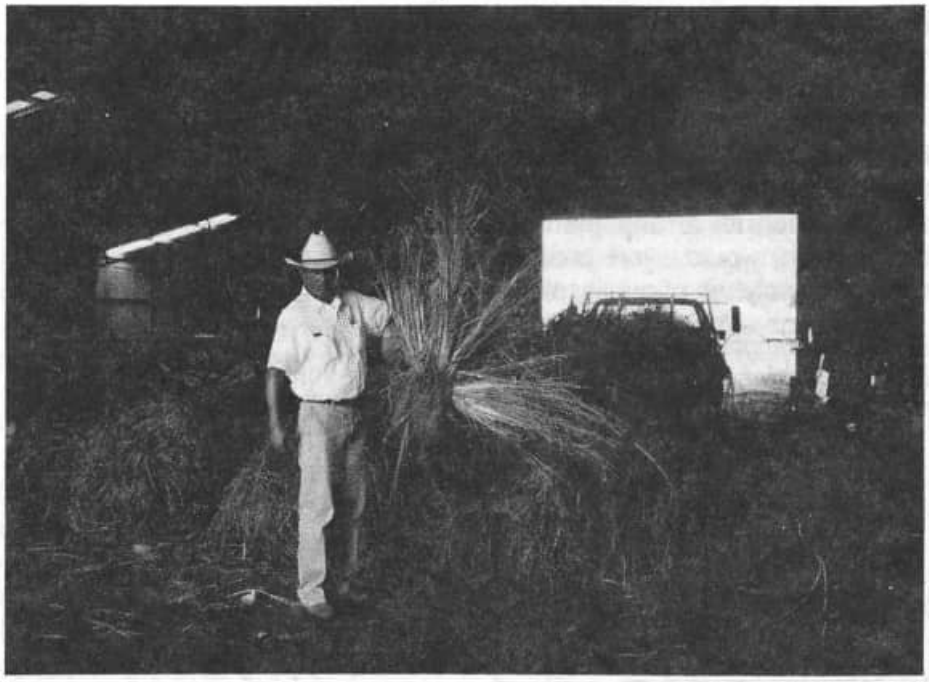


Photo courtesy of Joan Miller

Photo 11. The Boucard's vetiver stump slicer which cuts clumps into 5cm x 5cm blocks for use in the planter.

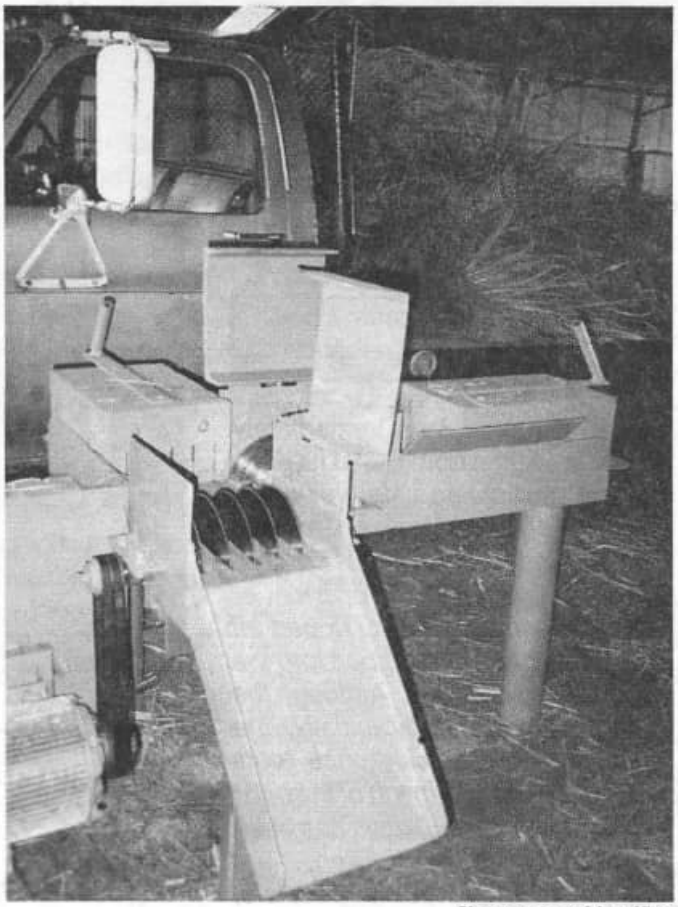


Photo courtesy of Joan Miller

Photo 12. Mr. Gueric Boucard demonstrates how a mechanized planting unit works.

note: Mr. Boucard has confirmed that his planter could be modified easily to both accommodate closer spacings between slips and planting across steep (by United States standards) slopes.

2. Vetiver grass mower. *AVC can assert with confidence, for having tried them all, that no commercial mowers of any design, currently available on the U.S. market, will mow a 24" diameter vetiver clump. The special sickle bar mower designed by AVC and mounted on a New Holland self-propelled mower will even mow vetiver to ground-level at nearly normal mowing speeds. In the event that all the clumps will be used either for replanting or for sale to others for erosion hedges, the entire field will have to be mowed 8" above ground in order to accommodate the mechanical transplanter. The cost of manual shaving of root from the clumps will have to be offset by revenues from the sale of the clumps.*

3. Vetiver root digger. *After modifying, testing and destroying several potato diggers, peanut diggers, rock pickers etc, AVC developed its own heavy duty vetiver root digger. This implement must be pulled by a very large 4-wheel drive tractor such as the Steiger tractor or other makes of similar horsepower and wheel traction. The machine goes 16" deep and uproots two rows of vetiver clumps with each pass. Given good loose sandy soil, the roots are shaken clean before falling into the wagon riding next to the digger. In less advantageous soil conditions, the roots have to be shaken again by means of a stationary tumbler, at the processing shed where the seedling preparation takes place.*

4. Vetiver stump slicer. *After shaving the roots, the clumps with 8" long leaves remain to be divided up into seedlings of the adequate uniform size to accommodate the mechanical transplanter. AVC has devised a machine with two sets of gang saws which slices the clump into clusters of seedlings (4 to 6 seedlings per cluster) measuring 2" by 2", 8" long. This machine would not needed be needed if preparing large 12" diameter clumps for planting fast-developing erosion hedges. This is not to say that the smaller seedlings could not be used for erosion hedges. But the shorter the growing season, and the shorter the rainy season, the more advisable it is to plant large clumps in order to get the hedge established quickly.*

Mr. Boucard provides some estimated cost figures for a mechanized 3,000 acre (1215 ha) vetiver farm, more about which can be found in this Newsletter on Page 14 in the article entitled "The Potential For Commercialization of Vetiver"

Alternative Propagation Methods

The paragraphs immediately below are taken from BOSTID's upcoming publication : ***Vetiver : The Thin Green Line Against Erosion.***

Currently, vetiver is propagated mainly by root division or slips. These are usually ripped off the main clump and jabbed into the ground like seedlings. Although the growth may be tardy initially, the plants develop quickly once roots are established. Growth of 5 cm per day for more than 60 days has been measured in Malaysia. Even where such rapid growth is not possible, the plants often reach 2 m in height after just a few months.

It is easy to build up large numbers of vetiver slips. The plant responds to fertilizer and irrigation with massive tillering, and each tiller can be broken off and planted. It is important to put the nurseries on light soil so the plants can be pulled up easily.

Planting slips is not the only way to propagate vetiver. Other vegetative methods follow:

- ***Tissue culture.*** *Micropropagation of vetiver began in the late 1980s*
- ***Ratooning.*** *Like its relative sugarcane, the plant can be cut to the ground and left to resprout.*
- ***Lateral budding.*** *Researchers in South Africa are having success growing vetiver "eyes" (intercalary buds on surface of crown) in seeding dishes.*
- ***Culms.*** *Young stems easily form new roots. This can be an effective means for propagating the plant. Laying the culms on moist sand and keeping them under mist results in the rapid formation of shoots at each node. This is an effective way to propagate new plants from hedge trimmings.*
- ***Cuttings.*** *One Chinese farmer has successfully grown vetiver from stem cuttings. The cuttings, each with two nodes, are planted at a 60 degree angle and then treated with a rooting hormone—in this case, IAA (indole acetic acid). He achieved 70% survival. An interesting point was that the original stems were cut in December, buried in the ground over winter, then, stem cuttings were taken from these in early spring and planted in April.*

Photo courtesy of Joan Miller

Photo 13. The Boucard's multi-row vetiver planter. The tank on top holds a liquid fertilizer/fungicide mixture which treats each piece of planting material as it is put into the ground.

The following is reprinted from Dr. P.K. Yoon's article in Vetiver Newsletter #6. Since the Newsletter's readership extends beyond those on our mailing list, we want to be sure that this Newsletter is as complete as possible for those who may not have access to the previous ones.

Multiplication By Culm-Branches

When Vetiver clumps are repeatedly topped at 40 cm and when they are more than 3 months old, the cut-culms produced many branches at the internode. These branches can be detached for planting. A trial was set up to study the multiplication and growth of these culm- branches which were separated into various types as follows: A - most vigorous with young shoots (with roots); B - less vigorous with young shoots (with roots); C - most vigorous (with roots) - single plant; D - less vigorous (with roots) - single plant; E - least vigorous (without roots) - single plant; F - Terminal shoots; G - Young shoots plants that were growing horizontally (with small roots/without roots). All types produced good root system under mist and transplanting success into polybags was nearly 100% for all types (lowest 99.6% for type E). The multiplication and growth of the various branch types will be discussed later.

Multiplication By Culm-Cuttings

It is recommended that clumps of Vetiver be cut-back to 30-50 cm to encourage tillering. Early observations suggest that too short cut-backs result in die-back of many culms under Malaysian conditions. An ad hoc trial testing 30, 40, 50, and 60cm cut-back height suggested 40cm to be the best with least set-back to growth, minimum die-back, and good tillering.

The tops are normally discarded after cut-back at of 40cm height. However, if the vetiver clumps are 3 months or older, the cut-tops include many culms. Each culm has varying numbers of internodal buds which can be induced to sprout and produce new plantlets under mist. Three methods of rooting under mist were tested :

(I) Layering of culms. *The whole stem was buried in sand-bed with the following results after 5 weeks: (a) With leaf-sheath intact - 23.2% rooted; (b) With leaf-sheath removed - 28.4% rooted; (c) With leaf-sheath slit - 35.7% rooted.*

(2) Rooting of individual node with leaf-sheath intact *- at 5 weeks 5.1% rooted; at 9 weeks 14.6% rooted.*

(3) Rooting of individual node with leaf-sheath slit *- at 5 weeks 31.4% rooted; at 6 weeks 52,7% rooted and; at 8 weeks 76.3% rooted.*

Treatment (3) of rooting each nodal culm cutting with the leaf-sheath slit was the most promising.

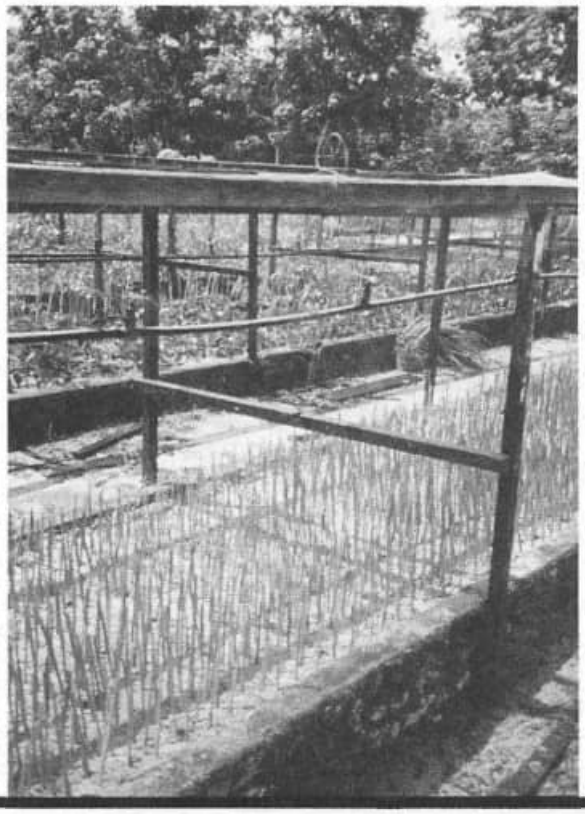
An assessment of 5-month old clumps in the ground yielded 16.4 ± 1.4 cuttings. The number of cuttings from each clump was highly variable. Note that the above work was done under mist. However, based on experience with other crops, similar results would likely be obtained if materials are rooted in sand-bed under polythene sheet to keep the atmosphere moist; this has not been specifically tested because of time constraint.

Conclusion

Vetiver is easy to multiply at low cost. Under normal conditions, multiplication by planting with tillers will give satisfactory results. However, refined methods of vegetative propagation by culm branches and culm-cuttings may be considered from 2 view points: (1) They will be of little value in mass vegetative propagation because they may not be commercially cost-effective (2) They will be of value in the following scenarios: (a) Initial stage of multiplication of a newly found cultivar. (b) Initial stage of multiplication of a newly imported cultivar. (c) Where base cultivars are imported at high cost from other countries. Certainly these methods are much cheaper than the tissue culture method. However, once the base source for multiplication is established, the normal method of splitting the tillers should suffice. In the early phase of my work, all methods using all plant parts are used. This accounts for the large amount of materials that I have produced and distributed.

Photo 14. A mist chamber and sand bed for propagation of vetiver from culms.

Photo courtesy of Dr. P.K. Yoon



Different Tiller Types

Preliminary observations have suggested that each clump of vetiver produces different types of tillers; thus their growth and tiller formation would be quite different. This would lead to high variations in response of experimental treatments where assessment is by tiller formation and dry matter production. This could be one of the causes of non-significant effect of fertilizer, soil types, etc. previously reported. The experimental error may be higher than the treatment effect. To overcome this, the tiller types must be sorted out and the within-population studied before planning any experiment. The starting material must be the same tiller type and fine-tuned to minimize experimental errors. The 4 major types are :T

Type A - the most mature and multiplies fast. The culm produces a variable number of culm-branches; dry matter production is thus highly influenced. This type is not good for experimentation;

Types B & C - mature tillers, but with no culm formation. Suitable for raising plants for experimental purposes.

Type D - youngest tillers. Tend to give variable growth.

Different Culm-Branches

Previous work (reported here) shows that different types of culm-branches can be rooted easily under mist and then transplanted easily into the soil. The rate of tiller production was studied and the results showed significant differences of tiller production by the various culm-branch types which also lead to differences in dry matter production. For experimental pur-

pose the different types of culm-branches should be grouped separately.

Tissue Culture

There are a number of individuals on the Network who are currently working with tissue culturing of vetiver. For a listing of those individuals names and addresses, please write to :

James Smyle
Attn : Vetiver Tissue Culture
1818 H St. NW
Washington, DC 20433
USA

Specify whether you currently are carrying out tissue culture with vetiver or if you are in need of information on how to tissue culture vetiver.

The Potential For Commercialization of Vetiver

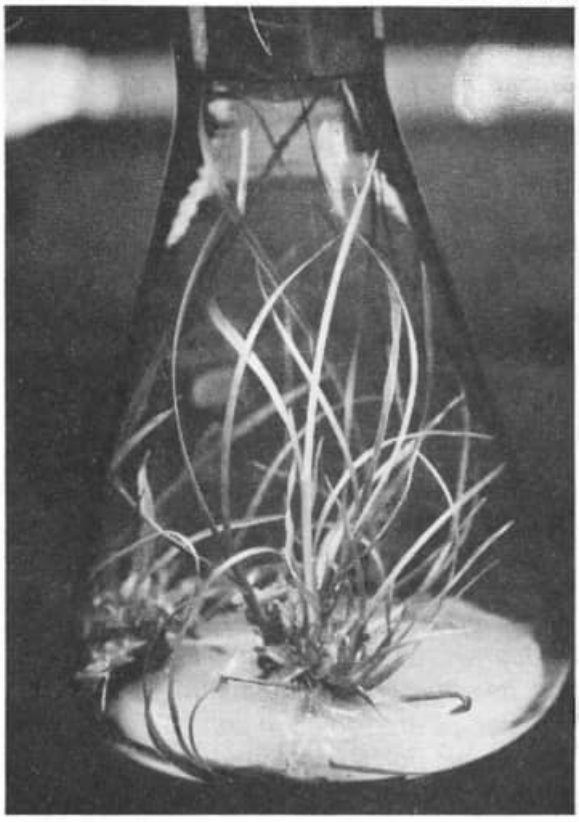
The following is abstracted from a very interesting letter which **Mr. Guerlc Boucard** sent to the Network. It envisions the development of a unique, vetiver-based, farming/commercial operation.

As producers of vetiver and other essential oils, it would be fair for ***American Vetivert Corporation's*** *(AVC) principals to caution vetiver enthusiasts that vetiver farming for the purpose of root production and essential oil production is not to be looked upon as a new crop for every farmer to get into on any significant scale. We estimate the world consumption of vetiver oil from all sources to be 2,000 drums per year or roughly 1 million pounds (see editors note, below). Based on the yield of roots per acre and the yield of oil per ton of roots, this translates into approximately 10,000 acres of vetiver worldwide, planted by small farmers in garden-size plots, in countries such as Haiti, Indonesia, China, etc. Apparently, producers in the Reunion Island and Brazil do have larger fields and some degree of mechanization. A vetiver plantation of 1,000 acres would have to claim a 10% market share and one new 2,000 acre would immediately create a glut and, typically, the price of the oil would drop below the cost of production for several months, hurting all the producers in third world countries, and perhaps putting them out of business.*

However, the large-scale mechanized propagation of vetiver would seem to have considerable merit in other areas of agriculture, such as a combined biomass fuel production and as a source of vetivert seedlings for planting erosion hedges in the entire Southern United States and Mexico. For instance, based on AVC's own yields of vetiver grass per acre, a 3,000 acre irrigated vetiver farm could produce 120,000 tons per year of dry biomass fuel (vetiver leaves). Vetiver being a perennial grass which can he harvested (mowed) all year around, the entire 3,000 acres could he mowed once or twice a year at the rate 8 or 16 acres per day (say a maximum of 50 acres a day to make up for rainy days), and furnish an average of 329 tons per day, i.e. 14 tons of fuel per hour to fire a boiler. Again, based on AVC principal's own experience of firing boilers with waste biomass on a smaller scale, such an amount of fuel (taken at 6,000 btu/lb) could produce sufficient steam to generate 14 Megawatts of electricity. Assuming that the operation of such a large-scale vetiver grass farm would cost US$100 per acre per year (grass farming only), the cost of biomass fuel would translate into US$ 0.002 per KWh, notwithstanding the cost of operating the power plant. Power utilities would purchase the electricity at about US$ 0.03 per KWh, generating more than US$ 3 million of revenues for the farm. Or, the dry, pelletized vetiver leaves could be sold as roughage to feed mills, or as fuel to existing power plants and cement kilns at US$ 10 per ton, for US$ 1.2 Million per year, without the capital cost and the headache of running a power plant or any other major industrial facility.

After 3 years, the diameter of the vetivert clumps will become so large that they will touch each other on the row, and become too large (about 24 inches diameter) for the mower wheels to ride on the soil between the rows. The clumps will have to be uprooted, divided up, and replanted, the latter which would require only 20% of the uprooted vetiver. There will be considerable

Photo 15. Tissue culturing of vetiver.
Source unknown



root production from this operation, and although the quality and the yield of the roots of 3 year old plants is poor, sufficient oil could be extracted from such roots to pay for the operation and generate a profit, without upsetting the vetiver oil market. ***Texarome Inc.****, of Leakey, Texas, a distiller of essential oils has a standing offer to purchase vetiver roots at US$ 350 a ton. At a root yield of 3 tons per acre, this translates into over US$ 1 million of additional revenues for the farm.*

Still, some 70% to 80% of the uprooted clumps would be available for sale to farmers for planting erosion hedges. Assuming that one-third of the farm (1,000 acres) would be replanted every year, just so that no plant is ever more than 3 years old, then 1,000 acres of 3 year old clumps up to 24" in diameter would produce 2.6 linear miles per acre, or a total of 2,600 solid miles of vetivert clumps 24" wide. Preferably, such large clumps should be at least quartered for planting erosion hedges with clumps of 12" diameter on 18" centers. If that is the case, then, after using 20% for replanting, the 1,000 acres could furnish enough extra material to plant 12,480 miles of erosion hedges per year — assuming the clumps are quartered and planted 18" apart. Given the economy of scale, if the 12" diameter clump seedlings were to be sold to farmers at US$ 0.05 a piece, the farming operation would have additional revenues of US$2,196,480. From the point of view of the erosion fighting farmer, could plant one mile (5,280 ft) for US$176. After just one summer's growing season, the vetiver would grow to a solid and permanent hedge. The cost of doing the same thing with any other erosion fighting method would be significantly higher and perhaps prohibitive for most farmers.

As shown above, the total yearly revenues of such a farm could add up to more than US$4.2 million, and do a lot of good things in the process. A rough estimate of capital and operation costs for this hypothetical 3,000 acre vetiver operation would be US$ 5 million, of which, 60% would be for the irrigated farm and irrigation system, 20% for farming and processing equipment and buildings, and 20% for operating capital.

Ed. Note : According to information from the International Trade Centre, in 1986 the world trade in vetiver oil comprised about 250 tons or 550,000 pounds. World demand for vetiver oil has not significantly increased in recent years nor does it appear to be doing so now.

Reminder — Vetiver Awards To Be Given In June 1993

Please remember that once again the Network has found funds which will be utilized to recognize those 'jobs well done' by both individuals and groups in promoting, managing and researching the use of vetiver grass for contour vegetative barriers. A total of $32,000 will be awarded. Below are the categories within which the awards will be given. The Network has split the awards in order to encourage a number of different, valuable areas. Please note that "work of interest" is indicative only, we do not want these categories to limit anyone, on the contrary we encourage any useful and practical work outside these areas as well. Be assured that any one sharing information on an area not contained below will have their work treated equally with that which does fall under the categories set out below. Wherever appropriate and possible, costs or cost estimates for implementation of recommendations should be included.

The Network will be accepting your 'entries' until April 15, 1993. At that time an independent, external panel will choose the awardees (with the exception of the Yolo County Award, see below); all awards will be made by June 1, 1993. All materials received should be sent with the understanding that they will not be returned and that they will become public information and shared with the Vetiver Network. All relevant information received will be incorporated into a Newsletter (or Newsletters if warranted) for publication by July 1993.

The Awards

The King of Thailand Research Award.

His Majesty, The King of Thailand has offered $10,000 in awards to promote the dissemination of useful and practical information on vetiver grass. One-half of these funds ($5,000) will be awarded to the individual contributing the most significant piece of research work.

Research Awards

The Plant - Total $7,000

Work of interest on : Vetiver taxonomy, e.g. species/varieties/types, their identification & comparison of characteristics in : growth and/or management needs and/or palatability/non-palatability and/or applications based on differences and/or pollen, flower, seed fertility/sterility by type; effectiveness as soil/water conservation species as a function of its roots, strength of tops and hedge-forming ability; pest repellency effects by type; allelopathy; cold or drought tolerances; pests and/or diseases; mycorrhiza and vetiver; pH-related questions; and other physiological characteristics. Awards = 1st - $2,500; 2nd - $1,500; 3rd - 1,000; 4th - 4 awards of $500 each.

Engineering Applications - Total $ 6,500

Yolo County Flood Control and Water Conservation District

Award for most comprehensive and/ or unique viable applications for vetiver in stormwater and wastewater reclamation. The winner of this award will be determined jointly by Mr. James Eagan, General Manager of the Yolo County Flood Control and Water Conservation District and Mr. R.G. Grimshaw, Chief, ASTAG/World Bank. Award = $2,000;

Other work of interest on : stabilization of cuts and fills, protection of infrastructure from run-on and sedimentation, stabilization of the infrastructure:soil interface, stabilization of canals and ponds, groundwater recharge. Awards = 1st - $2,000; 2nd - $1,500; 3rd - 1,000.

Management - Total $7,000

Work of interest on : pests, their importance/significance and management (insects and/or weeds); "how-to" guides for most efficient propagation and/or viable, alternative propagation methods (eg. layering); "how-to" guides for most efficient establishment of hedgerows (be specific about soils, climates and land use conditions); establishment and management system costs under varying conditions; "how-to" guides on mycorrhizal inoculation of vetiver; management of vetiver hedgerows for secondary benefits; economic analysis of the benefits of vetiver hedgerows relative to other approaches; im pacts on soil loss, runoff/soil moisture and crop yields on steep slopes. Awards = 1st - $2,500; 2nd - $1,500; 3rd - 1,000; 4th - 4 awards of $500 each.

Promotional/Extension Work and/or Materials - Total $5,000.

Best Video. Awards = 1st - $1,150 and a painting contributed by Mr. Reginald Pollack, a renowned contemporary artist, 2nd - $600, 3rd - $250; please include an english-language script if there is any untranslated speech in the video. While the quality of the video, editing, etc is appreciated, the content of the video will be more important. Do not worry if your video is not a 'professional' production.

Best Photograph, Poster, or Drawings. Awards = 1st - $850, 2nd - $400, 3rd - $250

Best Proven Approaches for Extension/Technology Transfer. Awards = 1st - $850, 2nd - $400, 3rd - $250; please include photgraphic evidence and testimonials from farmers/users.

Farmer Awards - Total $1,500

These awards will be given out to farmers who are using vetiver grass hedges and have sufficient experience to be able to discuss what they are doing, tell how they work with other farmers and/or report other farmer's opinions of what they are doing, give their honest opinions of vetiver's strengths and weaknesses, and recommend to us what we should be telling other farmer to convince them to give it a try. The form provided on the back page of Newsletter #8 (6/92) may be used or a voice recording of the farmers with an english translation; photographic evidence should, if at all possible, be included. Awards = 15 awards of $100 each.

The findings, interpretations, and conclusions expressed here are entirely those of the authors and should not be attributed in any manner to the World Bank.

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER INFORMATION NETWORK, AST*, WORLD BANK, NUMBER 10, OCTOBER 1993

THE NEWSLETTER

It has been almost one year since our last Newsletter. Our intention was to have this particular one in your hands by July, because this is a very important issue. In this Newsletter (#10) we announce the winners of the Vetiver Awards. However, an administrative restructuring and subsequent changes, including the termination of ASTAG as a division, has slowed us down a bit...but it has not in any way diminished our desire to get the word out on vetiver and to keep you up-to-date.

The majority of what you will read in this latest issue comes from the information that was sent in to us for the Awards competition. In the judging there was quite a bit of discussion over how to rank the entries. Last year the judges had two criteria : (i) the contribution made toward providing significant information about some aspect of vetiver as a species and/or its utilization and/or its impacts and (ii) the degree of personal initiative displayed in carrying out the work or providing the information. This latter criteria was and still is very important as the resources available to the individuals varied greatly. However, this year, because there were a number of instances where there were more deserving individuals than prizes, we came up with a third criteria to solve this dilemma. We also looked at the individual's contribution toward promoting the Vetiver Technology. That is, given the choice between two good pieces of work, the individual or individuals who were trying to apply their findings and/or who were working with users and actively promoting vetiver would be awarded the prize. The Network feels that it is important that these Awards be utilized to promote research and demonstration work that is practical. How can someone know if what they are doing is truly useful, truly practical unless they get out and work with the users ? So, first we would like to thank all of you who participated in this year's competition, especially those of you whose work did not receive an Award. Almost everything we received was good and represented excellent initiative. Secondly, we congratulate our Awardees for their fine work. And, lastly, we challenge you all to now get out and put your information to work. The Network is doing what it can to pass your ideas and recommendations on to others, but it is more effective if you, yourself extend it to those nearby who would benefit from your knowledge. Research is only the beginning.

All of those who receive an Award this year or who received an Award last year will be receiving a certificate within the next few months that notes their achievement. We are currently having the certificates designed and printed.

Photo 1. *His Majesty, King Bhumibhol Adulyadej of Thailand planting a vetiver grass hedge. His Majesty is heading a country-wide initiative on soil and water conservation with vetiver grass.*

Photo courtesy of Mr. T. Sumet.

TABLE OF CONTENTS

The Awards	2
Letter From Dick Grimshaw	3
A Look See At Vetiver in Malaysia, By Dr. P.K. Yoon	5
Effects of Extreme Soil pH, By Dr. P.N.V. Truong	11
Application of Molecular Diagnostics, By Dr. S. Kresovich, et al.	13
Comparative Measurements, By Mr. Materne & Ms. Schexnayder	14
Effects of Shading and Cutting, By Dr. Xia Hanping	14
Effects of Hedges and Mulch, By Dr. Chen Kai	15
Soil Salinity Tolerance, By Mr. G. Cook	16
Stabilization of Roadcuts, By Mr. A. Tantum	17
Vetiver Protected Channels, By Dr. Sahu, et al.	17
Vetiver in Hong Kong, By Dr. R.D. Hill	18
Vegetative Hedgerows, By Dr. Tiwari, et al.	19
Soil and Water Conservation, By Dr. D.V. Rao	19
Evaluation of Hedgerows, By Drs. Sagare and Meshram	20
Experiences with Vetiver, By Dr. G.M. Bharad	21
The Largest Vetiver Planting, By Mr. M. Robert	22
A Commercial Source of Vetiver	23
Report on Mortality	23

Because of the length of many of the entries and the large numbers of photographs and figures which we received, it was not possible to include everything that we desired in the Newsletter. We have had to do some fairly heavy editing and as such some readers may wish to request unedited versions of some of the pieces. To do so, please write to either Dick Grimshaw or myself, Jim Smyle, at the address on the last page of this Newsletter.

As previously mentioned, the Vetiver Information Network is no longer a part of the Asia Technical Department, Agriculture Division (ASTAG) because that division has been eliminated. As a result, our Newsletters may not be coming out as often as they have

* - Asia Technical Department

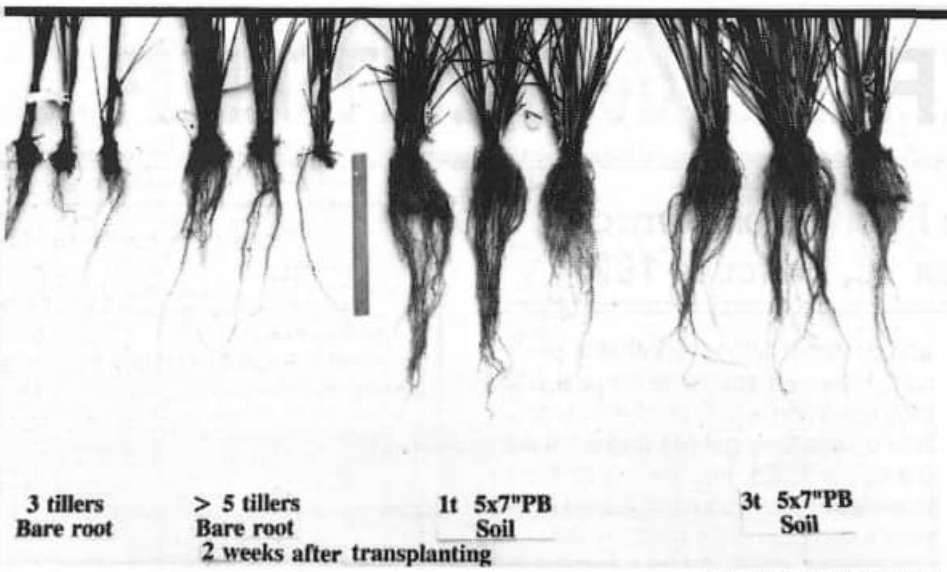


Photo courtesy of Dr. P.K. Yoon

Photo 2. A comparison of root development at two weeks after transplanting between bare root and polybag vetiver planting material. From left to right, 3 tillers, bare root; >5 tillers, bare root; 1 tiller, 5"x7" polybag; 3 tillers, 5"x7" polybag.

in the past, but be assured that they will be published as often as we can manage. Already we have enough information on "Non-Award" items to either double the size of this Newsletter or put out another one in the next couple of months. To those of you that have sent us pieces to put in the Newsletter and do not see it here, I assure you it will be in the next one which should be out after the first of the year. Keep up your good work and keep sending us information. We will always put it to good use.

The Awards

As you read down the list of Awardees, you inevitably will notice that one individual, **Dr. P.K. Yoon** of Malaysia, has managed to secure the bulk of the honors. This researcher, Head of Plant Sciences (now retired) at the Rubber Research Institute, early on recognized the potential of vetiver for Malaysian agriculture. Taking the initiative, he searched for months to find a few plants, raised funds entirely on his own from private sources and began the process leading to his highly successful research and field applications. This year the Vetiver Incentive Awards recognize the enormous influence that this one individual has had.

The King of Thailand Award of US$5,000 for overall excellence goes to Dr. P.K. Yoon of Malaysia for the tremendous body of analytically rigorous and eminently practical and useful work that he has done. The Network would like to recognize his achievement in single-handedly extending our knowledge of vetiver and its management so significantly across almost all aspects of interest to users. Congratulations, Dr. Yoon.

Research Awards

First Prize (US$2,500) : Dr. P.K. Yoon of Malaysia for his work on production of quality planting material, roots and root regeneration and response to management by different vetiver cultivars.

Second Prize (US$1,500) : Dr. Douglas Laing (ex- of CIAT), Mr. Martin Rupenthal and the University of Hohenheim/CIAT program on upland erosion control for their work in the study of roots, mycorrhiza and rooting patterns; digestibility/palatability of vetiver cultivars; and vetiver/legume plantings. *NOTE : This work is not published here, refer to Vetiver Newsletters 7 and 8.*

Third Prize (US$1,000) : Dr. Paul Truong of Australia for his work on vetiver's tolerance to extremes of pH.

Fourth Prize (US$500) : Mr. Mike Materne and Ms. Cindy Schexnayder of the United States for their work on stem measurements, stem mapping and other parameters for physical characterization of vetiver grass for use in identifying effectiveness and utility of other grasses for stiff grass hedges.

Fourth Prize (US$500) : Drs. Kresovich, Lamboy, Li, Ren, Szewc-McFadden and Bilek of the United States for their work on DNA fingerprinting of accessions and clones of vetiver grass.

Fourth Prize (US$500) : Drs. Xia Hanping and Chen Kai of the People's Republic of China will share this award for their separate works on vetiver's growth habits and interactions with orchard crops.

Fourth Prize (US$500) : Mr. Gregg Cook of Australia for his work in comparison of salinity tolerance in two accessions of vetiver with two native grasses.

Engineering Applications Awards

First Prize (US$ 2,000) : Dr. P.K. Yoon of Malaysia for his work on highway and road stabilization, stabilization of culverts and drains and stabilization of irrigation canals in Bangladesh.

Second Prize (US$1,500) : Mr. Anthony Tantum of South Africa for his work on highway stabilization.

Third Prize (US$1,000) : Drs. Sahu, Sharma and Nayak of India for their work on stabilizing small irrigation channels with vetiver grass.

Yolo County Flood Control and Water Conservation District Award (US$2,000) for vetiver use in storm and wastewater reclamation : No Awardee. Surprisingly, the Network received no submissions in this area. This is one area where vetiver is a natural as a biological filter!

Management Awards

First Prize (US$2,500) : Dr. P.K. Yoon of Malaysia for his work on establishment, management and maintenance of vetiver for a wide range of uses and conditions which has resulted in entirely new applications and approaches to utilization of vetiver grass.

Second Prize (US$1,500) : Messrs. Gueric and Victor Boucaro for their work in mechanizing the pro-

duction and planting of vetiver. Information on their work may be found in Vetiver Newsletter #9.

Third Prize (US$1,000) : Mr. Mike Materne for his work on propagation, establishment and demonstration of vetiver grass. Mr. Materne's work has been a turning point for focusing attention on the stiff grass hedge technology in the United States.

Fourth Prize (US$500) : Dr. R.D. Hill for his work on establishment of vetiver on difficult sites, the introduction of its use into Hong Kong and its fuel values. In addition, Dr. Hill's support of the Vetiver Network through his Newsletter "Asia Pacific Uplands" has been invaluable.

Fourth Prize (US$500) : Drs. Tiwari, Igbokwe, Burton and Waters for their work on the impacts of vetiver grass hedgerows for erosion control.

Fourth Prize (US$500) : Dr. Rao of India for his work on economic analysis of the impacts of vetiver grass on the farm and watershed levels.

Fourth Prize (US$500) : Drs. Sagare and Meshram of India for their evaluation of vetiver hedgerows compared to graded bunds and other vegetative hedgerows.

Promotional/Extension Work and Materials

Best Video Award

First Prize (US$1,150) : Dr. P.K. Yoon for his video record of the entire range of his accomplishments, demonstrations, trials and research.

No Second or Third Prizes are to be given as no other eligible videos were received.

Best Photograph, Poster or Drawings

First Prize (US$850) : Dr. P.K.Yoon for his photojournalism-approach to his work with vetiver and for the extension posters he creates.

Second Prize (US$400) : Mr. Mekonnen of Ethiopia for his photographic record of vetiver usage in Ethiopia.

Third Prize : Not given as no other eligible visual materials were received.

Extension/Technology Transfer

First Prize (US$500) : Messrs. Vietmeyer and Dafforn of the United States for their dedication in making sure that the "vetiver story" reached the widest possible audience worldwide.

Second Prize (US$300) : Dr. G.M. Bharad of India for extending his research work and practical experiences directly to farmers and other users.

Third Prize (US$200) : Mr. Maxime Robert of South Africa for the largest (known) individual plantings of vetiver hedges (146 ha). Mr. Robert began planting vetiver only in 1989. Since then, he has protected his sugarcane fields, stabilized culverts, drains and a river bank, and protected young trees. The demonstration effect from one motivated farmer, such as Mr. Robert, can be tremendous.

Fourth Prize (US $100) : Drs. Khandwe and Saran for their Hindi language extension leaflet on vetiver hedgerows for soil and moisture conservation.

Farmer Awards

First Prize (US$300) : Mr. Maxime Robert of South Africa

Second Prize (US$200) : Mr. Kulkarni of India

Third Prize (US$100) : Mr. Lebene of Ethiopia

Third Prize (US$100) : Mr. Sunday of Nigeria

Third Prize (US$100) : Mr. Ngwainmbi of Cameroon.

Third Prize (US$100) : Mr. Patil of India.

The six additional third prizes were not awarded as no other eligible entries were received.

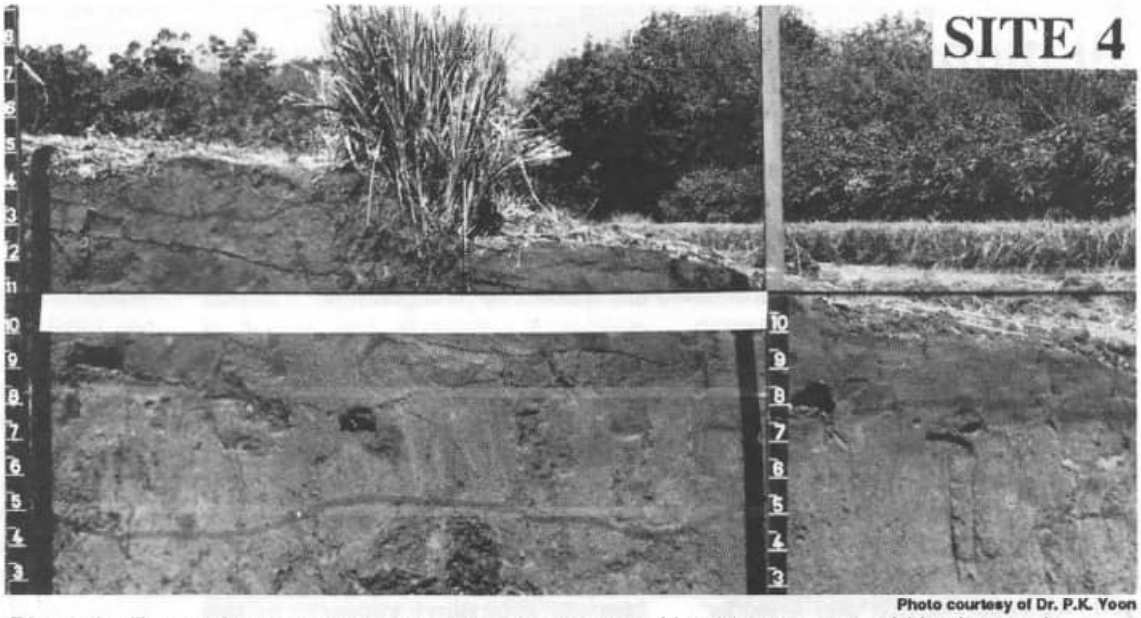


Photo courtesy of Dr. P.K. Yoon

Photo 3. *Excavation reveals the quantity of soil trapped by this 24 month-old hedgerow in Malaysia. Approximately 55cm of soil have been deposited.*

Letter from Dick Grimshaw

Let me first congratulate all the prize winners for this year's Awards. We have awarded $28,000 to more than 30 vetiver participants. Particular congratulations to **Dr. P.K Yoon** of Malaysia who has won the **King of Thailand's Award** for overall excellence in furthering use and knowledge about vetiver. Also special mention should be made of **Noel Vietmeyer and Mark Dafforn**, both of the National Academy of Science, who were responsible for the production of "The

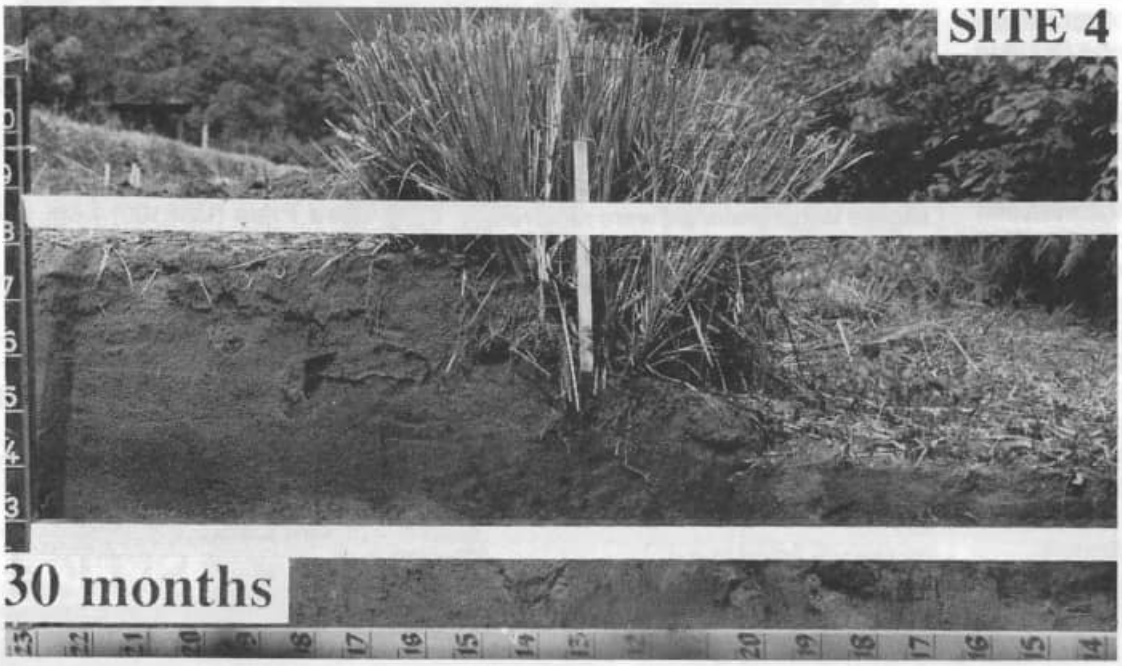


Photo courtesy of Dr. P.K. Yoon

Photo 4. *This 30 month-old hedgerow is farther downslope from the one shown in Photo #3. The wooden peg in the center of the hedge was placed at the time of planting, with the painted portion above the ground. Note the compactness of the hedge with many live culms; there is no dead center. It can be seen here how the crown of the vetiver climbs with the accumulation of trapped soil. The marks on the rulers are spaced 10cm apart.*

Thin Green Line". Lastly, I thank people like **Alemu Mekonnen** of Ethiopia who sent me an excellent set of photographs of vetiver in Ethiopia, some of which were used in the recent publication "Agri Business, World Wide", and farmers in Karnataka, India, who just write simple one sentence letters - "thank you, we read, we did and it works". What more do we need?

Recently I visited six Central American countries (Panama, Costa Rica, Honduras, El Salvador, Nicaragua and Guatemala). Vetiver is known in all six countries, but is used most widely in Costa Rica, Honduras, and Guatemala. In Honduras the grass is known as "zacate violeta" and in Guatemala "zacate valeriana". In Honduras it is used widely for medical purposes, and has special use (as a tea from the root) for curing hangovers, and calming the nerves of people and horses! In Costa Rica vetiver has been used for five or six years by coffee farmers in the southwest as a hedge against erosion, and with the arrival of a nasty fungal attack that is wiping out lemon grass, vetiver is expected to be used more widely in that country. It grew very well on most sites that I visited - some with over a 60% slope. Apart from farm use, it has great potential for checking the mass of widespread erosion point sources found along unprotected road sides and from hillside slumps.

In Honduras, LUPE, a USAID-supported conservation group, is very strongly promoting vetiver. In this country it is seen as the best grass for the creation of barrier hedges. **In Guatemala the NGO, SHARE**, is working with 20 other NGOs to establish vetiver in all the key highland zones of the country. SHARE reports that vetiver grows well at all its altitude testing sites including the highest at 2,800 meters. Some Guatemalan coffee plantations have used vetiver for at least 20 years to stabilize water ways, ditches, and road sides. The only constraints to widespread adoption of the technology are lack of farmer training, lack of information flow and planting material. All of which could be resolved given the necessary funds. I was pleased to see that in **Costa Rica** soil conservation is now a compulsory subject in the school curriculum, and that grass barriers with vetiver is one of the lessons.

In the Central American countries there is great awareness that more attention must be given to soil conservation. In these countries, with neither formal conservation agencies, nor available funds for conservation grants, their focus is on low cost biological systems. Vetiver fits their needs well and will do well throughout the region. One thought that struck me was that not only do the large farmers need to improve on-farm soil conservation, but those same farmers could do well by growing vetiver planting material for the smaller and poorer upland farmers. Often large and small farmers reside in the same watersheds, and it would be to the advantage of the large if they could provide planting material to the small - I would imagine it would also be good for community relations as well.

A couple of other snippets that might interest you. **Peter York from Zimbabwe** Tobacco Board writes to say that oven dried vetiver has a fuel energy of 17.5 MJ per kg. This is equivalent to about 56% of the energy value of coal. So maybe we have a small farmers fuel (Vetifuel) in vetiver to replace tree fuel, and if grown as a conservation hedge on the farm, perhaps rural women would love it. Anybody interested in researching what might be the the right sort of stove for vetiver and other phytomass fuels ? (S.O.S. to UK's Intermediate Technology Group)

Ted Rice of the World Bank has a farm near Recife (northeast Brazil). When looking for vetiver to conserve his farm he found to his amazement (and shame!) that vetiver had been planted 30 years ago by the Federal Highways Authority to maintain the shoulders of the road adjacent to Ted's farm, and he had never noticed - Ted is an economist so he has an excuse!

farm, and he had never noticed - Ted is an economist so he has an excuse!

Colin McLoughlin of Vancouver called me the other day to say that he had planted vetiver (using some cold tolerance "snake oil" only known to Colin) at 59° North, and it is surviving. Has anybody else had success under such northerly or southerly conditions ?

Jano Labat of Zimbabwe writes to say that he thought that he had lost his 3 ha vetiver nursery to drought - it looked completely dead. In 1992 it received only 60 mm total rainfall, and of that 15 mm was a single occurrence. In mid-December, the rains broke and within two weeks his nursery was alive again. I get the impression that in Zimbabwe vetiver has a great potential, but is being held back by disinterest in some Government agencies. If any of you readers are cotton and tobacco growers, vetiver could provide the conservation technology that you are looking for.

Jef Embrechts from Belgium writes to say that following Dr. Yoon's visit to Bangladesh his company is testing out vetiver on the flood embankments that protect the land from sea surges. Vetiver is doing well, so he says, under quite saline conditions.

Harbans Singh from Haryana, India, tells me that he planted vetiver as a farm boundary hedge some four years ago. It grew well, and acts as a good stock fence. He tried Bougainvillea but found it difficult to manage. Four years later his neighbors have approached him for some vetiver planting material - a good example of how slow and cautious farmers are when adopting new technologies.

Following the current Mississippi flooding, perhaps the **United States Army Corps of Engineers** might care to take a hard look to see how vetiver could be used to stabilize flood levees along the southern reaches of the Mississippi.

Finally, from the **new Minister of Agriculture in Fiji, Mr V.F. Dreunimisimisi**, commenting on NAS's "The Thin Green Line" - *"I have a keen interest in this grass as I know what a friend it is to farmers. I was a Technical Field Officer with the South Pacific Sugar Mills and can vouch for all mentioned in the book."*

A Look See At Vetiver In Malaysia
A Second Progress Report
By Dr. P.K. Yoon

Dr. Yoon is now retired from the Rubber Research Institute of Malaysia and is pursuing his passion for vetiver grass on his own.

I met Vetiver grass on 12/14/89 and spent the rest of the year getting to know her. In 1990 some ad hoc trials were started. The First Progress Report summarizes the efforts up to February 1991 (See Newsletter # 6). After that Report was circulated by The World Bank I was honoured to be asked to organise the First International Vetiver Workshop in Kuala Lumpur. I have since been requested to carry out consultancies in Thailand and Bangladesh. In my own country, I was asked by the Public Works Department to assess the potential uses of vetiver as biological protection of highway embankments in Sabah and along the East-West Highway. In the local scene, I was invited to lecture to Members of the Institute of Engineers, Malaysia; The Director-General and staff of Malaysian Highway Authorities; Director and staff of the Institute of Highway Research, Malaysia; Site highway engineers in Sabah and site engineers of East-West Highway. In addition, I was visited by many interested parties, both locally and from overseas, and received much correspondence and feed-back from interested parties, especially from those in the Vetiver Network.

All the above interactions and activities serve to stimulate my interest and increases my awareness of the potentials of vetiver hedgerows. It also makes me conscious of the many problems and how little we know about the plant. From all these I was able to better target my simple investigations to solve specific needs or answer specific questions.

In the conduct of my trials, collection of quantitative data is difficult in many cases because of staff constraints and logistics problems. Also, much of vetiver's adaptive performance cannot be easily quantified. I have, therefore, resorted to sequential photography which can give a clear picture of the performance of vetiver under various conditions. Consequently, I have built up a large library of photographs on different aspects of vetiver hedgerow technology. However, such records, involving many photographs, would be too expensive to reproduce. Accordingly, I attempted to video-record the photographs. Originally, I was hoping that the video recording would serve as my Second Progress Report. But as this is the first time I am using a video camera, the quality of reproduction is rather poor, the colour is distorted and the definitions are not clear. Therefore, this hastily written report includes only certain selected photographs.

The First Progress Report summarizes mainly the efforts of 1989 and 1990. In the preparation of this Second Progress Report, which starts thereon, materials that were already in the First Progress Report are generally left out. However, those trials which were initiated as stated in that report will now be discussed in fuller detail as additional data are available.

This Second Progress Report concentrates on five main themes presented as 5 separate parts. They are :

1) Production of Quality Planting Materials
2) Establishment and Management of Quality Vetiver Hedgerows
3) Use of Vetiver Grass as Mulch in Rubber Plantings
4) Vetiver Uses - Case Studies
5) Observations to Show Special Characteristics of Vetiver Hedgerows

Readers may find that there is much emphasis on quality planting material and quality hedgerows. The quick establishment of quality hedgerows is critical under tropical conditions with heavy monsoon rain. It will be justifiable to use quality hedgerows for protection of expensive structures such as highway embankments, culverts, etc. Quality hedgerows will cost more, but they may not be necessary under many other circumstances. I am not after a perfect system, only aiming for a cost-effective system to suit prevailing needs.

Cultivar	Tillers Mean per Bag 3x5	4x6	5x7	6x9	Mean	Mean Dry Weight (g) Tops 3x5	4x6	5x7	6x9	Mean	Roots 3x5	4x6	5x7	6x9	Mean	Total 3x5	4x6	5x7	6x9	Mean
India	7.0	8.4	9.6	10.2	8.8	15.3	22.4	25.6	27.4	22.7a	5.1	5.1	7.0	7.1	6.1a	20.4	27.6	32.6	34.5	28.8a
Parit Buntar	5.0	3.8	5.4	6.8	5.3	13.4	13.5	21.5	27.9	19.1 b	3.0	2.7	4.1	7.9	4.4 b	16.3	16.2	25.7	35.8	23.5 b
Taiping	6.4	8.6	7.4	7.4	7.5	12.3	16.5	18.3	18.0	16.3 cd	3.0	5.6	6.1	7.0	5.4a	15.3	22.1	24.4	25.0	21.7 b
Sabah	5.4	5.8	8.8	9.8	7.4	11.0	12.0	21.5	27.2	17.9 bc	2.7	3.5	5.8	6.3	4.6 b	13.7	15.5	27.3	33.5	22.5 b
Sabak Bernam	5.8	6.6	7.2	9.2	7.2	10.7	14.6	22.9	23.3	17.9 bc	1.9	2.7	4.3	5.6	3.6 c	12.6	17.3	27.2	29.0	21.5 bc
Raub	6.0	5.6	7.0	7.2	6.5	10.9	11.8	19.3	20.1	15.5 d	2.1	2.7	3.5	5.1	3.3 c	13.0	14.5	22.8	25.2	18.9 c
						d	c	b	a		d	c	b	a		d	c	b	a	
Mean	5.9	6.5	7.6	8.4		12.3	15.2	21.5	24.0		3.0	3.7	5.1	6.5		15.2	18.9	26.7	30.5	

Means with the same subscript are not significantly different at P<0.05

Table 1. *Effect of cultivar and bag sizes (inches) on dry weight (g) of vetiver tops. Measurements taken at 15 weeks after planting.*

The readers will have to calculate the Benefit:Cost Ratio under their own respective requirements.

The results of the trials and other ad hoc observations carried out so far and the feed-back information have shown clearly that vetiver hedgerows have tremendous potential for many areas of human activities. In the next few years we should translate them to reality in practical applications. The trip has just begun, but we can see the ultimate glorious goal at the end of the journey!

Production of Quality Planting Materials

The quick establishment of good hedgerows is important for tropical conditions where heavy monsoonal rains will wipe away any poor planting. This is particularly critical for structural works such as highway embankments, road shoulders, bridge abutments, culverts, etc.

To be able to produce quality hedgerows, quality planting materials must be used. Good planting materials must still begin with young and active tillers. In the First Progress Report, I devoted a lot of attention to propagation techniques and also pointed out the effect of various tiller types on subsequent growth. Readers can refer to that for more information. This part concentrates on:

1) Root Regeneration
2) Effect of Age of Polybag Plants on Subsequent Growth
3) Effect of Tiller Numbers at Planting on Growth
4) Effect of Cultivar and Polybag Sizes on Growth
5) Raising Vetiver Plants in Biodegradable Containers

Root Regeneration

This section examines the regeneration of cut-roots in slips. The old roots do not regenerate. They do not even form any secondary roots. As the old roots do not regenerate, they are only useful for anchorage. New roots are only formed from the new tillers or from the nodes of the old culms. Therefore plantings using slips with cut roots would be very slow in establishment and growth relative to container raised slips whose roots have been regenerated before outplanting.

Effect of Age of Polybag Plants on Subsequent Growth

Early work has shown that plants at 4 months have a good root system for transplanting and will take off immediately to produce good hedgerows quickly. This section investigates the optimum duration for raising container plants in the nursery. Plants raised up to 11, 16, 23 and 51 weeks in polybags were transplanted into the ground. Weekly examination shows very good regeneration and early growth of the root system of 23 week and also 16 week plants. Plants raised for 11 weeks show early growth but were less vigorous. Growth of 51 week-old material was very poor. Previous experience has also shown that older (70 weeks) polybag plants perform even worse. The very old container plants are not good for subsequent growth in the field as the old roots are so bag-bound that they do not regenerate. The optimum duration seems to be about 23 weeks, but it may not be economically satisfactory to keep plants for such a long time in the nursery.

Effect of Tiller Numbers at Planting on Growth

The target is to improve materials for transplanting out earlier than 4 months in the nursery but still maintaining the same good root mass at the time of transplanting. This attempts to find out whether quality planting materials can be produced in a shorter time by using more tillers as starting material.

Trial 1 — This trial compares the use of 1, 3 or 5 tillers at the time of planting into polybags. Harvesting of plants were carried out at 4, 6, 8, 10 and 12 weeks after planting. On each occasion, 10 plants were randomly selected from each treatment, roots washed, photographed, the number of new tillers counted and the dry weights determined. Plants starting with 5 tillers have a lower number of new tillers compared with those started with 3 tillers or 1 tiller. It is difficult to get 5 tillers in a clump without resorting to usage of the more matured culms; and the older the materials, the slower they are at producing new growth. Therefore, to use 5 tillers will include using older culms which are not the best for use in the production of quality planting material. The usage of 5 tillers is also a

Bag Sizes (inches)	Gap (cm) At Months After Planting										
	1	2	3	4	5	6	7	8	9	10	12
6 x 13	8.2 b	6.7 b	5.8 bc	5.3 b	4.9 b	4.0 c	3.3 b	3.0 b	2.6a	1.3a	1.0a
6 x 9	8.5 b	6.7 b	5.6 c	5.1 b	4.8 b	4.0 c	3.3 b	2.9 b	2.5a	1.1a	0.3a
5 x 7	8.4 b	7.0 b	6.0 bc	5.4 b	5.0ab	4.3 bc	3.7 b	3.1 b	2.5a	1.2a	0.5a
4 x 7	9.7a	7.9a	6.6a	6.0a	5.4a	4.8a	4.2a	3.8a	3.0a	1.8a	1.3a
4 x 6	9.3a	7.6a	6.2ab	5.4 b	5.1ab	4.4ab	3.7ab	3.4ab	2.9a	1.5a	0.9a
s.e. (+/-)	0.20	0.17	0.15	0.14	0.15	0.14	0.15	0.17	0.23	0.25	0.21
LSD (P<0.05)	0.6	0.5	0.5	0.4	0.4	0.4	0.5	0.5	-	-	-

Means with the same subscript are not significantly different at P<0.05
Note : Data on 10 and 12 month are too variable and should not be used. It is presented here only for the record.

Table 2. *Effect of bag sizes on hedge closure. After three months, the size of the polybag used had no apparent effect on the rate of hedge closure. The data above shows the gaps between clumps (cm) over time (months) after planting.*

waste of materials with little advantage gained. Polybag plants with 1 tiller as starting material produced new tillers at the fastest rate. This supports my earlier work that we should use good young active tillers for early growth. The mass of roots produced by polybags that started with 3 tillers was greater after 8 weeks than that of 1 tiller after 10 or 12 weeks. Where the root system is concerned, 8 weeks with 3 tillers starting material can easily be substituted for 12 weeks with 1 tiller.

Trial 2 — Polybag plants produced from 1 tiller and 3 tillers were planted into the ground. There was not much difference in plants started with 1 tiller compared with those from 3 tillers. However, those plants started with 3 tillers were more uniform than plants started with 1 tiller. On that basis alone, it would be advisable to use 3 tillers as starting materials.

Trial 3 — This compares the performance of polybag plants with bare root slips (Photo 2). Those bare root slips with more than 5 tillers were faster growing than those with only 3 tillers, but even those started with more than 5 tillers had much less roots than container plants. For 15 week-old container plants there was not much difference in growth between those started with 3 tillers, compared with those started with 1 tiller. However, the nursery time for the 3 tiller material could have been only 8 weeks, in which case, it would have performed better than material started from 1 tiller (Photo 2).

Effect of Cultivar and Polybag Size on Growth

The cultivar used in all the earlier trials was collected from Taiping. Since then, we have made other collections. Those cultivars with enough materials for study and especially for destructive sampling, come from Parit Buntar, India, Sabak Bernam, Sabah and Raub. A trial was set up to study the different growth rates of these cultivars and how they are influenced by bag sizes. At 15 weeks, harvesting was carried out with 10 plants per treatment. Only the 4 smaller of the bag sizes were harvested then as the larger bag sizes of 6" x 13", 7" x 15" and 8" x 12" are considered too large for practical use. There was a decrease in the number of tillers and top dry weights production from the largest bag to the smallest bag. The results are summarised in Table 1. The Indian cultivar was the best performer. It is 30% better than the Taiping cultivar in the top dry weight, 13% higher in the root dry weight. Overall it was performing 33% better in dry matter production when compared with the Taiping cultivar. In the case of the Parit Buntar cultivar, it was 17% better for the tops. (**Note:** *Taxonomic studies have not been done to confirm that these are distinct cultivars.*) The topping of the materials for all 7 bag sizes at 40 weeks, suggests that there is not much difference in dry matter production between those raised in 5" x 7" polybags and those in the larger polybags nor with the smaller bag of 4" x 6". But the 3" x 5" polybag produced lesser tops. The Indian cultivar is 69% better and Parit Buntar 23% better than the Taiping cultivar. This is a preliminary trial. Even so, there are clear indications that cultivars like India and Parit Buntar may perform better than the Taiping cultivar.

Raising Vetiver Plants in Biodegradable Containers

All the container plants discussed so far use plastic bags which are not biodegradable and therefore not environmentally friendly. We therefore investigate other biodegradable containers to access whether they can be used as substitutes for polybags. Two types were tested: (i) paper pots imported from Japan, and (ii) bags made from old newspapers. At 6 weeks the growth of plants in newspaper bags was satisfactory. However, the newspaper bags had started breaking down and by the 12th week, most of the paper bags were broken. Therefore, we must find a system to prolong the life of newspaper bags or try other types of papers. This should be the subject of future investigation. Growth of plants in paper pots was very good if they were underlaid with a polythene sheet, but if they were not underlaid and left touching the ground, the growth was poor. Paper bags were also found to be satisfactory for continued growth up to 3 months at which time the plants were ready for field planting. However, they cost 10 times more than polybags and therefore are not economical to use.

EFFECT OF UNORTHODOX ROOTING-

Effect of Unorthodox Rooting-Media on Vetiver Growth

Why this approach? The most important reason is the cost of transporting polybag materials. The use of polybags with good soil produces quality planting materials. However, unless the polybag plants can be raised on site, transporting of these planting materials tend to be very expensive. Because of that problem we tested other potting materials which are lighter and at the same time may perform better. Many materials were tested including saw dust, paddy husk, empty old palm bunches, etc. with generally disappointing results. So far, foam is the most promising unorthodox root-media.

We also investigated the influence of light conditions, testing growth under full sun and 65% daylight. The various durations under mist frame and irrigation sprinklers to produce the desired quality of the planting materials was also studied. Previously I have reported that vetiver is sensitive to shade, but nurseries are still set up underneath trees or by the side of houses, etc. where the light condition is not full daylight. In addition to the poor growth of the shaded nursery plants, the poorer quality appears to continue into the ground after transplanting; growth in the first 4 weeks was distinctly inferior to plants raised in full sun. Vetiver is shade sensitive, and nursery plants should never be raised under shade. Usage of the foam method ensures much better subsequent growth when compared with bare root tillers. In addition, the usage of the foam ensures easy and cheaper transportation costs and easy and cheaper distribution in the field. The development of the foam system (*) is most encouraging. More work will be carried out on more detailed comparative studies.

(*)Patent pending.

Establishment and Management of Quality Vetiver Hedgerows

It would be cheapest to plant vetiver slips directly into the ground. However, compared to containerized plants, such an approach can often require :

1) replacement of dead plants
2) filling of gaps of less vigorous growing slips
3) slower establishment
4) less uniform establishment

Under certain conditions, such as highway embankments, steep slopes in housing estates, etc., it would be more advantageous and possibly more cost-effective to use containerized plants. This ensures virtually 100% survival, fast establishment and good uniformity, producing the best hedgerows in the shortest time. In addition, to assess the Profitability Index or the Benefit:Cost Ratio, consideration must be given to the cost of repair of any failed structure and the inconvenience/cost of failure which disrupts other economic activities. For example, a failed road embankment could cut off transport affecting the economy of many activities.

The approaches affecting production of quality hedgerows are:

1) Effect of Bag Sizes on Establishment of Quality Vetiver Hedgerows
2) Effect of Spacing cum Fertilizer on Growth of Vetiver Hedgerows
3) Use of Selective Herbicides to Maintain Quality Vetiver Hedgerows

These are discussed in the following sections.

Photo courtesy of Dr. P.K. Yoon

***Photo 5**. Layering --attempting to protect a slope with a vetiver cover. The old culms are being pegged down using U-shaped steel wires. Where available, stones are used to hold the culms down.*

Effect of Bag Sizes on Establishment of Quality Vetiver Hedgerows

The total cost of establishing hedgerows using polybag plants will be greatly affected by bag size, in that these are reflected in the costs of : i) bags, ii) filling the bags, iii) transporting the bags, iv) digging the trench, and v) planting the polybag plants. A trial was therefore started to assess the practicality and cost-effective reduction in possible bag sizes without compromising the quality and speed of hedgerow formation.

Five bag sizes (4"x6", 4"x7", 6"x9", 5"x7", 6"x13") holding different weights of soil were used. The planting distance was kept at a constant 15cm between clumps. Fertilizer application was 1 Kokei (6g of 5-5-5-1(Mg)) per point at the time of planting and then 2 Kokei nuggets at 5, 8 and 11 months. Also at 11 months, 2 Field King Nuggets (15g) were applied. Good hedgerows formed after only 8 weeks growth.

The gaps in the hedgerow were measured at monthly intervals. It is interesting to note that the plot coefficient of variance (c.v.) increases with the months after planting. This should be expected as the error of measurement will increase as the absolute value becomes smaller. C.V.s of the first 6 months are readily acceptable while those of 7 - 9 months are tolerable.

Photo courtesy of Dr. P.K. Yoon

Photo 6. *After 12 weeks, layering of culms had produced good results. The embankment seen in Photo 5 is now covered with vetiver.*

However, the data from 10 and 12 months are too variable. Thus the validity of the mean as an indicator is questionable and gap measurement for planting distance of 15cm should not be considered after 9 months.

At the beginning, the inter-clump gap size was determined by the different bag sizes since the planting distance was constant. Later, any change would be due to the different growth rates of plants from different polybag sizes.

Table 2 summarizes the gap reductions between measurements. Other than the period of 2-3 months after planting, they are not influenced by the original bag sizes used. This suggests that the clumps were growing (expanding) at the same rate, though they may have originated from different bag sizes.

The tops above 40cm were cut and the dry weight determined. For the first 10 months this was done monthly, thereafter, it was carried out at 2-monthly intervals until the trial stopped at 16 months. Other than the first month's measurements, the top dry weights from all bag sizes were not significantly different.

In using quality polybag plants, the transplanting success was 100%. However, the trial did not include a treatment of using slips of newly cut tillers. Another weakness in the trial is the absence of measurement of the dry weights of tops and roots of plants raised in different bag sizes before transplanting to the ground. These two points should be included in subsequent trials involving different cultivars. Despite the limitations in the trial, the results showed that plant growth in the smallest bag size treatment of 4" x 6" produced similar inter-clump gap size from the fourth month and similar dry matter production from the second month after planting. Thus, the conclusion is that the small bag size of 4" x 6" could be the most economical size for fast and good establishment of vetiver hedgerows.

My earliest work uses 6" x 9" bags holding 1,486g of soil per bag. This was later changed to 5" x 7", thus reducing the weight to 837g. Now the weight could be further reduced to 401g/bag. This weight decrease is substantial especially when plants have to be transported from central nurseries to field sites over long distances.

Effect of Spacing Cum Fertilizer on Growth Of Vetiver Hedgerows

(**Ed. Note** : *Only conclusions are presented from this particular piece of work. Those desiring the full text may write to the Network*)

Since this was only an observation trial for practical application the conclusions are tentative. More fertilizer treatments and wider range of spacing would be preferred. Additional fertilizer seemed to have an effect on dry matter production in the early months, but the higher level did not produce any increase later. Spacing plays a big role in dry matter production; the wider spacing produces significantly higher dry matter per clump. The reverse was noted in dry matter production per linear distance, reflecting the interaction of individual plant growth and the planting density. There is an apparent time x density interaction and 30cm spacing seems to have caught up with the 15cm spacing after 8 months. However, 60cm spacing stayed consistently lower. The dry matter studies, the measurement of inter-clump gaps and gap reduction, strongly indicate that close planting of 15cm is preferred for quick establishment of a functional hedgerow. Use of layering of culms to fill the gaps between wider spacing is of little value.

Use of Selective Herbicides To Maintain Quality Vetiver Hedgerows

Weed management is an important aspect in the maintenance of quality vetiver hedgerows. In Malaysia, weeds grow luxuriantly under high rainfall, humidity and temperature. These weeds compete with the vetiver directly for nutrients, water and light. The last factor is most important as vetiver is not shade tolerant. In a severe weed-infested situation, even an established vetiver hedgerow will weaken and be less effective for its intended purpose.

A weed is a plant growing where it is not desired. In vetiver hedgerow establishment and maintenance, the weeds are mainly grasses and broadleaves. The grasses are less important. The more damaging weeds are broadleaves such as *Asystasia intrusa, Chromolaena odorata* (Siam weed), *Mikania micrantha* and the leguminous creepers normally grown as covers in agricultural plantations. These latter are the most noxious because they swarm over, strangle and shade out the vetiver hedgerows.

Based on other ad hoc experi-

weeds are as follows:
Chromolaena odorata (Siam weed) — Ally 20 DF (150g) or 2,4-D amine (1.5L) or Starane200 (1.25L)
Mikania micrantha — 2,4-D amine (1.0L) or Starane200 (0.5L)
Pueraria phaseoloides (legume) — Ally 20 DF (100g) or Starane200 (0.375L)

Use of Vetiver Grass as *In Situ* Mulch In Rubber Plantings

The good growth of vetiver, under many adverse conditions suggests it to be highly competitive. In a preliminary trial, vetiver without regular slashing, has been demonstrated to be competitive against Hevea (rubber); the diameter growth of young Hevea was depressed when vetiver was planted within 24". On the other hand, vetiver's growth characteristic can be exploited for various uses as in situ source for mulch when the tops are regularly slashed. Six experiments were set up to test this in three estates. The experimental details are:

Trial 1 — Alternate plots of linear planting of vetiver hedgerows and legume covers were replicated 3 times. This is a large scale observation area comparing the effect of mulching produced by the vetiver hedgerows with normal estate practice.

Trial 2 — The design is randomized blocks with 4 treatments x 6 replications. Treatments are : 1) control with legume covers; 2) linear planting of vetiver at 6" from trees; 3 & 4) circular plantings of vetiver at 18" and 24" from trees.

Trial 3 — This is sited on a steep slope. Vetiver is linear planted as hedgerows for mulch in a block flanked by commercial practice on either side.

Trial 4 — Trial layout is similar to that of Trial 1, but replicated 5 times.

Trial 5— Double grouping of treatments in a 5 x 5 Latin square was adopted for this trial sited on hilly terrain. The treatments are: 1) control - No vetiver; 2 &3) circular planting 24" from trees with 13 and 26 vetiver plants/tree; 4 & 5) circular planting 18" from trees with 10 and 20 vetiver plants/tree.

Trial 6 — This is sited on very steep land with very poor soil (Gajah Mati) in North Peninsular Malaysia where there is a very pronounced dry spell. The trial is a randomized block design of 7 treatments x 9 replications. Treatments are : 1) circular planting of vetiver at 18" from trees with 20 plants/tree; 2, 3 & 4) circular planting of vetiver at 24" from trees with 10, 13 and 26 plants/tree; 5 & 6) linear planting of vetiver, 6" and 12" away from trees; and 7) control with legume covers (estate practice).

The effect of vetiver as *in situ* mulches on the early Hevea growth over 1-2 years are rather disappointing. In 2 trials no effect was detected, while in another 3 trials, vetiver growing round a Hevea plant seem to be competitive and suppressing the growth and growth rate of Hevea. Linear planting of vetiver was beneficial for Hevea growth in two trials in the earliest girth measurements but thereafter is depressive though not as severe as circular plantings. All the above suggest that vetiver is competitive; this could be due to excessive number of vetiver plants used and the vigorous growth of vetiver. However, it should be noted that normally, in Hevea research the girth rates of the first 2 years are rarely used to assess the overall effect on the immaturity period of 4 - 5 years. We shall continue to monitor the results. Special attention will be paid to the effect of shading on the growth and competition of vetiver as the Hevea canopy close over.

Uses of Vetiver - Case Studies

This part of the report summarises the adaptive uses of vetiver on 3 commercial estates. More details are found in the video recordings which features the time sequence photos of specific sites of interest and the current situation existing as at March 1993. The following photo-essays attempt to highlight only the major points of interest.

(**Ed. Note :** *The Newsletter, unfortunately, cannot present this portion of the report to you as it utilizes about 90 photographs to tell its stories. We hope that in the coming year we will be able to find sufficient funds to allow the Network to edit Dr. Yoon's videos and add in these photos which we would then make available to Network members at cost. Any semi-professional editors out there who can volunteer to help us ?*)

Observations To Show Special Characteristics of Vetiver Hedgerows

This part examines certain special characteristics of vetiver hedgerows :

1) Resistance to Fire Damage :

A trial in ex-mining land was severely damaged by a fire. Sequential examination at weekly intervals showed fast and good recovery.

Vetiver hedgerows recovered rapidly from fire damage. The older and dry parts of the vetiver clumps were burnt, but culms which were green and active were only damaged in the upper portions. The lower parts, near the crown and partly buried in the sand, were not burnt. Similarly, there was little sign of damage to the massive root

Table 3. *Chemical analysis of soils used in Dr. Truong's experiment #1 on the impact of acidic conditions on vetiver.*

Soil pH (1:5 water)	: 3.65	Cu	: 0.1 mg/kg
EC	: 0.55 $mScm^{-1}$	Zn	: 4.0 mg/kg
Cl^-	: 358 mg/kg	Mn	: 2.0 mg/kg
NO_3^-	: 45 mg/kg	Fe	: 286 mg/kg
PO_4	: 115 mg/kg	Al (exch)	: 9.1 meq%
Ca	: 1.30 meq%	Ex Acid	: 10.30 meq%
Mg	: 1.95 meq%	Al saturation	: 62%
Na	: 1.65 meq%		
K	: 0.74 meq%		

system buried in the ground. Within a week, new tillers were produced from the unburnt portion of culms. By 4 weeks, all clumps have recovered, with vigorous new growth.

2) Growth in Highway Embankments with Difficult Soil Types:

A very difficult area on a highway embankment was used to test this. These trial results clearly show that the vetiver root system will seek out any weak point in a difficult soil structure.

A small stretch of the North-South Highway near Taiping, Perak Darul Ridzuan, was specially selected because the maintenance engineers had failed to establish any grass covers despite repeated attempts. Vetiver hedgerows, however, established well and showed good results. The tops of the vetiver hedgerows grew well. Excavation of the two difficult soil types in this small area showed that vetiver roots will seek out any weak spot in the soil. Despite the relatively poor root system that was able to develop on these difficult sites, the highway engineers were most impressed by the performance of these vetiver hedgerows to trap soil-wash and other debris from polluting the drain. Also, by slowing down the run-off, the hedgerows have allowed other grasses to grow where they were not able to earlier.

3) Excavation of Vetiver Hedges :

Excavations at various sites were done to study the soil trapped by vetiver hedgerows in cross-sectional soil profiles, the dynamics of the growth of vetiver hedgerows, and the root system. Photos 3 and 4 serve to highlight certain special features of the vetiver hedgerows.

4) Layering in Vetiver Hedgerows:

Vetiver was chosen for hedgerows because of its non-spreading characteristics. It is distinctive and compact and is an effective biological barrier for soil erosion and moisture conservation. However, under certain conditions it may be desirable to produce blanket cover for the whole area. By layering, new shoots are produced from the culms and we can make vetiver grass into a "runner" of sorts.

In the First Progress Report, it was pointed out that buds in the nodes of old culms can be induced to produce new plants. Layering of the culms, either detached or still attached to the mother clump, was used to produce culm branches for multiplication.

The same method of layering could be used to establish new plantings. A trial was carried out to determine the success of such an approach. 245 culms were pegged onto the ground by a U-shaped steel wire. Very good results of new plant production were obtained in the open (Photo 5). Only 14.1% of the culms failed to produce any plants. 27.3% of the culms produced 2 new plants each while 33.3% produce 3 - 5 new plants each. Beneath the canopy shade of the Hevea plants, the production of new plants was poorer with also less new plants per culm.

The distances where the new plants were produced on the culms were measured and partly mapped schematically. New plants were produced within 0.5m of the hedgerow and tended to be produced at the furthest end; the youngest portion of the culm. This could be partly due to the shade effect imposed by the overshadowing hedgerow. However, the more likely reason is the age of the buds on the culms; young buds tend to sprout faster.

A simple demonstration of the use of layering to protect the embankment was set up. A 15 month-old vetiver hedgerow at the crest of an embankment had its old culms pegged down by U-shaped steel wire or split bamboo. The results from this simple demonstration attracted a lot of attention during the First International Workshop in Kuala Lumpur 1992. The method using the split-bamboo did not give satisfactory result as the lower portions of the culms tend to curve up; few new plants were produced at those portions and those plants so produced, hanged in the air and did not take root. The culms pegged down by U-shape wire produced very good results and the slope on the embankment was soon covered by vetiver plants (Photo 6).

Biologically, vetiver is a clump grass of erect habit with no running rhizomes or stolons. However, this trial shows that vetiver can be converted into a runner, if necessary, by layering the culms.

The Effects of Extreme Soil pH On Vetiver Growth

By Dr. P.N.V. Troung

Dr. Truong is currently working with the Queensland Department of Primary Industries in natural resource management.

The main objective of this series of experiments was to study the effects of very low and very high soil pH levels and their associated nutritional problems on the growth of vetiver grass.

Table 4. *Sulphur and $CaCO_3$ rates used to modify pH levels in Dr. Truong's experiment #1. Basal dressing equivalent to 184 kg/ha of N, 144 kg/ha of K and micronutrients (Zn, Cu, Mn, Fe and B) and 50 kg/ha of Ca as $CaCl_2$*

Treatment	Fertilizer (t/ha)		
	Elemental S	$CaCO_3$	Basal Dressing
Control	0	0	No
1	5	0	Yes
2	2.5	0	Yes
3	0	0	Yes
4	0	0.25	Yes
5	0	0.50	Yes
6	0	1.00	Yes
7	0	2.50	Yes
8	0	5.00	Yes

TREATMENTS	PLANTING			HARVESTING		
	pH	Al*	Mn*	pH	Al*	Mn*
0	3.9	9.1	1.6	4.0	8.8	2.0
1	2.1	78.0	24.0	2.0	75.0	24.0
2	2.3	75.0	22.0	2.2	79.0	22.0
3	3.8	10.5	2.1	3.8	10.3	2.0
4	4.3	6.0	1.4	4.4	5.6	1.0
5	4.9	2.1	1.3	4.8	2.0	1.0
6	5.4	0.2	1.0	5.5	0.1	1.0
7	7.3	0.1	T	7.3	T	T
8	7.4	0.1	T	7.6	T	T

* in meq%; T = Trace

Table 5. *Soil pH, exchangeable Al and exchangeable Mn levels at planting and harvesting times.*

Acidic Conditions

A soil with extremely low pH which is known to cause Al toxicity in corn was used in this pot experiment. The very high level of exchangeable Al and relatively low exchangeable Mn concentration of this soil suggested Al toxicity rather than Mn toxicity would be the main problem of this extremely acid soil (Table 3). Eight levels of soil pH were obtained by applying varying quantities of elemental S and CaCO3 to the soil. All eight treatments also received a basal dressing of N,P,K, Ca and micro nutrients. In addition, a control treatment was also included where no S, CaCO3 or basal fertilizers were applied (Table 4).

The required quantities of S and CaCO3 were thoroughly mixed with the dry soil of each pot. Following the application of S and CaCO3, soil moisture was kept at field capacity level for two weeks before planting to allow for the stabilization of soil pH. Basal fertilizers were applied at planting. For watering, a closed system was used. Each pot was lined with two plastic bags to prevent leakage. Soil moisture during the trial was brought to field capacity by daily watering with deionized water. Plants were cut at crown level eight weeks after planting.

Table 5 indicates that the quantities of S and CaCO3 used provided a wide range of pH levels. Although both exchangeable Al and Mn concentrations were directly affected by soil pH, exchangeable Al had a larger response. Therefore the nutritional problem caused by the change of pH would be most likely due to the change of Al concentration rather than Mn. From other work it has been observed that in most cases, where both soil Al and Mn are high, plant growth reduction is due to Al not Mn toxicity.

Table 6 shows that when adequately supplied with essential nutrients, vetiver could produce excellent growth even under extremely acid conditions (pM = 3.8) and at very high level of soil Al saturation percentage (68%). However, vetiver could not survive at Al saturation level of 90%.

These results indicate that vetiver is highly tolerant to low pH and high Al saturation percentage in the soil, although these results did not show the critical toxic level of Al. Observation during the trial indicated that the critical Al toxic level for vetiver could be much higher than 68%. If the critical Al toxic level of vetiver was between 68% and 87%, then vetiver would be extremely tolerant to Al toxicity. At this level vetiver would be much more tolerant to Al toxicity than some of the most tolerant crop and pasture species. A relatively Al tolerant crop, would respond to liming when Al saturation percentage of the soil was at 15% or higher. This experiment shows that when essential nutrients are adequately supplied, vetiver growth was not improved by liming even when soil Al saturation percentage was as high as 68%.

It was also observed that proportionally more fine roots occurred under low pH and high Al saturation percentage than under low Al conditions.

The results of this experiment indicate that vetiver is extremely tolerant to high soil acidity and particularly Al toxicity. This high tolerance to Al toxicity may be traceable back to its natural habitat. Vetiver is commonly found in the tropical and sub tropical wetlands of Asia where acid sulphate soil with extremely high level of exchangeable Al in the dry season, commonly occurs.

Alkaline Conditions

An extremely alkaline and sodic soil was used in this experiment. The soil, an 18 month old spoil from an open cut coal mine, was highly erodible and very difficult to revegetate. Table 7 shows that this soil is extremely alka-

Table 6. *Dry matter yield of vetiver. These results indicate that vetiver is highly tolerant of low pH and high Al saturation.*

Treatment	D.M. Yield (g/pot)	Relative yield (%)
0	29.0	100
1	0	-
2	0	-
3	47.5	164
4	47.8	165
5	49.4	170
6	46.5	160
7	49.3	170
8	46.9	162

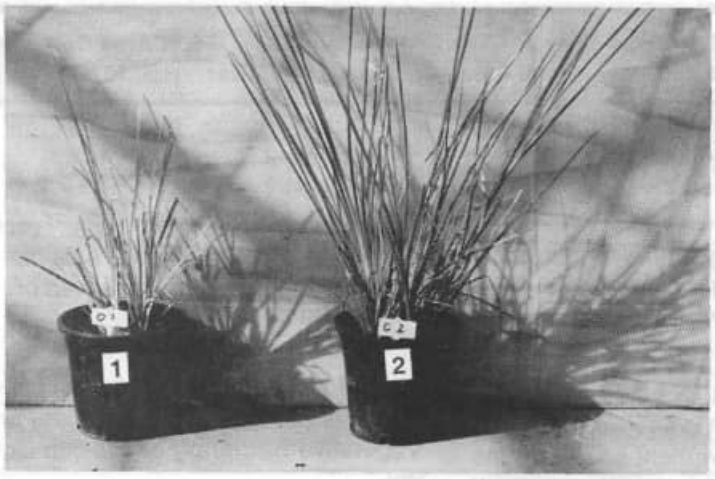


Photo courtesy of Dr. P. Truong

Photo 7. Excellent growth of vetiver in a highly alkaline and sodic soil with adequate supply of N and P. 1 = Control, no fertilizer; 2 = Treatment 1, 100 kg/ha N and 110 kg/ha P.

Photo courtesy of Dr. P. Truong

Photo 8. Excellent response to N and P application. Vetiver did not respond to gypsum. 1 = Control, no fertilizer; 2 = 100 kg/ha N and 110 kg/ha P; 3 = 4 t/ha gypsum, 110 kg/ha N, 220 kg/ha P; 4 = 8 t/ha gypsum, 200 kg/ha N, 110 kg/ha P.

line and sodic with high levels of Mg as well. The exchangeable sodium percentage (ESP) was 33%. It is also very low in N, P, Ca and S.

A pot experiment with four replicated and two levels each of fertilizer grade di-ammonium phosphate (DAP) and gypsum was carried out. For watering, the same system was used as for the previous experiment. All plants were harvested 10 weeks after planting.

Only a very small reduction in soil pH (from 9.6 to 9.0) occurred in treatments which had received fertilizer applications. At the end of 10 weeks, there was no difference in vetiver growth in all treatments receiving fertilizers (Photo 7). Vetiver grass has a moderately high level of tolerance to Na toxicity as it can be established and flourish at ESP level of 33%. The overall result is typified by the difference in vetiver growth between the control and treatment #1 which only had 100kg/ha of N and 110kg/ha of P but no gypsum (Photo 8). These results indicate that vetiver can be established on very alkaline and highly sodic soil with the application of 100 and 110kg/ha of N and P, respectively. This experiment shows that vetiver can be established and maintain good growth in very alkaline and sodic soil when N and P are adequately supplied.

Table 7. Chemical analysis of soils used in Dr. Truong's experiment #2 on the impact of alkaline conditions on vetiver.

Soil pH (1:5 water)		9.5	Ca (Alc)	(meq %)	6.0
EC $mScm^{-1}$		0.36	Mg (Alc)	(meq %)	20.0
Cl^-	mg/kg	256	Na (Alc)	(meq %)	12.0
NO_3^-	mg/kg	1.3	K (Alc)	(meq %)	0.43
PO_4	mg/kg	13	CEC *	(meq %)	36
SO_4^-S	mg/kg	6.1			

(Alc) = Alcohol extract; * at pH = 8.5

Application of Molecular Diagnostics for Discrimination of Accessions and Clones of Vetiver Grass

By Dr. S. Kresovich, et al

Drs. S. Kresovich, W.F. Lamboy, Li Rugang, Ren Jianping, A.K. Szewc-McFadden and S.M. Bliek are currently working with the USDA-ARS, Plant Genetic Resources Unit, Cornell University, Geneva, New York.

Because origins and genealogies of vetiver grass are poorly documented, and morphological uniformity and infrequent flowering precluded proper identification of selected clones, we employed molecular diagnostics linked with rigorous biometric analysis to :

1) establish if molecular diagnostics might be useful to resolve identity questions among vetiver grass accessions and clones;

2) implement a strategy, experimental protocol and analytical approach for the application of this approach toward broader issues in plant genetic resource conservation and use.

Accessions of vetiver grass were obtained from various sources. Tested were : 'Huffman' - an accession received as two clones of undetermined origin (*); 'Boucard' - an accession received as two clones from Jamaica and/or Guatemala; and PI196257 - an accession received as three clones of Indian origin.

DNA was extracted from young leaf tissue of each clone, amplified and analyzed.

The data support with a high degree of certainty (P>0.05) that the accession 'Huffman' and 'Boucard' were essentially the same genotype. The three clones of accession PI196257, on the other hand, were found to be genetically unique. A review of records (the accession was provided from a government plant materials center)

	Total Stem Count	Sample Average	Stem Total Compared to Vetiver	% Compared to Vetiver	Total Area	Total Area Compared to Vetiver	% Area Compared to Vetiver
Vetiver	589	294.5	------	------	10,066 mm2	------	------
M. sinensis	629	314.5	+ 20	+ 6.8%	5,606 mm2	- 4,460 mm2	- 44.3%
M. zebrinus	1,455	413.0	+118.5	+ 40.2%	7,057 mm2	- 3,010 mm2	- 29.9%

Table 8. *A comparison of stem count and area occupied by stems for vetiver and two species of Miscanthus -- a clump grass under testing by the US Soil Conservation Service as a cold climate substitute for vetiver. Sampling consisted of measurements taken on two plants of each species; all plants were the same age.*

government plant materials center) show that this accession was introduced into the United States as a vegetative propagule, but seed was subsequently produced and collected domestically. Progeny of the seed increase were grown and then vegetatively propagated. On further investigation, one of the clones within this accession was found to have a mixture of genotypes among its individual culms, i.e. the plant was a mixture of genotypes. The mixture of genotypes among the three clones of accession PI196257 can be explained by its history of sexual rather than vegetative propagation. As to how an individual (supposedly) clone could be, rather, a mixture of genotypes is a matter of conjecture. One likely hypothesis is that unmonitored vegetative propagation occurred among accessions.

The work done here highlights how detection of genetic similarities and differences is important when classical morphological characterization information was of limited value. There are currently over 20 accessions of vetiver grass available for field trial in the United States. Serious consideration must be given to any planned introduction or improvement based on the characteristics of this genetic spectrum. More extensive surveys and/or acquisitions of material available globally would aid vetiver grass researchers as they attempt to resolve the chronic problem of soil erosion.

(*) **Ed. Note :** *Mr. Gueric Boucard believes that the clones designated 'Huffman' have their origins in Guatemala.*

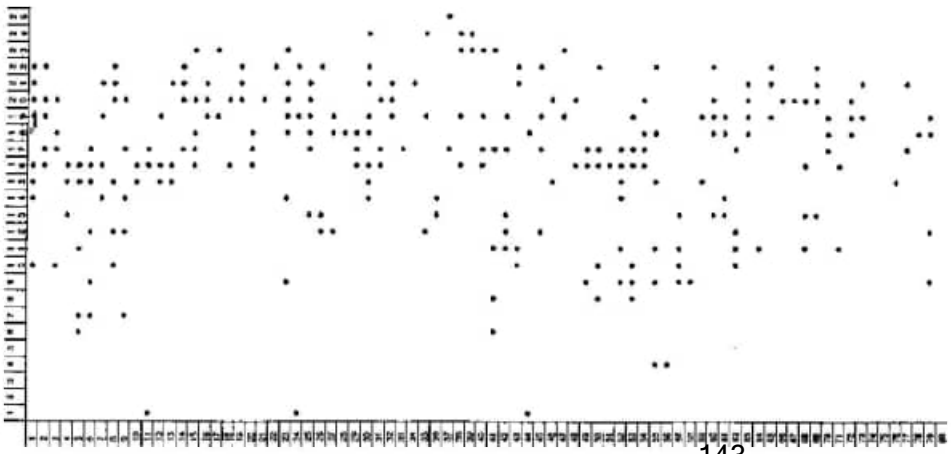
Comparative Measurements of Vetiver and Miscanthus By Mr. M. Materne and Ms. C. Schexnayder

Both Mr. Materne and Ms. Schexnayder currently work with the U.S. Soil Conservation Service in Baton Rouge, Louisiana.

The following are excerpts from Mr. Materne's December 1992 talk at the meeting in Oxford, Mississippi of the Work Group on Grass Hedges (cum Vegetative Barriers) For Erosion Control.

Some of these vegetative barriers (VBs) planted 30 months ago have now accumulated about two feet of sediment in front of them. Native plants which could not grow on the scoured hard beds of these wash areas prior to the vetiver hedge plantings are invading the accumulated sediments rapidly providing additional stability to these soils. The vetiver grass has sprouted from the nodes on portions of the stems buried by the sediment. The vetiver plants have adapted to the sediment deposition and are growing well. Extensive vetiver and miscanthus barriers planted about 18 months ago are all performing as barriers to water and sediment accumulations. The miscanthus begins growing about 6 weeks earlier than the vetiver (in the spring), but the extremely rapid summer growth of the vetiver produces more volume of stem growth and results in denser hedges (Table 8, Figures 1,2, and 3). Clipping hedges increased the stems per plant. Burning the hedges when they were dry increased mortality. Fertilization gave dramatic increases in growth rates of the VBs. Elevation profiles along the beds of the gullies across which hedges were planted in 1991 are showing significant depositions of sediment in front (upslope) of those hedges.

Figure 1. *A stem map of Miscanthus sinensis; each dot represents one stem. Marks on the scale are in centimeters. The area mapped is 25cm x 80cm, and represents a section of Miscanthus hedge.*



Effects of Shading and Cutting On the Growth of Vetiver By Dr. Xia Hanping

Dr. Xia is with the South China Institute of Botany in Guangzhou, PRC.

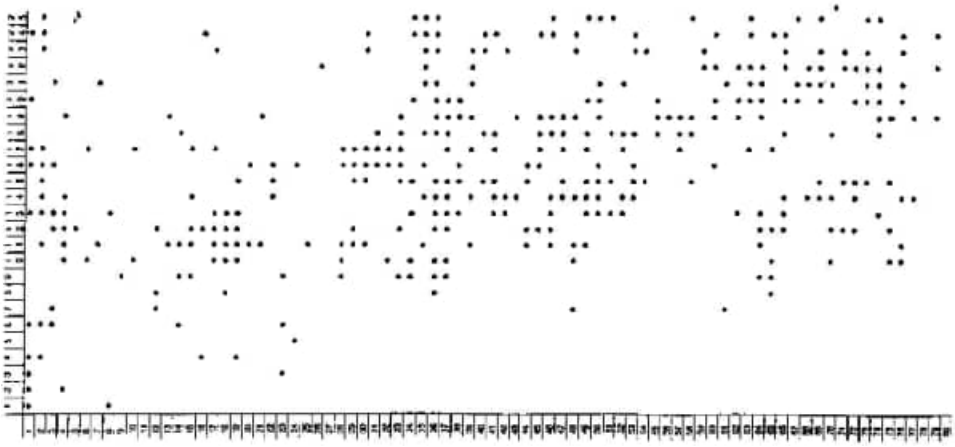


Figure 2. *A stem map of Miscanthus zebrinus; each dot represents one stem. Marks on the scale are in centimeters. The area mapped is 25cm x 80cm, and represents a section of Miscanthus hedge.*

Four treatments comprising two groups (shaded/non-shaded and pruned/non-pruned) were established in March of 1992. With the exception of the treatments themselves, all management was uniform across treatments (e.g. weeding, watering, fertilization). Beginning when the first new leaves appeared, the shade treatment was applied (75% shade) and maintained for 15 weeks (March 26 to July 9). Pruning treatments were applied three times (June 9, September 9 and December 8).

As expected, while under shade the rate of tiller formation was much lower than in the non-shaded plants. Upon removal of the shade, however, tillering rates were very close between the two treatments. We could conclude that shading only has a temporary effect on vetiver. However, the effect of shading on plant height and dry weight persisted. Height growth of the shaded treatment, measured by monthly net increments, was 85% of the non-shaded treatment in the four months following removal of the shading. Dry weights of the shaded vetiver were only 52% of the non-shaded. We conclude that when vetiver is planted in association with crops, it should be done at the same time or earlier than the crop and kept the maximum distance possible away from the crop.

Pruning of vetiver at 30cm was carried out three times. It is believed that pruning can enhance the rate of tillering. Our observations show that to do so, cutting must be timely and not too frequent or growth will be lost. Rates of tiller production between pruned and unpruned vetiver remained about equal until after the third pruning, when the rates of the pruned vetiver fell to 78% of the unpruned. With no further pruning, similar tillering rates were once again achieved. However, non-pruning of vetiver slows growth, that is, if allowed to grow into the reproductive stage growth rates will diminish. Therefore, it is suitable to prune vetiver twice annually. Once in February to March, and the second time in August to September. This will accelerate tiller formation relative to unpruned vetiver.

Effects of Vetiver Hedges and Mulch on Micro-Site Factors in a Citrus Orchard

By Dr. Chen Kai

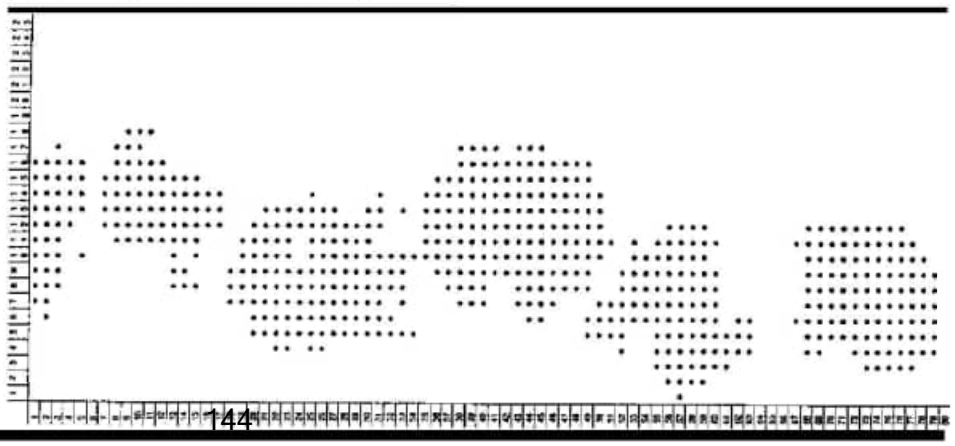
Dr. Chen is currently working with the Department of Horticulture at Nanjing Agricultural University in Jiangsu Province, PRC.

Based on 4 replicated trials in our department's orchards we have come to the preliminary conclusion that vetiver hedgerows and mulches have a significant, beneficial impact on a number of micro-site factors. We attribute its utility, and thus its beneficial impacts, to : i) its rapid growth and significant accumulation of annual biomass and ii) its excellent adaptability to the periods of extreme temperatures and water stress found in the eroded red soils regions of southern China.

Mulch production from vetiver hedgerows (in tons green weight per 100 m^2 of hedgerow) averaged 11.4, 14.7 and 17.8 in years 1, 2 and 3, respectively. (**Ed. Note:** *100 m^2 of hedgerow was equivalent to about 230 linear meters of hedge)*

Hedgerows, functioning i) as windbreaks, ii) to shade the soil, and iii) as a source of mulch provided a synergistic effect resulting in amelioration of the micro-climate. For example, on 22 August 1992 the differences between the controls and the vetiver treatments were measured. Air, soil surface and

Figure 3. *A stem map of Vetiveria zizanioides; each dot represents one stem. Marks on the scale are in centimeters. The area mapped is 25cm x 80cm, and represents a section of Vetiver hedge. Note the density of the vetiver hedge relative to the Miscanthus hedges.*



Treatment	Mean Daily Air Temp. (C)	Relative Humidity (%)	Soil Surface Temperature: Mean Daily (C)	Max (C)	Min (C)	Fluctuation (C)	Rhizosphere: Mean Daily (C)	Soil Moisture
Control	29.3	59.2	33.8	58.6	22.5	36.1	29.2	17.4%
Vetiver	26.5	63.5	28.7	39.5	24.2	15.3	27.5	20.2%

Table 9. *Micro-climatic improvements associated with mulching and vetiver hedges combined.*

rhizosphere temperatures were all lower in the vetiver treatments. Also, in the vetiver treatments, relative humidities and soil moisture contents were higher; diurnal temperature fluctuations were less than half of the control's (Table 9).

Three years of mulching and erosion control with the vetiver hedges also significantly improved the orchard soil's physical and chemical properties (Table 10).

In view of our findings we have extended the use of vetiver throughout the orchards in our experiment station.

The Soil Salinity Tolerance of Vetiver Grass Species Compared with Two Native Australian Species

By Mr. G. Cook

Mr. Cook is a student at the University of New England in Australia.

This paper investigates 2 native species, *Vetiveria filipes* and *Lomandra longifolia* and compares their soil salt tolerance with that of *Vetiveria zizanioides* and *Vetiveria zizanioides* var Grafton. The objectives were :

- To set up a pot trial to test the salt tolerances of each species.
- To establish the relationships between soil ECse (Electrical Conductivity soil extract, a unit of measure to describe soil salinity) and the Relative Yields (increase in biomass) through statistical analysis.
- To determine the Lethal Dose 50%, or LD_{50}, for each species.
- To compare the results with Paul Truong's results (**Ed. Note** : *see Vetiver Newsletters #6 and #8*) and make comment on the differences.
- To make comment and recommendations on the potential of the various species.

The plant material was divided into individual culms (growth shoots), except for the *Lomandra longifolia*, which was trimmed so that the most dominant and central stem was the only one left. The leaves on all of the species were then trimmed to approximately 10cm and the roots were trimmed to a similar length. The soil used was supplied by the N.S.W. Soil Conservation Service/Kempsey Division. This soil was a free draining black coastal sand. The sets of culms were then planted into 17cm by 17cm black polyethylene pots. Each pot was fertilized with 5 grams of slow release fertilizer. (Total N - 18%, Total P - 2.6%, K - 10%, S - 4%, Ca - 0.6%). The plants were then watered daily for one week so as to give the plants time to acclimatize after transplant stress.

There were 5 salt concentrations used in the experiment by 4 species by 5 replicates per species. This pot trial set up was done in accordance with the methods laid out in the N.S.W. Soil Conservation Technical Handbook "Pot and Field Trials" (Anon. 1984). Each of the pots was free draining. Five NaCl salt solutions were made up daily. These concentrations were : 20 mS/cm, 15 mS/cm, 10 mS/cm, 5 mS/cm and 0 mS/cm. Degree of error = -0.1 mS/cm at 18.4 degrees C.

V. zizanioides tolerance to salt was high and even at the highest salt concentration there was still active growth in some of the culms. TheLD_{50} for shoot growth was calculated at 14.15 mS/cm while the LD_{50} for total growth was 14.75 mS/cm. This result compares well with Paul Truong's work (17.5 mS/cm). The accuracy of Truong's work is limited by the range over which the experimental Soil ECse was conducted. This experiment was conducted over a greater range of treatments. It can be confidently concluded that *Vetiveria zizanioides* has a very high tolerance to salt. *V. zizanioides* has a LD_{50} range of 13 - 17.5 mS/cm. Soil ECse at 16 mS/cm or higher are considered to be highly saline by the U.S. Salinity Laboratory.

Of the four types of grass tested., *V. zizanioides* shows the highest potential for the construction of hedgerows as a soil conservation measure in saline soil areas. It can be confidently concluded that it has a very high tolerance to salt. According to the U.S. Salinity Laboratory Soil ECse at 16 mS/cm or higher is considered to be highly saline. *Lomandra longifolia* exhibited greater salt tolerance (LD_{50}s = 23.2 mS/cm and 20.0 mS/cm, for shoot and total growth , respectively), but its open form and sexual reproduction make it less

Table 10. *Impact on soil properties of 3 years of mulch application and protection with vetiver hedges.*

Treatment	Bulk Density g/cm3	Porosity (%)	pH	Organic Matter	N	P	K	Ca	Mg	Zn	B
Control	1.35	48.6	4.7	1.03%	0.47%	0.07%	0.24%	2.52%	0.74%	0.01%	0.001%
Vetiver	1.26	52.4	5.4	1.49%	0.64%	0.09%	0.75%	5.26%	0.92%	0.03%	0.001%

does, however, have a very dense and soil binding system of roots. *V. zizanioides* var Grafton appears to have a salt tolerance similar to that of *V. zizanioides*. This variety's ability to tolerate repotting stress and osmotic stress is, however, considerably lower than that of *V. zizanioides*. Additionally, it is known to set viable seed, from which it readily reproduces. *V. filipes* was found to have the lowest salt tolerance (LD_{50} = 11.1 and 10.9 mS/cm for shoot and total growth, respectively). Additionally, though it exhibited vigorous root growth, its roots did not form the type of dense mat desirable for soil conservation.

At this stage, the critical factor limiting *V. zizanioides* use in Australia is the evaluation of its weed potential.

Stabilization of Highway Roadcuts with Vetiver
By Mr. A. Tantum

Mr. Tantum operates his own consulting firm. One of his prime objectives is to demonstrate the value of vetiver grass in soil conservation and civil engineering in South Africa.

The face of a roadcut was gunited along its entire length in 1990/91. In addition, vetiver grass was planted above one section of the gunited road cut to observe its impact (if any). The lines of vetiver were planted and then left alone. No fertilizer or irrigation was applied. As there was no maintenance, vetiver slips which washed out prior to establishment were not replaced. Primarily, washouts occurred among the vetiver lines that were at the bottom (downhill side) of the planting. The top lines suffered little washout. The gunited surfaces below the vetiver hedges, in subsequent inspections, were found to be in good condition (Photo 9). In the areas with no vetiver hedges above to control runoff, the eroding of the gunite was well advanced (Photo 10). The non-protected areas will require re-guniting with in a short period.

Stability of Slopes of Vetiver Protected Irrigation Channels
By Dr. Sahu, et al.

Drs. A.P. Sahu, S.D. Sharma and S.C. Nayak are working with the College of Agricultural Engineering and Technology, OUAT, Bhubaneswar, India.

Conveyance and distribution of water are integral parts of any irrigation project. Unlined earth channels are frequently used in the water conveyance systems. These channels are usually designed in trapezoidal sections. The flowing water in the earthen channels cause erosion and sloughing of side slopes. In the long run the side slopes become flatter and the channels take more or less parabolic shapes. The design capacity of the channel is, therefore, changed with the change of its cross-section.

Channel side slopes are determined principally by soil texture and stability. Earthen channels should be built with stable side slopes and with banks strong enough to carry the required flow of water safely. It has been recommended that the side slope of 3:1 (H:V) is suitable for channels constructed in sandy loam or porous clay soil and that permanent irrigation channels should not have side slopes steeper than 1.5 horizontal to 1 vertical. Where polyethylene has been used as a liner to prevent seepage, the protective soil cover placed over it also limits side slopes and permissible velocities. A 3:1 side slope has been recommended by some, though the National Committee on the use of Plastics in Agriculture (NCPA) recommends a minimum side slope of 2:1 where earth cover is used for LDPE film lining. But a flatter slope is required depending upon properties of the cover material. Using flatter slopes, as in LDPE film lining, larger areas will be lost by construction of channels.

As a potential solution to this problem, the ability of vetiver grass to protect side slopes from erosion and to stabilize the channel sections was tested. Whether or not it would be effective was assumed to be a function of the plant's root system, i.e. density or soil binding capability and depth of the effective root system.

Two rectangular field channels (one lined with LDPE and the other unlined) were laid out (20cm wide x 20cm deep, gradient = 0.1%, length = 19m) with vertical sides and vetiver grass was planted in lines 10cm back from the channel lips; a 10cm spacing between plants was utilized. Soils were a sandy loam with a maximum (dry) bulk density of 1.75gm/cm3.

After planting, the vetiver was allowed sufficient time to establish before water was run through the channel. Water flowing through a steep-sided (in this case, vertical) channel will erode the sides until such time as a stable condition is achieved. An average of 10 liters/second was run through each channel for one hour per day. Water was run through the unlined channel and the LDPE lined channel for a total of 9 and 6 hours, respectively. Table 11 shows the details.

Photo 9. *Vetiver demonstration plot, highway roadcut in South Africa. Hedges were planted to protect gunited surfaces from runoff.*

Photo courtesy of Mr. A. Tantum

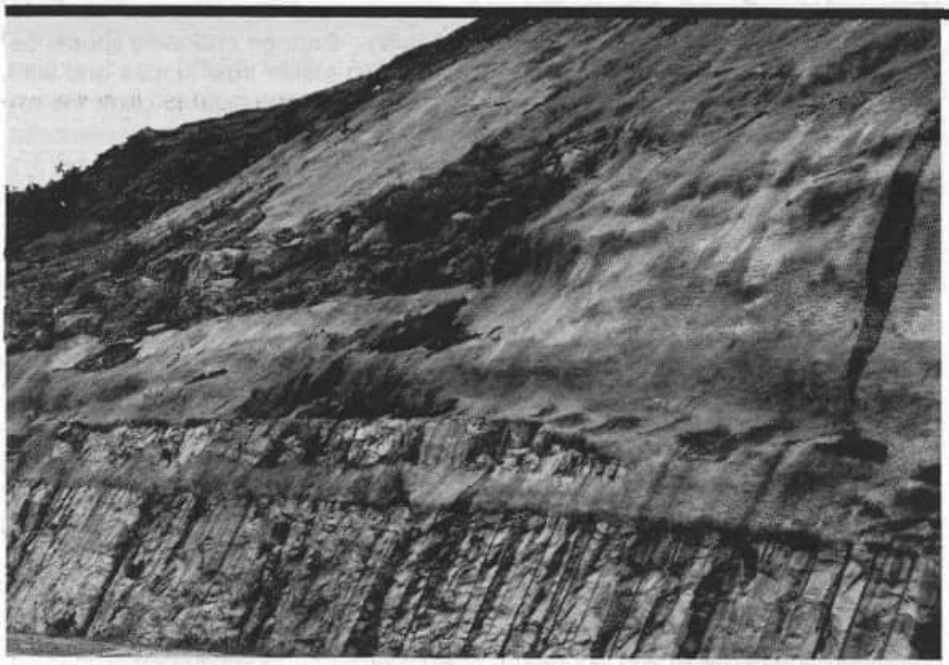


Photo courtesy of Mr. A. Tantum

Photo 10. *Where no vetiver hedges were planted to control runoff, the gunite has begun to erode.*

The side slopes of the field channels planted with vetiver remained vertical in the lined channel and nearly so in the unlined channel. This indicates the high efficiency of the vetiver root system in binding and holding the soil together. It also suggests that in designing channels with vetiver grass, one can go for earthen channels with much steeper sides in sandy loam soil. Since the vetiver grass protected channels can maintain steeper sides, they occupy less space as compared with conventional earthen channels.

Vetiver in Hong Kong
By Dr. R.D. Hill

Dr. Hill works with the University of Hong Kong and is the editor of the Asia-Pacific Uplands Newsletter.

A number of experimental plantings for erosion control have been made since 1989, some of which have been previously reported in Vetiver Newsletters. One, a planting carried out in 1991 on eroding, decomposed granite of very low nutrient status at Jordan Valley is now flourishing. This planting was made at the beginning of the dry season to test survival of the tillers with the further object of seeing if vetiver planting might provide dry-season employment. However, the spring of 1992 was early and was very wet so that the high rate of survival (98%) that we observed may be atypical. By mid-1992 the plantings had hedged up, except in gully floors where wash-outs occurred, and adventitious plants had begun to cover the surface above the hedges. Soil formation has begun in the trapped sediment and this has been assisted by periodical cutting of the vetiver to 30cm and throwing the cut material upslope of the hedges to form a mulch. The mulch persists for up to a year and while adding nutrients also protects the soil surface from raindrop impact and reduces sediment mobilization. This planting was under government supervision and some objection on aesthetic grounds has, apparently, been made to using vetiver. Monitoring of the build-up of soil above the hedges has proved impossible in this public-access area as erosion-pins inserted for measurement purposes have been pulled out. This part of the experiment has therefore been abandoned.

A further, recent planting is part of a study to establish contour-planted hedges of two fodders - Stylosanthes for wet-season production and *Cajanus cajan* for dry-season production. Vetiver is first planted for erosion control in single contour rows at 10cm spacing on burnt-over grassland. We prefer to do this using soil augers as these disturb the soil much less than using conventional hoes or pick-axes. Once the vetiver is established Stylo and Cajanus are sown in contour furrows. This experiment has just begun and will continue in the 1993 planting season.

Our initial vetiver planting, on 18 January 1993, was less than successful. Slips were trimmed to 30cm of leaf before planting at 15cm depth. This proved to be too shallow, and of the 300 or so slips planted 18% were subsequently blown out and died. Several weeks of strong winds - the site is an exposed ridge -, temperatures below 15° and little rain also contributed to further losses, a further 39% had (apparently) not established when we surveyed the planting on 29 March 1993. The burnt area we are planting is the result of an uncontrolled fire which occurred in early November 1992. We wanted to plant the site immediately after the fire to protect it but we delayed the planting because we thought to be too late to rely on residual soil moisture as we had in the abovementioned Jordan Valley planting. It is hoped that a further planting in late March will be more successful since the spring flush of growth had by then begun. Further plantings at monthly intervals are planned.

In Hong Kong we prefer to use stiff, old tillers and new tillers planted together in the same hole. There are two reasons for this. Our 'mother stock' has been in the same plot for several years because high labour costs and limited demand for slips have made it uneconomic to divide and replant. More importantly it is desirable that the 'comb-like' action of the vetiver in trapping sediment begins at once. If using young, green, relatively flaccid planting material there is a delay until it matures and stiffens up. On some sites pebbles and small boulders are mobile and by using stiff, mature material these are trapped even by very new plantings.

Vegetative Hedgerows for Erosion Control in Southwestern Mississippi
By Dr. Tiwari, et al.

Drs. S.C. Tiwari, P.E. Igbokwe, J.L. Burton, and R.E. Waters, Jr. are all associated with Alcorn State University in Lorman, Mississippi, USA.

A field experiment was carried to investigate four vetiver grass accessions (Nos. 196257, 213902, 271633 and 302300) and a switch grass (*Panicum virgatum*) accession "Alamo" for sediment retention on an undulating field with a 6% slope. The study was conducted on a Memphis silt loam (Typic Hapludalf) soil. A randomized complete block design was used. Planting was done in single straight lines across the slope with four replications (blocks) per accession. Each block was 7.6m long and was planted with 10 plants from each of the five grass accessions planted 16cm apart. A 3.6m wide area immediately above each hedgerow was kept free of vegetation by constant cultivation to represent a farmland prone to soil movement due to tillage and absence of ground cover. A wire, 200mm above the ground level was stretched above the grass planting line, and used to determine changes in soil elevation. This field study, which began on May 5, 1991 (hedgerow planting date), was terminated June 30, 1993 after two growing seasons. At the end of the first growing season, all were pruned to 25cm. Every month, the rise in soil mass along the line beneath the 200mm wire was determined by five measurements at 5 randomly selected locations. Similarly, for each grass accession within each block, monthly measurements were taken to determine the rate at which the gaps between the clumps of grass were closing, i.e. rate of hedge formation. Data collected on soil elevation and gap closure during the two years of study were analyzed by the analysis of variance and means separated by the Duncan multiple range test.

There were no statistically significant differences between the different grasses tested and the rates of hedge formation or sediment accumulation (Table 12). However, soil elevation (sediment accumulation) was highest due to vetiver grass accession 271633, and least due to the vetiver accession 302300. The percent change in elevation was similarly highest due to vetiver grass accession 271633, and least due to the grass accession 302300.

The gap closure rate was highest due to vetiver grass accession 302300, and least due to the other vetivers and Alamo grass accessions. The percent gap closure was similarly highest for vetiver grass accession 302300.

Although all grass accessions showed potential for controlling sediment movement on a Memphis silt loam soil of Southwest Mississippi, it is observed that vetiver grass accession 271633 seems to have the greatest potential for the control of sediment movement even though vetiver grass accession 302300 seems to have faster rate of hedge formation than the other accessions in this study. After 13 months of growth in this area, for all accessions, the average rate of gap closure (lateral growth) was 124.2mm, and the average increase in soil elevation was 47.9mm.

These findings suggest that :

- These grass accessions are well adapted to the Memphis silt loam soil of Southwest Mississippi, and will slow runoff and cause the deposit of sediments when planted for use as vegetative barriers.
- Average slope between two hedgerows can be reduced significantly in only two growing seasons. In this trial, average slope was reduced by about 67%.

The authors wish to thank the United States Department of Energy and Mississippi Department of Energy and Transportation Division, Economic and Community Development for funding this project.

Table 11. *Effectiveness of vetiver in stabilizing irrigation channels. The sideslopes of the vetiver-protected irrigation channels remained nearly vertical, indicating the high efficiency of the root system in binding soil.*

Channel Description	Average Top Width, T (cm)	Average Bottom Width, B (cm)	Average Depth of Section D(cm)	Tan 0 = $\frac{D}{\frac{(T-B)}{2}}$	0 = Arctan $\frac{D}{\frac{(T-B)}{2}}$	Sideslope H:V
Unlined, vetiver protected	32.6	29.0	16.2	10.2	84.4 degrees	0.1 : 1.0
Lined (LDPE film), vetiver protected	22.2	22.2	17.2	infinity	90 degrees	0.0 : 1.0

Soil and Water Conservation A Dimension of Sustainability at the Watershed Level
By Dr. D.V. Rao

Dr. Rao is working with the Institute of Economic Growth in New Delhi, India.

Our study pertains to the Maheswaram watershed development project in Ranga Reddy district of Andhra Pradesh. One of the outstanding features of this project is that the soil and moisture conservation encompass both engineering structures and vegetative barriers with khus (vetiver) grass hedges. A stratified random sample of 121 farms was surveyed during the year 1988-89 in the project area to analyze the relative merits of different conservation technologies and approaches adopted at the watershed level.

The conservation measures undertaken are expected to increase the yield and value of crops. An impact assessment shows that the yields of sorghum-pigeonpea and castor are 51.2% and 17.5% higher, respectively, on farms with engineering measures than that of those with no conservation. They are 74.2% and 32.6% higher, respectively, on farms with vegetative

Grass Accession	Soil Mass Elevation Y Soil Elevation (mm)	Elevation (%)	Lateral Plant Growth X Gap Filling (mm)	Gap Filling (%)
Switch "Almo"	47.78	23.89	122.70	86.17
Vetiver 196257	51.53	25.76	124.95	87.75
Vetiver 213902	44.20	22.11	122.83	86.25
Vetiver 271633	54.30	27.15	122.70	86.17
Vetiver 302300	41.08	20.54	127.58	89.59
Mean	47.78	23.89	124.15	87.19
CV, %	36.41	36.41	4.08	4.08

X - Based on the initial within row plant distance (152.4mm)
Y - Based on the initial height of stretched wire from soil level

Table 12. *Hedgerow effect on soil mass elevation, rate of gap filling.*

measures. Similarly, the incremental land values are 25% and 45% more with engineering and vegetative measures than that of lands with no such measures. These conservation measures need regular care and maintenance. For instance, the decrease in productivity and land values on farms with old bunds that were constructed 15-20 years ago indicates further degradation of dry lands. This suggests that stabilization of conservation structures is crucial.

The results of benefit cost analysis show that the annual incremental net benefit for sorghum-pigeonpea and castor are Rs. 300 and Rs. 291/hectare with engineering measures over that with no conservation measures at their market prices. The benefits are Rs. 453 and Rs. 480 for these crops with vegetative measures. Similarly the incremental net present values, NPVs, are higher for vegetative measures, i.e. Rs. 3045 and Rs. 2839/hectare for sorghum intercrop and castor, respectively. Whereas the NPVs are only Rs. 1101 and Rs. 586/hectare with engineering measures at 12% discount rate. However, the annual benefits and NPVs are much higher with castor with vegetative measures at their shadow prices as castor earns foreign exchange.

Optimal land use strategies suggest that within the available resource constraints, greater areas, as much as 80%, should be brought under vegetative measures of conservation to contain soil loss as a whole. Further, income can also be increased. Obviously, there is no conflict here between optimal land use with conservation and income maximization. To sum up, soil and water conservation programs are profitable if they are implemented on a watershed basis with regular care and maintenance. Vegetative barriers with khus hedges are found to be more profitable, even during the initial stages, due to their efficiency and low cost. Therefore the vegetative measures are expected to be in large areas in years to come by virtue of their replicability, efficiency and profitability.

Evaluation of Vetiver Hedgerows Relative to Graded Bunds and Other Vegetative Hedgerows By Drs. Sagare and Meshram

Drs. B.N. Sagare and S.S. Meshram are working with PKV University, Akola, Maharashtra, India.

During the period 1989 through 1991, data was collected to compare the impacts of vetiver hedgerows relative to graded bunds and other vegetative barriers of *Leucaena leucocephala* (Subabul), *Cymbopogon flexuosus* (Lemon grass) and *Chrysopogon martinii* (Tikhadi). The study areas receive about 840mm average annual rainfall.

Vetiver vs. Bunding

Experimental plots were located on shallow, relatively flat areas (22cm soil depth, 1.5% slope). The plot soils comprised Lithic Ustorthents with moisture holding capacity at -0.3 bar and -15 bar, 38% and 25%, respectively. Available water content was 170.3mm/m. Treatments comprised cultivation across the slope and along graded bunds with 0.2% grade at 1m VI (vertical interval) and contour cultivation along with vetiver hedgerows (0.5m VI). Subplot treatments included various cropping systems: sorghum, cotton and mungbean; sorghum + mungbean (2:1); and cotton + mungbean (1:1). Net plot sizes were 96.2m x 9.8m. Recommended rates of NPK were utilized for each crop.

Leaf area (LA) of functional leaves of representative plants was measured by automatic leaf area meter and leaf area indices were calculated. Periodic soil samples from 0 to 22cm depth were collected for gravimetric moisture determination and soil moisture storage calculations. Moisture Use Efficiency (MUE) was calculated on the basis of yield (kg/ha) divided by total moisture

use by crop. Determination of NPK status of soil was carried out before and after the harvest of crops.

Maximum increases in LA was recorded with vetiver hedgerow treatments (with contour cultivation) as compared to cultivation across the slope and graded bunds at all the stages of crop growth. Average LA in vetiver hedgerow treatment was 20.6% and 12.5% greater than across the slope and graded bund treatments, respectively.

Maximum enhancement in yields of sorghum, cotton and mungbean was due to vetiver hedgerows followed by graded bunding and across the slope. Average increase in total productivity due to vetiver hedgerows was 17.1% and 32.3% as compared to cultivation along graded bunds and across the slope, respectively (Table 13).

The highest monetary returns was obtained with vetiver hedgerows followed by cultivation along graded bunds and across the slope. Vetiver hedgerows recorded maximum benefit:cost ratio followed by across the slope and graded bunding (Table 14).

Graded bunds and vetiver hedgerows were found comparable in respect of mean moisture use by various crops. However, MUE within the vetiver plots was 17.2% and 33.1% higher (i.e. greater production per unit of water) than that for graded bunding and across the slope treatments, respectively.

Residual soil nutrients consistently tended to be higher on the vetiver plots versus the others. N was 2.9% and 1.9% higher, P_2O_5 was 6.6% and 2.7% higher and K_2O was 11.5% and 7.7% higher in the vetiver plots versus the across slope and graded bund plots, respectively.

Vetiver vs. Other Vegetative Barriers

To assess vetiver hedgerows in relation to other vegetative barriers, a randomized block design experiment with three replicates was conducted during 1992 using cotton as a test crop. Plot soils comprised Typic Chromusterts of moderate depth on relatively flat areas (58cm soil depth and 2% slope). Moisture holding capacity at -0.3 bar and -15 bar were 40.4% and 19.4%, respectively. Treatments included across the slope cultivation and contour farming along with various vegetative hedgerows: *Vetiveria zizanioides* (vetiver or khus), *Leucaena leucocephala* (Subabul), *Cymbopogon flexuosus* (Lemon grass) and *Chrysopogon martinii* (Tikhadi) established at 0.5m vertical interval. Net size of plots was 98.2m x 14.8m. The recommended dose of NPK was applied to all the plots. Moisture use, MUE and soil nutrient status was estimated as per previously described.

Yield of seed cotton from vetiver with contour cultivation plots was 25.5% greater than that from across the slope cultivation without any hedgerows. Leucaena, lemon grass and chrysopogon treatments increased seed cotton yield by 24%, 15% and 11%, respectively, versus the across the slope cultivated plots.

Highest gross monetary return (Rs. 4734/ha) and benefit:cost ratio (1.55) were recorded due to vetiver barriers followed by leucaena and lemon grass barriers (Table 15).

Highest mean soil moisture percentage, profile and available moisture storage were recorded due to vetiver and leucaena hedgerows. Lemon grass and chrysopogon hedgerows recorded comparatively less available moisture than that of vetiver and leucaena barriers. This might be due to higher mortality rates in lemon grass and chrysopogon hedgerows, which resulted in decreasing intake of water and available soil moisture.

Maximum MUE (0.80 kg/ha/mm) was found with vetiver hedgerows followed by leucaena (0.75 kg/ha/mm), lemon grass (0.70 kg/ha/mm) and chrysopogon (0.69 kg/ha/mm). This indicated that growing of cotton along with vetiver hedgerows gave more yield of cotton per mm of water as compared to leucaena, lemon grass and chrysopogon hedgerows.

Table 13. *Total productivity (q/ha) by treatment and by crop.*

Treatments	Sorghum	Cotton	Mung Bean	Sorghum + Mung Bean	Cotton + Mung Bean	Pooled Mean
Across the slope	18.10	7.83	1.89	19.67	8.09	11.12
Vetiver hedgerows	23.36	9.51	3.38	25.86	11.42	14.71
Graded bunds	19.38	9.02	2.49	21.08	10.84	12.56
Mean	20.28	8.79	2.59	22.20	10.12	

	SEm +/-	CD 5%
Main treatments	0.38	1.45
Sub treatments	0.31	0.89
Interaction effect	0.55	1.56

Experiences with Vetiver
By Dr. G.M. Bharad

Dr. G.M. Bharad is working with PKV University, Akola, Maharashtra, India.

Dr. Bharad has been working with vetiver grass on, primarily, Black Cotton soils (vertisols) since 1987. His work has been covered in a number of previous Newsletters. In order to avoid redundancy, only a few excerpts from his paper, a compendium of his management and research experience, are published below.

Selection of non-flowering material : Variation in the flowering patterns of our vetiver stocks was observed. It was also seen that flower culms die in the next season and flowering diminishes plant vigor. Non-flowering clumps were identified, propagated and planted out in lines in 1991. Neither in 1991 or

Treatments	Sorghum	Cotton	Mung Bean	Sorghum + Mung Bean	Cotton + Mung Bean	Pooled Mean
Across the slope	1.84	2.26	0.68	2.29	2.69	1.95
Vetiver hedgerows	2.48	2.76	1.22	3.41	3.79	2.73
Graded bunds	1.26	1.54	0.44	1.60	1.98	1.36
Mean	1.86	2.19	0.78	2.43	2.82	

Table 14. *Benefit : Cost Ratios by treatment and by crop.*

1992 did any of this material flower. The material from this line is being further tested and multiplied.

Selection and preparation of planting material : Old material with senescing or dead flower culms should be rejected. Prune shoots to 15-20cm and leave 5-7cm of roots to help anchor the slip. Treatment of stacked material with 25g/l of copper oxychloride is a good idea.

Planting : Be absolutely sure that the soil is well-compacted back around the slips when they are planted. Failure to do this is one of the major reasons for high mortality at planting.

Gapfilling : Vetiver normally establishes in within 2 to 3 weeks after planting. Gapfilling should be done 3 to 4 weeks after planting. Later than this, well-established, containerized plants should be used to fill gaps.

Maintenance : Pruning is essential and should be carried out 2 to 3 times during the rainy season; however, pruning should not be below 40 to 50cm or it will effect vigor and growth. When weeding the field NEVER throw the uprooted weeds into the hedgerows. Do not plow or cultivate within 20cm of the hedge until it is well-established. May burning of hedgerows helps to keep them termite-free.

Gully stabilization : Rows of vetiver planted at a 0.5m vertical interval appears to work well. Be sure to plant the vetiver in a V-shape, with the point of the V upstream. This lessens the chance for washouts. Where waterways or drains exit fields, two or three lines of vetiver planted across the waterway and tied into single lines of vetiver planted on the field boundary is effective to control runoff and scour.

The Largest (Known) Individual Planting of Vetiver Hedgerows By Mr. M. Robert

Mr. Robert is a private farmer in South Africa.

This letter has been written to inform the Network of the progress of vetiver planted on the sugarcane farms, Vallonia Estate. The total area of the farms is 300 hectares. Vetiver was introduced to this area from Mauritius about 70 years ago by my grandfather, the late Mr.Charles De Charmoy. The grass has been planted on the sides of roads on the above mentioned estates for the past 40 years.

The most common method of soil conservation on sugarcane farms in this area is to establish fields as strips aligned horizontally on the contour. The field boundaries are infield roads which are spaced according to slope and soil type.

On our existing fields, to change from our current practices to that presently applied was considered undesirable for a number of reasons, both economic and practical. In short, the current system would be too costly to apply, would take up land and restrict mobility. Through MASDAR I acquired a copy of your vetiver handbook, the concept made so much sense that I started implementing the hedgerow system right away and to date have planted 146 hectares to this system. I am now into the fourth growing season using the vetiver system and I am very pleased with it (Photo 11).

The vertical interval (VI) between hedgerows varies from between 3 to 7 meters. Vetiver grass can be planted in cane fields either during the planting operation or in a ratoon crop. Most important, the vetiver must never be cut back to promote tillering if the sugar cane is going to cause too much shading. Then when the sugar cane is cut, cut the vetiver back. In our area, the vetiver would be cut back once in every 12 to 18 months. The operation to promote tillering will cease once the desired hedge thickness has been achieved. Burning of vetiver also promotes tillering.

An effective planting approach for using vetiver in watercourse stabilization is shown in Figure 4. It is very important that the first line of grass is planted just above the base (line 1) and thereafter work your way up the slope (lines 2 and 3). The vetiver planted across the base (A) can be taken out once natural grasses are growing so as not to impede the flow of water. The lines 1, 2 and 3 will always remain.

Table 15. *Gross returns and benefit : cost ratios of vegetative treatments versus across the slope cultivation.*

Treatments	Gross Returns (Rs/ha)	B : C Ratio
Across the slope	3812	1.24
Vetiver	4734	1.55
Leucaena	4664	1.52
Cymbopogon	4336	1.42
Chrysopogon	4241	1.39

Photo courtesy of Mr. M. Robert

Photo 11. *Vetiver hedgerows on Mr. Robert's farm in South Africa (1991).*

line 3) as you will get undermining in the waterway and eventually the bank will collapse.

When using vetiver in gully stabilization, where possible, shape the gully or bank before planting. Rows of vetiver planted half a meter apart will soon stabilize it.

We also stabilized a river flowing through the farm using vetiver in conjunction with indigenous trees.

Leechee trees were also planted together with vetiver. "Half-moons" of vetiver were planted on the downhill side of the tree to retain moisture. No young trees were lost in the 1992 drought even without irrigation.

All vetiver planting is done manually using between 3 and 5 slips, in clump form, which are dipped into water and planted 15cm apart. All the planting material is cut back to 200mm before planting. For maintenance, the vetiver is cut back periodically to 50cm in height to assist tillering. While young plants are growing, hand weeding is required; however, once mature chemical weedkillers can be used which do not affect the vetiver.

The use of the vetiver system has proved to me that in the long term it is the most effective and cheapest form of soil and moisture conservation. A lot of interest is being shown in vetiver and it is just a matter of time before more people start making use of it. In the short term I truly believe that one can expect an increase in crop yields. Some of my own experiments have proved this to be the case.

A Commercial Source For Vetiver Planting Material

One of the most common questions asked of the Network is *"Where can I obtain vetiver grass ?"*. Recently, a new source has come to the attention of the Network. **The American Vetivert Corporation, Inc.** has informed us that they now can offer vetiver planting material in commercial quantities through the mail. The material they offer comes in two forms :

1) Vetiver clumps of 15cm to 20cm diameter. Roughly, a 15cm clump comprises about 50 tillers. Leaves and roots are trimmed and it is treated with fungicide and packaged in 27.3 kg cartons for shipment. The cost (not including shipping from Dilley, Texas) is US$6/clump or about roughly US$300/27.3 kg carton.

2) Vetiver plantlets, comprised of about 3 or 4 tillers/plantlet. The plantlets are about 5cm in diameter at the base. Leaves and roots are trimmed and it is treated with fungicide and packaged in 27.3 kg cartons for shipment. The cost (not including shipping from Dilley, Texas) is US$2/plantlet or about roughly US$400/27.3 kg carton.

This material is the 'Boucard' clone that was DNA fingerprinted as related in the molecular diagnostics article in this Newsletter, and is genetically distinct from the 'seedy' vetivers.

For more information contact :
American Vetivert Corporation, Inc.
P.O. Box 166
Leakey, Texas 78873
Fax (210) 232-5716

Report On Mortality In Vetiver Hedgerows In India

Jim Smyle, editor of the Vetiver Newsletter, visited the Maheshwaram watershed in Andhra Pradesh, India. During the visit he investigated reports of dieback in established vetiver hedgerows. The following summarizes his findings.

I was able to observe a range of conditions under which older, established hedgerows of vetiver grass were intact and functional through to conditions where once functional hedgerows had virtually disappeared. These observations led to the formulation of the following **opinions** on the vetiver hedgerows and causes of the observed dieback.

No single cause of the die-back is apparent, rather it appears to be a combination of factors leading to loss of the hedges.

Vetiver is close to the edge of its range in terms of available moisture, with "available moisture" defined as a function of the combination of rainfall (semiarid zone with an average moisture deficit period of 9 to 10 months each year (*)), soil moisture holding capacity (low) and soil depth (shallow). It therefore is not as vigorous as it is under more humid conditions. However, it still is sufficiently adapted to the climate and soils in the Maheshwaram watershed to be useful so long as it is not subjected to prolonged periods of high stress.

To varying degrees — minimal in protected areas with some irrigation, to severe in rainfed areas under fallow — white ant (termite) nesting within vetiver clumps seems to be having the effect of suppressing regrowth of new tillers

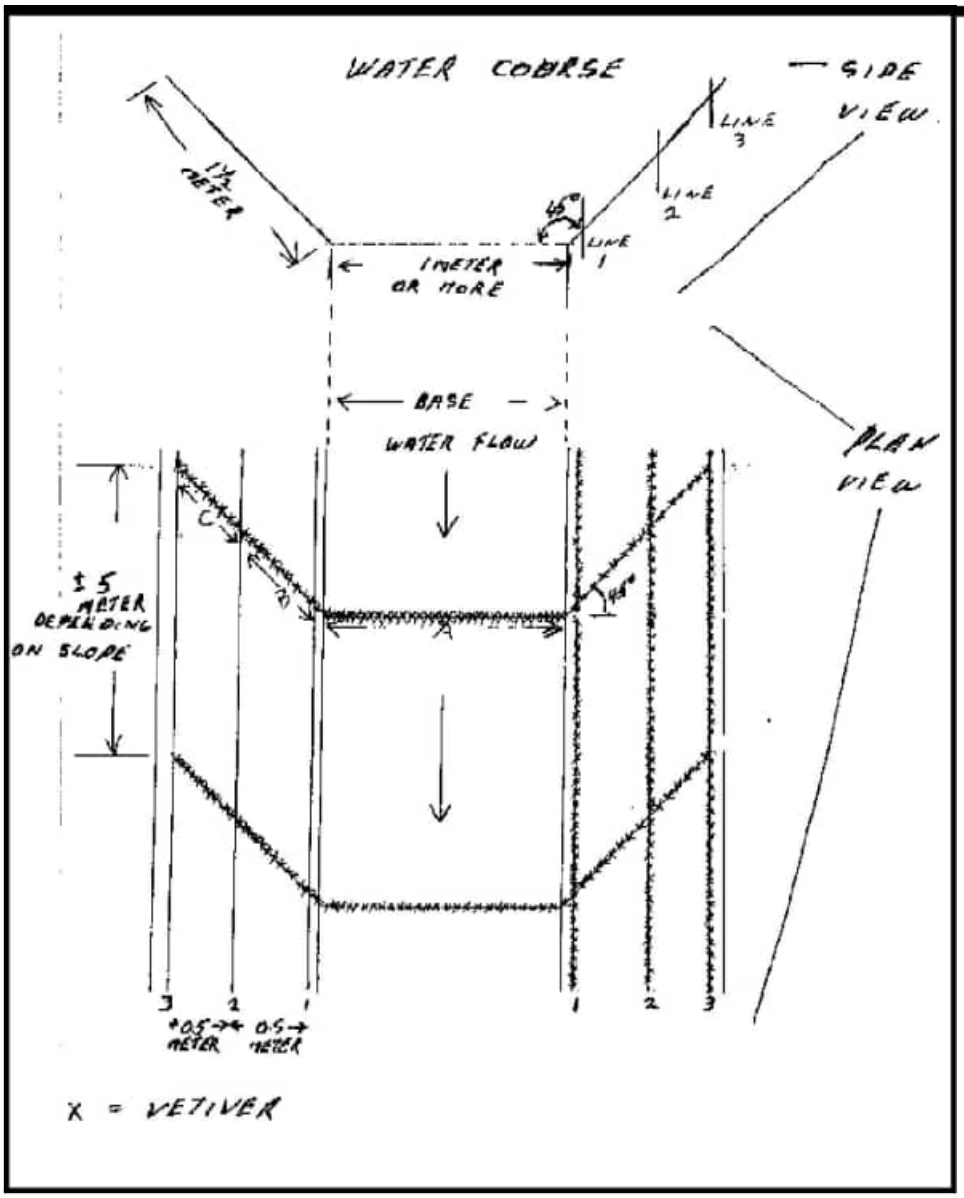


Figure 4. *Mr. Robert's approach for stabilizing watercourses. This is a method which Mr. Robert has used successfully on his own farm. Note the lines of vetiver running parallel to the direction of the flow.*

suppressing regrowth of new tillers within the centers of the clumps. The medium term effect is for the hedges to become hollowed out. The hollowing reportedly becomes noticeable about year 4 after planting.

With the hollowing of the clumps, the only new tillers are those which are coming out on the periphery. These young tillers are not protected by the presence of the older, woody growth. As a result, grazing commonly keeps the new tillers cut down near ground level.

Where fields are not cultivated for one to two seasons, unrelieved grazing pressure exhausts the roots and the clumps die and the hedges disappear. Where fields are cultivated, the plants are better able to persist. However, even under these conditions lack of regrowth in the centers and dry season grazing pressures are still causing loss of function and mortality such that the utility of the hedgerows for controlling runoff and sediment is being lost.

Under protected conditions — e.g. in irrigated horticultural plantings where increased soil moisture levels minimize the incidence of white ants — vetiver hedges are well-able to maintain themselves.

Under rainfed conditions where grazing does not occur, the vetiver hedges are in decline from (white ant-caused) lack of regrowth in their centers.

In summation, it appears that a hierarchy of problems exists. Firstly, the white ants suppress regrowth making the plants vulnerable to grazing. Secondly, grazing pressures keep the plants from maintaining themselves. Thirdly, under the prevailing climatic and edaphic conditions the plant is unable to overcome the stress.

Recommendations

The main concern at this point is to ascertain to what extent the causes of mortality in older hedges are amenable to management and under what circumstances such management practices would be practical. Since it appears that die-back in the older hedges is a function of white ant activities both suppressing regrowth in the hedges' centers and thus leaving the plants vulnerable to grazing, the first step is to target white ant control. Two strategies should be trialed by the project as a short term stop gap :

-- Annual burning of hedgerows in order to remove dead material upon which white ants feed. Hedgerows can be burned sometime in January through May within farmer's fields (**). With protection of the fields from grazing at onset of monsoons, the hedgerows could recover sufficiently to provide some runoff control by the time the more intense rains of late July and August occur. ICRISAT's runoff plot vetiver trials could include burning of vetiver as a treatment to verify the efficacy of this approach under local conditions.

-- Chemical control. The current practice of using BHC or Aldrin at time of planting gives only short term protection to the plants; also these chemicals are undesirable both from environmental and human health aspects. Any annual applications of insecticides are probably impractical and most chemicals capable of providing long term protection are highly toxic and environmentally unsafe. Some relatively new granular formulations recommended for forestry use may provide a solution; these are slow release, long acting (5 to 7 years) formulations that have low toxicity and

are considered to be environmentally acceptable.

Concurrently, research support is needed to verify the cause of mortality. Studies which should be done could include :

-- Ascertain the impact, if any, of termite nesting on regrowth of the centers of vetiver. Possible mechanisms of suppression could be: (i) Mechanical: the walls of active termite nests as well as the material from abandoned termite nests which washes into the centers of the clumps appears to have a high bulk density. New, young tillers may be unable to push through this material and, then the covered portions would be shaded out; (ii) Chemical: there may be some allelopathic mechanism with termite castings which suppresses vetiver regrowth; (iii) Biological: increased humidity levels within termite nests could promote fungal, viral or bacterial activity inimicable to the growth of vetiver.

-- Verify that the fungi on older clumps is saprophytic, rather than pathogenic (i.e. causing mortality);

— Continue pruning studies to look at effects of long term, continuous grazing which keeps plants below 20cm in height; and

— Carry out accession trials to ascertain if any provenances or types of vetiver are better suited/more resistant to white ants, drought, etc. The traditional, so-called "farmer selected" vetiver from the Kabbalnala/ Gundalpet area should be tested immediately.

Other apparent causes of decline and mortality in hedgerows related to: (i) Farmers plowing through the hedges; (ii) Shading out of hedges as associated forestry species overtopped and closed canopies and; (iii) Farmers piling of weeds and other residues on hedgerows.

Hedgerow Management

Generally farmers (and often project staff) seem to be operating under the assumption that the vetiver hedges require no management. There are no systems which do not require management. For example, experience and experimental data indicate that, for example :

-- Some parts of the plant should be culled as they have low survival rates; culling, however, is not carried out;

-- Soil moisture levels are critical to vetiver establishment — however, planting reportedly continues almost irrespective of rainfall in order to meet targets. The example in Rajasthan of farmers carrying out their own planting appears to be the best solution here.

-- Planting depth and re-compaction of soil around slips is essential, yet one can commonly observe that these are not done correctly.

-- Any gapfilling should be done in the first year, yet gapfilling is not commonly carried out immediately or at all.

-- Pruning of hedgerows is beneficial to their growth and vigor; however, pruning below about 40cm stresses the plants. The majority of hedgerows observed were well below 40cm or, if above this height, were generally unpruned. The former situation is almost certainly detrimental to long term persistence when it becomes the norm and the plants are not allowed to recover.

— Repeated plowing operations immediately along the hedges damages plants and causes mortality. While such plowing is necessary to control hedge width, it probably is undesirable until the hedge attains a width of about 50cm.

Undoubtedly, greater levels of management inputs are needed in order to sustain the vetiver hedgerows, particularly under the semi-arid conditions in the Plains. This should not necessarily be a drawback. Narrow, stiff grass hedgerows as a technology for controlling surface runoff are likely to maintain a relative advantage in establishment and maintenance costs over structural and other vegetative (e.g. grass strips, woody perennial hedgerows) approaches.

Footnotes

(*) According to Nieuwolt, S., 1977, Tropical Climatology, John Wiley and Sons Ltd. London, England. pg. 191-92.

(**) There may be conflicting priorities in terms of when to burn. Intuitively it makes sense to burn the hedges as early as possible to remove the dry material before white ants nest. However, preliminary data from Maharashtra indicates that later burning (April) is preferred as early burning stimulates growth which is grazed or dries out in the dry season — this reduces plant vigor in the early monsoon season.

The findings, interpretations, and conclusions expressed here are entirely those of the authors and should not be attributed in any manner to the World Bank

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER INFORMATION NETWORK, NUMBER 11, JUNE 1994

THE NEWSLETTER

This newsletter has been entirely prepared by the vetiver users of Thailand and we give special thanks to **Dr. Sumet Tantivejkul**, Secretary-General, The Office of the Royal Development Projects Board. The newsletter provides an interesting account of the remarkable progress that has been made in the introduction of vetiver in a relatively short time. It is particularly important in that it describes how a major-country wide initiative has been undertaken involving policy makers, agencies, officials and the general public. I believe that we can all learn a lot from this initiative in Thailand, and I hope that it inspires some readers to mount similar efforts to reduce soil losses and improve water conservation. The Thai initiative also reflects on the professionalism and leadership of Thailand's King, **His Majesty, King Bhumibhol Adulyadej**. His Majesty has provided the leadership, and has demonstrated his keen interest through His personal participation and that of His Family. He has clearly inspired his people to act. He has also inspired a lot of people outside of Thailand, and in recognition of this, the Vetiver Information Network, at a private ceremony at the Royal Chitralada Palace, awarded His Majesty a specially commissioned bronze vetiver sculpture.

I would also like to take the opportunity of the occasion of this Newsletter to notify you that **Jim Smyle** will, from the beginning of June, be full time in Central America working out of San Jose, Costa Rica. I would like to take the opportunity of this newsletter to thank Jim for all the hard work that he has put into the Network both in the field and for the Newsletter. Without him we would not be where we are today. Fortunately we have not lost him. He will be establishing a vetiver network for Central and South America, and I hope, over time, those of you from that part of the World will direct your queries to Jim. He will respond to you in Spanish!! His address in Costa Rica will be: James Smyle, RUTA, Barrio Escalante, Del Parque Francia, 25 Metros Sur, Casa #342, San Jose, Costa Rica. Tel (506) 255 4011; fax (506) 222 6556.

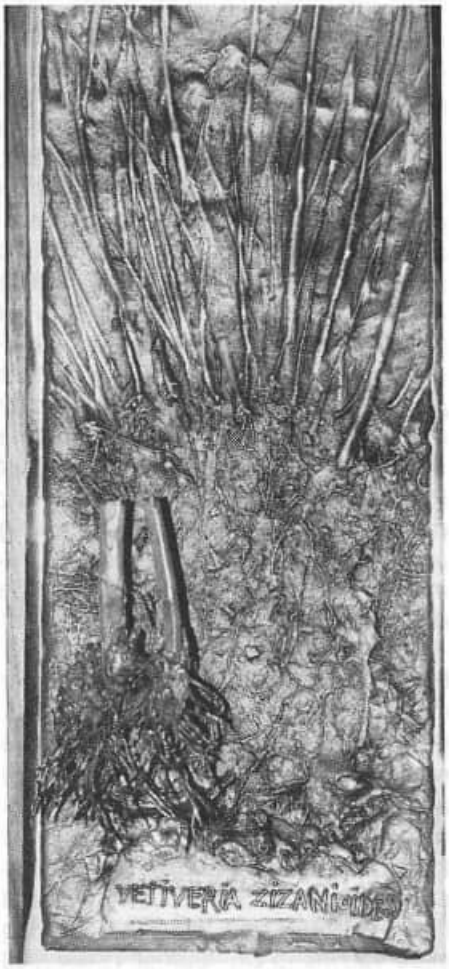


***Photo # 1.** Bronze sculpture, by Reginald Pollack, of Vetiveria zizanioides presented to His Majesty The King of Thailand, by The Vetiver Information Network.*
***Photo Credit:** R.G.Grimshaw*

The next Newsletter, #12, will be published very shortly and will contain feedback from many of you who have kindly supplied information to the network, as well as some notes on my recent visit to India where there are some interesting activities occurring in the use of vetiver.

Dick Grimshaw

Development and Promotion of the Utilization of Vetiver Grass in Thailand

***Photo #2.** His Majesty The King of Thailand and Her Royal Highness the Princess Mother discussing the merits of some good quality vetiver planting material at Doi Tung Development Project.*
***Photo Credit:** Dr. Sumet Tantivejkul*

BACKGROUND

Thailand's soils are currently deteriorating at an unacceptable level that have reached a critical stage. Statistically, one third of the country, equivalent to 107 million rai (17 million ha —1 ha = 6.25 rai) has been seriously affected by soil erosion, particularly in the northern, north-eastern, central and southern parts of the country.

The problem arises from continuous misuse and non-protection of arable lands, deforestation, expansion of the business and industrial sectors into agricultural areas and increase in population, all of which combine to force farmers to exploit and devastate forest lands in the high plains or mountainous areas including the cultivation of short term crops without appropriate preventive measures against soil erosion. Recognizing the importance and necessity of solving the problem, His Majesty the King initiated the use of vetiver grass for conserving soil and water and improving the environment in cultivated and forested areas. His Majesty's initiative concerning vetiver grass was first received by Dr. Sumet Tantivejkul, Secretary-General of the Office of the Royal Development Projects Board, and other concerned people on June 22, 1991 at the Royal Chitralada Palace as quoted below:

"Vetiver Grass is a plant which has a deep root system penetrating straight into the soil and spreading like an underground fence capable of filtering sediments and protecting soil surface runoff. Given these favourable characteristics, studies and experimentation on the cultivation and use of vetiver grass should be conducted at the Royal Development Study Centres and other appropriate locations on a wide scale, and consistent with topographical conditions of the areas. On mountainous locations, vetiver grass should be planted as horizontal contour hedges across the slopes and gullies for protection against soil erosion and slippage and the maintenance of moisture in the soil. On the plains, vetiver grass should be cultivated around or on cultivation plots, in one or two contour lines. When inter-cropped with field crops it should preserve moisture in the soil, absorb nitrogen, and prevent toxic, and other chemicals from flowing into rivers and canals. Moreover, vetiver grass should be planted around reservoirs to prevent the soil from collapsing into and filling up the reservoirs, as well as preserving the soil surface at the upper part of the reservoirs and accelerating tree growth in forest areas which receive adequate water. In addition, there should be a study on efficiency of vetiver grass in controlling the spread of the lalang grass (Imperate cylindrica) in the areas where the lalang is wide spread. At the upper part of the reservoirs, vetiver grass should be cultivated to trap sediments and absorb chemicals and toxins before flowing into waterways. These substances are then stored in the root and stem until they transform into fertilizer useful for plants. It is important to photograph the vetiver before and after the experimentation Additionally the results should be recorded with respect to vetiver's growth, i.e. stem and root; capability of vetiver grass in conserving soil, increasing soil fertility and preserving soil moisture as well as studies on different species and ecotypes of vetiver".

His Majesty the King has paid regular visits to various areas where vetiver grass is grown in order to observe the results of the experimentation and give advice. Furthermore, His Majesty donated US$10,000 from His private fund to the Vetiver Information Network to support research on vetiver grass and its uses. His Majesty made the following observations to Dr. Sumet Tantivejkul on August 28, 1993 at the Royal Chitralada Palace.

"Vetiver grass must be planted 15 cm. apart for large clumps and 2-3 cm. apart for small clumps. However, the latter approach using small clumps at 2-3 cm. interval is believed to be more effective as it will economize the planting slips and form a dense hedge within a few months. By using large clumps with wider intervals, it may take about 2 years for the hedge to become effective. This time frame is too long. The plantings at the Doi Tung Project are rather expensive because vetiver grass is planted in a very dense hedge. However, the project is intended to be an experiment with rapid results. In conclusion, planting smaller clumps at closer distance is appropriate. The vertical interval between rows should be two meters according to the technical paper; the interval being measured vertically along the slope of two meters descending from top to bottom. The interval might not always be 2 m. distance, but can be 1.50 m. as practical. At 1.50 m. apart, it might be more "comfortable" since it is approximately the height of a person. If it is 2 m., a person would have to stretch, but this is also practical, since it would enable the person to view the second row more easily".

Following His Majesty's initiatives to use vetiver grass for soil and water conservation, government and non-government agencies gave greater attention to the impotance of soil and water conservation. The Office of the Royal Development Projects Board provided a central coordinating role for 16 agencies: Department of Land Development, the Royal Forestry Department, Department of Agriculture, the Royal Irrigation Deprtment, Department of Agricultural Extension, Office of Agricultural Land Reform, Department of Livestock Development, Department of Border Patrol Police, Department of Public Welfare, Office of the Accelerated Rural Development, Department of the Royal Highways, Kasetsart University, Chiang Mai University, Khon Kaen University, Prince of Songkla University and Scientific and Technological Research Institute of Thailand.

These agencies were assigned the role to conduct studies and experiments on cultivating and using vetiver grass at different locations and under different uses. In order to allow the activities of these agencies to operate in a cooperative and consistent manner, former Prime Minister Anand Panyarachun, in his capacity as the Chairman of the Royal Development Projects Board, mandated the establishment of the Committee on Development and Promotion of the Utilization of Vetiver Grass under His Majesty's Initiatives on June 24, 1992. The late, His Majesty's Privy Councilor, His Royal Highness Prince Chakraphandphensiri Chakraphand, was the

President of the Committee, with the Permanent Secretaries of the participating Ministries and Director Generals of different agencies acting as the executive members of the Committee. The Secretary-General of the Royal Development Projects Board was appointed as the member and secretary. This Committee is responsible for formulating policies and guidelines in the development and promotion of the use of vetiver grass according to His Majesty's initiatives, as well as monitoring and providing suggestion concerning the operation of the projects.

On August 13, 1992, the Chairman of the Committee on Development and Promotion of the Utilization of Vetiver Grass officially set up the Master Plan Team on Development and Promotion of the Utilization of Vetiver Grass, and the Monitoring and Evaluation Team, both involving representatives from the agencies. The Master Plan Team drafted a master plan for the development of the vetiver grass program, the features of which reflected the consistent and supportive framework of an operation due for completion within 2 years (1993-1994).

The Master Plan contains five plans for the overall operation of the project as follows:

Research, investigation and experimentation plan is subdivided into three groups comprising: the botanical and genetic research group; appropriateness of the utilization of vetiver group; and propagation of vetiver grass using tissue culture techniques group.

Public relations plan involves making of posters, publications, leaflets and brochures; promotion through various sources of mass media; making of video and slides; organizing of seminars targeting 200 concerned officials per year throughout the country as well as preparation of occasional exhibitions.

Dissemination of knowledge plan embraces organization of training for the trainers from concerned agencies, practical seminars for research officials and field practitioners, as well as overseas training in specific fields on technology for the utilization of vetiver grass.

Demonstration and promotion of cultivation in targeted areas plan focuses on campaign promotion on the use of appropriate vetiver species (Vetiveria zizanioides), appointment of the Office of the Royal Development Projects Board and the Department of Land Development to be the central agencies to distribute the correct species/ecotypes of vetiver grass; and to prevent the uses of wrong species which may become noxious weeds and damage the country. At present, the agencies have produced and propagated more than 3 million tillers for distribution to other agencies for further propagation purposes.

Monitoring and evaluating plan: The Committee on Development and Promotion of the Utilization of Vetiver Grass is responsible for studying documents, collecting field data, interviewing the field implementing officials for field data and taking photographs. Moreover, the responsible agencies in the areas where vetiver grass is grown are required to report the results of the operation to the Committee every four months, in the form of a published report, including detailed data analysis. The reports would be further disseminated.

The results thus far of the monitoring and evaluation of the vetiver plantings in the targeted areas from October 1992 to September 1993 are summarized below:

STUDY AND RESEARCH

Collection of Species of Vetiver Grass: The Department of Land Development has collected all the species of vetiver grass, both locally and abroad, to grow in different habitats of the country so as to conduct a comparative study on their growth in different conditions of habitats. Currently, the vetiver grass can be classified into two species as follows:

Vetiveria zizanioides (Nash). This species is able to adapt very well and grow fast in various environmental conditions. Most of the exotic types which were introduced from India, Sri Lanka and Indonesia are especially selected plants and are treated under the factors different from the natural conditions, such as regular cutting, in order to accelerate stem propagation, limit the emergence of inflorescence and prevent cross breeding and mutation. The vetiver grass which is commonly found in natural habitats in Thailand adapts itself to suit the different conditions of the ecosystem, exhibiting many inflorescences and cross-pollination every year.

Although the cross-pollination makes the vetiver grass tolerant to diseases and climatic crisis, mutation may cause the unsteadiness and reduction of the volatile oils. The blade of the grass is 45-90 cm. long and 0.6-0.9 cm. wide, curved on upper surface and flat near the apex, with a smooth and waxy texture, and dark green in color. The color of the lower surface is paler than that of the upper surface. The septum can be seen clearly especially at the basal and middle part of the blade; whereas, the midrib is obscured and buried in the blade.

The one year vetiver has long roots that enable it to penetrate more than one meter below the soil surface. This depends on soil conditions and on the strength of the plant. In alluvial sandy soil, the grass will produce the longest root possible. On December 19, 1991 at the Doi Tung Development Project, Chiang Rai Province, observations showed (by digging around the grass and washing off the soil with water) the deep and expansive pattern of the root of the Surat-Thani ecotype grown on laterite soil, the upper part being alluvial and the lower part being clay. The vetiver grass which was 7 months old had leaves 1.50 m. high and roots penetrating vertically 3.10 m.

Vetiveria nemoralis (Camus). This species is known as the local vetiver,

and appears limited to the Southeast Asian region which embraces Thailand, Laos, Cambodia, Vietnam and Malaysia. Nevertheless, there is no evidence of its uses. This type of vetiver grass is normally found in dry areas or in the type of soil which allows good water drainage in every region of Thailand, especially in dipterocarp forests. However, the species is rare on the peninsula. The grass grows well in areas exposed to both strong and moderate sunlight. The uppermost part of the "bush" bends down in the same manner as in Cymbopogon sp. The stem does not stand upright as in Vetiveria zizanioides. In some areas, the grass forms a dense bush serving as ground cover over a large area, for example, in the area of Wong Tee Kai at Huai Kha Khaeng Wildlife Sanctuary, Uthai Thani Province. Those grown in dipterocarp forests are often threatened by forest fires because their dry leaves can easily catch fire. However, since the basal part of the bush is very dense, it is not easily destroyed by forest fire, and new leaves emerge shortly afterwards. The Vetiveria nemoralis leaf is 35-6 cm long, 0.4-0.6 cm. wide, and pale green. The transverse section of leaf shows triangulate shape in outline.

The leaf texture is coarsely rough and slightly waxy making it fade in appearance. The color of the lower surface of the leaf is the same as that of the upper surface except it is paler. The septum can not be seen; whereas, the midrib is hard and forms the prominent ridge.

The root of this type is shorter than that of Vetiveria zizanioides. The grass of about one year produces a root which is 80 - 100 cm. long. The inflorescence can appear in many different colors, particularly that of the Uthai Thani and Nakhon Pranom ecotypes. Commonly found are those ranging from creamy white to purplish red.

Production and Propagation of Tillers: The Department of Land Development is the principal government agency responsible for producing and propagating vetiver grass. The Department has been propagating 10 ecotypes of vetiver which are primarily selected according to their individual locality. These ecotypes are Loei, Nakhon Sawan, Kamphaeng Phet 1, Kamphaeng Phet 2, Roi Et, Ratchaburi, Prachuap Khiri Khan, Surat Thani, Songkla 3 and Sri Lanka. The Deparment intends to propagate a total of four million tillers in the fiscal year 1993. The purpose is for distribution to other agencies for further multiplication.

Photo # 3 Different ecotypes of vetiver grass after one growing season at the comparative experimentation plot at the Pikun Thong Royal Development Study Centre.
Photo credit: Dr. Sumet Tantivejkul

Photo # 4 Propagation of vetiver grass in plastic bags conducted in Department of Land Development's various stations in the country.
Photo credit: Dr. Sumet Tantivejkul

The rest will be distributed to interested farmers and used in demonstration activities in other locations under the Department of Land Development.

The production and propagation of vetiver tillers is also undertaken at the Royal Development Study Centers, where it is mostly used. The Doi Tung Development Project, the largest producer in the country, has also been producing a large number of tillers for uses in the project. At present, it has reached a total of eight million tillers, most of which are the Surat Thani ecotype of Vetiveria zizanioides. The most popular method of propagation of vetiver is by shoot separation, since the grass can produce many shoots at a fast rate. The propagation of vetiver using this technique is performed in three ways: in plastic bags; in raised fields; and in large cultivated plots.

Study of Propagation of Vetiver Grass Using Tissue Culture Techniques: Since propagation of vetiver grass in plastic bags imposes problems on transportation, Dr. Uthai Jaranasri, of the Doi Tung Development Project, has succeeded in propagating vetiver grass using a tissue culture technique using maristematic tissue of the inflorescence. This method is appropriate because it

Photo # 5. Propagation of vetiver grass in large cultivation plots at the Doi Tung Development Project.
***Photo credit:** Dr. Sumet Tantivejkul*

does not promote mutation; besides, tiny vetiver tillers make it easy for transporting large quantities to other areas. Moreover, the Department of Botany, Kasetsart University (Deputy Professor Kamolpan Namwongseprom and Assistant Professor Malee Nanakorn, 1992) has experimented with this technique using lateral or terminal buds of vetiver in order to promote rapid multiplication. The experimentation indicates that 70% of plantlets survive which renders the method effective. The vetiver grass tillers produced by this technique are then planted on sites of the Kasetsart University and Kamphaengsaen Campus and show healthy growth.

Study of Germination of Vetiver Grass Seeds: The Huai Hong Khrai Royal Development Study Centre (by Chiang Mai University) and the Kung Krabaen Bay Royal Development Study Centre (by the Department of Land Development) have studied germination of vetiver seed and reported that the seed does not germinate. The reason is believed to be because of defective seed collected from the immature inflorescence. After studying the development stages of the vetiver's inflorescence from flower to seed, Dr. Weerachai Nanakorn (Botanical Garden Organization) found that under optimum conditions, seed can germinate.

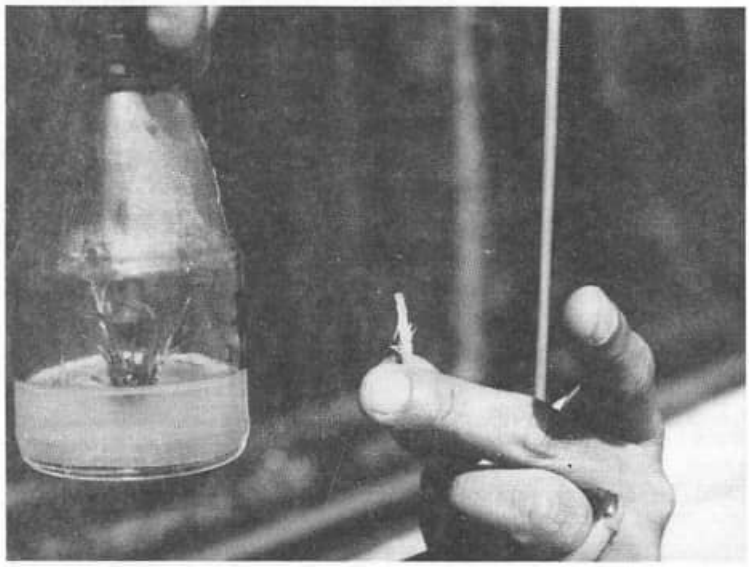


Photo # 6. Between the fingers is the maristematic tissue which will develop into an inflorescence, and in the bottle is the seedling (plantlet) of vetiver produced from the tissue culture of the buds.
***Photo credit:** Dr. Sumet Tantivejkul*

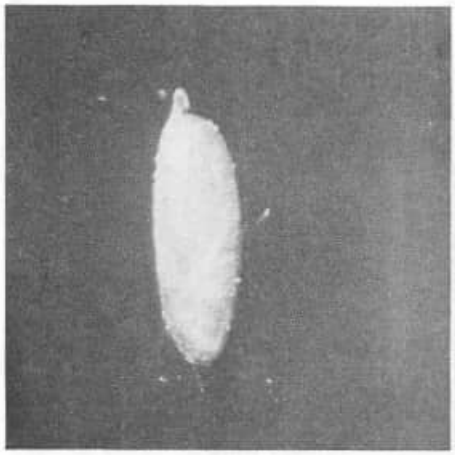


Photo # 7. Vetiver seed having sticky, tapioca like, brown color texture.
***Photo credit:** Dr. Sumet Tantivejkul*

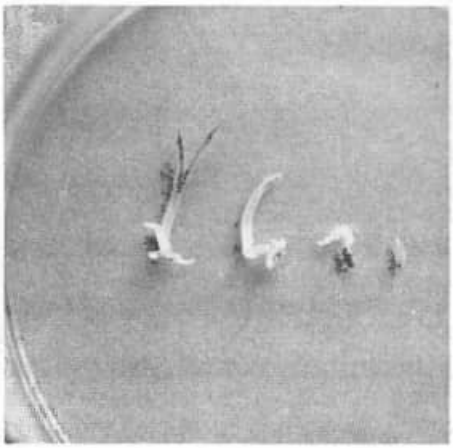


Photo # 8. Different stages of germination.
***Photo credit:** Dr. Sumet Tantivejkul*

Study of Efficiency of Vetiver Grass in Soil and Water Conservation in Agricultural Areas: Presently, experiments relating to the efficiency of vetiver in soil and water conservation have been conducted in many agricultural areas throughout the country. The agencies responsible for the projects are the Department of Land Development, the Royal Irrigation Department, Kasetsart University, Chiang Mai University, Khon Kaen University, Scientific and Techno-

logical Research Institute of Thailand and Department of Agricultural Extension. Most of the experiments have only just started and the monitoring work in the field has not yet been conducted.

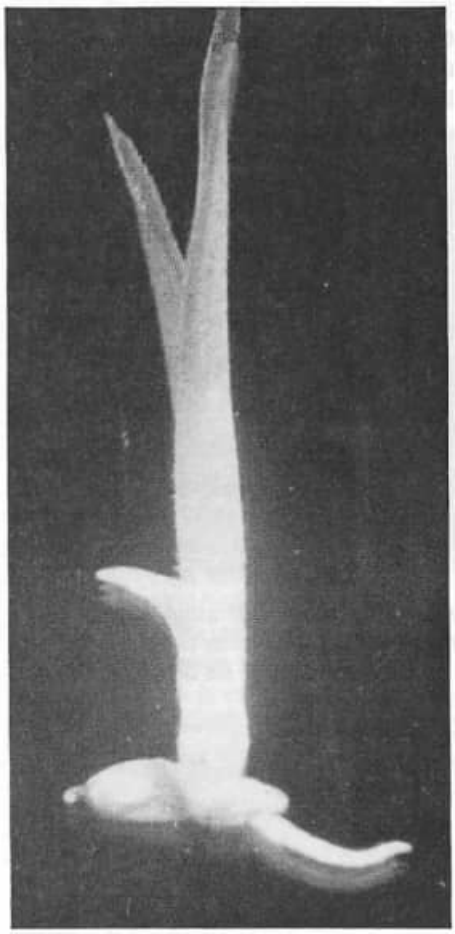


Photo # 9. *Seedling at four days develops clear spines on the edge.*
Photo credit: Dr. Sumet Tantivejkul

Study on Root System of Vetiver Grass: The Khao Hin Sorn Royal Development Study Centre has conducted the study on root system of the six ecotypes of vetiver by planting the material in individual rows measuring one meter with vertical interval of 50 cm. and digging the soil to observe the root depth. The Doi Tung Development Project has also studied the growth of the root of the Surat Thani ecotype and indicated that vetiver grass at seven months of age had a height of 150 cm. and a root 3.10 meters long.

Study on Growth of Vetiver Grass under Critical Conditions: Vetiver grass was planted under **shade** in the conserved forest at the Khao Cha-ngoom Deteriorated Soil Rehabilitation Project in Ratchburi Province and in Suan Phai Ruak at the Sirikit Conserved Forest Project. Most of the plantings died. From this experimentation, it can be concluded that the vetiver grass hardly grows under shade. At the Khao Hin Sorn Royal Development Study Centre, Chachoengsao Province, experiments on the cultivation of vetiver grass, both of Vetiveria zizanioides and Vetiveria nemoralis, under an eight year para-rubber plantation revealed that these two species responded to shade to a different degree. Only 50% of the Khao Hin Sorn ecotype of Vetiveria nemoralis survives, whereas, the Surat Thani ecotype of Vetiveria zizanioides showed increase in height despite little branching. The Khao Hin Sorn Project finds that **in flooded areas** the Surat Thani ecotype of Vetiveria zizanioides had good growth.

Photo #10. *Vetiver at seven months grown on natural loose and solid laterite developed a 3.10 meters long root.*
Photo credit: *The Doi Tung Development Project, Chiang Rai Province*

At the Kung Krabaen Bay Project, vetiver grass survives on laterite soils and in spaces between rocks on roadside slopes (where it is a good soil binder). The Puparn Royal Development Study Centre, Sakon Nakhon. The Regional Forestry Office, Petchburi Province, has grown vetiver (with supplementary and occasional watering) on **hard pan soils**, and found that vetiver shows moderate growth. The result showed that vetiver grass roots can successfully penetrate hard soil.

Photo # 11. *Vetiver grass of one year and six months old can grow well in laterite soil.*
Photo credit: Dr. Sumet Tantivejkul

Study on Cultivation of Vetiver Grass to Maintain Moisture for Fruit Crops: The Khao Hin Sorn Royal Development Study Centre conducted an experiment on the cultivation of vetiver grass in a circle around fruit trees and obtained unfavorable results, for the likely reason that the vetiver grass blocks the flow of soil moisture to the fruit trees and/or effect of competition between the vetiver grass and the fruit trees. Additional studies on cultivating vetiver grass in semicircles around the fruit trees are being undertaken, but have yet to be analyzed.

DEMONSTRATION AND IMPLEMENTATION WORK

Cultivation of Vetiver Grass on the Banks of the Pond: Cultivation of vetiver grass on the banks of ponds to collect sediments and prevent collapse of newly constructed banks was successful and efficient.

Cultivation of Vetiver Grass on Earth Banks: At the Pikun Thong Royal Devel-

Photo # 12. *Vetiver planted to bind earth banks which were constructed to prevent the brackish water from flowing into the fields at the Pikun Thong Royal Development Study Centre.* ***Photo credit: Dr. Sumet Tantivejkul***

opment Study Centre, Narathiwat Province, vetiver grass has been planted on earth banks built to obstruct the flow of brackish water into farmers' land. The results indicate that the grass maintains the shape of the banks and reduces the degree of damage from the brackish water.

Cultivation of Vetiver Grass in Water Gullies: Demonstration of using vetiver grass hedges in the inverted "V" shape, and other configurations, have been carried out at the Huai Hong Khrai Royal Development Study Centre, Chiang Mai Province; the Kung Krabaen Bay Royal Development Study Centre, Chantaburi Province; and the Khao Chagoom Deteriorated Soil Rehabilitation Project, Ratchaburi Province.

Cultivation of Vetiver Grass to Rehabilitate and Improve Deep Gullies: At the Kung Krabaen Bay Royal Development Study Centre, vetiver grass has been cultivated in association with sand bags to arrest sediments in deep gullies. At the Doi Tung Development Project, the vetiver grass has been cultivated in small gullies by the road sides to collect sediments and reduce the velocity of water flows.

Cultivation of Vetiver Grass to Rehabilitate Deteriorated Soil: The Khao Changoom Deteriorated Soil Rehabilitation Project, Ratchburi Province, demonstrated the cultivation of vetiver grass as horizontal contour hedges on slopes of hard, dry and barren laterite soil that are affected by surface run-off. Cultivation of vetiver grass in this manner reduces erosion, allowing water to penetrate the soil and increase soil moisture. The result is that the yellow barren soil became covered with fresh green plants; a condition that indicates an improvement of soil quality to the extent that it could eventually come back into agricultural use.

Prevention of the Collapse of High Road Cuts and Road Shoulders: Vetiver has been cultivated on steep road shoulders in the Doi Tung Development Project. The results are under study.

Cultivation of Vetiver Grass to Trap Toxic Substances: The demonstration is conducted along the edges of the reservoirs at the Huai Sai Royal Development Study Centre with the objective of preventing toxic substances of the nearby golf course from flowing into reservoirs.

Other agencies which have carried out experimentation on vetiver grass are as follows:

The Department of Agricultural Extension has cultivated vetiver grass for demonstration and propagation purposes in area covering 5,870 sub-districts in 73 provinces, each with one kilometer of vetiver.

The Royal Forestry Department has cultivated altogether 1,408,500 vetiver tillers within 60 watershed management units in Chiang Mai, Chiang Rai, Phayao, Phrae, Nan and Lampang provinces.

The Royal Irrigation Department has propagated and conducted studies and research on general aspects of vetiver grass as well as the use of vetiver grass to conserve large water resources.

The Office of Accelerated Rural Development has cultivated 803,673 vetiver tillers in the area of reservoirs and check weirs in Lampang, Lamphun, Chiang Mai, Chiang Rai, Phayao and Phrae provinces.

Border Patrol Police Headquarters has cultivated 626,175 vetiver tillers within schools and villages under their responsibility, covering an area of 124 rai.

The Department of Public Welfare has cultivated vetiver grass within the area of the Hill tribe Development and Welfare Centres in the northern part of Thailand covering 13 provinces.

The Department of Livestock has conducted studies on efficiency of vetiver grass for feeding animals in terms of nutritious value.

The Department of Agriculture has conducted studies on the efficiency of vetiver grass as part of integrated farming systems.

The Royal Highway Department has cultivated vetiver grass along road embankments.

The Office of Agricultural Land Reform has cultivated vetiver grass along the banks, reservoirs and dikes within Udon Thani, Nakhon Ratchasima, Nong Khai and Lop Buri provinces.

The Department of Cooperatives Promotion has prepared propagation plots and encouraged the members of the cooperatives to participate in the activities of the Community Cooperative Units, Cooperatives Demonstration

Photo # 13** Vetiver planted on cut and fill slopes of newly constructed roads to prevent erosion and collapse of cut and to stabilze fill embankment at Doi Tung Development Project, Chieng Rai Province.* ***Photo Credit : Dr. Sumet Tantivejkul

Centres, Cooperatives Demonstration Units and Agricultural Cooperatives. The total area of the plots is 10 rai with 32,800 vetiver tillers.

The Department of Land Development has cultivated 5,367,224 vetiver tillers within the areas of land development stations throughout the country.

The Scientific and Technological Research Institute of Thailand has conducted a study on the use of vetiver grass root and volatile oil extraction from its root.

The Universities of Kasetsart, Chiang Mai, Khon Kaen and Prince of Songkla have conducted studies and research on efficiency of vetiver grass in various aspects.

Vetiver Grass can be used in many ways, using its different components, i.e. leaves or root. Vetiver grass can also be cultivated for soil and water management to protect against soil deterioration and to maximize land use.

In terms of environmental and biolgical conservation Vetiver grass can be used for soil and water conservation in many ways:

Cultivation of vetiver grass as horizontal contour hedges on slopes to reduce the rate of water flow and to increase the trapping of soil sediments (the latter naturally become earth banks).
Cultivation of vetiver grass to protect against gully erosion.

Cultivation of vetiver grass to maintain underground moisture.

Cultivation of vetiver grass to protect against damage to bench terraces or hillside ditches.

Cultivation of vetiver grass to prevent soil sediments from flowing into canals, waterways, and farm reservoirs.

Roofing and household uses e.g. using its fragrant roots to freshen the air and repel insects in the closets.

Feeding animals such as cattle and goats with part of the tillers and young leaves. Research shows that vetiver grass can bet used as animal fodder.

Making herbal medicine and fragrance. It is reported that vetiver grass has traditionally been used as ingredients in ancient herbal medications which are capable of eliminating stomach gas, and treating stomach problems. The root can be extracted for volatile oil which is made into fragrance and thus, becomes commercially beneficial and valuable.

Photo # 14** Vetiver planted on a steep slope on a cooperative member's farm. The hedge is well formed and is already forming an effective barrier against erosion.* ***Photo Credit : Dr. Sumet Tantivejkul

INTERIM REVIEW

After a period of implementation of the Project on Development and Promotion of the Utilization of Vetiver Grass Under His Majesty's Initiatives, the Office of the Royal Development Projects Board, as the coordinating agency organized a practical seminar in Chiang Rai Province on September 1- 4, 1993. The purpose was to offer the opportunity for representatives from participating agencies, both at the policy making and implementing levels, to exchange experiences, academic viewpoints, and opinions; as well as problems and obstacles in the administration and their solutions, so as to fulfill the objectives and produce the greatest benefits according to His Majesty's initiatives.

Furthermore, the Department of Land Development has been assigned the leading role in collecting and propagating species and ecotypes of vetiver grass as well as disseminating knowledge and technology with respect to vetiver to other government agencies. The Department organized a practical seminar for scientists, technicians and field practitioners working within the Project on Development and Promotion of the Utilization of Vetiver Grass Under His Majesty's Initiatives on September 21-22, 1993 in Chon Buri Province.

Overall, the aforementioned seminars contributed to the understanding of the principles of project implementation arising from participant exchange of viewpoints and experiences. The seminars also laid the foundation and preparedness on the part of the project officials to be able to accommodate the organization of the 1995 international seminar on vetiver grass in Thailand in partnership with the World Bank. The two seminars have further led to constructive understanding of the following viewpoints:

Project operations in general, results and activities, should be reported and presented to the concerned parties every year. Moreover, a yearly conference to discuss progress and encourage exchange of viewpoints should be organized.

With regard to the collection and evaluation of species and ecotypes of vetiver grass, there should be a discussion on the methods, use and standardized classification.

Study and research work should be broadened in order to cover a variety of fields. Characteristics of vetiver grass should be considered in full details so as to promote various and appropriate uses by taking account of the direct use in soil and water conservation, along with indirect and economic uses in which vetiver grass can beneficially coexist with other plants.

In the future, there should be greater emphasis placed on extending the advantages of vetiver grass for on-farm soil and water conservation. There is a need to further evaluate whether the technology is accepted by farmers. The promotion of the use of vetiver grass at present is limited by seedling propagation and transportation from nurseries to the planting areas, especially on slopes which rely solely in rainwater.

CONTACT PERSONS

Interested people can access additional information regarding Thailand's vetiver program by contacting the following persons:

Dr. Sumet Tantivejkul, Secretary-General, The Office of the Royal Development Projects Board ..... Research and utilization of vetiver grass in the Royal Development Study Centres.

Mr. Sitthilarp Wasuwat, Director General of the Department of Land Development.....Research and demonstration on the use of vetiver grass for soil and water conservation.

M. R. Disnada Diskul, Director of the Doi Tung Development Project.....Propagation and the use of vetiver grass for embankment stabilization and protection against soil collapse along the slope of highway embankment and cut.

Mr. Taweep Taweepanich, Director General of the Department of Public Welfare ..... Demonstration and promotion on the use of vetiver grass on high plains.

Mr. Taweesak Sesavej, Director-General of the Department of Livestock ..... Research on evaluation of the nutritious value of Vetiver grass for animal fodder.

Dr. Weerachal Nanakorn, Director of the Botanical Garden Organization..... Study and classification of species and ecotypes of vetiver grass.

The Vetiver Information Network, Room MC 8-307, Asia Technical Department, The World Bank, 1818 H Street N.W, Washington DC. 20433, USA.
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The findings, interpretations, and conclusions expressed in this Newsletter are entirely those of the authors and should not be attributed in any way to the World Bank.

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER INFORMATION NETWORK

July 1994
NUMBER 12

Commentary

This newsletter, number 12, pulls together information from a number of states in India, that we recently visited, that are in the process of developing comprehensive watershed development programs. The states include those from the relative high rainfall areas of eastern India (Orissa > 1,000 mm of annual rainfall) to the drought prone western India (Rajasthan) where rainfall is sometimes less than 300 mm. We visited three groups of programs: The Pilot Project for Watershed Development in Rainfed Areas (covering the states of Andhra Pradesh, Karnataka, Madhya Pradesh, and Maharashtra - started in 1984 - recently completed and under evaluation); The Integrated Watershed Development (Plains) Project (covering the states of Orissa, Gujarat, and Rajasthan - started in 1990); and the Integrated Watershed Development (Hills) Project (covering Jammu and Kashmir, Punjab, Haryana, and Himachal Pradesh — started in 1990). The main objective of all the projects is to improve farm incomes and nonfarm land productivity, through interventions that include: in-situ moisture conservation measures, rehabilitation of degraded lands and gullies, planting of trees, shrubs and grasses, livestock developing, the training of participants, and expanding the use of NGOs. The newsletter will focus on vetiver and related in-situ moisture conservation components.

You will also find in this newsletter information from users in Asia, Africa, and Central America. Some notable activities are taking place in southern Africa following **John Greenfield's** visit in November 1993. **Steven Carr**, from Malawi, reports a growing interest in vetiver in his country, as there is also in Zimbabwe, Zambia and South Africa. **Ato Akalu**, from Addis Ababa, has reported on the effective application of vetiver in Ethiopia. **Jano Labat** (Zimbabwe) and **Tony Tantum** (South Africa) both report new interest in the use of vetiver for mine dump stabilization. **P.K. Yoon** (Malaysia) has once again demonstrated how vetiver can be used to stabilize very large highway embankments in Malaysia. **Paul Truong** continues to demonstrate the tolerance of vetiver to very high levels of toxic minerals, in this case manganese. **Ray Wijewardene** of Sri Lanka reports on the inclusion of vetiver hedges as part of the SALT system for soil and moisture conservation in tea and tobacco.

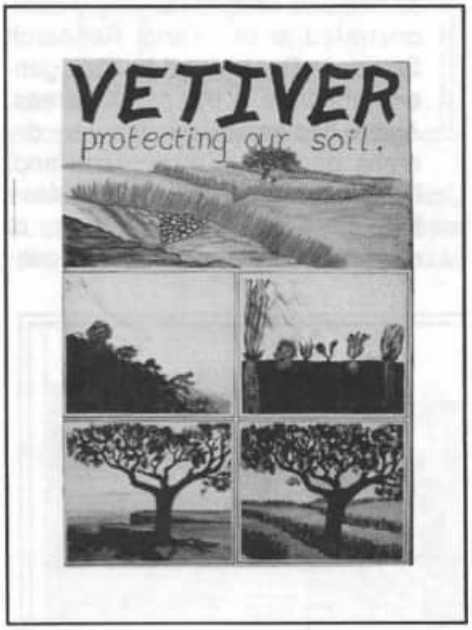

Photo #1. *Eco-Link - a South African NGO's promotional poster for using vetiver grass for soil and water conservation.* ***Photo credit...Sue Hart***

As demand grows within and outside your countries, some of you may be involved in the sale of planting material — a word of reminder that we must aim to produce high quality planting material and handle it properly, and reduce transportation time to a minimum to assure high survival rates.

During the past six months, the Network has sent to selected participants a number of interesting documents. These include (a) Technical Information Package Volumes 1 and 2 — these volumes reprint (including photographs) of some of the work submitted for last year's Vetiver Awards; (b) Use of Vetiver for Soil Erosion Control of Embankments in Bangladesh by P.K. Yoon; (c) Neem - A Tree for Solving Global Problems by the U.S. National Research Council; and (d) a manual on "Communications for Technology Transfer in Agriculture" by the U.S. Academy of Educational Development. Anyone not receiving

these papers and who would like a copy please let us know. We will bulk up the responses and get a print rerun in October.

India — A Progress Report

In-situ moisture conservation, applied in a number of forms, has proven in all localities to have been successful in: improving crop yields; tree and shrub survival and associated growth rates; reducing rainfall runoff and soil loss, and improving ground water recharge. There are differences as to the degree of success between technologies and between sites:

- Contour, across the slope cultivation: This measure has virtually zero cost and depending on soil type and rainfall has, compared to traditional along the slope (AS) methods, increased yields of annual crops from 10% to 25%.

- Vetiver grass hedges: 15% to > 50% incremental crop yields are reported as compared to AS cultivation methods. Vetiver when planted on black (vertisols) soils, particularly black shallow soils, show significant incremental yields (**Chart 1**). This technology has a good chance of success (**Photo 2**) under rainfall regimes of more than 700 mm, and on selected moisture rich sites (such as gully bottoms, river banks and saline areas) in areas where rainfall is less than 700 mm.

- Other grasshedges: Other species are being tested. These include Saccharum munja, Agave sislana, Eulaliopsis binata, and Pennisetum purpureum. Saccharum and Eulaliopsis are difficult to establish as effective hedges (as amply demonstrated at the Kandi Research Station in Punjab and by their general absence in the project areas. Agave has potential in the very dry areas, particularly on nonfarm land. Napier grass (P.Purpureum), unless fully protected, has no chance of survival under drought or uncontrolled grazing conditions. Over 95% of all grass hedges appear to be based on vetiver grass.

- Continuous Contour 'V' Ditch (CCVD). CCVD as applied to non farm land, is now a widely accepted technology as is the basis for land preparation for tree planting. Survival rates are normally well above 80 to 90%, and growth rates have improved significantly. CCVD is occasionally modified as a trench rather than a "V" ditch; there appears little evidence for the additional expense involved in trenching. CCVD at 8 meter horizontal intervals in most cases reduces runoff by as much as 97%.

- Chisel ploughing: This technique as being experimented in Rajasthan involves ripping to 50 cm depth, in contour lines 2-3 meters apart, using a chisel plough powered by a 40 HP tractor. It has good potential and may have equivalent water conservation benefits as CCVD. More testing is required.

Reduction in rainfall runoff: At all long term experimental sites, vetiver grass hedges reduced rainfall runoff better than any other method under on-farm

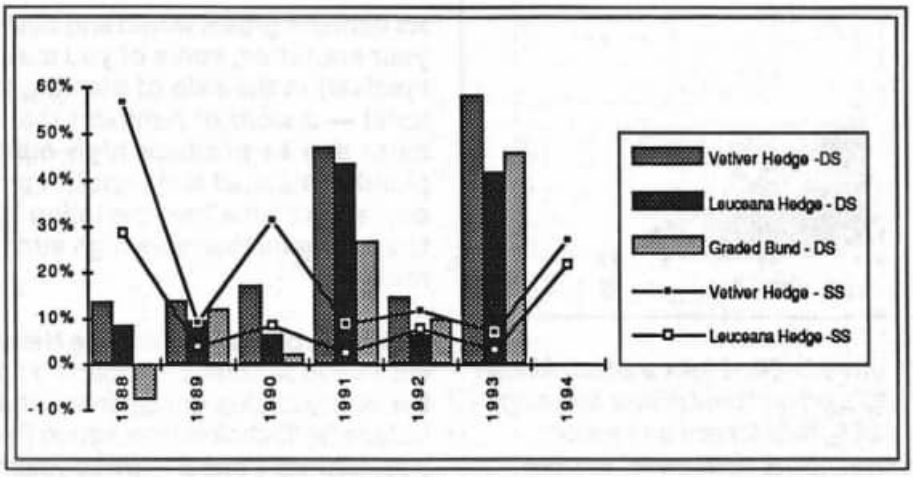

Chart #1. *India, Maharashtra, Akola. A comparison of the impact of three soil and water conservation sytems on shallow (SS) and deep (DS) black vertisols measured as percentage incremental yield increases.* ***Source ... Dr. G.M.Bharad.***

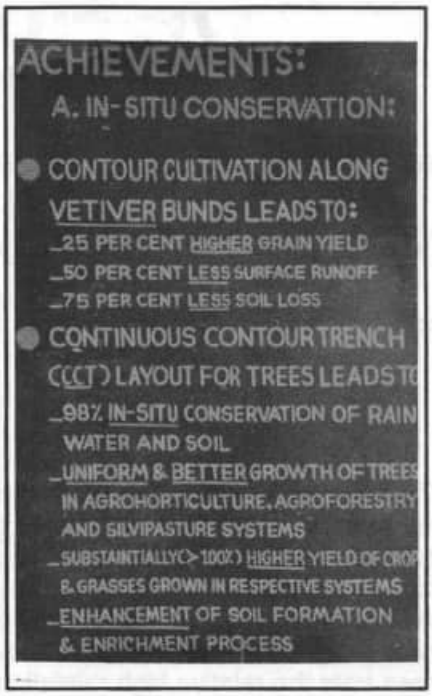

Photo # 2. *Dr. Bharad's Information Board at his 20 ha experimtal site at Akola.* ***Photo Credit ...R.G.Grimshaw***

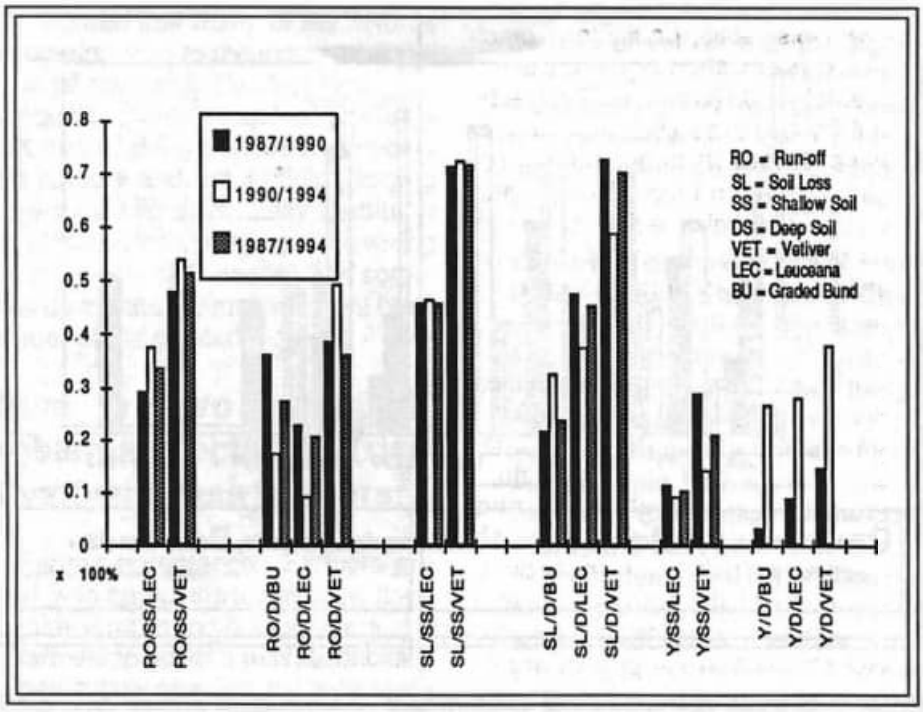

Chart # 2. *Comparison of different conservation barrier treatments at Akola Maharahtra. Incremental soil loss (SL) and run off (RO) reductions expressed as a percentage of the control (along the slope cultivation).* ***Source...Dr. G.M. Bharad.***

conditions. CCVD, supported by vetiver, performed best under nonfarm (nonarable) conditions. Runoff reductions varied between 35 and 70% with the best results on shallow soils. There seemed not much difference between runoff reductions at ICRISAT (Hyderabad — red soils) and Akola (Maharashtra — black soils). As a rule of thumb, Vetiver hedges were significantly better at reducing runoff as compared to both Leuceana sp. hedges and earth bunds (**Chart 2**). The probable reason for this is vetiver's ability to spread water more evenly, bring water velocity to a minimum, and, via its deep root system, provide a better infiltration zone at the hedge barrier.

Reduction in Soil Loss: At all sites, vetiver hedges proved significantly better than other technologies for reducing soil losses. For example, on shallow soil, at Akola, soil losses were reduced by a mean of 70% over 6 years compared to 45% for Leuceana and 24% for earth bunds. Similar results were obtained under operational research projects in Karnataka and at ICRISAT. In physical terms, a vetiver hedge will reduce soil loss from about 8 -11 tons (somtimes very much higher rates i.e.> 40 tons) per ha to 2-3 tons per ha. This is well within acceptable soil loss limits.

Gully and structure stabilization: There appears to be virtual unanimity of the superior performance of vetiver for gully stabilization and for the stabilization of structures. This is because in most cases there is better moisture conditions on water course sites, and vetiver grows particularly well under such conditions. The most impressive results appear to be in Orissa, where in some areas the use of vetiver has been a traditional practice for stabilizing outflows in field-to-field irrigation of paddy fields (**Photo 3**). This practice is now being used at Phulbani and Jagganath Prasad Districts to stabilize earthen spill ways, gully check structures, etc.

Photo # 3. *Orissa, India. For generations, farmers have used vetiver grass as a means of stabilizing paddy field bunds at the point of outflow to the lower field.* ***Photo credit...R.G.Grimshaw***

Ground water recharge: As should be expected by the positive runoff reductions, ground water shows significant recharge where in-situ moisture conservation techniques are being practiced. At Manoli (Maharashtra), as a result of ground water recharge, some 319 new wells have been dug, and over 500 ha of land has been brought under irrigation. At the research farm at the University of Akola, it is estimated that recharge has improved by 30%, and is sufficient to drip irrigate 25% of the unit area if put under perennial horticulture. **We may well find that this recharge, if properly used, will be one of the most important economic benefits from in-situ conservation.**

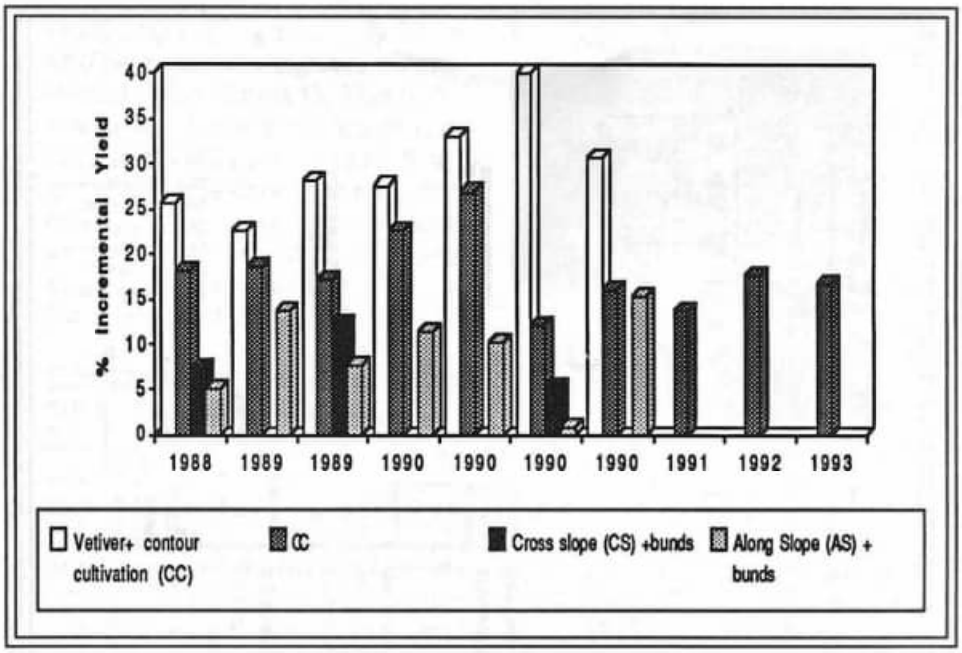

Chart # 3. India, Mahahrashtra, Department of Agriculture annual crop cutting statistics on farmers' fields from Manoli Watershed comparing the impact of different land treatments on incremental yields with along the slope cultivation as the base comparator. **Source...Maharashtra D.O.A**

Technical issues, observations and recommendations

Vetiver Grass: In most instances, vetiver should be the preferred species on the basis of its functionality and its adaptation to a wide variation in site conditions. There appears to be few problems where there is no major water stress. There can be problems in drought years, and when planted on soils with extremely limited water capacity. For instance, in Rajasthan, trials show that the survival rate of vetiver in the first year increases from 55% to 80% if grown in the bottom of a "V" ditch as against on the top of the "V" ditch bank. The same applies to planting vetiver on the edge of inward sloping terraces on the steep slopes of the Shivalik Hills. The latter have very shallow to no soil at all, and the terrace lips are devoid of moisture. In these cases, it is better to plant at the intersection of the terrace bed and riser. The effect should be the same, but more moisture will be available for hedge establishment. (Incidentally on the deeper and wetter soil of Assam, it is reported that planting vetiver on the lip of terraces has reduced terrace collapse from 25% to zero). It is suggested that in dry areas, experiments should be made in planting vetiver directly into chisel plough rip lines (a continuous lateral column of water can be expected in these rip lines immediately after a rainfall occurrence). In Rajasthan, 100% first year survival has been achieved by using vetiver slips grown in containers (4 inch polybags). The cost is about Rps. 4 (US $ 0.125) per linear meter and is probably economical. Further testing of this technique should be carried out. In dry areas, site location will be an important factor in using vetiver. In all areas, the correct time of planting (early in the monsoon — Kashmir and other Himalayan eco-sites in early spring) will effect survival rates considerably.

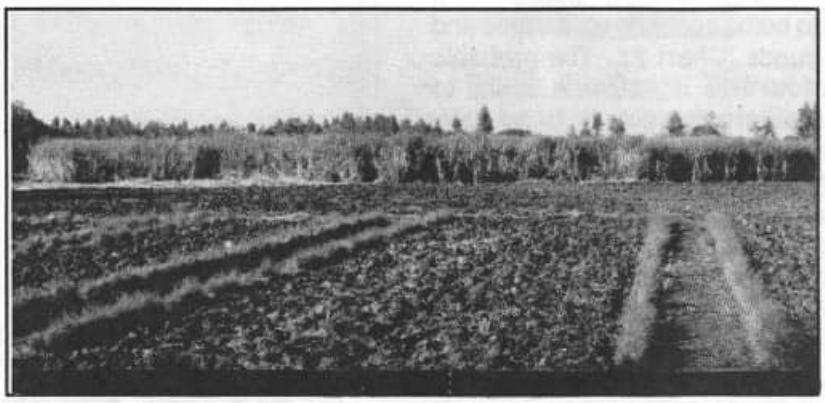

***Photo # 4.** Maharashtra, Akola. Use of vetiver to protect raised beds in wet areas.* **Photo Credit...R.G.Grimshaw**

It is agreed that many of the failures can be attributed to the incorrect application of technology, including: use of poor quality planting material (perhaps even dead), delays between removal from nursery and actual field planting (more than two days delay results in only 60% survival), planting at the wrong time (late in the wet season), and sometimes deliberate mismanagement (yes, it's true) of the planted material.

There are two immediate problems effecting the use of vetiver grass barriers:

- Farmer acceptance: Farmers are slow to accept the technology. It will take time, maybe four years, for farmers to adopt a new technology, particularly one that, to the farmer's eyes, appears to have no immediate short term benefits. There is a need to greatly improve farmer participation in the use of, and the marketing of the technology. Farmers need proper training in all aspects of the technology including reasons for using it (conservation, risk reduction, crop yield increases, thatching, mulching, fodder, handicrafts), and proper training in its application. A **social marketing strategy** should be developed that would include demonstrations, training, radio, TV, and written propaganda. The marketing plan should take account of the role of all the stakeholders including farmers, extension, research, conservation and forestry staff. Farmers are likely to adopt the technology more quickly in the better rainfall areas (>700 mm). Farmers should be involved in the production of vetiver planting slips, and except, perhaps, for initial demonstration, should not be paid to plant the material on their farms. *Farmers need to learn good management practices, including:* gap filling, cutting for fodder, burning for termite control, and adjacent cultivation techniques to minimize damage to the hedge. If farmers could relate the use of vetiver with the significant recharge of ground water and the consequent improvement in well and pumped water, adoption of the technology could be expected to accelerate.

At the end of the day, farmers are looking for yield increases. Chart # 3 shows, from a random sample of farms in Manoli Watershed near Akola, that a vetiver hedge barrier consistently (where recorded) shows the highest incremental yield increase, whatever the crop. Cultivation on the contour is the next best technology. The relative small difference between the two may be the reason why the adoption of vetiver grass barriers is rather slow. The key to accelerated adoption will come through better farmer training and greater farmer comprehension of the other benefits (particularly long term) that vetiver hedges provide.

- Vetiver dieback: In the drier areas (< 600 to 700 mm) and on shallow soils (< 15 cm), vetiver may be subject to dieback from about the fourth to sixth year after planting. This is compounded by intensive overgrazing. Dieback is associated with termite infestation, but it is now thought that the termite damage may be a secondary symptom as a result of a primary attack by a root fungus occurring under conditions of moisture stress. This fungus has been identified by AKV Akola. It can be contained. Investigations by **Dr. B.S. Hegde** at Bangalore (Karnataka) show that vetiver cultivars differ in susceptibility to termites (or perhaps to primary root fungus). We may therefore be able to deal with the problem through cultivar selection. **It is very important to test out under different ecological conditions the main vetiver cultivars available in your countries**, as has been done in Thailand. In India, it is reported that over 100 cultivars exist. Apart from testing for dieback, testing will enable appropriate cultivar selection according to need and rainfall conditions. (It should be noted that in Thailand, of 30 cultivars site-tested (20 sites), about 8 have been recommended for use). Additionally, bad management practices, such as ploughing through the hedges, dumping crop residues on hedge rows, and failure to fill gaps and control livestock, has also led to the destruction of the hedge rows. These bad practices can be reduced through better farmer education.

Photo # 5 . Vetiver planted in a "triangular wedge" at the bottom of a gully in Orissa. Photo Credit ... R.G. Grimshaw.

Other Observations

Regenerating vetiver hedges: Under dry hostile farm conditions, it may be necessary to replant vetiver hedges every 6 to 10 years. The cost of this is minimal. Probably no more than the cost of 1 man day per 100 running meters.

Photo # 6. India - Phulbani District, Orissa. Containerised vetiver plants ready for transport to field site. Note nurseries are in close proximity to final point of planting. **Photo Credit... H.S.Kumar**

A useful technique has been developed by **Dr. Bharad**, at Akola, in the use of planting vetiver to protect the edge of raised beds (8 sorghum rows wide) on wet badly drained black soils. A good crop of sorghum can be grown on the raised bed, and the surplus water drained off to the inter-bed area is enough to support paddy rice (**Photo 4**). Vetiver can also be used to spread flood water on gently sloping lands and can help channel the surplus along vetiver defined waterways. This system is also an effective method of flushing excess salts from saline areas (Akola District - Maharashtra, and Bhilwala District - Rajasthan).

Rats are not welcomed by vetiver in the higher rainfall areas, or along paddy field bunds - could this be because the soil is moist, as would be the root system of vetiver? In the dry areas, there is ample evidence of rats making their homes in vetiver hedges (as seen at the Kandi Watershed Research Station in Punjab). In the latter case, the vetiver roots are dry, and probably make a pretty good habitat for rats. The rat issue is more likely to relate to moisture conditions rather than to root odor. Interestingly, we heard recently that USDA Wildlife Research Center at Denver Colorado may be doing some research in this area.

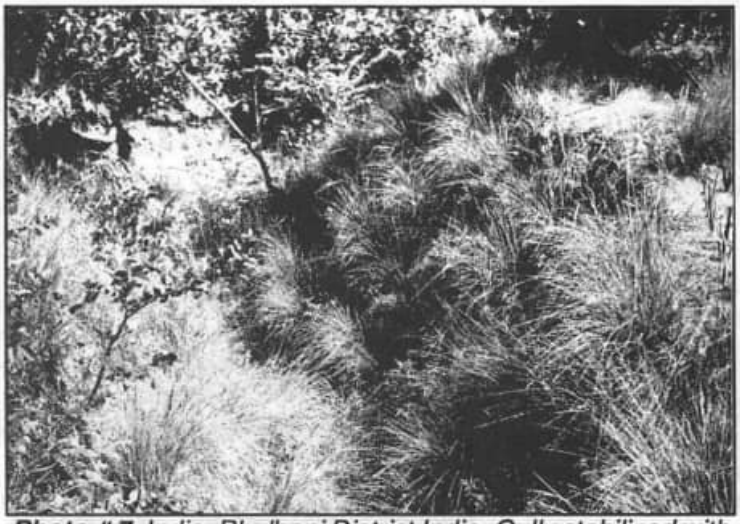

Photo # 7. India. Phulbani District India. Gully stabilized with vetiver at 1 year old. **Photo Credit... H.S Kumar**

Vetiver and gullies: Vetiver will be most effective when planted as a hedge across the gully floor, and along the bottom of the gully wall adjacent to the gully floor. In such cases the vetiver hedge will reduce undercutting and will allow a slow collapse of the gully wall to form an angle of natural repose. Of course, where the gully wall is sloping, vetiver can also be planted along the wall, but one can often see poor growth when planted along the top lip of the gully with vertical sides because of limited soil moisture (**Photo 5**).

Photo #8. *India. Phulbani District, Orissa. Vetiver used for spillway stabilization - note vetiver has been heavily grazed.* **Photo Credit.... R.G.Grimshaw**

Vetiver nursery information It is important that farmers get involved in producing vetiver slips. They can do it easily, and often they have better land resulting in better output. The following data from Akola gives some indication of production costs (note US 1= Rps 30):

- Nursery production: 40 - 70 tons of slips per ha. 40 slips/kg @ Rps. 2/kg i.e. Ps. 0.05 per slip.
- Planting material requirement for nursery establishment at 20 x 40 spacing is 2.5 tons per ha.
- Net nursery income approx. Rps. 24,000 per ha.

- Hedge establishment. Rps. 120 per running 100 m (6x3x100x0.05) = Rps. 90 + labor + transport.

Photo 6 shows some good quality poly-bagged vetiver produced at Phulbani, Orissa, used for stabilizing gullies and spillways (**Photos 7 & 8**).

Treatment/grasses	Run off - mm	Soil Loss - Kg/ha
Discharge 180 litters per hour, 60 mm applied.		
Vetiveria zizanioides	2.4	14
Cymbopogon martinii	8.7	48.5
Panicum maximum	6.1	33.9
Saccharum munja	10.7	209.4
Fallow Field (control)	**12**	**223**
Discharge 2,400 litters per hour, 40 mm applied		
Vetiveria zizanioides	20	201.3
Cymbopogon martinii	21.6	216.3
Panicum maximum	22.4	218.6
Saccharum munja	25	3495.8
Fallow Field (control)	**30**	**6716.2**

Table 1. *India - Madhya Pradesh. Comparison of effectiveness of different grass species in controlling erosion and runoff when grown as a barrier hedge.* **Source...Dr. D.P.Nema**

India - Madhya Pradesh - Vetiver: Its Application to Black Vertisols - Great Possibilities

The Jawaharlal Nehru Krishi Vishwa Vidyalaya (University) at Jabalpur has been conducting research into vegetative soil and water conservation measures at three sites with rainfall ranging from 900 to 1,200 mm. **Dr. D. P. Nema,** Director of Research, has sent us some of the results. All the sites are classified as semiarid. Studies were carried out in planting vetiver in gullies on the Kymore Plateau. It was found that due to the high velocity of rainfall, in order to assure high survival rates, vetiver needed to be planted in more than one row across the gully or be reinforced with loose stones (*another alternative is to use poly-bagged vetiver as done in Orissa).*

Another experiment compared plots, one barren and the other having a vetiver hedge (3 rows at 1.1 m vertical interval) + natural grasses + wild fruit trees, both on a 4.1% slope. After three years, there was a deposition of 44.6 tons/ha of soil on the vetiver plot, and a soil loss of 350.6 tons/ha on the barren plot.

At Sehore, Vindhyan Plateau, measurements of soil loss/deposition at two vetiver contour hedges showed that over 6 years soil deposition had increased from 6.8 cm to 19.1 cm and that by the fifth year (due to the increased density of the hedge) soil erosion had been reduced to zero.

In comparative trials to evaluate survival rates of grasses, it was found that vetiver had the highest survival rates (V. zizanioides - 98.3%, Sorghum halepens - 92%, Cymbpogan martinii - 83.7%, Saccharum munja - 78%, Cynadon dactylon - 16.7%).

Another study compared runoff and soil losses between grasses. The results are shown in - Table 1:

Rajasthan - the Driest Region of India - Vetiver's Limit?

We received a special report on experimental studies involving some of the agronomic features of vetiver grass. Experiments were carried out at five sites on soils that were primarily sandy loam to sandy clay loam Alfisols. Average annual rainfall, depending on site was from 300 mm to 630 mm. The average number of rainy days per annum varied from 12 to 29. The pH was between 8.3 and 9.

Generally under these dry conditions soil moisture is the critical factor in establishment and growth. The work, under well recorded and controlled conditions by **Dr. Mahnot** at the College of Technology and Engineering at Udaipur, is worth following, and some of his three years' experiments are recorded below.

- Under dry conditions, vetiver should be planted 10 to 20 cm apart with 3 slips per planting hole. The difference in spacing was not significant, but survival increased from 51% (1 tiller) to 82% (3 tillers).

- Inorganic and organic manures and polymers had an impact on survival. The most cost effective and practical was farm yard manure, which when applied at 0.6 kg per meter, resulted in survival of 87% (control 67%), tillers per clump — 24 (control 10.5) and girth of clump - 44.5 cm (control 22 cm).

- Vetiver planted in bottom of "V" ditch resulted in highest survival of 80% after one year.

- If field planting was delayed to 3 days after lifting from nursery, survival rates were reduced to about 70%.

- Polybag-raised vetiver plants had 98% survival as compared to bare rooted vetiver - 17% (2 tillers per planting hole).

Because vetiver is very responsive to moisture availability at the time of planting, and conversely is difficult to establish under very dry conditions (as in Rajasthan during the past two or three years), it will be essential to look into different establishment techniques that involve optimizing soil moisture at planting time. The use of polybags is clearly a successful technique, but may be too expensive for general use. On the other hand, it may be quite economic for use under special circumstances involving the stabilization of costly structures.

Kerala - the Church and Vetiver

The Archbishop of Trivandrum, the **Most Reverend Benedict Mar Gregorios** writes to say that he has started the multiplication of vetiver and is widely promoting its use. He sees a good potential for vetiver in sea shore stabilization — Kerala has 600 miles of eroding shoreline. He writes, "Although vetiver is a native of Kerala. It is very much neglected. People emotionally care for crops that bring money immediately!" The issue of farmer adoption of vetiver is critical and requires special attention in designing and implementing soil and water conservation programs.

The following quote sums up the difference between adoption and non-adoption:

"There is a huge difference between telling someone to do something because it is good for them and explaining clearly why something is good so that they can make up their own minds" ***Isabel Carter***

Too often we tend to "tell" farmers; the successful vetiver programs should be characterised by the inclusion of a well thought out action plan that includes good farmer programs that explian the benefits and use of vetiver (through, for example, quality promotional programs and training).

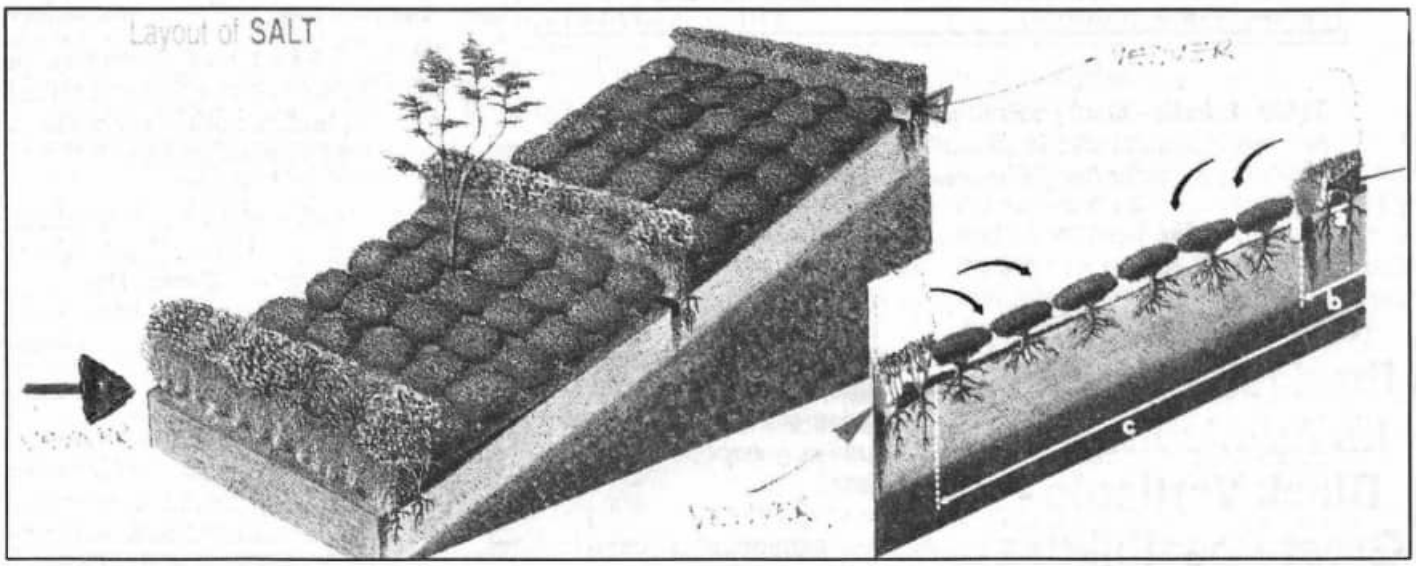

Figure 1. *The width of the avenues between the double-hedgerows varies between 6 and 7 meters depending upon the tea clone used and the corresponding planting density. The total width covered by the hedgerow, inclusive of the vetiver-grass strip need not exceed 1 meter. Spacing between hedge row and tea row 1 to 1.5 meter. a = 40 - 50 cm, b = 100 cm; c = 6 - 7 meter.* ***Source...Tea Research Institute of Sri Lanka, and the Upper Mahelwall W atershed Management Project.***

Photo # 9. *Malawi. Vetiveria zizanioides hedge protecting a young pine plantation.* ***Photo credit...Stephen Carr***

Sri Lanka -Tea - SALT and Vetiver Grass Hedges

Ray Wijewardene has developed a "sustainable land management system for tea" that combines a double row of leguminous hedge row and a single row of vetiver (known in Sri Lanka as *Savandra* grass) aligned on the contour with 6 rows of tea between hedge rows. A 1.5 m space is allowed between hedge row and the first line of tea (**Figure 1**). There are eight different species of leguminous shrubs that can be selected according to site and end use. Ray writes to say that they now have more than 6,000 ha of degrading tea and tobacco lands under this system. Benefits include improved soil nutrition, reduced erosion and improved soil moisture which together adds up to sustainable and increased tea and tobacco yields. It also results in reduced costs because drains no longer fill with sediment, and eventually he thinks that drains will not be needed. The SALT (Sloping Agricultural Land Technology) system pioneered by Rev. Harold Watson in the Philippines is a well known technique and the incorporation of vetiver into SALT provides pretty nearly a fool proof system. Just one more bit of history. Back in 1947, vetiver hedge rows were identified by Eden (the recognized "tea" scientist at that time) as the best means of erosion control in tea following experimentation in the Usambara Mountains of Tanzania. So there is nothing new in this technology! If you need more information on this application in Sri Lanka I suggest you write to the Tea Research Institute of Sri Lanka, St. Coombs, Talawakelle and/or The Upper Mahaweli Watershed Management Project, PO Box 98, Kandy, Sri Lanka. Fax 08 32343. They have produced a very simple and descriptive brochure about the system.

Photo # 10. *Malawi. Vetiver hedge protecting fruit orchard.* ***Photo Credit ...Stephen Carr***

Photo # 11. *Bangladesh. Vetiver can be propagated from nodal shoots.* ***Photo Credit.... Pou Jensen***

A Malawian Initiative

Stephen Carr writes to say that vetiver workshops have been started in Malawi for all senior soil conservation officers. He has sent some good photos of vetiver being used on farm and forestry demonstrations (**photos 9 & 10**). He has encountered problems in some nurseries from a fungus that has led to reduced growth in the nurseries and extensive dieback in the field. It has been identified as Helminthosporium spp. I wonder if there is any relationship with the Indian problem mentioned above. Perhaps Malawian and Indian researchers could exchange some views. The wife of one of his farmers was "delighted with vetiver stalks which made far better fire lighters than other local grasses (Hypperhenias) particularly on damp mornings." IFAD is reportedly about to implement a project in Malawi that will use vetiver as a key technology.

Philippines On-Farm Research Notes

The Farm Resource Management Institute (FARMI) of the Eastern Visayas has initiated a project on the "Adaption/ adoption of Appropriate Upland Technologies at Punta". One of the studies includes the adoption of contour hedge rows using vetiver grass as the foundation. The activity is not yet completed, but it is promising that the initial 40% turn out of targeted clientele who are adopting the intervention on contour hedge rows using vetiver grass on a trial basis is indeed noteworthy. Observations show that the receptivity of farmer cooperators is promising; from the original two farmers, it had risen to 15 - 20 farmers at the time of the report. We will keep a watch on this study.

Bangladesh Vetiver is Ideal Plant for Erosion Control and FloodEmbankment Stabilization

Pou Jensen of the Royal Danish Embassy in Dhaka (previously she was a vetiver enthusiast inAfrica) writes to say that vetiver is quite common in Bangladesh. Its local name is *Binna or Binda* and is used for thatching, fodder and bund protection. There is plenty of vetiver in the Chittagong District, and she says it is also used widely in the northern Dinajpur District. She says that she has not seen any flowering vetiver - yet. In drier areas, she has found that vetiver can self-propagate at the stem nodes (**Photo 11**). We have seen this phenomena in other countries. It provides a means of multiplication, and of course is the basis for "layering" of vetiver. As a reminder, we have copies of P.K. Yoon's report on embankment stabilization in Bangladesh (it contains some very useful photographs). If you would like a copy, please let us know.

Photo # 13.** Zimbabwe - Chiredzi. Jano Labat's sugar cane field drain protected by vetiver grass. Hippo Valley Estates are now following this practice. John Greenfield on left side.* ***Photo credit... John Greenfield

Please note we are told that the Government spends over $150 million a year for maintenance of river and sea wall embankment stabilization — Vetiver could reduce this cost considerably.

Photo # 12.** Zimbabwe - Centenary. Vetiver used to stabilize wall of dam on tobacco farm.* ***Photo Credit....Colin Nethersole

Zimbabwe - Commercial Farming Applications

Colin Nethersole is a relatively new vetiver user. He farms at Centenary, and incidentally has the nicest vetiver logo that we have seen. He has used vetiver to protect a dam wall (**see photo 12**), and is about to protect 30 hectares of his farm using the vetiver as contour hedge rows. He has established a number of nurseries and has vetiver planting material for sale. He reports that most seeds seem to appear sterile; no visible pest or disease problem, and no nematode damage to roots; vetiver shows very vigorous regrowth are burning; vetiver is not a weed problem; and

Photo # 14** .Malaysia - East - West Highway. Stabilization of down slope fill of highway using Vetiveria zizanioides. Six months old vetiver planted from containerised grown plant material. Consulting Biologist - P.K. Yoon.* ***Photo Credit:... P.K. Yoon

in fact keeps invasive weeds out, and reduces the need for herbicides. He seems pretty happy with vetiver, growing it on sandy to sandy loam soils, temperature range 10°- 30° C, and rainfall averaging 800 mm (the last two years > 600 mm).

Jano Labat from Chiredzi, the network's most dynamic and dedicated vetiver user in Zimbabwe, has used vetiver in a number of ways on his farm, including for the stabilization of drains (**photo 13**). He has been working with Zimbabwe's largest sugar estates - Hippo Valley Estates Ltd. - which produce 250,000 tons of sugar per year. Hippo's Assistant Field Manager, **John Kavumbura**, wrote to Jano, "We now believe there is no other grass that will serve the same purpose as vetiver grass, and to this end we have embarked on an ambitious program of planting vetiver to the tune of 6 km per section per month. All our vetiver will be planted in drains..."

United Kingdom, An NGO at Work

Bob Mann of the Methodist Relief and Development Fund writes that his organization has established vetiver nurseries in the Gwembe Valley in Zambia, also at Pobe in Benin. On a recent visit to northern Ghana, he found vetiver (Vetiveria nigratana) on the banks of reservoirs near the town of Wa in the west. The local people simply know it as "conservation grass", brought to the area many years ago by engineers who were building the dams. It was surviving well in this very dry area. He understands that V. nigratana grows naturally in northeast Ghana, but not in the north west.

In the Gwembe Valley, a drought stricken and very poor area adjacent to Lake Kariba, Bob Mann and **Felix Kalikiti** (a Zambian forester) found vetiver in a remote valley south of Chirundu. The seeds are sterile, the grass is used to thatch huts, and the cane-like stems are used to make the walls of their huts. The local names are "Masanga" in Tonga, and "Masindasulu" in Goba. Felix Kalikit, who is multiplying vetiver for farmer soil conservation trials has confirmed that the vetiver is V. zizanioides. For those of you working in northern Zambia, V. zizanioides is available at Mpika Research Station. Also John Greenfield found it at Msamfu Research Station, in the early 1980s, where it had been established in the same lines for 60 years. Bob sees (and we agree) that it is very important that farmer managed vetiver nurseries are established so that farmers can see how the plant grows and behaves before it is established on the farm. In the Gwembe Valley, vetiver was sold for thatch - so here we have an alternative economic use.

China - "A Fix for Soil Aluminium Toxicity"

Mr. Xia Hanping from the South China Institute of Botany reported on some of his Institute's experience in Guangdong Province. Using vetiver, some 400 ha of severely eroded lands in four counties have been brought under control. At one area, known as "the Red Desert", erosion has been completely controlled over two years, and has resulted in economic and environmental benefits. One interesting observation relates to vetiver's ability to decrease the content of exchangeable aluminium, and take up other toxic minerals. For further information on these initiatives in south China, refer to the special edition of the Vetiver Information Network bulletin of December 1993.

Photo # 15. *Malaysia - East - West Highway. Cross section of vetiver hedgerows (photo #14) across road fill embankment. Note overlay lying on original land form (see root - lower right). Vetiver roots have struck through fill into original material - some measure 3.4 meters.* ***Photo credit:...P.K.Yoon***

Malaysia The Wizard at Work!! Highway Stabilization

P.K. Yoon, the winner of the King's Award for Vetiver Research, has extended his initial trials on Malaysia's East-West Highway to a large test site on a very unstable section of the Highway affected by serious slippage. Although only planted within the last six months, the hedges have been well established and are effective. **(Photos 14 and 15)**. It seems that Malaysia's engineers are impressed as the demand for containerised grown vetiver planting material is greater than supply. P.K. is also helping a company in Spain to get started in vetiver. **One of the many reasons that he is so successful is that he combines his great depth of scientific knowledge with a very practical approach which, above all, depends on assuring that the technology is applied properly.** For those of you who know the plantation industry (P.K. is a rubber scientist), a key to success is in the correct application of technology. The same should apply to small farmer and engineering uses of vetiver as well. P.K. has recently been to Spain to help establish a vetiver grass operation there, it will be interesting to hear his views on the possibility of using vetiver grass in Mediterranean type climates.

Nepal - Abundant Opportunities, but Very Few Takers

The Community Welfare and Development Society of Nepal is undertaking trials using vetiver. Other users in Nepal might be interested in contacting the Society for more information. We are concerned that a lot more use could be made of vetiver in Nepal, but we don't get much feedback, and there seems to be little promotion of the technology. It has been used successfully on irrigation projects in the Terai, and for hill road embankment stabilization in eastern Nepal. Please, could readers of this Newsletter in Nepal give us some feedback.

Fiji - Where it All Started

David Meadows, the World Bank's coconut specialist, while visiting Fiji, took time out to look at vetiver. He writes "It was quite clear that Vetiver had been extremely effective in controlling sheet erosion. Vetiver hedges were also extremely effective in protecting the banks of waterways and strengthening bunds, even under extremely saline conditions ..... because of neglect and lack of maintenance, vetiver, that had been planted in the 50s and 60s, had spread ....farmers reacted by tearing out the whole thing rather than restoring the hedge to the original dimensions ....vetiver hedges have been damaged by cane trucks, since the hedges have impeded the trucks, large gaps have been cut in the hedges with consequence reduction in conservation effectiveness .... the Chief Extension Officer, **Mr. Subramanian,** indicated that vetiver did well under tree crops including tea, and needed no maintenance as the shade from the trees reduced the vigor of the grass..."

Ethiopia - Vetiver could be the Key to Soil and Water Conservation

Ato Akalu Ngewo from Addis Ababa has written to say that there is a growing interest and use of vetiver in western and southern Ethiopia. There are a number of NGOs promoting vetiver, and the Fincha Sugar Estates are using it for erosion control. Ato Akalu writes "...With the devolution of power to the regions, many institutions, NGOs, civic organizations, development associations are mushrooming in all regions ... It is interesting to note that all of them aspire for relief, rehabilitation and development through conservation and other infrastructural development... Government is also making a conducive atmosphere for NGOs to participate in rural development .... The coming three or four years could be crucial for Vetiver

Photo # 16. *South Africa - Natal. Maxime Robert's main farm drain running through a sugar cane field stabilized with vetiver. Note the spurs to deflect storm water tfrom the center.* ***Photo Credit ...John Greenfield***

Grass Technology (VGT) promotion, trials, demonstrations, research and development in Ethiopia, and the opportunity should not be missed ..... I believe that the jump start of VGT could be turned into sustainable vegetative soil and water conservation development in Ethiopia.." There has been some excellent work done with vetiver in Mettu (Western Ethiopia) and there are some very good opportunities for the technology in this highly erodible but potentially very fertile country. **Ato Akalu** has been the driving force behind the introduction of vetiver in his country, and The Network would like to congratulate him on his efforts. Those NGOs and others who participate in the Vetiver Information Network and who are working in Ethiopia and want to know more about the technology should contactAto Akalu Ngewo at his home address — PO. Box 1562, Addis Ababa, Ethiopia.

Kenya - Slow Progress, but Opportunities Abound

Vetiver hedges have been tested in a number of areas in Kenya, and have been found to be effective. Perhaps it might be a good idea to test vetiver in the tea and coffee growing areas. If anybody needs further information, please contact Jacob Kampen at the World Bank's office in Nairobi or fax the Vetiver Information Network directly - **USA - 202 522 1658**

Costa Rica and Central American Growers Accelerating Interest in Vetiver

Following a Vetiver Network visit to Costa Rica last year, the **Department of Agriculture** has stepped up its promotion of vetiver in the south of the country, particularly in coffee growing areas. We look forward to hearing more about the program there, as well as in other Central American countries, following Jim Smyle's establishment in San José. **SHARE - Guatemala**, having tested vetiver with farmers for the last four years, and convinced of its utility, have, we understand, decided to go ahead with a program that will train 22 other NGOs in Guatemala and 3,500 farmers in the use and merits of vetiver grass hedgerows. Those Panama readers who are always looking for vetiver. We now have confirmation that it is growing and thriving.

Indonesia - River Bank Stabilization

We have heard from **Dr. Ramu**, River Basin Adviser, that the Directorate of Water Resources has the funding to establish four substantial test sites in different river basins in Sumatra in order to study and test the effectiveness of vetiver for river bank stabilization.

South Africa - New Horizons

Tony Tantum is the Network's key person in South Africa and has been instrumental in the promotion of vetiver grass technology. Under South Africa's new government, opportunities abound for using the technology for the conservation of natural resources. In previous Newsletters, we have reported on Tony's work, but would remind you that in South Africa the technology has already been effectively applied to: on-farm conservation **(Mr. Maxime Robert - Photo 16)**; highway stabilization; erosion control on firebreaks; railroad embankment stabilization; building site stabilization; and now the mining companies (Anglo American) are taking a keen interest in using vetiver grass to stabilize mine dumps . *The Network suggests that containerized grown vetiver be used for this task, since mine dump soils are generally very bad (low pH, devoid of nutrients, and often with limited water).* Tantum also suggests that Salt bush will grow on these mine dump "soils", and is quite a good stabi-

lizer.

Australia - Believe it or not

Paul Truong has just completed a study on the tolerance of vetiver grass to manganese toxicity. Together with its tolerance of aluminium toxicity the results help to explain why it can thrive on poor and hostile environments. He was unable to induce Mn toxicity when reducing soil pH to 3.30 and increasing extractable soil Mn to 578 ppm (**Photo 17**). Plant Mn at 890 mg/kg was also very high without showing any toxicity symptoms. In comparison Mn toxic contents of some of the common crops are 217 ppm for sorghum, 494 ppm for cotton, and 210 ppm for corn. Paul adds that he hopes to start a project looking at some of the native Australian vetiver species such as V. filipes, V.elongata,V.pauciflora, V. rigida. This would be a valuable contribution to expanding our knowledge about vetiver grass. Are there any of our readers prepared to help finance this new task?

Paul Truong has received funding to test out vetiver to replace terraces on very steep sugar lands near Cairns (Queensland), and for the replacement of stubble-fallow strips in a strip cropping layout on the flood plain in the sub-tropical/temperate region near Brisbane. The objectives of this latter work would be to monitor in the field the effectiveness of the hedges in spreading flood flows and in reducing flow velocities and soil movement -- Altogether about 10 km -- of hedge. In connection with the latter **Paul Dalton** and **Dr. Rod Smith** of the University of Southern Queensland have carried out experiments to determine some of the hydraulic characteristics of vetiver hedges. The first year's results are positive and it appears hydraulically feasible to use vetiver hedges to control flood flow and erosion on cropped flood plains. The hedge spacings required are comparable to, and slightly greater than, the strip spacings required for conventional strip cropping, but are far less sensitive to the magnitude of discharge. There appears to be a limited range of slopes for which the hedges alone would provide adequate protection against erosion. Note this experiment was carried out on vetiver grass of less than one year old. Experiments will continue with mature hedges.

Photo # 17. *In search of Vetiver,*
Photo Credit:...Charles Maquire

Vetiver Information Network, Room MC - 8-307, The World Bank, 1818 H Street N.W. Washington D.C. 20433. U.S.A.
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The findings, interpretations and conclusions expessed in this Newsletter are entirely those of the authors, and should not be attributed to the World Bank

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER NETWORK
NUMBER 13 JANUARY 1995

Editor's Page

Getting it right. Unless a technical application is correctly applied it won't work properly. This is true for Vetiver hedgerows and most other technologies. Proper application means effective user training, correct specifications (both plant material and field planting), and good continuing advice in the field. **Getting it right** means good development, a happy user, and in the case of Vetiver a low cost solution that meets many of todays environmental objectives in the area of soil and water conservation.

The application of Vetiver grass hedge rows for soil and water conservation is not the only technology that can be used for this purpose, but rather should be used as one of a number of options and combinations. However there is an accelerating use of Vetiver grass in many parts of the world, particularly as people get to know of its wide range of applications and its very positive attributes. It is therefore important that we keep Vetiver grass information flowing. This newsletter is quite long as it includes some unabridged articles written from the field, not only is the information useful, but it represents good examples of the extent to which Vetiver is being used, and the serious approaches being taken by many users around the World.

The Network would like to congratulate Mr. Linnus Folly, of the International Center of Economic Developmental Integration in Africa, who organized a Vetiver Grass workshop in Accra, Ghana, at the end of November 1994. By all accounts it was highly successful, and will have done much to stimulate the further use of Vetiver grass for soil and water conservation in Africa. We will write more on that workshop in the next newsletter.

It is three months since the Vetiver Network has become semi-private. We still get lots of help from the World Bank, but now there is a more pressing need to help ourselves. The Network has received many encouraging letters, all of which strongly endorse the continuation and expansion of this newsletter. There is also a general feeling that the Network should remain centralized as it can provide a world wide perspective of Vetiver "events" and "responses". A number of you suggested that the network should be regionalized. There is nothing to stop motivated individuals or agencies in specific countries or regions from establishing local networks. This has been done in China, Thailand, and currently Jim Smyle is setting up a network in Central America. These local networks can operate totally independently, but will continue to receive information

Table of Contents

Editor's Page.....1
Lest We Forget 2
Information.....3
Letters to the Editor.....4
News from the Field......7
Asian Grass to Lift Lambing Percentages....ToniSomes.....7
Vetiver grass to combat soil erosion:Gwembe South, Zambia.....8
Vetiver development in Zambia. Alex Mundia.....8
Vetiver in Central America. Jim Smyle. 8
The Lupe Project's Experiences With Vetiver Barriers In Honduras. David Leonard.....10
Vetiver In Ethiopia. Shimelis Kebede.....13
Report On The Potential Weed Problem Of Vetiver Grass And Its Effectiveness In Soil Erosion Control In Fiji. Paul Truong and Colin Creighton.....16
Uses of Vetiver Grass in the Land Rehabilitation and Maintenance of Military Installations.....24
Research Papers 25
Biotreatment of Produced Waters. Progress Report. Ray R. Hinchman, R. Gerald McNally, and M. Christina Negri.....25
Vetiver grass, its potential in the stabilization and rehabilitation of degraded saline land. P.N.V. Truong 26
Hedgerows And Mulch As Soil Conservation Measures Evaluated Under Field Simulated Rainfall. Oscar S Rodriguez.....26
Research and Development on the Application of Vetiver for Soil conservation in Indonesia. SolehSukmana.....26
Use Of Vetiver In Sunflower Dominated Cropping System. Shri. A.P. Wankhede, Dr. T.G.Chimanshette, Shri A.P.Kadam..... 28
Vetiver Grass As A Preventative maintenance Measure For Irrigation Systems. Geoffrey Spencer.....28
Important Biological Considerations In Use Of Vetiver Grass Hedgerows (VGHR) For Slope Protection And Stabilization. Dr. P. K.Yoon. 29
Specifications For Vetiver Quality Hedgerows. Dr. P.K.Yoon.....31
Vetiver Hedges on Contour for in-situ Rain Water Management on Arable, Non arable, and Wet Lands. G.M. Bharad.....32

from the Vetiver Network here in the USA. I hope the local networks will send information to me for further dissemination.

One point made by a number network members is that the network should not depend on user subscriptions for its operating funds, as many users do not have local funds to cover a subscription. More importantly most of our members do not have access to foreign exchange, or cannot cope with the hassle and cost of acquiring foreign exchange. I know this to be true, and therefore will resist moving towards a subscription system of funding. However we need funds. It costs about $500 per month in postage and other communications to run this network. It costs a lot more if the printing and mailing of the newsletter, and other technical papers, slides and videos that are available, are included. Fortunately the World Bank is covering part of this cost over the next two years.

There are a growing number of private network users, corporations, consultant companies, government agencies and NGOs, who are making good use (even profitable use) of the network and its information. If one hundred of you would be willing to donate US$ 100 or more each, those funds would cover the minimum cost of the day to day administration of the network for one year (there are no salary costs). Please give it some thought, and if you wish to make a positive statement of support send a check to the Vetiver Network. All funds received will be acknowledged and fully accounted for. If any of you have connections with donor agencies in the developed world, you might care to suggest to those agencies that the Vetiver Network deserves some support.

The Network can only be as good as its members make it. That means sharing experience and information. Some users (promoters) like P.K.Yoon, Tony Tantum, Paul Truong, Shimelis Kebede, Alex Mundia, David Leonard, Jim Smyle, Govind Bharad and others have been most generous in sharing their experiences. There are many more of you with good information, please find some time and write 500 - 1,000 words or more on what is happening in your area.

The Network is getting a lot of requests, particularly from South America, for Vetiver planting material. It is believed that Vetiver is available in most countries, but often its whereabouts is not known to the general public. Most countries have representatives of the International Agricultural Research Centers (CIP, CIAT, CYMMIT for Central and South America), IMMI, IRRI, IBSRAM and ICRISAT (for Asia), and IITA, ILCA, ICRAF, and ICRISAT (for Africa). All these institutes are members of the Network. I would ask the Director Generals of the Institutes to make available Vetiver germplasm, or at least have a list of localities where Vetiver is available, if requested. The international research institutes are public organizations and are supposed to serve the public, so let's use them!!

Photo.1. His Majesty the King of Thailand, M.E. Prince Bhitsatej, and Dick Grimshaw discussing the vetiver bronze presented to His Majesty in recognition of His Majesty's outstanding leadership in the field of natural resource conservation and the promotion of vetiver grass technology. Photo by The Royal Palace,

Lest We Forget

Nuttige Planten Van Indonesie. (Useful Plants Of Indonesia) By K. Heyne (Part I. Pages 193-195) Published in the 1920s. Translated By Ed Boerma.
Andropogon Zizanioides Urban (Vetiveria Zizanioides Stapf) Local Names: Khas-Khas, Etc. A vigorous, perennial, which tillers strongly to large clumps, some 150-250 cm tall grass, with an extensively developed, rather strongly aromatic root system, erect, or with slightly creeping root forming stems, with long, narrow, rather stiff, non-aromatic on crushing, gray-green leaves and green to purple colored small ears with small awns, which form ear like side stems and then rather large plumes. Near Jakarta and on Kangean island it is found growing wild at an altitude of 5 -100 meters a.s.l. in swampy terrain in the west monsoon; the (seldom flowering) unawned species is found in Central Java to an altitude of about 900 m, often along the edge of water. There are very few reports about cultivation of the grass. It has already been reported (Publication No. - (1920) of the Trade Section) to be planted at two estates in Soerabaja and Madioen, which have 35.5 ha pure and 2.8 ha mixed stands.

Vorderman (Plants on Madura No. 162/219) stated that the local population plants the grass along maize fields,

near the town of Slopeng . It is also quite often found near and in Garoet Kedoe near Wonosobo. In West Java it is found along natural water courses to prevent scouring, and in tea gardens it is used to protect edges of terraces. An article on page 816 of the Indische Mercuur, the grass "djokoet wangi" (local name of Vetiver) is strongly recommended for planting on steep slopes and along furrow edges, because of its easy cultivation and the formation of a dense hedge with a very extensive root system, it prevents breaking of the soil in the dry season and prevents erosion within furrows (because of the spread of roots within the furrow). Due to its hardness, it is of no value as a fodder grass according to Backer (author); but is for the aromatic roots, which are (after suitable growing conditions) - ready for harvesting after one year. According to annual reports of the Board of Scientific Advice for India 1913-14 and the 1918 Yearbook of the Madras Department of Agriculture (p.66), the change in weather prior to the wet season is most suitable for digging the roots in India. De Jong (Yearbook 1910, Department of Agriculture, Industry and Trade, p.48) obtained poorly flowering plants in full sunlight and which were regularly cut (which apparently improved the root formation - De Jong 1923) and planted at 3x3 ft. and which yielded 150 gram roots after 12 months and 190 gram roots after 22 months. An experiment with wider spacing and a longer growing period provided lower yields. After digging, the roots are washed and dried in the shade which changes the color to reddish-brown. The local population really appreciates the aroma of the roots, which V. D. Burg (Geneesheer III, p.128) calls mild or dull aromatic; they use it to perfume clothes. For that purpose they make fans and similar objects from the roots, which will, as long as they are kept moist, spread the vague but somewhat nauseating perfume. Vorderman (Geneesmiddelen III, page 128) mentions the roots as an pharmaceutical item of trade. V. D. Burg mentions that they are used for the preparation of arak obat (a local pharmaceutical) and that its tea (brewed product) makes you feel hot and sweaty. At Ambon and in Central Sumatra the population sometimes distills (extracts) the brown oil which sticks to glass. Oil distillation is according to Schimmel's October News of 1913, not easy, and would almost always have to be done in Europe. Root export statistics (from Customs reports) indicate varying levels; from 2.3 tonnes in 1918 to almost 143 tonnes in 1925 (with most years less than 50 tonnes. When processed fresh a more liquid oil is obtained than from the dried raw material. According to De Jong (Bericht No. 7 of the Colonial Institute p.102), oil cells are only found in the bark of the roots and a special pretreatment is needed to obtain the highest extraction rate. He mentions a yield of 0.4 to 1.0% of the weight of dry roots, sometimes increasing to 2% depending on climate and time of harvest. A sample out of akar wangi from Garoet some 2.2 to 2.7 % oil was obtained. The roots were ground and soaked in water for 2 days. After pressing and decanting the wat:er, the mass was heated with steam and then distilled for 12 hours with steam of 3-4 atmosphere pressure. From the still water some 0.34% oil could be obtained through shaking with light benzine. The oil is used because of its low level of vaporization as a fixative for the preparation of perfumes and is considered absolutely necessary for the preparation of fine soaps. The quality of the Indonesian oil has been found superior to that of other producer countries.

Information

Vetiver Grass for Soil and Water Conservation, Land Rehabilitation, and Embankment Stabilization. This collection of Papers and Newsletters, compiled by the Vetiver Network, is currently being published by the World Bank's Publisher and will be available free to all Network members. Additional copies may be available on request.

Dr. H. Zvi Enoch of The Volcani Center Institute of Soils and Water (fax: 972 3 960 4017) and Prof. Mark Hussey of Texas A&M (Fax: 409 845 0456) are hoping to undertake collaborative research on Vetiver in the areas of soil salinity, cold tolerance, forage and aridity. If any one is interested in making a funding contribution, providing some good advice, or providing germplasm for testing (local accessions of Vetiver sp.) please contact either of them.

Script for 80 Vetiver slides Some years ago we issued a set of 80 Vetiver slides. Some people have asked for copies of the script. I lost the script, but have now found it. If you need a copy please write for one.

Vetiver Mailing List. All members of the network should have received a hard copy (green cover directory). Some of you may like a diskette of the list. This is available in DOS or Mac format - Excel.

Vetiver Nomenclature. As we discover different "types" of Vetiver we sometimes get confused with the terminology. I would suggest that within a given species i.e. Vetiveria zizanioides we refer to different genotypes as "accessions". This might reduce confusion at a later date.

Type Font. If you are sending me information by letter or fax I would appreciate that if possible you use a Courier font. Courier font scans very well and makes it easier for your editor.

Videos. I have four videos that are available on Vetiver technology. Three produced by P.K. Yoon, and one by John Greenfield (Fiji visit in 1986). If you need copies please let me know the TV system you use (PAL or NTSC). They cost US$ 20 each. Payment in advance please. The titles are:

- Production of Quality Planting Materials.

- Case Studies: Bandar Sri Iskandar.

- Excavation; Resistant to Fire Damage; Case Studies: Sg. Chinoh & Hwa Li.

- Vetiveria zizanioides A Method of

Photo 2. *Tony Tantum(left) of South Africa, and John Greenfieldm(right) of New Zealand. Two Vetiver stalwartsget together in Natal during Greenfield's visit to Southern Africa in 1994.* ***Photo by Tantum***

Vegetative Soil Conservation

Philippines. The Department of Public Works will be using vegetative methods to stabilize slopes rendered unstable by the 1990 Luzon Earthquake. Vetiver grass barriers will play a major role in this stabilization program. Further information may be obtained from the "Office of the Secretary, Earthquake Reconstruction Project, Department of Public Works and Highways, Manila, Philippines".

South Africa. Tony Tantum continues to spearhead the drive to use Vetiver grass technology in Southern Africa, he has recently been working with a gas drilling company in Mozambique to advise on the rehabilitation of a site destroyed by a gas well blow out.

Jim Smyle is now resident in Costa Rica. See his comments on Vetiver grass in Central America later in this newsletter. Jim is Spanish speaking, and can do a much better job in helping those of you in South and Central America than I can, so please make use of his experience and advice. Some of you writing to me in Spanish will get a reply from Jim, as I am passing some of the letters on to him.

Fuel briquettes from Vetiver grass leaves A number of you have shown interest in the potential of making fuel briquettes from Vetiver grass. If you need general information on this technique you can get it directly from VITA (Volunteers In Technical Assistance), 1600 Wilson Boulevard, Suite 500, Arlington, Virginia 22209, USA. and from The Intermediate Technology Development Group, 103/105 Southampton Row, London WC1B 4HH, UK. Also Tony Tantum in South Africa is working on the topic.

Letters To The Editor

Dick.....I am working in a coffee plantation in Illubabour, Ethiopia. I don't know where it comes from, but Vetiver grass has dominated our farm as a soil conservation measure since 1986. Also we see that weeds do not grow near Vetiver grass, so it may serve as a weed control measure. We also use it like a fence, for decoration and protection against wind damage to coffee plants. It also is used for thatch, and in the country side for stuffing mattresses.... **Lulu Gebremariam, Irrigation Engineer.**

Mr. Richard G.....I am writing to up date you about the information related to Vetiver as on our demonstration farm at 6000 ft. altitude. Please find enclosed some photographs of Vetiver plants which were photographed in early August this year. The clump visible is just one year old, multiplied through one slip planted in last monsoon. We are trying to bring out the details of Vetiver planting and its multiplication pattern at this altitude which is definitely slower than in a tropical climate, even in Nepal. This year, we have planted it on several terraces of our farm to observe its growth and terrace binding capability in order to know whether this plant could be used to check terrace bund slides together with soil erosion. Whatever we are doing is out of our own interest knowing its importance through your publications which we are receiving regularly. To be honest, I, being an agriculturist by profession since last 30 years, have not been able to see and observe even its practical use in Nepal, and or abroad, as described for Malaysia, although we have tropical climate in Terai (plain) area in Nepal.

All this needs financial assistance to support our activities. If World Bank or other funding assistance could be made available for this research work, CWDS would be able to work quite intensively on Vetiver at different altitudes in different parts of Nepal. If you consider it appropriate, we can work on it at length. However, we will continue within our limitations and keep you informed as appropriate.

Photo 3. *Vetiver grass at 2,000 m asl in Nepal.* **Photo by S.P.Yadav**

Thanking you very much for keeping us informed through your publications and putting our (CWDS) name in Vetiver Newsletter July 1994. Let us find some-

thing more on which we can work together for the benefit of the community and ecology in large.....**S. P. Yadav. Community, Welfare and Development Society,Balaju, Khatmandu, Nepal.**

Dick Grimshaw.....Vetiver Boundaries in Zimbabwe I am one of your less active correspondents from Zimbabwe, although I have benefited over the years from your newsletter, thank you. I have for the past few years been trying to introduce vegetative, "general" boundaries in a resettlement scheme south of Chipinge in Zimbabwe. AGRITEX, the Government, Agricultural extension department, have been very cooperative in providing manpower to do the actual planting, and nearby commercial farmers have been very obliging about providing as much planting material as we could use (your list helped in putting me in touch with interested farmers). However the exercise has met with several difficulties, mainly of human nature, as I will outline below:

- Even a plant as robust as Vetiver needs attention until it is properly established, in the way of weeding and, if the rains fail, even occasional watering. Once established the grass lives up to its promise, and is very hardy, but until established it can quite easily be choked by weeds or die off from lack of water. It was even found that "white ants", or termites, eat the planted grass as soon as it dries out a little after planting. In a country with a rather brittle environment, and with a clearly defined "rainy season", there is an optimum time of year for planting, in order to make the most of the rains, and at this time a farmer's best energies are focused on planting the year's crop, and weeding and nurturing it until it is established. Clearly there is a conflict or interests here between the food or cash crop on the one hand and the grass boundary on the other. The stark economic reality is that the Vetiver boundary has to take second place because its benefits are more long term.

- Another problem, is that in a brittle environment with quite a short rainy season and a very dry remainder of the year, Vetiver does not establish itself in a single season unless it is irrigated; rather it is a two or three year process. Since human beings tend to find long term investments harder to appreciate than short, they will not in general sustain their initial effort. if they do not perceive immediate returns. In Zimbabwe, a commission has been looking into introducing registration of title for the half of the country which is under communal (secondary) tenure, and one of the factors which has had to be taken into account in deciding on the type of boundary system to introduce, and the time it would take to establish Vetiver general boundaries. It also has to be borne in mind that even if some farmers were diligent about establishing their grass boundaries, and these boundaries showed up from the air in two or three seasons time and could be mapped for producing title deeds, other farmers might not have put in the time, and the resulting map might be rather piecemeal, and might require a great deal of additional ground survey . (S.R. Simpson and P. F. Dale have both described this very thing happening in Kenya).

- Finally, it was found in the Chipinge pilot scheme, that the logistics of multiplying grass, distributing and planting it, were formidable. The grass is bulky, and trucks are needed and they need to make their deliveries in the rainy season when roads frequently become impassable and rivers sometimes come down in flood. While some farms can be reached, it is difficult. to guarantee that all farms will be.

Even if all of the grass does reach its destination, one then comes up against the problems described iabove, namely that farmers will be working against time to get their cash crops in, and will be reluctant to break off to plant boundary hedges, and even if they are convinced of the rather nebulous long term benefits of title deeds, and do agree to get the hedges in, they might by the following season, or the one after, have lost the vision and the momentum, and they will need to be convinced afresh that they should take time away from the cash or food crops to weed and care for the hedges.

I hope that these experiences might be of value to anyone else thinking of introducing Vetiver as a boundary hedge, and by the same token if there are experiences of successes or failures elsewhere in the world I would be grateful to hear about them (in a less brittle environment I suspect that the picture would be very different). **David Goodwin, Department of Survey, University of Zimbabwe, PO BOX MP 167, Mount Pleasant, Harare. Zimbabwe. Telephone: 263 4 303211. Fax: 263 4 732828**

Dear Mr. Goodwin,

Thanks very much for your letter of November 28th. Your observations on Vetiver and its application are quite correct. Let me try and give you some advice.

Vetiver has been grown successfully in India and northern Nigeria under similar conditions to Zimbabwe. In both countries farmers have used Vetiver as farm boundaries (primarily) and for conservation (secondarily). Records in both countries indicate that more than 100 years ago the local Surveyor General approved the use of Vetiver as boundary markers. If farmers really understand its use and want to use it it will work (unless the climate is completely adverse). In China some farmers are using Vetiver to demarcate farm boundaries. If the legal system and tenure rights are convincing then farmers do want to demarcate what is theirs.

For surveying and boundary purposes I would like to make a suggestion that you could try out. I enclose an article by P.K. Yoon on the use of Vetiver for engineering purposes, in it is plenty of food for thought. The key of success is the use of containerized plants, and setting and holding to technical standards

If you want to establish immediate Vetiver survey markers I would suggest that you seriously consider using polybagged Vetiver plants, not to create full length hedges, as this would be expensive, but rather to mark say 3 meter intersection boundary lines, either "Ts", "Ls" or bars which would grow quickly and vigorously and be imaged by aerial photography. The intervening boundary line spaces could be completed at a later date by farmers using less expensive bare rooted plant material.

The advantage of using containerized plants is that there is no growth set back after planting, and as long as there is some soil moisture the plants will grow vigorously. If you have a squarish 1 ha farm plot you would need about 160 pots. We have found in Rajasthan, India, where rainfall is less than 300 mm, that 100% survival is possible when containerized plants are used. (Yoon's paper describes pot option sizes etc.). Yoon also describes a foam rubber system of growing Vetiver -- the foam substitutes for soil. This results in very light "pot plants", and therefore easy to transport. One person can carry 50 of such pots very easily. If you are interested in this suggestion, I would strongly urge you to visit Yoon in Malaysia, or get him over to Zimbabwe. Why don't you discuss this with the AGRITEX people? Incidentally I also believe that for purely survey purposes only (particularly if you want to get 100% coverage) you should set up the Vetiver marker program as 100% cost to government, and pay trained labor and supervisors to do the job. You could have qualified farmers to produce the containerized plant material near to the end use sites. ***Editor***

Dick.....I am very interested in Vetiver both as an erosion control plant for our revegetation/rehabilitation work and as a potential phytoremediation species in our research on plant-based contaminant cleanup systems. I certainly don't need to tell you of all the erosion control and soil stabilization uses of Vetiver, but I will offer a brief overview of the use of large, robust grasses (including Vetiver) and other plants in phytoremediation systems.

We consider the use of green plants to clean up contaminated waste water and soil to be an emerging technology with much promise. Phytoremediation is not applicable in all cases; but where it is appropriate, it has considerable advantages. The major advantage is its lower cost. Phytoremediation methods are often orders of magnitude lower in cost than competing "harsh" cleanup technologies. It is also "low-tech"; it does not require extensive mechanical installations that often require intensive maintenance and are subject to breakdowns. These aspects make plant-based contaminant cleanup systems ideal for use in developing countries.

Phytoremediation of contaminated soils has the advantage of leaving the soil ecosystem intact, or actually improving it. Almost all the other currently used soil cleanup technologies (incineration, thermal desorption, solvent washing, etc.) either destroy or severely alter the essential biotic component of the soil, and can change the physical structure as well. Productive use of soils following treatment by one of these harsh remediation techniques usually requires additions of soil amendments (mulch, compost, or other sources of organic carbon), fertilizer to replace the plant nutrients that are lost or made unavailable, and inoculation with untreated, uncontaminated soil to provide a source of propagates of soil organisms to repopulate the essentially sterile "clean" soil. Even with all these measures, the physical soil structure may be altered so completely that the soil can never be returned to its former state.

Phytoremediation of contaminated waste waters has the advantage of simultaneously reducing the volume of the waste water through enhanced evapotranspiration via the aerial parts of the plants, while the root system and its associated rhizosphere function as a biological filter to absorb, sequester, degrade, and/or metabolize heavy metals, trace elements and organic contaminants as a single, integrated, ongoing process.

For all of these reasons, we believe that phytoremediation of contaminated soils and waste waters has a place in the array of in-situ remediation technologies that the government and industry are currently evaluating. At Argonne National Laboratory, in the Reclamation Engineering and Geosciences Section we have staff members with extensive experience in basic and applied plant research, plus an ongoing project that is evaluating innovative phytoremediation approaches to the volume reduction and cleanup of produced water — the saline waste water that is produced by natural gas wells along with the gas.

I have enclosed a copy of the abstract from a draft report on this project, entitled, *Biotreatment of Produced Waters - Progress Report,* plus several other documents relating to phytoremediation of both waste water and contaminated soils. The diagram entitled "Plant Bioreactor Model" may be of particular interest in relation to our discussion of one type of low-tech plant-based waste water treatment system that may be appropriate for small villages in developing countries. This model is based on actual data from the greenhouse studies described in the abstract of the draft report. This general type of system could also be used to treat non-saline waste water (e.g., sewage, agricultural runoff, mine drainage, etc.), could be installed in simple trenches in the ground, and use Vetiver in one or both of the compartments. **Dr. Ray R. Hinchman, Reclamation Engineering & Geosciences Section, Energy Systems Division, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439. Phone 708/252-3391 fax 708/252-6407. Internet e-mail: hinchman @ anl.gov**

Dick.....My name is Auemama Rakanui, the only Agricultural Officer responsible for Vetiver cultivation on my home island,

Atiu (Cook Islands, South Pacific). I wish to thank you for the letter of December 1993 written about Vetiver and people involved in soil protection. Thank you also for the News Letter (December 1993). I have been involved in soil protection, especially Vetiver plant cultivation introduced to Atiu by DEK MILLER and MIKE POSHKHUS (United Nation Volunteer from the USA), in 1992 . My home island is the 4th biggest in the Cook Islands. It is a raised volcanic island. The central part of the island is a raised plateau where people live. Our biggest problem is that, due to the slopes of the hills being cleared of trees, and from around about 1970 ,for planting pineapple, and because a lot of land has been cleared with no soil cover, soil erosion had occured. This is really bad. No work was actually done to solve this problem until Poshkus arrived. He carried out some study on soil problems in Atiu. Then I was seconded to work with him , up to his departure in 1993. I continued the project by myself under the direction of Mr Kapao Kapao, Supervisior of the Forestry Project of Atiu. Without much assistance, except for a garden spade and a bush knife, I have managed to plant more than 9,000 "done" of Vetiver in scattered locations on Atui. **The result is immediate and very good.** Soil is building up along the areas protected by the Vetiver growth. The island is always open to soil erosion because it is mainly hills. Unless soil cover or vegetations are grown on the slopes this problem will continue.

I am interested in the Neem tree. I know we have very strict laws prohibiting importing of plant material in the Cook Islands. May be one day we can find a way to look further into the pros and cons of Neem in the Cook Islands. I will also look to see if I can send you some photos on the progress of Vetiver growing in Atiu. I hope this will be a start in sharing experiences on our effort to save our soil. **Auemama Rkainui**

Dr. Grimshaw *(editor's note ....Dick Grimshaw is not the proud holder of a PhD, such references to "Dr" by writers must be purely honory!!!)*

According to the report we received from Mr. Edwin Balbarino, Field Coordinator of the Farm and Resource Management Institute (FARMI), the Visayas State College of Agriculture (VISCA) started using Vetiver grass in early 1991 when they started a project in soil and water conservation in Matalom under the IDRC-funded Upland Development Project-Philippines. They read about the potential of the grass to control soil erosion. Incidentally, Vetiver is available in the locality (Western Leyte). It is used by farmers in stabilizing the dikes of lowland rice fields.

The 32,000 meters of hedgerows established by farmers are not all Vetiver grass. In the latest survey, there are about 5,000 meters of Vetiver (locally known as Mura) planted by the farmers. Other hedgerow materials include other grasses and leguminous tree and shrub species. Vetiver is also used in stabilizing the soil in the Upland Rice Research Consortium research area.

As far as evaluation is concerned, a study was conducted in 1991 to get farmers' evaluation of the grass and VISCA is now monitoring the performance of Vetiver in controlling soil erosion. FARMI has produced a technoguide on Vetiver which was distributed to interested individuals. **F.A. Bernado, Deputy Director General for International Services, IRRI, The Philippines**

News from the Field

Asian Grass to Lift Lambing Percentages....Toni Somes, Queensland Country Life, November 10 1994

An Asian grass, already used extensively to control soil erosion may soon prove instrumental in boosting lambing in western Queensland. The Vetiver grass (Vetiveria zizanioides) is being grown as part of shade plot trials at Toorak, QDPI research station, south of Julia Creek. Research has already found artificial shade plots on Mitchell grass country can boost lambing percentage by 15%.

According to Toorak manager, Tony Barnes, the Vetiver grass has considerable advantages over native trees and its predecessors, articularly Prickly Acacia and Parkinsonia. "Introducing thorny trees and shrubs like Prickly Acacia and Parkinsonia, for animal welfare reasons, has seriously threatened the viability of Mitchell grass pastures," Mr Barnes said. But research shows Vetiver doesn't spread - it can only be propagated by root division or slips - and therefore will not compete with natural grasses like Mitchell and Flinders. "It also grows rapidly, and is capable of providing adequate shade for adult sheep after at least 12 months."

The Vetiver grass is already recognised world-wide as an effective way to control soil erosion. it has been described as fire resistant, well adapted to humid and dry conditions, tropical and temperate climates and can also survive under water for a reasonable period.

Although the Toorak trial is in early stages, research officer, Greg Bortolussi, said he was confident of finding favourable results. "We planted the grass in February last year and now it stands about 1.7 m high and provides quite adequate shade for sheep," he said. Mr Bortolussi said: "Heat stress is currently blamed for approximately 20% reduction in live birth weight of lambs, and up to 30% increases in lamb mortality. He said the addition of artificial shade plots for pregnant and lactating ewes on Toorak had increased overall productivity by 15%. "Already we know that nothing really eats the grass, stock won't touch it, and although kangaroos use it for shade they don't touch it either" he said The Vetiver grass trial is being run alongside native tree shade

plot trials at Toorak

Vetiver grass to combat soil erosion: Gwembe South, Zambia....

Bob Mann, Methodist Relief and Development Fund, Division of Social Responsibility, 1 Central Buildings, Westminster, London SWIH 9NH, United Kingdom.

As part of the soil conservation program of the Gwembe South Development Project (GSDP) in southern Zambia, two Vetiver grass species were established in a nursery at Kanchindu village in November 1992. Those species were Vetiveria zizanioides, originally from Mauritius, a recent introduction to the valley, named locally by the Tonga people as Masanga Mpika, and Vetiveria nigratana, indigenous to Gwembe valley and known locally as "Masanga Zambesi".

These two species have both grown vigorously, they have very prolific vertical root systems, and will be equally useful if planted as hedges on the contour for erosion control. However, they do have different leaf growth; Vetiveria zizanioides grows to a height of about 1 meter, its leaves are narrower, and farmers say it may be better for fodder, while the local plant, Vetiveria nigratana, is taller when full grown, reaching about 1.5 meters in height, it's leaves are relatively broader, and it is said to be better for thatching.

When the rains started in December 1993, clumps of Vetiver grass were lifted from the main nursery at Kanchindu and distributed to other village farmers who were keen to start their own nurseries. This is the start of a long-term program in Gwembe valley aimed at assisting farmers in their efforts to prevent soil washing from their fields.

Vetiver development in Zambia.

Alex Mundia. World Bank, Lusaka.

Mr. R K Shula is Project Coordinator, Vetiver Promotion, located in the Soil Conservation Unit in the Irrigation and Land Husbandry Branch (ILHB), of the Ministry of A g riculture. During 1993/94, MAFF started the campaign, following the visit of Mr. J Greenfield in November, 1993. The implementation strategy is to have a coordinated approach through the Soil and Water Conservation and Agro-forestry Extension (SCAFE) program under ILHB, working through the Extension Service and supported by SMSs from the Forestry and Natural Resource Departments of the Ministry of Environment and Natural Resources.

The main focus of the campaign in 1993/94 was Vetiver plant material multiplication. Under the program, funded under the SCAFE, about 326,000 Vetiver slips were acquired and distributed to demonstration plots and nurseries.

Most of the slips were acquired from a commercial farmer in Mpika, Northern Province at K7/slip, except for Eastern province which had its own local supply through SCAFE. This slip supply fell far short of requirements, which were estimated at 2 million for the envisaged initial program last year, and 1.8 billion, in terms of potential national demand (defined as 600,000 small farmer planting at least 2 hectares each at the seedling rate of 3000/ha). The major problems with the 1993/94 program were the late start of the program and lack of planting material, along with poor logistics of sourcing and distributing planting materials. There were delays in delivery of slips to actual planting sites and as a result the roots of the grass were exposed to drying, resulting in poor survival rate of the planted slips. This will mean that the 1994/95 campaign program will have to primarily focus on planting material multiplication as its main objective. A comprehensive budget had been drawn and ZAREP had committed $1 million for the program over two years. For various reasons the appointment of the Coordinator was delayed considerably, so that in the begining the program suffered from lack of leadership and focus. In this regard, the recent appointment of Mr. Shula is a welcome development indeed.

The main components of the 1994/95 program will be, as stated earlier, seedling multiplication and nursery establishment, as well as training of field staff and production of publicity materials and extension messages. Planting materials will be limited though. We tried from the resident mission here, in April and May this year, to assist in getting supply sources from Zimbabwe, which has established commercial producers, without success: the quotations we received through our Resident Mission in Harare were outrageously high at farm-gate price of K127/slip! Mr. Shula will be making an assessment of the number of slips available locally, from the sources mentioned above, to enable him to formulate a plan for: i)distribution to districts where demonstrations will be conducted ii) identify, through the extension service, demonstration farmers and design training program and iii) identify districts which have nurseries and year-round irrigation facilities for further multiplication. Thus the scale of operations for 1994/95, will depend entirely on the number of slips which can be obtained from the various locations where the grass is presently being propagated. If you, or anyone, know of any other sources of Vetiver slips in the region that could be competitive in price, please let me have their contact address, so Mr. Shula can follow them up.

Vetiver in Central America. ...

Jim Smyle. San Jose, Costa Rica.

This is the first of what will hopefully be a series of articles on Vetiver grass in Central America. As in most parts of the tropical world, Vetiver has a long history of use in this region; not only for conservation but also for medicinal uses. It is for this latter purpose that the grass is most widely known. Called variously "zacate violetta", "valeriana", or "Vetiver", an infusion from the roots is said to be useful for upset stomachs, to calm nerves, insomnia, and as a hangover remedy. The dried roots are readily available from herbalists in the market places and on the streets. It is not un-

common to find one or two plants in home gardens for medicinal uses.

The present picture of vetiver's use as a conservation species in Central America is unclear. The information that is available shows that vetiver's application for conservation has been recognized by Central American farmers for several or more decades. Over the last five to ten years, use by farmers and awareness among conservation professionals has been growing. More and more commonly contour barriers of Vetiver are becoming part of the menu of technologies promoted in sloping land agriculture. In civil engineering, however, it appears that the tremendous potential for using Vetiver as a low cost means of protecting and stabilizing infrastructure is unrecognized and thus, untapped.

In obtaining information for this article it was obvious that the Network has access to only a small fraction of information on the activities taking place regionally. More information, such as that from David Leonard (Proyecto LUPE) on activities in Honduras is needed. As yet, our group of correspondents is too small. From the Network's experiences in Asia we know how important it is to be able to inform potential users on activities in their own country or region. Any good extensionist will tell you that people are best convinced by seeing and learning from experienced individuals who work under the same conditions and in their same situation. So please, help us to update and expand on the information below so that we can be more effective in getting this technology moving. Contact:

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Costa Rica

Vetiver can be found in home gardens and along roadsides from sea level around Limon and Puerto Viejo up into the Central Plateau region. Its use for conservation appears at present to be primarily in the Central Plateau, and down to the south through the coffee growing areas near the Panama border.

The Costa Rican Ministry of Agriculture is carrying out trials and demonstrations with Vetiver grass in the central plateau in the heavily deforested area of Purisceil where hillslope agriculture is prevalent. This work has been ongoing for over three years. According to one informant from that area, Mr. Marco Tulio Rojas Arroyo, when he was a student at the Colegio Agropecuario Puriscal (before 1983) he planted Vetiver during field exercises in the school's fruit and coffee orchards. Mr. Rojas believes that Vetiver and lemon grass have been used for 20 years or more in that area to stabilize and protect contour infiltration and drainage ditches in perennial crops and tobacco. He told the Network that the use of live grass barriers has been increasing in that area, especially following the GTZ/Ministry of Agriculture/Ministry of Natural Resources "Agriculture and Forestry Development Project" between 1986 and 1993. According to Mr. Rojas, **it was the project's education campaign which increased farmer awareness of the need for conservation, resulting in greater use of this technology and Vetiver.**

Dr. Charles Buford Briscoe, also living in the central plateau region of Costa Rica, reported to the Network in 1991 (Newsletter #7) that he had been using Vetiver for 6 years. Today he is still using Vetiver, primarily to stabilize steep areas around his home. He says that in his area the main interest in Vetiver is among new property owners who are using Vetiver to arrest erosion in active cutting areas on their newly purchased properties. Dr. Briscoe reports that he receives several requests a year from people in other countries in the region requesting information and planting material. In his ten years of experience with Vetiver, Dr. Briscoe confirms that he has had no pest, disease or dieback problems with his hedges. The only maintenance that they receive are about three prunings a year when they are cut back to around 40 cm (as recommended by Dr. P.K. Yoon).

Dr. Briscoe also mentioned that in the 10 years since planting, those hedges that he tried to establish with widely spaced plants (18 inches or 45 cm) have never closed up. **This is a reminder to all readers that the appropriate way to establish a hedgerow is to put the plants close together (i.e. 15 cm or less, preferably less). DO NOT try to stretch your planting material to cover larger areas.** If you cannot cover all your needs in the first year, harvest material from your established hedges can be used for subsequent expansion of Vetiver barriers. The technology is only useful if you apply it correctly.

He also mentions that Arachis pintoi (mani forrajero) is working very well in his area as a groundcover (*editors note: Arachis pintoi is potentially invasive and thus requires good management*) and that, in the Pacific lowlands, there is interest in planting of grass barriers of "Taiwan" grass in forestry plantations.

El Salvador

The use of Vetiver for soil conservation is only very recent in El Salvador. Apparently, however, there are some very dynamic people there who have been making steady progress in setting out demonstrations and beginning a country wide program. CENTA, the government's agricultural and forestry technical agency, has established its Vetiver nurseries and begun a Vetiver program.

CENTA has been working with an NGO group, Fundacion Para El Desarrollo Agricola y El Equilibrio Ecologico (FUNDAE) which is promoting the establishment of a country wide technical assistance program to demonstrate and promote Vetiver grass for soil and moisture conservation. FUNDAE became aware of Vetiver during the visit of Dick Grimshaw to El Salvador in 1993, and later sent a representative to Washing-

ton D.C. to hold further discussions with Mr. Grimshaw. Subsequently, FUNDAE developed a proposal for a five year country effort to introduce the use of contour vegetative barriers (based on Vetiver grass). The priority areas/clientele that they have identified for their efforts are small farmer's maize crops on slopes above 12%. Their role would be primarily to provide technical assistance and planting material to start programs with NGOs cooperatives and government (CENTA) extensionists.

Since 1993, FUNDAE has collaborated in the establishment of about 24 ha of demonstration plots on slopes of 30 to 50%. For the next rainy season a massification program is to be kicked off and they expect to get over 250 ha of steep lands protected with Vetiver. FUNDAE reports that their main problem at this time is servicing requests from the large number of farmers who wish to establish Vetiver hedges They say that Vetiver is so far finding better acceptance among basic grain crop farmers (corn and beans) than among cash crop farmers (e.g. flowers).

Guatemala

Of all the Central American countries, Guatemala has the longest history and tradition of using Vetiver for soil conservation. For at least the last 50 years Vetiver has been associated with many of the large coffee fincas (as in Kenya and Ethiopia) where it is used not only for in-field conservation, but as a source of mulch and for stabilizing road sides.

Beginning in 1990/91, an NGO group in Guatemala (SHARE) began a program to demonstrate and extend the use of Vetiver through their own programs and in collaboration with government extensionists and some 20 other NGO groups. Since then, Vetiver has been tested in most of the countries latitudinal zones to 2,800 meters above sea level; at the higher altitudes its growth is slowed by the lower temperatures.

As a result of SHARE's efforts, Vetiver grass is now becoming well established within the menu of soil conservation technologies promoted in Guatemala in the Altiplano. They report that the technology of contour grass barriers is readily grasped by farmers, and that vetiver's efficiency and low level of competition with crop plants makes it more readily acceptable to them. **Its use, however, is not spreading very quickly due to the limitations in the supply of planting material and resources for training and extension.**

Honduras

See the article in this Newsletter by Mr. David Leonard

Nicaragua

As far as the Network has been able to ascertain, Vetiver has no history of use for soil conservation in Nicaragua though the plant is well known in some parts of the country for medicinal purposes. According to Ing. Julio C. Alonso of the Nicaraguan Institute Agricultural Technology (INTA), a recent Vetiver user himself, Vetiver is found most commonly in the north of the country particularly around Esteli. In 1993, INTA established about a 0.1 ha Vetiver nursery to begin propagating the plant for trial and demonstration work. This year they established their first demonstration plot under a joint INTNFINNIDA project in Masaya.

The project with the most experience with Vetiver is the Agricultural Development Project in the Meseta Carazo. This is a joint Nicaraguan/European Economic Community project. According to Ing. Lenin Tellaz and Ms. Myriam Gaitain Diaz, both from the project, Vetiver was purchased in 1992 from Costa Rica and transplanted directly onto the farms of 10 key farmers in the project area. Now established, Vetiver is harvested from these existing hedgerows and used to protect additional areas on these and other farmers' farms. At present, about 100 farmers have planted Vetiver to establish hedgerows.

The project is working in the establishment of perennial crops (e.g. Pitahaya or Echinocereus spp., a fruit producing cactus) and Vetiver hedges are being planted both in hillside and lowland orchards. The project is only using Vetiver because of its efficiency, relatively low maintenance requirements, and low level of competition with associated crops. The project staff reported that farmers are very receptive to the use of Vetiver and that the initial users were able to generate some income through sales of planting material to other farmers. The project has also translated and adapted the World Bank Vetiver handbook to the specific needs and conditions of the project.

Panama

The Network has almost no information from Panama other than there is some interest among NGOs, the Panama Canal Commission, and some individuals. A few months back the Network received a letter from Mr. Wayne A. Hughes of Panama stating that Vetiver existed in the country and that the roots are used medicinally. Mr. Hughes reported that he had found a source in the country from which he could purchase Vetiver and would be establishing some on his farm in the near future. Mr. Hughes has promised to keep the Network posted on developments in Panama.

The Lupe Project's Experiences With Vetiver Barriers In Honduras David Leonard

David Leonard is the Hillside Farming Technologies Advisor for the USAID-funded LUPE Project (Land Use Productivity & Enhancement) in Honduras and works for Associates in Rural Development

The Honduras LUPE Project (1989-1997) has been actively promoting Vetiver barriers since 1992 and would like to share its experiences and strategies in hopes of stimulating a technical interchange with other projects, particularly in Central America. First, some background on LUPE.

Project Background

LUPE targets limited-resource hillside farm families on slopes of 15-75% in 8 agro-ecological zones ranging from 0-1800 meters and 700-2,500 mm rainfall with a 5-6 month dry season. LUPE's major goals are to increase farm productivity and income while simultaneously conserving and enhancing the resource base (soils, trees, water). The project currently works with 7,000 farm families (eventually 25,000), mostly basic grain producers (maize, sorghum, and beans) in soil management, cattle, small animals, home gardens, nutrition, and home improvement.

LUPE operates 41 rural extension offices ("agencies"), each staffed by 2 university-trained extensionists who provide technical support and training to approximately 12 "contact farmer trainers" (CFT's). Using his/her own farm to demonstrate the major technologies being promoted, each CFT works as a grassroots extensionist with up to 30 farmer neighbors. The CFT's are selected from the local community on the basis of proven leadership and respect, farming skills, ability to read, and desire to serve. They are paid on a part-time basis to compensate for their time away from their own farms. To facilitate the CFT effort, LUPE collaborates with 5 local PVO's, including CARE and Save the Children, who provide administrative supervision to the CFT's.

LUPE's Soil Management Strategy and the Role of Vetiver Barriers

Past failures: For many years, hillside soil management in Honduras tended to neglect productivity, focusing mainly on conservation by means of labor-intensive rock walls, contour ditches, and bench terraces, often promoted through farmer subsidies (food, sometimes tools). Unfortunately, subsidies create an unhealthy dependence and paternalism, and, once they end, maintenance and further construction of conservation works drop off quickly, since soil conservation alone seldom provides sufficient immediate yield boost to maintain farmer interest.

A new approach: During its first 2 years, LUPE analyzed the failures of past hillside extension efforts and developed an effective soil management strategy and technology menu that could "sell" itself without subsidies. This approach stresses both soil conservation and productivity, and its 3 key elements are:

Soil conservation based largely on:

- Ground cover: Mulching with crop residues and cover crops rather than field burning; improved plant spacing and density.
- Low-cost grass barriers instead of conservation structures.

Soil productivity enhancement by improving fertility and physical condition through legume cover cropping, alley cropping with N-fixing trees, not burning fields, and judicious use of phosphorus fertilizer in seriously deficient soils. Additional productivity is often gained through the moisture conservation effect of mulching and grass barriers.

A systematic scheme for technology introduction that generates an early productivity boost to maintain farmer enthusiasm and receptivity, thus "buying time" for slower-acting practices to "kick in". Such immediate success doesn't have to entirely from soil management practices but can include others such as improved crop varieties and pest control, dry-season alternatives for cattle feeding, or construction of an improved cooking stove that uses 50% less firewood.

Where Vetiver fits in: Although mulching and improved plant spacing can reduce erosion by up to 95%, even on steep slopes, Vetiver grass barriers are still considered a vital component of typical LUPE soil management packages for several reasons:

- On steep slopes, the barriers act as a safety measure to prevent possible mulch washout during heavy downpours, while the deep root system helps stabilize slippage-prone soils.
- They allow formation of semi-level terraces over time, given sufficient soil depth.
- Planted along the upper border of rock walls, Vetiver helps prevent collapse and also eliminates the need to add more rocks as soil accumulates.
- The Vetiver prunings are a long-lasting mulch.
- Not a cure-all: Despite its effectiveness in controlling erosion, Vetiver, by itself, isn't a cure-all for soil degradation which is the most serious problem facing hillside farming. Caused mainly by erosion and accelerated by annual field burning and dry-season overgrazing of hillsides, degradation is the loss of fertility, physical condition (vital for erosion resistance and water-holding capacity), and beneficial biological activity. In fact, soil degradation is much more serious than erosion, itself, because it drastically reduces productivity long before declining soil depth becomes a limiting factor. Although Vetiver barriers can reduce degradation's pace substantially, they should be combined with other soil management practices (such as those mentioned above) that actually reverse degradation by boosting fertility and organic matter.

Discovering and Validating Vetiver

In Honduras, barriers of elephant grass and King grass (an elephant grass x pearl millet hybrid) had been used for many years, usually in combination with contour ditches to stabilize their upper banks and prevent sediment fill-up. However, both grasses are invasive,

compete with the associated crop through root competition and shading, are heavy nitrogen users, and require frequent pruning. Except for the few LUPE farmers with enough cattle to benefit from the abundant forage, most were dissatisfied with these grasses. Even those seeking forage would usually be better off growing solid stands of elephant or King.

Seeking alternatives, LUPE became interested in Vetiver in early 1991, thanks to the Vetiver Newsletter and the World Bank's green pocket manual. Vetiver grass was already widely distributed in Honduras, since nearly every rural family maintains a clump in its garden area, using the roots to make Vetiver tea, an effective tranquilizer, sleep inducer, and remedy for headaches and hangovers.

However, Vetiver barriers were uncommon here except in the isolated highland community of San Manuel Colohete. LUPE technicians visited the area and were impressed with the barriers' effectiveness and their rapid diffusion among local farmers. It was also apparent that barriers, by themselves, could replace the need for contour ditches except on soils especially prone to saturation-induced slippage or poor drainage.

During the 1991 drought-plagued rainy season, we ran 3 Vetiver validation trials in different agro-ecological zones and were impressed with vetiver's rapid growth and survival. LUPE now felt it had sufficient validation to begin Vetiver promotion, starting with on-farm demonstration barriers and relying on numerous empirical field observations to guide the technology's fine tuning.

Getting Started

In late 1991, LUPE began irrigated dry-season production of planting material in 2 regional nurseries totaling 1000 m^2, using 4 local Vetiver cultivars and one obtained from the SHARE Project in Guatemala. Field production was chosen over polybags, due to its lower cost and management requirements. In 5 months, the nurseries produced enough slips for 10 km of demo barriers or about 200 meters per extension agency. During the 1992 wet season, farmers were impressed with the barriers' growth and low-labor requirements (60-120 meters of Vetiver barrier can be established per person-day compared to. 5-10 meters of rock wall or contour ditch).

Production and Promotional Guidelines

With vetiver's profound impact and acceptance virtually confirmed, LUPE analyzed its own experiences and those gleaned from the newsletter and developed the following technical and promotional guidelines for 1993 onward:

- Be flexible re. choice of species: Don't discount the use of elephant grass, King grass or other species for farmers desiring better forage production, but encourage them to use Vetiver on the most erosion-prone sections of their fields.

- Minimize reliance on nurseries: On hillsides, Vetiver is an especially "bulky" technology as far as planting material. For slopes of 15-60%, each hectare needs from 600-2400 m of barrier or about 4000-16,000 slips (15 cm spacing). This requires roughly 50-200 m^2 of nursery area per hectare of barriers (based on a 12-fold multiplication factor during the 6-month dry season). For a low-budget project like LUPE, the high cost ($0.60 US/100 slips or $40 US/km of barrier) and management/irrigation demands of nurseries proved infeasible for large-scale slip production. Instead, LUPE used nurseries only to establish a "critical mass" of barriers in the communities. Thereafter, the barriers themselves became the major source of planting material extracted through judicious thinning and farmer-to-farmer transfer, requiring much less dependence on vehicle transport. One meter of new barrier can provide sufficient material for 5-15 additional meters within a year or two.

- Be flexible re. barrier spacing: LUPE's spacing guidelines (Table 1) are based primarily on soil slope and soil depth (the latter to prevent subsoil or bedrock exposure resulting from natural terrace formation). However, these spacings can be relaxed, even on shallow soils, by including complementary conservation practices. For example, natural terrace formation on very shallow soils (< 50 cm) isn't realistic on slopes over 40%, since the close spacings required (1.7-3.5 m) aren't realistic. However, the addition of minimum or zero tillage, crop residue mulching, and improved plant spacing can reduce between-barrier soil movement by up to 95%, allowing LUPE to use a minimum barrier spacing of 4.5 m even on shallow soils with a 60% slope.

- Fertilize barriers where appropriate: One application of 18-46-0 at 15 grams per linear meter followed by 3 applications of urea (46% N) at 10 grams during the 6-month wet season would easily double the barriers' tillering rate and seemed a good way to accelerate slip production. However, most LUPE farmers can't afford such inputs and could be understandably tempted to apply any donated fertilizer to their grain crops rather than to a common grass. Secondly, farmers could easily conclude that Vetiver barriers actually required fertilizer. Therefore, we discarded this option except for those farmers already using chemical fertilizer on their crops.

- Combine barriers with agro-forestry where appropriate: N-fixing trees such as Leucaena spp. and Glircidia sepium can be direct seeded along Vetiver barriers, preferably on the lower side, since farmers prefer reserving the richer, moister upper border for the main crop. The trees can be planted simultaneously with the barriers or anytime afterward, and tree growth appears unaffected by the associa-

tion, even when the barriers expand out into the tree row. Close tree spacing (15-50 cm) and frequent pruning (every 8-12 weeks during the wet season) maximizes green manure and/or forage production, while wider distances (100-200 cm) and infrequent pruning (once every year or two) maximizes firewood, stake, and pole production.

LUPE recommends that tree rows located within actively cropped fields be managed for green manure and/or forage, since the tall growth resulting from lengthy pruning intervals can cause severe shade competition with both the crop and the barriers. Direct seeding is preferred over bag planting due to time and cost savings. Stake planting of Gliricidia produces a shallow, lateral root system with no tap root, causing poor drought tolerance and increased root competition with the associated crop.

Future Plans

In 3 years of promotion, LUPE has established some 80 km of Vetiver barriers and is now poised for a 3-5 fold increase during each of the next 3 years. Our main barrier management problem is lack of adequate pruning to stimulate maximum tillering, possibly because unrestricted Vetiver growth is slow to cause shading problems compared to Elephant and King grass.

In June, 1994, LUPE acquired 100 tillers of Karnataka Vetiver via Malaysia thanks to the tireless efforts of renowned Vetiver researcher, Dr. P.K. Yoon, and a generous price discount offered by the supplier, Metro Imbang Sdn Bhd, a subsidiary company of the Perak State Gov't, Malaysia. Arranging shipment and permits entailed an exchange of 45 faxes between LUPE and Yoon. LUPE is interested in Karnataka's superior dry-season growth and palatability and is currently multiplying the tillers at the Pan American Agricultural School (Zamorano) for field testing and continued propagation next year.

(NOTE: Neither LUPE nor Zamorano will be able to share Karnataka material until mid-1995. For technical networking, Mr. Leonard can be contacted until July, 1995 at Tel./FAX (504)391740 (Honduras) or by mail at Dept. 236, P.O. Box 025320, Miami, FL 33102).

Vetiver In Ethiopia.....

Shimelis Kebede, Diversification Manager, Fincha-a Sugar Project (FSP) Ethiopia.

Introduction

Ethiopia is located at the horn of Africa and extends between 3 to 18° latitude, North and 33 to 48° longitude, East . Although Vetiver is an Asian grass it is found growing at various locations in Africa.

Ethiopia is one of the 24 African countries where Vetiver is currently known to exist. Vetiver was first introduced to Ethiopia by Indian scientists in the early 1970's as a coffee diversification program, when medicinal plants and uses of essential oil were given emphasis.

It was mainly planted at Jimma research station, an institution largely engaged in coffee research. For about a decade it was mostly confined in the institution before being introduced to the then newly establishing large scale coffee plantations in 1982/83.

The state coffee plantations introduced Vetiver with the objective of protecting coffee fields by planting Vetiver barriers against infestation of couch and Bermuda grasses (Digitaria scalarum and Cynodon dactylon).

For many years after its introduction, Vetiver was not widely known as a remedy against erosion. Coffee estates, rather, were using Vetiver as grass weed barrier, mulch grass, roof thatching etc..

It was in the late 1980's that most Vetiver users in Ethiopia diverted its use towards soil conservation. **Especially, the commencement of Vetiver Newsletter circulation contributed greatly in introducing this famous grass including its diverse use.**

On July 6, 1990 a seminar sponsored by Ministry of Agriculture of Ethiopia was conducted on vegetative approaches of soil conservation in Addis Abeba, Ethiopia. It is probably the first forum in Ethiopia where the significance of Vetiver was discussed in detail. Later in April 1992 another workshop was conducted by joint sponsorship of Ministry of Agriculture and Environmental protection and Development (MOAEPD) and the World Bank where the Vice Minister promised support for promotion of Vetiver.

Ecology and Distribution

Jimma Research Station, located in the western regional capital, is the first center of distribution of Vetiver starting from early 1980's. Thereafter most coffee estates re-distributed among each other and to the peasant areas. Some non-governmental organizations, who were aware of the uses of Vetiver purchased and promoted it for the purpose of introducing to the peasant areas. With in two decades after introduction to Ethiopia, Vetiver is known to exist in the following localities and coffee estates:

- Jimma Research Station.
- Coffee estates: Gomma 1 & 2, Kossa, Suntu, Gummer, Bebeka, Teppi and Arbagugu, where about 20,000 ha. of coffee is managed.
- Ilubabor Region at the peasant associations of Hurumu and Gore/ Metu zone.
- Mizan Teferi and Sheko peasant areas.
- Yirgacheffe, Haru, Nole and Kaba (3).
- Finchaa Sugar Project, Wellega Region.
- Tea estates in Keffa and Illubabor region managing about 1000 ha. of tea.
- Coffee Improvement Project nursery sites in the south and western regions.

The above localities where Vetiver is found growing are situated at different agro-climatic zones. Vetiver is currently

found between altitudes ranging from 850 to 2400 meters above sea level, with maximum temperature ranging between 24 to 39˚C. The rainfall of the above areas is also in the range of 1,000 and 2,500 mm per annum.

So far, the major types of soils, where Vetiver is found growing are Nitosols and Luvisols .

Propagation

In most areas where Vetiver is found in Ethiopia, propagation is done by slips or root divisions. Mostly there are no formal nurseries and extension is simply done by taking 20 cm high slips from the already existing line of Vetiver on road sides or coffee block boundaries.

The biggest bunch of Vetiver could yield as many as 100 splits fit for propagation with in less than a year in the most favourable growing areas like Bebeka and Teppi.

Probably the first formal Vetiver nursery in Ethiopia was established at Finchaa Sugar Project site, Wellega Region. This nursery is equipped with over head sprinkler irrigation system. Cultural practices like periodic chopping toencourage tillering, weeding, cultivation and fertilization are carefully conducted.

Primarily the slips are planted 50 cm apart. In due course of time the gaps shall be filled by expanding Vetiver tillers giving rise to bigger crown. The nursery remains permanent even after transplanting by leaving slips 50 cm apart and the cycle can be repeated several times.

Uses of Vetiver in Ethiopia

As already mentioned in the introductory part, vetiver's primary objective was only targeted to diversifying essential oil bearing and medicinal plants. These days, Vetiver is getting very important attention as the cheapest means of erosion control. In Ethiopia in the last 14 years Vetiver has been utilized for various purposes. The following are experiences of Vetiver growers in Ethiopia:

- Vegetative weed barrier: During the earliest years of state coffee plantation development, some noxious perennial grass weeds like Cynodon and Digitaria spp have been a problem. In the high rainfall zones these weeds expand through their stolons and rhizomes by creeping horizontally. Thick Vetiver hedges planted at the edges of coffee fields have proven to be effective vegetative barriers preventing infestations from road sides.

- Mulch Grass: Mulching is one of the most important cultural practice in coffee growing. Coffee growers need hectares of mulch grasses for their mulching practice. There are different types of mulch grasses having appreciable nutritive value, effective suppression of weeds and conservation of moisture. For instance, Napier grass, Guatemala grass etc. are widely used in the coffee fields. Napier grass which is commonly used mulch grass is more of stemmy and creates difficulties after mulching the field by its weedy behavior. These days large scale coffee estates are almost entirely using Vetiver as a mulch. Adugnaw(1994) compared 5 different sources of mulch materials together with Vetiver. These include: Coffee husk; Vetiver grass; Eragrostis curvula (African love grass); Hyparrehenia ruffa, Fresh coffee pulp.

- Coffee husk is found to be more nutritive and provided higher moisture to the soil, but, the material completely decomposed and vanished 6 months after application. Vetiver grass with 5, 10 and 15 cm mulch thickness proved best next to coffee husk. Moreover, its effect persisted longer even after 6 months as opposed to coffee husk. It's long term effect can help coffee growers minimize their cost of weed control and conserves moisture during the dry spell.

- Roof thatching: Most peasants in Ethiopia are living in grass roofed houses. There is a grass conventionally known as 'Bita" used for thatching roofs. In some country sides thatching grass are very scarce. Certainly, Vetiver will gain top popularity and acceptance by peasants in the Ethiopian condition if it is demonstrated as house a construction component. Thereafter its expansion as a remedy to soil erosion could be easier. Vetiver's wide ecological adaptation helps farmers to grow it for the purpose of roofing where ever in the country. Between 75 to 90% of the grass roofed houses are thatched out of Vetiver in most coffee estates where majority of the work force is living in huts. For instance, at Gummer farm, between 1000 to 1500 labor force and family are living in Vetiver thatched houses. Mattress stuffing is also widely exercised by farm workers in the coffee estates.

- Perfumery: Though not given emphasis, there is a report on essential oil extraction by the Ministry of Industry of Ethiopia. Its future expansion may be dependent on the expansion of Vetiver grass itself.

- Soil conservation: The most important objective of Vetiver in Ethiopia these days is tending towards soil conservation. Productivity loss is becoming severe in farms as a result of erosion hazard. People are advised to be aware of environmental deterioration which resulted into drought and famine. In Ethiopia Vetiver grass is receiving greater popularity in the field of soil conservation from late 1980's onwards.

- Though not given attention in the national program, coffee estates (and peasants in the vicinity), as well as some non-governmental organizations (NGO) working with peasants are promoting the uses of Vetiver grass in very promising condition.

Some practical exercises observed:

- Vetiver grass hedges planted at the edges of coffee blocks for boundary and weed barrier purposes are in the later years indicating unexpected, outstanding protection of road sides from runoff. In most coffee farms erosion on road side ditches stopped expansion immediately after they reach the boundaries where Vetiver hedges were planted.

- Lateral and tertiary irrigation ditches with Vetiver lines along their edges resulted in little or no siltation.

- Cost of ridge maintenance is reported to be minimized in coffee estates with ridges planted with Vetiver.

- Between 200-300 ha. of very steep coffee blocks are planted with Vetiver lines according to report by Gummer farm manager. These areas are contour planted with Vetiver with approximately 15 - 20 m contour interval. The slopes range between 12 to 25% and the Vetiver is planted after level bunds are dug out. Though not consistent the Vetiver on the bunds are continuous to avoid collapse of bunds during stormy rains.

- About one fourth of Kossa farm (300 ha.) is contour planted with Vetiver. Some areas were observed with drain ditches below the Vetiver lines. It is probably a modification of the system called level Fanyajuu.

- It is better to avoid digging drains as Vetiver will eventually form a terrace by accumulating silt in front of the line.

- An NGO called Menschen Fur Menschen has obtained outstanding results in a peasant area called Hurumu in Illubabor region. They took the Vetiver planting material from one of the coffee enterprises in 1991. Currently, they have a model area with 23% slope having successfully established Vetiver grass on contours. They integrated it with agro-forestry with trees like Sesbania sesban and Acacia salina planted on slopes. Coffee, Turmeric etc. planting and bee keeping activities are found in a promising condition.

- In the vicinity where Menschen Fur Menschen is doing its best, farmers were also advised to contour plant Vetiver in their arable fields. Approximately 25 - 50 ha. of area was seen planted with Vetiver. Up to 25% slopes were adequately conserved by Vetiver with about 50 -70 cm high terraces formed.

- The Finchaa Sugar Project is situated in a very fragile environment, as a result the project concentrated on Vetiver in the earliest years of its establishment. It has now started implementing massive afforestation programs together with effective use of Vetiver grass. One and half ha of Vetiver nursery was established after purchasing the planting material from the coffee enterprises, 780 km away and Vetiver had the chance to be shifted to north-western part of Ethiopia. The Vetiver nursery is equipped with over head sprinkler irrigation system. The seedlings are fertilized with NPK/15:15:15 at a rate of 200 kg per ha. based on the report on Vetiver Newsletter number 7, Nov 1991(8). The appropriate cultural practices are carefully implemented in the nursery. The objectives of the Vetiver nursery is to supply material for:

- To plant out the edges of 38 km long irrigation canal in length to protect it from frequent siltation.
- Stabilization of gullies.
- Protect road side ditches from runoff.
- Plant thousands of hectares of terrace drains of cane fields with Vetiver.
- Contour planting cane fields on steeper slopes to protect sheet erosion etc.
- The canal side planting has already started and a total of 16.9 km of Vetiver were planted. These are 6.5 and 6.7 km east and west of the canal, respectively. Drains made to obstruct water from coming to the canal were planted with 2.8 km of Vetiver. Some slopey spots on siphon structures were also planted on 852 meters of contours. These are intermittent plantings made also as informal nurseries and gap filling will continue when previously planted Vetiver matures.

Plan in year 1995.

All the activities regarding Vetiver in Ethiopia are very scattered and need to be promoted to a centralized organ. I have designed a plan to organize "National Committee of Vetiver" composed of various professionals, NGO's government organizations etc..

- Its general objectives are:

- To promote Vetiver to a level of national significance so that Ministry of Natural Resources and environmental Protection and Development can give due emphasis for its expansion.

- To create a forum for various Vetiver users in the country so that they can exchange experiences research views etc.

Very shortly an organizing committee shall be formed to register members and eventually conduct a founding conference.

Report On The Potential Weed Problem Of Vetiver Grass And Its Effectiveness In Soil Erosion Control In Fiji.

Paul Truong and Colin Creighton. Queensland Department of Primary Industries.

Background

Vetiver grass (Vetiveria zizanioides) is a grass native to South and South East Asia. It has several attributes such as drought, frost and water logging tolerance, it can be established on soils with extreme levels of pH, Al, Mn, salt and Na and it is very deep rooted. When planted on the contour Vetiver forms a thick hedge acting as a living barrier to spread and slow down surface runoff. Recognizing its potential in soil erosion control, the World Bank has promoted its use as a soil conservation measure worldwide in the last 10 years. Dr. Paul Truong, Principal Soil Conservationist, Natural Resources Management Unit, Division of Land Management, has been working with Vetiver grass for the last 6 years. Field trials have shown that Vetiver is very effective in the stabilization of gullies, embankments, waterways and steep slopes. Vetiver is also very successful in the reclamation of grossly disturbed lands such as quarries and salt affected lands. It acts as an effective filter strip in trapping sand, gravel and silt. Most importantly Vetiver has not set any seed in any of the Queensland plantings over the past 6 years from Cairns to Ipswich.

Although the sterile cultivar of Vetiver grass has been registered (as Monto Vetiver) and approved for release by the Queensland Herbage Plant Liaison Committee since August 1993, the Department has not released Monto Vetiver for public use due to the concern expressed by the Department of Environment and Heritage and the North Region's Regional Assessment Panel on its potential weed problem, particularly in the wet tropical coast of Queensland. Recently an international Land Use Consultant, in a letter to the Minister and the Senate Standing Committee on Landcare, urged the Department to release Monto Vetiver for public use as he has found it is a very effective soil conservation measure and widely used in Africa and Asia.

With the above background a study tour to Fiji was carried out between 4 and 11 June 1994 with the following objectives:

- To observe and assess the potential weed problem of Vetiver grass in the wet tropics, with particular reference to the sugar industry.
- Management practices required to maintain its effectiveness.

Vetiver Grass In Fiji

Vetiver grass was first introduced to Fiji from India probably late in the 1800's to provide thatching material for houses and it is still being used for roofing and walls. Although it was commonly used to stabilize embankments, terraces and to delineate farm boundaries, its application as a soil conservation measure, was not realized until early in the 1950's. An Australian company, Colonial Sugar Refinery (CSR), at that time had complete control of the Fijian sugar industry, from sugar cane growing to milling. As the sugar industry expanded, CSR was faced with a very severe soil erosion problem on sloping lands, particularly on the northern area of the main island around Rakiraki, where the land is very steep and rainfall is often of very high intensity.

Recognizing Vetiver potential in soil erosion control, John Greenfield developed a soil conservation system for CSR, based mainly on the use of Vetiver grass. Greenfield with soil conservation experience in New Zealand and Australia, recommended the planting of Vetiver hedges in contour lines instead of the use of graded banks and waterways. This system was very practical from an implementation perspective (Fijian agricultural systems being labor intensive rather than mechanized) and very effective as a soil conservation measure. Vetiver also conserved water increasing subsurface recharge as runoff water slowly seeped through the hedge instead of being diverted off the field. This greater accession to subsurface and ground water has probably led to productivity improvements and an improved overall water management system with greater stream persistence in the dry.

CSR rigorously enforced this soil conservation technique on all sloping lands until the company left Fiji in the 1960's. Since then this system has not been enforced under the land use policy of the Government, despite steeper lands (up to 96% slope) being used for sugar cane production.

Records show that the first Vetiver contour hedge was established in 1952 in the Penang Mill area, near Rakiraki, and hedges over 40 years old are quite common in the area.

Fiji provides an ideal location to assess the potential weed problem of Vetiver grass, due to the following reasons:

- Fiji has a tropical climate similar to the Queensland wet tropical coast: same latitude as Ingham, high intensity summer rainfall (800-2,000 mm on the west coast and 3,800-4,200 on the east coast).
- Vetiver was introduced into a new environment with no threats from native diseases or pests.
- Vetiver has been in the country for more than 100 years.
- Vetiver has been widely used as a soil erosion control measure for more than 40 years over a wide range of land uses, soil types and habitats.

Vetiver Grass Is Not A Weed in Fiji

Extensive field inspections and interviews were carried out with farmers, extension officers, agricultural advisers, research officers and sugar mill executives on sugar cane growing area (west and north coast) and horticultural crops on the east coast. They all stated that Vetiver is not a weed in their cropping lands or in other natural environments including wetland habitats.

In fact they were all surprised when being asked whether Vetiver had become a weed in Fiji. They all emphasized that

***Photo 4.** A 2 m high terrace in Fiji has been developed by using vetiver grass barrier, This particular hedge has recently been cut for thatch.*
Photo by Paul Tuong

Vetiver remains where planted. Most sites visited are between 25 and 40 years old and Vetiver had only spread around its base through tillering. The seed situation is somewhat akin to sugar cane - while racemes form, no viable seed occurs and no seedlings become established. The only possibility where Vetiver could establish on site where it was not intentionally planted, was when a living clump of Vetiver was dislodged from its original site accidentally, such as with land slips and by road building machinery, as observed in the field. On such occasions Vetiver clumps only moved a short distance down the slope and remained there. Clumps lodged in locations such as creeks did not rapidly expand in size and would appear to be, as with Vetiver on dry land, very slow growing beyond the initial clump size. When it is not wanted, Vetiver can be eliminated by ploughing, repeated burning, or applications of glyphosate (Roundup) herbicide.

Vetiver Hedge System Is A Simple, Practical And Very Effective Soil Erosion Control Method

Vetiver grass is widely used in Fiji from simple road embankment and stream bank stabilization, to contour hedges in sugar cane lands, and, slashed and burnt plots. It is a common sight on all the farms visited that farmers planted Vetiver to stabilize farm roads, across a depression to spread and slow down the runoff water, and most often on contour lines to protect their vegetable crops from rill erosion.

According to local extension advisers, Vetiver grass systems provide a very simple and practical solution to the soil erosion problem on small farms where both educational and technological knowledge is minimal and labor intensive activities dominate.

Due to its very deep and extensive root system, Vetiver is very effective in stabilizing both cut or filled embankments. Vetiver is also highly salt tolerant, and was observed growing on tidal flats next to mangrove and marine couch.

When established on contour lines at regular intervals, Vetiver forms a thick hedge which slows runoff water and traps eroded soil moving down the slope. The hedge also collects and spreads water across the slope resulting in considerable water conservation/recharge.

In all sugar cane growing areas, from the low slope fields around Lautoka to very steep hillsides around Rakiraki, terraces formed by Vetiver hedges up to 2m high are quite common. These terraces were formed by soil erosion upslope and subsequent trapping by Vetiver hedges downslope over a 25-40 year period. The spacings between hedges are relatively close (averaging 30-40m apart). The quantity of soil eroded and then trapped by the Vetiver hedge to form these terraces clearly demonstrates the effectiveness of the Vetiver hedge systems and the huge soil losses that otherwise would have occurred off those steeply sloping lands.

With limited knowledge of soil conservation practice, farmers sometimes took out old established hedges on very steep slope resulting in massive soil erosion within a few years. In general, fields protected by Vetiver hedges often have higher yield than those unprotected by the hedge. The protection of Vetiver hedges was often demonstrated in paddocks where the hedges had been removed. Within a few years sugar cane yield from these unprotected fields was drastically reduced, covered with weeds and the ground surface was littered with stones.

In a simple demonstration trial, sugar cane yield of 48 ton per ha from a field protected by Vetiver hedges was reduced to 31 ton per ha from unprotected fields. This represents a 55% loss in production.

On the average, under the practice used on steep cane lands in the Rakiraki region, good yields can be expected for up to 7 to 8 ratoon crops if the field was protected by Vetiver hedges. The number of ratoon crops from unprotected fields was much reduced due to lower yield. Farm advisers attributed the loss of production to both soil and water losses on unprotected fields.

The recommended hedge spacing for the Rakiraki region varies with land

Photo 5. *A well maintained Vetiver hedge protecting a road in Fiji. This hedge was trimmed and topped each year to stop it spreading into the sugar cane crop. The hedge is 25 years old.*

Photo by Paul Truong

slopes, from 20 - 25 m for 44% slope to 75 - l00 m for 11% slope.

In the high rainfall area on the east coast near Suva (3,800 - 4,200 mm/year), under slashed and burnt practices, hedge spacing of 5 m on a 67% slope has produced very positive results.

Proper Maintenance Programs Are Needed

Although the effectiveness of the Vvetiver hedge systems in Fiji are obvious, farmers are often very reluctant to establish new hedges and occasionally have taken out well established hedges. The main reasons given by farmers are that:

- Vetiver hedges take up too much land;
- terraces formed by the hedges hinder farm machinery operation; and
- the hedges sometimes harbour rats.

Most of the hedges visited were between 25-40 years old. Where no maintenance was practiced, the single row of Vetiver had spread from about 30-40 cm width to 2.5-3 m width, trapping eroded soil and forming terraces up to 2m high. Rat colonies sometimes established under this thick and lush vegetation, particularly where weeds, vines etc. became established within the Vetiver hedgerow.

Photo 6. *Paul tuong in Fiji. Standing by an unmaintained hedge that had formed a 1 m terrace over aperiod of 15 - 20 years.*

Photo by Paul Truong

Local extension officers pointed out that under a proper maintenance program all these problems can be adequately overcome. On farms where the hedges were topped once or twice a year and their widths were trimmed to 0.3 to 0.5m every 3 or 4 years, the hedge system remains small and it does not encourage rat infestation.

On the question of terracing, farmers can rip the trapped soil every 3-4 years and spread uphill. Alternatively soil leveling and Vetiver replanting could be carried out after two plantings (10-14 years). This operation should be done in alternate hedges leaving every second hedge to protect the lands while the new hedges are being established.

Applications Under Queensland Conditions

After more than 40 years of application the effectiveness of the Vetiver hedge system in soil conservation and land stabilization in Fiji was clearly observed during this study tour.

Photo 7. *Draling Downs, Queensland, Australia. Monte Vetiver planted along side a row of barley inorder to study competion for soil moisture.* **Photo by Paul Truong**

Research Results: In Queensland, research conducted over the last five years has established that:

- Monto Vetiver can be established under extremely adverse soil conditions. It can tolerate soil pH between 3.3 and 9.5, soil Al saturation more than 68%, soil exchangeable Mn higher than 578 ppm, soil salinity at EC_e = 17.5 dSm^{-1} (50% yield reduction) and it has survived soil salinity up to EC_e = 47.5 dSm^{-1} and soil sodicity at more than 12 meq%.

- Monto Vetiver has not produced any seeds over the last six years from plantings from Cairns to Ipswich and the Darling Downs. It also has not produced any seeds under wetland conditions near Cloncurry last year.

- Monto Vetiver can be established under a wide range of climatic conditions although it is extremely drought tolerant, it also flourishes under wetland conditions. It can be established in areas with annual rainfall higher than 450 mm. It has survived ground temperature of -10° C and heat wave conditions at more than 45° C in north west Queensland.

- Monto Vetiver needs N and P fertilizer (DAP) at planting and during first year growth. No fertilizer is needed later if adequate soil moisture is available.
- Monto Vetiver is palatable to cattle, sheep, horses and wallabies. These animals graze Vetiver even when Rhodes grass and other native grasses are available. The grazing pressure is extremely severe during the dry period as it is the only green feed around. Monto Vetiver is moderately digestible (52% IVD), with 1.36% nitrogen and 2.5% Potassium.

- Field trials have also demonstrated that Monto Vetiver is highly effective in stabilizing gullies, steep embankments, dam wall stabilization, quarry reclamation and in filtering silt debris in drainage lines.

General Application: From the above results and experience, the following guidelines can be applied:

- *Soil types*: Monto Vetiver can be established on practically any soil type in Queensland from extremely acidic to highly alkaline and sodic soils. Its tolerance to Mn, Al and salt make it highly suitable for the rehabilitation of severely eroded lands especially salt affected lands.

- *Nutritional requirements*: Monto Vetiver requires moderate rates of N and P early in the establishment phase (1 to 2 years, depending on growing conditions). With very active micorhyzal activity in fully grown plants further fertilizer applications are not needed.

- *Climate*: Under Queensland conditions, rainfall is the only limitation to Vetiver establishment and growth. Overseas experience indicates that it can be grown in semi-arid environment with annual rainfall between 300-400 mm. Monto Vetiver has been successfully established in area with approximately 450 mm in the last few years.

  Monto Vetiver is extremely drought tolerant, this is due to its massive and very deep root system which can reach down to 3 - 4 m during its first year. Therefore once established Vetiver can survive extremely dry and harsh conditions.

  Severe frost browns off most of the top growth and provided soil moisture is available lower growth, including young shoots are not badly affected and sometimes continue to grow even under very cold conditions. Overseas work indicates that most growth ceased when soil temperature was lower than 15° C.

- *Palatability*: Monto Vetiver is quite palatable to both domestic and wild animals, so protection during establishment phase is essential to encourage hedge formation during the first two years.

- *Establishment requirement* In north and central Queensland planting can be done any time of the year provided either soil moisture is adequate on supplementary watering is carried out.

In southern Queensland and the Darling Downs, plantings is recommended between November and April. Where planting material can be harvested and planted within 48 hours, direct planting is recommended when the soil is wet or watering is available. Otherwise tubing is needed before planting.

RAINFALL EROSIVITY	SOIL RODABILIT	Vertical Interval Between Hedges (m) CROPPING INTENSITY HIGH	MEDIUM	LOW
Low	Low	4	5	6
	Medium	3	4	5
	High	2	3	4
Medium	Low	3	4	5
	Medium	2	3	4
	High	1	2	3
High	Low	2	3	4
	Medium	1	2	3
	High	0.5	1	2

HIGH CROP INTENSITY
Annual crops with low or any residue cover.

MEDIUM CROP INTENSITY
Annual crops with moderate to high residue cover levels.
Semi-permanent crops with moderate residue cover levels.
Permanent crops with moderate residue cover levels.

LOW CROP INTENSITY
Annual crops with high residue cover levels.
Semi permanent crops with high levels of residue cover.
Permanent crops with high levels of residue cover.

As Vetiver is very intolerant to shading, especially in its first year, weed control, particularly broad leave weeds, may be required. All pre-emergent and 2,4D type herbicide can be used.

Applications in Agricultural Lands: Works to date on agricultural lands have been concentrated on gully reclamation and waterways/drainage line stabilization. Guidelines for these works will be presented in the Land Stabilization section. The table to the left shows guidelines resulting from overseas work on cropping and grazing lands.

Two major projects, one evaluates the effectiveness/suitability of Vetiver hedges on steep cane lands in Queensland and the other on the flood/soil erosion/water conservation on the flood plain of the Darling Downs, are now in their second year. It is too early at this stage to draw any conclusion, preliminary results has demonstrated very favourable results especially in the cane lands where Vetiver hedges were established as a substitute for contour banks on steep slopes (12-18%). On these steeplands conventional soil conservation measures such as contour banks and waterways are not readily accepted by cane growers as these structures often hinder their farm machinery operations. South African works have demonstrated that Vetiver hedge systems of soil conservation on steep cane lands can be effectively incorporated into their cane farming systems. We are confident that a similar system can be developed for the Queensland cane industry not only for north Queensland but also for central and southern Queensland.

Applications in Land Stabilization and Reclamation: The following table sets out guidelines for the application of the Vetiver system in both agricultural and disturbed lands in Queensland:

- *Gully heads stabilization*: One or two rows of Vetiver planted on contour line above gully head. The hedges should be established 3 to 5 m above the head to allow for further erosion during establishment phase. On complex gully system where continuous rows are not practical, overlapping short rows can be planted instead. When the hedges are fully formed, runoff water will be spread out reducing flow velocity and time of concentration.

- *Gully floor*: To stabilize and build up gully Vetiver hedges should be established across the gully at regular intervals. For large and fast flowing gullies, hedges should be established 10-20 m apart. For smaller gullies larger spacings can be used and planting should be concentrated on badly eroded sections.

- *Embankment stabilization*: These guidelines are also applicable to high drainage line, waterways and creek banks. One Vetiver hedge should be established 1.0m from the top edge of the embankment and one hedge on the top of the bank. When slope length exceeds 1.0m, another row should be established in middle of the slope.

- For long and steep embankment, Vetiver hedges should be established as follow:

SLOPE	Vertical Interval (VI)
1:1 to 1.5:1	0.5 -0.8 m
>1.5:1 to 3:1	1.0 m
>3:1 to 5:1	1.4 - 2.0 m

Grassing by hand sown or hydroseeding methods should be used in conjunction with the Vetiver hedge system.

- *Filtering strip*: Vetiver hedge can provide a very effective filtering system to trap debris, coarse sediment (stone, gravel, sand) and also silt on water course and drainage lines. Vetiver row spacing varies with slope gradient, flow volume and sediment load. This filtering system has been very effective in trapping sand and gravel on a drainage line of a working quarry near Brisbane.

- *Other potential applications*: With its tolerance to extreme levels of soil pH, Al, Mn, Na and moderately tolerant to salinity Vetiver hedge system would provide a very effective means of rehabilitation of mine spoils and tailings. Other applications would be in the trapping of manure from runoff water from feedlots, piggeries and dairies.

- Maintenance Strategies: As observed in Fiji, unless a comprehensive maintenance was developed for the Vetiver system for each industry, their effectiveness and acceptance by farmers would be limited.

- Weed control, fertilization and supplementary watering are required during the establishment phase.

- On grazing lands, grazing should be allowed only in well established hedges.

- On cropping land hedges should be trimmed occasionally to keep hedge width to approximately 0.5m. To avoid the terracing effect caused by the accretion of eroded soil, methods used to maintain contour banks can also be used for Vetiver hedges, where excessive build up of silt is moved and spread upslope with a grader every 3-4 years.

Further Research, Development and Extension R&D to date has demonstrated the effectiveness of the Vetiver systems on a wide range of applications under very difficult growing conditions, further investigations into other applications are needed such as its water conservation potential in cropping lands, the reclamation of salt affected lands and revegetation of scalded alluvial flats along the major river systems of western Queensland. But most importantly, the suitability of the Vetiver hedge system for soil erosion control in the sugar industry, not only the wet tropical coast, but also in central and southern Queensland should be investigated. Appropriate hedge management practices need also to be worked out for each industry.

Conclusion And Recommendations

Mr. V. Sern, the Officer in Charge of Land Use and Soil Conservation of the Fijian Department of Primary Industries made the following summary:

"There is no doubt in my mind that Vetiver grass provides a very effective means of soil erosion control on steep lands. It is not a weed, it is very simple and practical for farmers to use, it does not invade the crops but it is a living barrier and it needs proper maintenance to provide the maximum benefit".

We are confident that Monto Vetiver, the sterile cultivar, will not become a weed under all Queensland dry land and wetland conditions. Its effectiveness in soil conservation has been proven both in Queensland and overseas. Its release will benefit Queensland primary industries and catchment management generally.

It is recommended that:

- Work on existing field trials in the Johnstone and Atherton Tablelands be intensified,

- Further demonstration sites established in North Queensland's cropping lands, and
- Activities to develop and promote a Vetiver management system appropriate to various Queensland industries and environments be enhanced.

The followings are summaries of the discussions/interviews with Fijian officials.

Mr. Jai Gawander, Senior Research Agronomist, Sugarcane Research Center, Fijian Sugar Corporation FSR), Lautoka.

- Vetiver grass is not a weed in any sugar cane growing areas of Fiji. Jai has never heard farmers complaining about Vetiver as a weed in contrast to their complaints about guinea grass, sensitive weed and climbing plants as weeds in their crop.

- However farmers are reluctant to plant new hedges as they cannot drive/use equipment across the hedges. This was due to the lack of hedge maintenance and soil spreading. Vetiver hedges need trimming every 4-5 years to check its spread which can be as wide as 2.5-3m after 30-40 years. Hedges form terraces up to 1.5 m high and require soil respreading at intervals as a function of soil accretion behind hedges.

- The only occasion that Jai observed Vetiver becoming established where it was not planted was when it was moved as a clump by landslides on steep slope or dislodged by machinery.

Mr. Jonathan Subarmaniam, Chief Extension Officer, Sugarcane Research Center, FSC, Lautoka.

- He has used Vetiver for 35 years for soil erosion control, gully and steep slope stabilization, road embankments, marking of farm boundaries.
- If not properly maintained Vetiver will form benches after 20-30 years of soil accretion.
- Soil leveling and Vetiver replanting should be carried out after two plantings (10-14 years). This operation should be carried out on alternate hedges, leaving every second established hedges to protect the lands while the new hedges are being established.
- Vetiver is not a weed and only spread by new plantings.
- No die back had been observed in old clumps, up to 35 years after planting.

Mr. Asish Sharma, Field Officer and Mr. Kishne Kumar, Extension Officer, FSC Office, Mota District, Ba Mill area.

- Vetiver is not a weed after more than 25 years application as soil erosion control measure in the region.
- Vetiver only spread from planted single row to 2.5-3m width after 35 years
- Vetiver did not spread by itself to swamps or other habitat
- Vetiver only moved down slope when a big clump was dislodged and washed down slope.
- Vetiver's main uses are for contour planting, stream bank and road cutting stabilization.
- Vetiver hedges need topping every year and trimming every 3-4 years to reduce row width.

Mr. Uday Singh, large land owner, ex Member of Parliament and Community leader.

- He has used Vetiver for soil erosion control for more than 40 years.
- Vetiver presents no weed problem on his farm - only vegetative spread laterally from the original clumps.
- Vetiver is effective in controlling rill and gully erosion and steep bank stabilization.
- Vetiver needs maintenance, and with appropriate maintenance there will be no problem with rats and other pests.

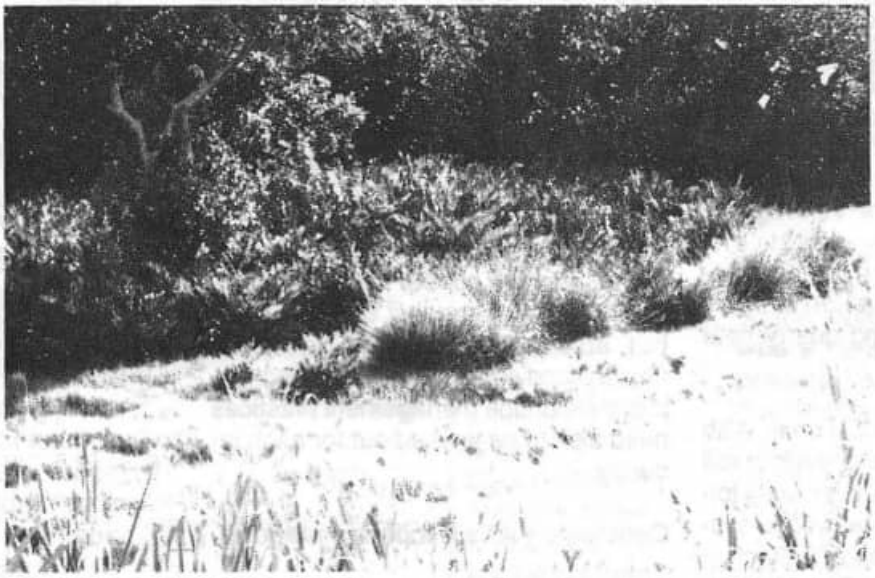

Table 8. Fiji. An old row of vetiver amongst one of the most salt tolerant grasses (Sporobolus virginicus) next to mangrove fern and mangrove itself on a tidal flat along the west Fijian coast. **Photo by Paul Truong**

Uday wants to encourage the local community to plant more Vetiver hedges. Farmer are reluctant due to lack of knowledge of soil conservation, limited extension effort and most particularly, the land ownership system of Fiji which does not encourage land stewardship.

Mr. Vinay Hand, Farm Adviser, Malau Sector, Penang Mill, Rakiraki.

- Sugar cane is grown on very steep land in the Rakiraki region. Most of the crop is grown on slopes between 20-60% and on one site up to 96% (43°) Rainfall intensity is also characteristically high (Table 1), producing massive soil erosion on steep slopes. The Vetiver hedge system was first introduced into this region by CSR with records of first contour hedge planting in 1952. Since the departure of CSR, soil conservation measures have not been enforced and farmers have often removed established Vetiver hedges, resulting in disastrous soil erosion and declined sugar production.
- Farmers are reluctant to establish new hedges. Reasons given are: old hedges harbor rats, and high terraces (formed from soil accumulated by Vetiver hedges) hinder farm machinery operation. Effectively a lack of maintenance of the hedge was the real problem.
- Rats are found only on very old and unmaintained hedges. With good maintenance rats are not a problem.
- Land slips are more common in ar-

eas where no Vetiver was planted.

- Land with Vetiver hedge systems often produce more ratoon crops of high productivity than where Vetiver was not planted.
- Vetiver has not become a weed in the area.
- One year old Vetiver hedges are quite effective. However the hedge system provides maximum effectiveness after 2-3 years.
- On one farm, where the farmer has taken out 3-4 rows of well established, 20 year old contour hedges, on a 45 % slope, massive soil erosion occurred within two years, removing most topsoil and exposing a thick cover of stone and rock. This farmer will replant Vetiver hedges next year.
- On another farm, two paddocks of the same slope and soil type were trialled. One with Vetiver and one without. A very good third ratoon crop was harvested in the paddock where the Vetiver hedge system had been kept. On the paddock where the hedges were removed, weeds predominated and sugar cane production was low.
- In a simple demonstration trial, sugar cane yield was improved by 55% (48 t/ha) as compared with a control plot (no Vetiver) where only 31 t/ha were harvested.
- In general, under the Vetiver system good yield can be expected for up to 7-8 ratoons, while yield from unprotected fields reduces with each ratoon crop.
- Recommended hedgerow spacings for the Rakiraki region are as follows:

SLOPES		SPACINGS BETWEEN ROWS
DEGREE	PERCENT	(m)
20	44	20-25
15	33	30-35
10	22	50-60
5	11	75-100

Mr. Osborne, General Manager, Penang Sugar Mill, Rakiraki.

- CSR had complete control of the sugar industry as landlord and also as mill owner. CSR has promoted strict soil conservation guidelines for sloping land. Either land was taken back or crop was not accepted by the mill if farmers did not comply to soil conservation guidelines.
- Native Land Board via the local tribe is now the landlord. The Board only administers the lease and has not developed a comprehensive land use policy. The mill has only a commercial link with farmers - receiving and milling product.
- Soil conservation ethics has not been enforced since CSR left.
- Although the mill's policy is to encourage more Vetiver planting, it can only be done through persuasion not enforcement.
- The extension method only has had high success rate with new farmers, not old established farmers.
- 75-80% of sugar cane crop in Penang Mill area is grown on slope higher than 11% (5°)
- Vetiver is not a weed in the region, and it is a very simple and effective means of soil erosion control.
- Like sugar cane, Vetiver flowers but it produces no seeds.
- When established on contour lines, Vetiver hedges also provide a good water conservation method.

Mr. Viii Seru, Senior Land Use Officer, OIC Land Use Planning and Soil Conservation, Department of Primary Industries, Koronivia Research Station, Suva.

- Mr. Seru was a Soil Conservation

Photo 9. *Fiji. A five year old, well maintained hedge, with very little teracing effect.* **Photo by Paul Truong**

Adviser with CSR in the 1950's and he has extensive knowledge on the Vetiver hedge system developed by John Greenfield of CSR.

- Since CSR left, the Native Land Board has no policy on land use. Therefore strong soil conservation ethics employed by CSR have been neglected.

- CSR limit on slopes without protective soil conservation measures was 12%, beyond which contour Vetiver hedges were needed.

- Under CSR, no contract for milling of product was provided if Vetiver contour hedges were not planted on steep slopes. This was enforced by very well trained extension officers.

- Vetiver is very effective in soil and water conservation.

- Vetiver grass has not become a weed even in the high rainfall region of the east coast (3,800-4,200 mm per annum).

- Vetiver has not spread to swampy lands.

- To obtain its maximum effectiveness the Vetiver hedge system needs to be maintained properly. Only simple topping and trimming are needed.

- When slashed, the clippings provides very good mulch for horticultural crops.

- Vili is now investigating the application of the hedge system under slashed and burnt conditions on slopes averaging 67 % (30˚).

- When planted in rows, 5m apart, first year results showed significant reduction in soil loss.

- With effective soil erosion control Mr. Seru expected farmers can significantly prolong their slashed and burnt cycle, leading to higher productivity, reduced disturbance to natural systems and reduced soil erosion and subsequent impacts.

- Mr. Seru summarized the use of Vetiver grass in Fiji as follows:

  "There is no doubt in my mind that Vetiver grass provides a very effective means of soil erosion control on steep lands. It is not a weed, it is very simple and practical for farmers to use, it does not invade the crops but it is a living barrier and it needs proper maintenance to provide the maximum benefit".

We are confident that the sterile Vetiver cultivar Monto, will very unlikely be a weed under all Queensland dryland and wetland conditions. Its effectiveness in soil conservation has been proven both in Queensland and overseas hence its release will only benefit Queensland primary industries and catchment management generally. it is recommended that:

- work on existing field trials in the Johnstone and Atherton Tablelands be intensified,

- further demonstration sites established in North Queensland's cropping lands; and

- activities to develop and promote a Vetiver management system appropriate to various Queensland industries and environments be enhanced.

Uses of Vetiver Grass in the Land Rehabilitation and Maintenance of Military Installations

The US Army Corps of Engineers Construction Engineering Research Laboratory in Champaign, Illinois has been investigating the possible uses of Vetiver in Army land management programs. Erosion and sediment control, along with road stabilization and stream crossing protection are some of the areas in which Vetiver is being used for land maintenance and erosion prevention. Various testing plots have been established on several installations in order to observe growth patterns and characteristics, rates of propagation, cold hardiness, slope and gully stabilization, building of bioterraces, and overall success. Plots and experimental designs have been implemented at the following military installations: Ft. Stewart, Georgia; Ft. Bragg, North Carolina; Ft. Campbell, Kentucky; Camp McCain and Camp Shelby, Mississippi; Ft. Polk, Louisiana; and USACERL Champaign, Illinois.

Over the course of the past five years, Vetiver has been incorporated into an array of various experimental designs measuring the effectiveness of Vetiver as a biotechnological tool in the stabilization of soil. In a number of different soil structures and textures, Vetiver has proven to be a useful strategy for land reclamation. At Ft. Campbell, Vetiver has been employed in the reclamation of abandoned strip mines and borrow pits. Stream bank stabilization has also been an issue of concern in land maintenance. Vetiver was used as a stream bank stabilizer to prevent further sedimentation of a lake which had previously been a pollution control problem at Camp Shelby. Strips of Vetiver have been planted in key locations to intercept runoff from impact training areas on several military installations, including Ft. Campbell and Camp Shelby. Gully and slope stabilization have been initiated at several sites at Ft. Bragg by using Vetiver to create a living bioterrace to trap sediment and halt further advancement of the gullies by the accumulation of sediment which, given time, will form stable terrace walls. Currently twenty bunches have been planted onsite at USACERL to determine cold hardiness. A variety of mulching techniques are being tested to determine if over wintering is possible in the temperate zone **5b.**

Researching and developing biotechnology for use by both military and civilian land managers is of primary importance

Photo 10. USA. North Carolina. Vetiver being tested for Sediment control at Ft. Bragg. Photo by US Army.

to the environment. The use of environmentally compatible technology that is affordable, effective and easily implemented is a main thrust area of the Corps mission and one that will be with us for some time to come. Vetiver displays characteristics which are well suited for this purpose. The addition of Vetiver to land reclamation and rehabilitation programs has proven to be very effective.

Preliminary results are in the process of being published. For further information, please contact one of the following: **Dr. Muhammad Sharif USACERL, P.O. Box 9005 Champaign, IL 61826-9005. Phone 1- 800 - 872-2375 ext.5519, Heidi R. Howard ext. 5475 or Gwyn L. Howard ext. 5467 or Suzie Delay ext 5205.**

Research Report

Biotreatment of Produced Waters. Progress Report. .. Ray R. Hinchman, R. Gerald McNally, and M. Christina Negri.

Abstract. Produced water is waste water that is brought to the surface along with the gas from natural gas wells. Its constituents, although acquired naturally, are considered to be contaminants. This project is investigating several biological approaches to the treatment and cleanup of produced water. These include volume reduction and contaminant remediation as potential low-cost treatment options. Argonne is designing, testing and evaluating components of an engineered ecosystem, called a contained bioreactor system, that incorporates hydroponic techniques and uses natural saline wetland ecosystems as a model. The plant bioreactor system maximizes plant evapotranspiration to reduce waste water volume, and concurrently, functions as a "biological filter" to enhance contaminant degradation and immobilization in the root/rhizosphere zone. To accomplish these cleanup functions the bioreactor system incorporates new, innovative hydroponic concepts, such as the nutrient film technique, aero-hydroponics, substrate manipulation, and mixed plant cultures. An extensive database of candidate halophyte species having attributes appropriate for use in plant bioreactors (salt tolerance and high transpiration rates) was developed based on a comprehensive literature survey. Ongoing greenhouse-based experiments are evaluating promising component processes and plant species. Detailed experimental data on transpiration rates, salt tolerance, nutrient requirements, and maximum salt concentration at which effective transpiration occurs has been generated for 6 candidate species and additional experiments are underway. For all species tested, the mean evapotranspiration rates were consistently above the open water evaporation rates at least up to a concentration of 2% salt in the nutrient solution. For several species this higher mean plant rate was maintained to salinities above 6%.

This data indicates for produced water cleanup in bioreactors, the "ideal" plant will be a large, vigorous, salt tolerant species that has a large aerial surface area of photosynthetic (transpiring) tissue and a dense fibrous root system that can develop an active rhizosphere to function as a biological filter. An experimental batch processing bioreactor is being assembled that will simulate planned pilot and field installations.

(Editor's comment. Clearly Vetiver fits the description of the idea plant perfectly)

Vetiver grass, its potential in the stabilization and rehabilitation of degraded saline land.

P.N.V. TRUONG. *Natural Resource Management Unit. Department of Primary Industries, Indooroopilly, Queensland, Australia*

Abstract. Vetiver grass *(Vetiveria zizanioides)* is a perennial grass well adapted to humid and arid, tropical and temperate climates. When planted as contour hedges the Vetiver system can stop sheet erosion and improve soil moisture. It can be equally effective in stabilizing steep slopes, eroded gullies and waterways. High soil salinity is having a major impact on Australian agriculture, at least 1.3 million hectares of

agricultural land are affected by high soil salinity. Vetiver grass was found to be moderately salt tolerant and it has a saline threshold value of 8 mS cm^{-1} which is comparable to some of the most salt tolerant crop and pasture species grown in Australia. Soil EC_{se} at 17.5 mS cm^{-1} reduces growth by 50%. The degree of tolerance was even higher in mature plants. Vetiver plants could survive soil salinity level at 47.88 mS cm^{-1} and established on a highly alkaline (pH 9.65) and sodic coal mine spoil. The findings of this work potentially opens up tens of thousands of hectares of degrading saline land worldwide within the climatic limits of 30° latitude and average annual rainfall of 500 mm.

Hedgerows And Mulch As Soil Conservation Measures Evaluated Under Field Simulated Rainfall.

Oscar S Rodriguez P. Professor. School Of Agronomy. Central University Of Venezuela. International Workshop Soil Erosion Processes On Steep Lands Merida - Venezuela May 16-20, 1993

Abstract. Four experiments were conducted under field simulated rainfall conditions at 1,800 a.s.l. in the mountain coastal range of Venezuela, with 5 m length and 0.5 m width plots and an average rainfall intensity of 55.6 mm/h using a double nozzle rainfall simulator, on an Aquic Paleudult soil with different humidity contents and two 15% and 26% slopes respectively. In order to evaluate the efficiency of five different hedgerow conditions: 50 cm wide Vetiveria zizanioides (Vetiver), Agapanthus africanus (Lily), Nehrolepis sp.(Fern), Andropogon citratum (Lemmon grass) and no hedgerow, and five levels of pine needles: 0 Mg/ha, 0.5 Mg/ha, 1.5 Mg/ha, 3 Mg/ha and 5 Mg/ha used as a mulch. Overland flow was simulated in order to obtain equivalent slope lengths using a 0 l/min, a 2 l/min, a 6 l/min and a 14 l/min flow, representing a 2 l/min flow equal to an 80% rainstorm runoff similar to that obtained under humid and saturated conditions on a 5 m length bare plot. Hedgerows and mulch are good conservation measures, especially when they are combined. The residue requirements are less when the slope is protected by hedgerows, and larger intervals between hedgerows are possible provided there is mulch on the surface of the soil between hedgerows. Soil losses in wet conditions were reduced to less than 1 Mg/ha by combining any residue cover and a Vetiver hedgerow against almost 8 Mg/ha on the bare 5 m length plot. Equivalent slope lengths increased soil losses up to 25 Mg/ha on a 40 m equivalent length bare plot. For the same slope equivalent length condition there was a soil loss of only between 1 - 2 Mg/ha with the highest residue level applied and a loss less than 1 Mg/ha when the residues and the hedgerows were combined. Vetiver grass and Nephrolepis (Fern) were the most efficient hedgerows because of their high density vegetative structure. Under dry soil and humid soil, slope effect was considerable, but under saturated soil the slope effect was not evident. Runoff was also diminished by the residue cover and hedgerows but efficiency was poor under saturated conditions. Simulated rainfall allowed to reduce time and costs of experiments as compared with natural rain. A table is presented as a semi-quantitative model to design spacing between hedgerows taking into account rainfall erosivity, soil erodibility, crop-management intensity and a minimum distance between hedgerows of 10 m.

Conclusions

The use of hedgerows represent an erosion control alternative. A soil loss ratio (P) between 0.11 and 0.55 was found being Vetiver grass (Vetiveria zizanioides) and the Fern (Nehrolepis s.) the more efficient. Runoff control was remarkable for dry and humid soil but in a lower proportion for saturated soil.

The highest hedgerow efficiency was associated with a high density vegetative structure like the ones shown by Vetiver and Fern. Behavior of the Lemmon grass and Lily might be improved by increasing hedgerow widths and time of establishment, but not discarding their use as hedgerows.

Soil losses increased in respect to slope gradients but they didn't adjust to the USLE's LS factor. The results were contradictory, especially under saturated soil conditions

The slope gradient effect interacting with the following factors: equivalent slope length, hedgerow efficiency, residue cover, and hedgerow was of low significance in the results obtained in this paper.

When the equivalent slope length increases, the hedgerow efficiency and residue cover efficiency also decreases, but high levels of residue cover alone or combined with hedgerows keep soil losses at satisfactory low levels.

Residue cover reduces soil losses and runoff. The observed data shows an exponential curve with a negative slope similar to others reported by many authors.

Hedgerows must be used in those situations in which the residues cannot be applied or when the terrain lacking in residue cover during high erosivity rainfall risk periods.

A semi-quantitative model is proposed to design spacing between hedgerows taking into account rainfall erosivity, soil erodibility, crop-management intensity and a minimum distance between hedgerows of 10 m. This model should be tested against other local conditions.

Research and Development on the Application of Vetiver for Soil conservation in Indonesia.

...Soleh Sukmana, Soil Conservation Researcher, Center for Soil and Agroclimate Research
Bogor, Indonesia.

In Indonesia Vetiver (Vetiveria zizanioides) has been known for decades and usually cultivated for oil pro

duction extracted from its root. In Indonesian language Vetiver is called "Akar wangi" (akar = root, wangi = fragrant).

Table 1. Effect of Vetiver hedgerows, on soil loss and runoff.

Site Ref.	Soil	Slope %	Year	Rain fall mm	Soil loss (t/h)	Run off(*) (mm)	Biomass (**) (t/h)
Citayam (Dariah et al,.1991)	Oxisols	13-15	1969/90	1680	24(v) 92(c)	102(v) 219(c)	nd
(Erfandi et al. 1994)	Ultisols	8-25	1991/92	1551	1(v) 6(c)	8(v) 15(c)	5.3(2)
			1992/93	3200	7(v) 17(c)	313(v) 576(c)	6.1(2)
(Tha'ohu et al. 1994)	Ultisols	5-35	1992/93	3438	9(v) 60(c)	120(v) 1341(c)	4.8(2)
Ungaran (UACP-FSR 1991)	Inceptisols	15	1990/91	2760	13(v) 106(c)	488(v) 628(c)	17.8(4)
Ungaran (UACP-FSR 1992)			1991/92	1649	1(v) 134(c)	71(v) 418(c)	15.0(3)
(Pusilt-Tanak 1994)	Coal mining dump	6-9	1993/94	1027	42(v) 230(c)	nd	6.4(4)

(*) v = Vetiver hedgerow plot, vertical internal 1-1.25 m,
except on coal mining dump the vertical interval is 0.2 m.
c = control plot (without hedgerow).
Between hedgerows (alleys) are planted to field crops, such as upland rice, maize, groundnut.
(**) Vetiver leaves production obtained from hedges.

(2) = number of cuttings is 2 times.

nd : data not available

The largest Vetiver production area, approximately 250 hectares, is found in Garut District (West Java). It was not known that Vetiver is useful soil conservation purpose until the World Bank introduced it to Indonesia scientists and practitioners in 1988 through seminars and other occasions. The Center for Soil and Agroclimate Research under the Agency for Agricultural Research and Development of Indonesia, has since been conducting research on the application of Vetiver for soil conservation purpose. Both on-station and on-farm trials have been conducted in some places. Some research results are highlighted in tables 1 and 2.I

- Vetiver hedgerow was found effective in controlling soil erosion. Soil losses and runoff occurred on plots treated with Vetiver hedgerows varied respectively from 1% to 41% (mean : 18%) and 9% to 77% (mean 43%) respectively as compared to control plots (without hedgerow.), see Table 1.

- Biomass (leaves) production of Vetiver Vetiver obtained from hedgerow. (2 - 4 cuttings) varied from 5 to 16 t/h, is a potential source of organic matter to improve soil physical condition and fertility. Nutrients content of Vetiver leaves is presented in Table 2 below.

Element	1*)	2*)	3*)	Mean
N	0.88	0.9	1.27	1
P	0.13	0.08	0.14	0.1
K	1.31	1.29	0.92	1.2
Ca	0.13	0.62	0.19	0.3
Mg	0.15	0.48	0.27	0.30

*Ref.: 1. Sudharto et al. (1994).
2. Unpublished data: sample from Garut.
3. Nur Hidayat (1994)

- Vetiver is being tested to reclaim coal minig dumps. The result so

far indicated that within 9 months (4 cuttings)Vetiver yielded about 6 tons of biomassper ha from hedgerows with 2 meter surface runs (vertical interval 0.2 meter).

- The development of Vetiver application for soil conservation purpose is still constrained with socioeconomic problem of the farmers. In general the farmers were reluctant to practice this technology because they did not obtain immediate benefit from planting of Vetiver. Attempts to make the farmers aware of the importance of soil conservation is being made. However, it takes time to get them on the way in achieving sustainability of land resource.

Use Of Vetiver In Sunflower Dominated Cropping System.

Shri. A.P. Wankhede, T.G.Chimanshette, Shri A.P.Kadam, Divisional Joint Director of Agriculture (Extension) Latur. Maharashtra State, India. 413 531

Latur region of Maharashtra State comprises of four districts. Out of these sunflower dominates in Latur and 0smanabad Districts of the State. The cropping system is dominated by sunflower, 26,600 ha in Latur and 94,600 ha in Osmanabad was grown in 1993-94 season.

The sowing of sunflower starts sometime in last week of July and continues up to the end of August. However, the major sowing period of sunflower is in the second fortnight of August. Thus the area under sunflower remains fallow during half of the wet season. In this region l58 mm of normal rainfall is recorded during June, 2193 mm in July and 208 mm in August. Thus more than 50% of the rainfall is recorded during the months of July and August. During this most important period as far as erosion is concerned, the fields in which sunflower is to be grown is in fallow. At this time there are major run-off and soil losses

To reduce these losses, Vetiver grass was planted in Latur district during 1992-93 and 1993-94. About 350 Vetiver contour "key lines" were planted in the watershed area in Latur District. Also vegetative hedges of Vetiver were planted on 670 ha area as for conservation purposes. Although Vetiver grass has not been established over large areas, where it has been established it has performed excellently. The Vetiver hedges on this fallow land could minimize both run-off and soil loss both. The minimization of soil loss can be visualized by the soil deposits near the Vetiver hedges. The soil deposits near the Vetiver hedges on the sunflower grown land was more than the soil deposits in the other groups.

On the basis of two years observations, it seems that the use of Vetiver hedges will be best possible solution for arresting erosion in the land in which sunflower is grown late in the wet season.

(Editor's note. The soils in the area described are black vertisols, and crops grow and mature on the residual moisture that remains after the rains. The soils become extremely water logged where conventional engineered conservation bunds are used. Vetiver hedges slow down run-off and prevents water logging. There are millions of hectares of vertisols in India and elsewhere in the world where this type of application has great potential.)

Vetiver Grass As A Preventative maintenance Measure For Irrigation Systems. ...Asia Technical Department World Bank December, 1992.

Geoffrey Spencer, ASTEN, The World Bank.

Introduction

Maintenance activities on irrigation supply and drainage systems, flood control levee banks and river waterways are dominated by the maintenance requirements of earthworks. If preventative measures can be developed to control the erosion of both man made and natural earthworks, significant savings can be achieved in maintenance effort.

Vetiver grass hedges offer a cheap, highly effective method of erosion control on and around water supply structures. The application of Vetiver must be encouraged at both the construction/ reconstruction phase of projects as well as becoming an integral part of recurrent maintenance programs.

Designers must look to incorporating these measures into design and the provision of this preventative measure is seen as being as important as the provision of access tracks, cross drainage, and lining where appropriate.

The innovative use of Vetiver should be encouraged be it at the design, construction or on going maintenance phase of a project. The following sketches have been developed from the handbook 'VETIVER GRASS - The Hedge against Erosion', Third Edition The World Bank 1990. (published in English, Spanish, and Portuguese) This publication provides an easy care guide to the use of Vetiver and provides information on the practical use and management tips for Vetiver grass. The booklet and other information is available from the World Bank Publisher's Office, or the Vetiver Network.

Application

Vetiver has particular application in the following areas:

- on high cut slopes of supply and drainage channel banks;
- on the inside and outside of remodeled channel banks and spoil banks where rilling is a problem either with erosion into the waterway or onto private property adjacent to works;
- on the inside of channels at actively eroding points such as the outside of bends.

Care should be taken not to cover the toe of an embankment where seepage is prevalent. The Vetiver hedge will con-

ceal any evidence of leakage and make detection difficult.

Important Biological Considerations In Use Of Vetiver Grass Hedgerows (VGHR) For Slope Protection And Stabilization. By Dr. P. K. Yoon, Kuala Lumpur, Malaysia

Introduction

There are growing interests in using Vetiver grass hedgerow (VGHR) for prevention of soil erosion and to effect stabilization of slopes. Some early attempts to use VGHR, both in Malaysia and in other countries, have met with failures, giving VGHR a bad name. However, most failures can be traced to poor understanding of VGHR concept and the need to pay attention to consistent and good quality practices. Therefore, this paper concentrates on the production of quality planting materials, establishment and maintenance of quality VGHR.

Where ever VGHR is to be used to complement civil engineering, it must be treated as any other engineering component with stringent specifications that are consistent and monitorable, verifiable and enforceable by the superintendent-engineer/consultant in charge of the work.

Production Of Quality Planting Materials

To produce quality hedgerows, quality planting materials must be used which must always begin with mature and active tillers from non-flowering nurseries. Aged tillers with culm formation are slow growing; too young tillers give low establishment success. In addition, the following points must be noted:

Root Regeneration The old cut-roots in slips do not regenerate; they form few and insignificant secondary roots and are only useful for anchorage. New roots are only formed from new tillers or from nodes of old culms. Any planting using slips with cut-roots would be very slow to establish and grow. Only container plants with regenerated roots should be used in engineering projects.

Effect of Age of Polybag Plants on Subsequent Growth Earlier work has shown that plants at 4 months have good root systems for transplanting and take off immediately to produce good hedgerows quickly. A trial, investigated plants raised 11, 16, 23 and 51 weeks in the polybags before transplanting into the ground. Weekly examinations showed very good regeneration and early growth of root systems of 23 weeks and also 16-week old plants. Those polybag plants raised for 11 weeks also show early growth but were less vigorous, growth of 51 - week old material was very poor. Previous experience has also shown that older (70 weeks) polybag plants performed worse. These older plants are too bag-bound. The optimum duration seems to be around 16 to 23 weeks.

Effect of Tiller Numbers at Planting on Growth A trial compared the use of slips with 1, 3 or 5 tillers for planting into polybags to determine the shortest time required to produce quality planting materials.

Plants produced from slips with 5 tillers have lower number of new tillers compared with those started with 3 tillers or I tiller because the 5 tillers in a slip involved more matured culms which were slower at producing new growth. These also produced less dry matter.

Plants starting with 3 tillers have more root mass after 5 weeks than those of 1 tiller after 10 or 12 weeks but the 3.2 new tillers of these container plants will fail the proposed specifications of 5 new tillers.

Polybag plants starting with 1 tiller, produced new tillers fastest, and meet specifications of 5 new tillers produced in-situ at 8 weeks. This confirms my earlier work that we should only use good, young, active tillers for fast early growth.

Effect of Unorthodox Rooting-media on Vetiver Growth The use ofpolybags with good soil produces quality planting materials. However, unless the polybag plants can be raised at site, transporting of these planting materials tend to be very expensive. Other lighter potting materials were tested, including saw dust, padi husk, empty old palm bunches, etc. with generally disappointing results. So far, foam is the most promising unorthodox root-media.

The foam system ensures easier and cheaper transporting and distribution in the field besides producing rapid establishment and better subsequent growth. All these were confirmed in the large scale planting of four slopes on the East-West Highway, a project of the Public Works Department, Malaysia. The planting materials were transported from central nursery to field sites over a distance of 400 km; the transport cost was reduced by 75 % compared to that of polybag plants with soil medium.

Effect of Different Accessions and Bag Sizes on Growth

A trial studied the different growth rates of six accessions from Taiping, Parit Buntar, India, Sabak Bernam, Sabah and Raub in four bag sizes (3 x 5", 4 x 6", 5 x 7", 6 x 9").

At 15 weeks, harvesting was carried out with 10 plants per treatment. There was a decrease in the number of tillers and top dry weight production from the largest bag to the smallest bag but there was no interaction between bag sizes and cultivars. **The Indian "Karnataka" accession was the best performer**. It produced 17% more tillers than the "Taiping" accession and was also 39% better in top dry weight, 13% higher in root dry weight and 33% better in overall dry matter production.

The Parit Buntar accession did not differ significantly from Taiping accession in total biomass production; while it was better in top dry weight, its root biomass was less. Another interesting feature was the lower number of tillers pro-

duced, though the tillers were broader. Accessions from Sabah and Sabak Bernam also did not differ from the Taiping accession in growth rates, but Raub accession was distinctly inferior.

At 40 weeks after planting, all 40 bags per treatment were topped. The Karnataka" (>57%) and "Parit Buntar" (>9%) accession were better than the "Taiping" accession. The other three accessions were poorer than the Taiping accession.

This is a preliminary trial, but there were clear indications that different accessions have different growth rates and points to the need to do more variety testing.

Establishment And Management of Quality Vetiver Hedgerows

Effect of Bag Sizes on Establishment of Quality Vetiver Hedgerows The total cost of establishing hedgerows using polybag plants will be affected by cost of bags, filling the bags, digging the trench and planting the polybag plants. A trial was therefore started to assess the minimum bag size, without compromising the quality and speed of hedgerow formation. Five bag sizes (4" x 7", 4" x 6", 6" x 9", 5" x 7", 6" x 13") holding different weights (498, 401, 1486, 837, 2492 gm respectively) of soil were used. The planting distance was kept at a constant 15 cm between clumps with uniform and adequate fertilizer application.

Timing Studies. Timing studies show that only the larger sized bags of 6 x 13" take significantly longer time to be planted and for the deeper trench to be dug. The other plants in the smaller sized bags have similar time requirements.

Inter-clump Gaps. As expected, the larger bag-sized plants had lower inter-clump gap sizes than the smaller ones. The 4" x 6" bag-sized clumps started with gaps larger than the 3 bigger bags, but from the third month, the different gap sizes were generally not polybag size-dependent. It was rather surprising that the 4" x 7" bag-sized plants produced consistently higher inter-clump gaps than those plants raised in 4" x 6" bag size (although the difference was not significant) and was significantly worse than 5" x 7", 6" x 9" and 6" x 13" for the first eight months.

Growth Rates. The tops above 40 cm were cut and the dry weights determined. For the first 10 months this was done monthly, thereafter, it was carried out at 2-monthly interval till the trial stopped at 16 months. Other than the first month's measurements, the top dry weights from all bag sizes were not significantly different.

Discussion and Conclusion

In using quality polybag plants and with proper care, the transplanting success was 100%. The results showed that plant growth in the smallest bag size treatment of 4" x 6" produced similar inter-clump gap size from the third month and similar dry matter production from the second month after planting. Thus, this small bag size of 4" x 6" (with the lowest weight) could be the most economical size for transport, and for fast and good establishment of Vetiver hedgerows.

Effect of Spacing Cum Fertilizer on Growth of Vetiver Hedgerows.

A trial was set up to test these, using three spacing distances (15, 30, 60 cm) and 2 rates of fertilizer applications. Good quality 3-month-old polybag plants, selected for uniformity, were used for all treatments. In the fertilizer treatments, slow release fertilizers (Kokei, N_5P_5KMg and Field King, $N_{14}PK_6Mg$) were used with F_2 having 2x amount of F_1

Inter-clump Gaps. Because of manpower shortage, inter-clump gap measurements were only started when the trial was 10 months old and only involved the wider spacings of 30 cm and 60 cm plantings. It was not possible to measure the 15 cm planting as the gaps would be too small for accurate measurement. From 10 to 25 months, the effect of higher fertilizer rates on gap size was marginal and was generally not significant. Spacing had highly significant ($P<0.001$) effect with the 60 cm planting having consistently higher gaps than the 30 cm planting. The 2 rates of fertilizer application had no effect on gap reduction. However, spacing effect was highly significant in the earlier periods of 10-12, 12-13 and 13-15 months with the 60 cm plantings closing at a much faster rate than the 30 cm plantings. Thereafter, spacing had no effect. From 19 months onwards, certain die-back was noted in the center of the clumps, mainly in the replications which became more shaded as the neighboring Hevea trees canopy developed. This got progressively worse and the trial was terminated at 25 months.

Top Dry Matter Production Per Clump. Generally the fertilizer effect was marginal and significant only up to the 7th month. Spacing did not have any effect in the first 2 months. Thereafter the lower spacing treatment produced consistently higher dry matter than those planted closer.

Top Dry Matter Production per 10 m Run. The higher fertilizer application produced more dry matter for the first 7 months only. The closest planting distance of 15 cm had the highest dry weight to 7 months. The 30 cm planted hedgerow caught up with the 15 cm from the 8th to 19th month. The 60 cm planting produced significantly lower dry matter over the entire period suggesting a much poorer hedgerow.

Layering. Attempts were carried out to fill the large gaps with new plants by layering the older culms from adjoining clumps along the hedgerow. The success was poor at 10.3%, compared with 85.9% success with layering the culms perpendicularly away from the hedgerow probably due to self-shading.

Discussion and Conclusion

Additional fertilizer seemed to increase the dry matter production in the early months, but the higher level applied had no effect later. Spacing played a big role

in dry matter production; the wider spacing produced significantly higher dry matter per clump. The reverse was noted in dry matter production per linear distance, reflecting the interaction of individual plant growth and the planting density; 30 cm spacing caught up with the 15 cm spacing after 8 months but 60 cm spacing stayed consistently lower. All these results strongly indicate that close planting of 15 cm is preferred for quick establishment of a functional hedgerow. Use of layering of culms to fill the gaps between wider spacing is of little value.

Use of Selective Herbicides to Maintain Quality Vetiver Hedgerows

Weed management is an important aspect in the maintenance of quality Vetiver hedgerows. In Malaysia, the more damaging weeds are broadleaves such as Asystasia intrusa, Chromolaena odorata (Siam weed), Mikania micrantha and legumious creepers normally grown as covers in agricultural plantations. These are the most noxious weeds because they swarm over, strangle and shade out the Vetiver hedgerows. The grasses are less important.

An evaluation of selective herbicides in the control of A. intrusa was conducted (This trial was planned and scored by Dr. Chee Yan Kuan of RRIM). The herbicides tested were Starane$_{200}$ 0.1 and 0.3 l/ha and 2,4-D amine 0.5 and 1.5 l/ha. The volume of spray was 450 l/ha.

Assessment at 7, 14 and 45 days after spraying showed that for control of A. intrusa, the recommended herbicide spraying are 2,4-D amine at rates of 0.5 and 1.5 l/ha ,or Starane at 0.3 l/ha.

Based on other ad hoc experiments in the establishment of Vetiver hedgerows, the various herbicides and rates recommended to control other weeds are as follows:

Chromolaena odorata (Siam Weed)

Ally 20 DF	150	g
2,4-D amine	1.5	l
Starane$_{200}$	1.25	l

Mikania micrantha

2,4-D amine	1.0	l
Starane$_{200}$	0.5	l

Pueraria phaseoloides (legume)

Ally 20 DF	100	g
Starane$_{200}$	0.375	l

Layering To Effect Full Coverage of Slopes

Vetiver grass was planted as rows with between-row vertical intervals of 1 m or 2 m. Under special circumstances, it may be desirable to have complete cover of slope with Vetiver grass so that its long roots will be over the whole area binding the soil. Buds in the nodes of old culms pegged onto the ground using an 'n'-shaped steel wire can be induced to produce new plants. Good results of new plant production were obtained in the open with 42.5% of the culms producing 1-2 plants each, 33.3% producing 3-5 plants each and 8.0% producing 6-8 plants. Only 14.1 % of the culms failed to produce any plants. Beneath the canopy shade of the Hevea (rubber) plants, the production of plants was poorer with also less plants per clump; 19.2% did not produce any plant, 58.3% producing 1-2 plants, 19.2% producing 3-5 plants and 2.8% producing 6-8 plants.

The distances where the new plants were produced on the culms were measured. Few new plants were produced within 0.5 m of the hedgerow. The details are given in the following:

Distance of Occurrence of Off-spring Tillers

	Off-spring Tillers			
Distance	Open		Shade	
(m)	Count	%	Count	%
<0.5	22	8.4	39	15.9
>0.5 - 1.0	141	53.8	98	39.8
>1.0	99	37.8	109	44.3
Total produced	262	100	246	100

The use of layering was subsequently tested on a few slopes with very friable soil type. In most cases, full coverage were observed after 4 months and the slopes were well stabilized.

The distinct Vetiver hedgerow is a good biological barrier for soil erosion control, and usually, there will be little need to blanket cover an area. However, this trial shows that clump characteristic of Vetiver can be converted into a runner, if necessary, by layering the culms. We can change nature to suit our need!

Specifications For Vetiver Quality Hedgerows

The Vetiver hedgerows should be considered for complementing engineering structures. Most biological systems are so variable that engineers shy away from them; this is an attempt to propose a specification which is monitorable by the SO (Superintendent Officer). (The inputs by Dr. Nik Ramlan and Encik Mat Borhan of IKRAM, Public Works Department, Malaysia, and Mr.Diti Hengchaovanich of MTD Construction Sdn. Bhd. are gratefully acknowledged).

Specifications for Vetiver Quality Planting Materials (QPM)

Item	Description
General:	The Vetiver hedgerow is used as bio-engineering system to complement structural works. Therefore it shall be of good and consistent quality.
Planting Materials:	The plant shall be Vetiver zizanioides. Only non-seeding types shall be used.
Starting Materials:	i) Vigorously growing young tillers shall be used. Older materials with culm formation shall not be used, or ii) Culm-branches
Container Plants Slips:	Vetiver hedgerows shall never be planted from cut-root(bare-root). Only con-

tainer plants shall be used.

Roots: The container plants must have active root-mass regenerated in the container media

i) For soil medium The polybag shall be of 5" x 7" (12.7 cm x 17.7 cm) dimension filled with good quality (sandy loam) top soil. The root-mass shall completely bind the soil so that the soil core does not collapse when the polybag is removed prior to field planting.

ii) For foam medium The foam shall be in polybag of 3" x 5" (7.6 cm x 12.7 cm dimension. The root-mass shall enmesh the foam.

Tops (shoot system):

The tops shall have 5 or more actively growing tillers which have been regenerated and produced in-situ in the container. Old tillers extracted from the ground nursery and senescent tillers must not be included in the count. At delivery to site nursery, the tops should be cut to a height of 30 cm.

Age ofContainer Plant:

Any container plants which are "bag-bound" and with aged roots age shall be rejected.

Handling of Plants:

Maximum care should be exercised in handling and transporting of plants container plants to minimize transporting disturbances.

Field Planting:

i) The specified Vetiver container plants shall be planted in rows as specified in the planting drawings or as directed by the SO.

ii) A 6" width x 9" depth (15 cm x 23 cm) trench shall be excavated to receive the container plants.

iii) In difficult soil types, the trench to be filled, may require borrowed top soil as directed by the SO.

iv) The between-plant distance (center-to-center) shall be not more than 15 cm.

Vetiver Hedges on Contour for in-situ Rain Water Management on Arable, Non arable, and Wet Lands.

... G.M. Bharad, Maharashtra, India. Paper presented on Vetiver grass: Environment and Development through Intermediate Technology organized by CEDIA and the World Bank at CEDIA, ACCRA. GHANA, AFRICA 21-26 Nov. 1994.

Abstract. Manoli project was one of the four pilot projects on watershed development assisted by the World Bank. Research components of the project included on-station and on-farm experiments with the broad objective of developing in-situ rain water management layouts for arable cropped land and perennial alternate land use systems especially on class IV lands. Considering the variation in field size and alignment of fields due to boundary bunds delineating the property rights, each field was taken as micro watershed for in-situ conservation layout for developing various farming systems. The results indicated that contour cultivation along Vetiver hedge recorded 28.6 and 14.27 per cent increase in yield of pearl millet and hirsutum cotton on shallow soils, over across/along the slope sowing. The magnitude of increase with these treatments in sorghum and hybrid cotton on medium deep soil was 14.49 and 38.03 per cent, respectively. Reduction in mean surface runoff with pearl millet/cotton crop on shallow soil by Vetiver and Leucaena hedge on contour as compared to across/along the slope sowing was 51.3 and 33.9 percent respectively. On medium deep soil respective reduction was 36.2 and 20.6 per cent. Reduction in soil loss with Vetiver and Leucaena hedges on contour over across/along the slope sowing was 71.59 and 45.79 per cent on shallow soils as well as 70.2 and 45.5 per cent on medium deep soils. Vetiver and Leucaena hedges were also observed to be superior to graded bund systems in increasing grain yield and in-situ rain water and soil conservation. On class IV lands development of agri-horticulture systems on "Continuous Contour Trench" - CCT - layout was found to be significantly better option followed by contour cultivation of crop along Vetiver hedge in terms of growth and yield of vegetation and in-situ rain water conservation. With CCT layout around 97 per cent rain water was conserved in-situ over the entire toposequence. Vetiver hedges on contour were seen to effective in wet land management with land configuration (LC) and crop combination (CC) approach for improving in-situ conservation and productivity.

Results and Discussions

Grain Yield Data related to economic yield of different crops indicated that contour cultivation along Vetiver hedge and Leuceana hedges were superior to across/along the main slope sowing and sowing along the graded bund. Mean increase in sorghum grain yield recorded by Vetiver hedge over across the slope sowing on medium deep soil and pearl millet on shallow soil was 14.5 and 28.6 per cent, respectively. Respective increase with Leuceana hedges was 6.8 and 11.4 per cent. In case of cotton, mean increase in seed cotton yield by Vetiver hedge treatment over along the slope on shallow and medium deep soil (on-station) was 14.3 and 38.0 % respectively. Similarly Vetiver hedge system was observed to be superior to graded bund (T4) system on medium deep soil indicating 12.0 per cent mean increase in sorghum grain yield over across the slope sowing as well as 8.9

per cent mean increase in seed cotton yield over along the slope sowing.

Surface runoff

Data related to surface runoff from different crops grown on different soils are presented. Mean surface runoff over three seasons (1987-88 to 1989-90) from 41 runoff events indicated superiority of vegetative hedges in significantly reducing surface runoff when compared with along the slope sowing on shallow soils. During second cycle (1990-91 to 1993-94) the reduction in surface runoff by vegetative hedges over along the par sowing was also significant. Mean reduction in surface runoff from pearl millet/cotton crop system grown on shallow soils over 6 seasons(75 events) due to Vetiver and Leucaena hedges on contour over along/across the slope sowing was 51.3 and 33.9 per cent, respectively. Vetiver hedge was further found to be better than Leuceana hedge indicating 26.3 per cent decrease in surface runoff during this period. On medium deep soils, surface runoff vents from sorghum during 1988-89 to 1990-91 and cotton during 1992-93 to 1993-94 were 44 and 20, respectively. Reduction in surface runoff from -sorghum due to contour cultivation along Vetiver hedge and hedge over across the slope sowing was 38.5 and 22.8 per cent, respectively. Respective reduction in surface runoff due to these two treatments over along the slope sowing of cotton was 49.4 and 32.3 per cent. Significant reduction was also recorded in per cent surface runoff from 64 events sorghum/cotton system over 5 seasons. Similarly Vetiver hedge was found to be significantly superior to graded bund system in conserving rain water.

Soil loss. Data related to soil loss from different crops grown on various soils are presentedand indicates that contour cultivation along Vetiver hedge and hedge recorded 71.8 and 45.8 per cent reduction in soil loss from pearl millet and cotton crop on shallow soils over along/across the slope sowing, within 75 runoff events recorded during 1987-88 to 1993-94 period (8 seasons). On medium deep soil, reduction was observed to be 70.2 and 45.5 per cent with these two hedges over along/across the slope sowing. The reduction recorded by Vetiver and Leucaena and hedges on contour over graded bund system was 60.8 and 28.4 per cent, respectively. Vetiver was also found to be superior to Leucaena hedge and recorded 45.2 per cent reduction in mean soil loss during 1988-89 to 1993-94 (seasons).

In rainfed areas, although the productivity of annual cropping systems raised on an arable lands very considerably due to variation in land/soil characteristics; the variation is mainly amplified due to rainfall pattern. However appropriate measures adopted for rain water conservation observed to mitigate effects considerably. Vegetative hedges on contour recorded substantial in-situ conservation of rain water and soil as compared to traditional along/across the slope sowing and graded bund system. Vetiver hedge was further found to be better than Leucaena hedge mainly because the Leucaena hedge became porous at ground level due dying of some seedling with aging.

Relationship between daily rainfall (P) and surface runoff (R) was observed to be significant indicating significant effect of amount of rainfall on runoff. However vegetative hedges, especially Vetiver hedge on contour, had disturbed the relationship considerably as evidenced from the R2 valves for different treatments.

Favorable effect of contour cultivation on crop yield and in-situ conservation of soil and water was reported by many workers earlier including Gupta et al..(1966). World Bank introduced the Vetiver for developing hedge on contour for in-situ conservation in semiarid regions (Grimshaw and Green field 1987); mainly because of its erect and densely fillers of shoot portion as well as thick dense and deep root system. These hedges inhibit the flow of water through them for some time as well as diffuse and spread of flow to a trickle though the grass slip with little or no erosion.

Alternate landuse - Perennial systems

Data related to surface runoff presented and indicated that mean surface runoff from along the slope sowing (S1), untreated pasture (S4), contour cultivation along Vetiver (S2) and perennial plantation system on CCT layout (S3) was 227.24, 187.16, 77.07 and 30.89 mm, respectively. Mean rainfall over three seasons was 998.1 mm. Statistical analysis of per cent runoff over surface runoff events indicated that CCT layout followed by contour cultivation along Vetiver hedge showed significant reduction in surface runoff over along the slope sowing and untreated pasture. Differences in surface runoff due to along the slope sowing and untreated pasture were not significant. Similarly the difference in mean surface runoff due to contour cultivation along Vetiver hedge and CCT was not significant.

Reduction in surface runoff due to S2, S3 and S4 over along the slope sowing (S1) was 66.1, 86.4 and 17.6 per cent, respectively. Similarly reduction in mean runoff recorded by CV and CCT over untreated pasture was 58.8 and 83.49 per cent, respectively.

Data presented regarding grain yield of pearl millet indicated that contour cultivation along Vetiver hedge (S2) recorded 51.57% higher grain yield over along the slope sowing. Grain yield of pearl millet grown on contour strips between two CCT at 6 m horizontal interval during first three seasons was 60 per cent higher than along the slope sowing.

Data related to growth of eucalyptus trees planted on CCT at 2 m spacing presented in Table-6 indicated that mean height and stem girth after 3 seasons was 4.86 m and 18.0 cm, respectively. At the end of 4 years mean height and stem girth was 5.90 m and 22.3 cm, respectively. Coefficient of variation in height of eucalyptus over the seasons ranged between 11.1 to 12.1 indicating uniformity in growth of trees. Growth of interplanted ber seedlings after two eu-

calyptus was also seen to be uniform.

Class IV lands are on upper and middle parts of the toposequence and characterized with very shallow soil depth and severely erosion. The natural vegetation is very poor and crop yields are very low on these lands. Farmers having large holdings are keeping these lands as fallow for grazing purpose. However, small farmers have the only option to cultivate these lands for their livelihood. The extent of such lands is increasing vastly in semiarid regions. On such lands, efforts to develop perennial plantation systems are being made, by the Government, NGOs and land owners. Perennial trees require long period (8-10 years) to establish and develop canopy to cover land surface. It is therefore necessary to have appropriate structure leading to in-situ rain water conservation. Earlier efforts were directed to develop perennial plantation on degraded lands with pit planting approach.

The results related to continuous contour trench (CCT) layout are promising in terms of growth of grasses and trees in silvi-pasture systems as well as growth of crops and fruit trees/ forestry species in either agri-horticulture and agri forestry or agrisilvi-horticultural systems. The CCT layout had effect on rainfall (P) runoff (R) relationship and observed to take care of runoff leading to uniform in-situ rain water and soil conservation to the extent of 96 to 97 per cent. Results of on-farm program over a period of 3 seasons varying in amount, duration and intensity ofrainfall clearly proved the feasibility and necessity of CCT layout for perennial plantation systems. With this layout conservation of rain water and soil, as well as vegetation growth was uniform over the entire toposequence of micro-watershed. For deciding options for use of class IV lands development of perennial plantation systems viz. agri—forestry, agri—horticulture, silvi-pasture on CCT should be at top priority followed by raising of short/medium duration crops with contour cultivation along Vetiver hedge. Keeping the lands fallow with uncontrolled grazing (untreated pasture) and cultivation along the slope for crop raising need to be totally discouraged on such lands.

Photo 11. New Zealand. One year old Vetiver hedge on a farm in Kerikeri. *Northerly aspect; soil shallow, rocky, volcanic; rianfall 1100 mm. Lat 35º 50' S. Variety - V.zizanioides.* **Photo by John Greenfield**

Considering the above results, in-situ rain water management layout with vegetative hedges on contour on cropped lands and with CCT layout for developing perennial plantation system lead to conservation of resources for developing sustainable farming systems in rainfed micro-watersheds.

Wet Land Management

Adoption of land configuration - crop combination (LC - CC) approach for in-situ conservation and utilization of rain water observed to result in good yields of both arable and paddy crops. The grain yield of maize, sorghum, cotton and pigeon pea were 43, 40, 12 and 10 quintal per hectare, respectively, mainly because of good aeration on raised beds. Paddy yield of 25 q per hectare was recorded because uniform accumulation of runoff and seepage water from raised bed to the entire ditch Vetiver hedges on both sides allowed clear runoff water from raised bed to gently enter the ditch with paddy. On the harvest of these crops it was possible to raise a second crop of chickpea with 10 q. per ha yield. The approach thus envisaged is to have in-situ rain water management instead of traditional surface or sub-surface drainage layout for taking water from the field and allowing to go to the main drain.

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Vetiver NetworkCoordinator and News Letter Editor: DickGrimshaw

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER NETWORK
NUMBER 14 SEPTEMBER 1995

Editor's Page

This newsletter is rather long. It contains a lot of feedback from users around the world - thank you all for the time and efforts that you put in preparing the material. It contains two long articles on vetiver that I consider useful. The first is an article written in 1949 about the world wide production of vetiver oil. A number of network members are interested in producing vetiver oil, and this article may help (but beware the market is pretty thin). It also gives a good insight to some field practices and other aspects of interest. The second article is the Spanish translation (thanks to Kevin O'Sullivan) of a paper that your editor presented at the World Soil Congress in Mexico last year. We have a growing number of users in Spanish speaking countries and this paper should be useful to them. In this regard the newslettter is prepared to publish articles in Spanish and French so long as the editor receives an English translation and that the topic is considered relevant and useful.

This newsletter also breaks from tradition and includes two articles on non vetiver technologies. The first describes a new plough used in Niger for the creation of in field micro basins. This technique has been used before with some success (in Australia for example) and helps to improve insitu water conservation on large scale agricultural and forestry operations in very dry areas. The second describes an offset disc that can be attached behind a large farm tractor for reforming road shoulders. In many developing countries, roads are the key to economic development in rural areas. Road maintenance is critical, roads often fail on the shoulders, and shoulder and surface materials end up in the side drains. This piece of equipment could be used in every district of developing countries for returning the road material to the road surface and for reforming road shoulders at minimum cost. Furthermore the equipment could be used by local farmers (owning tractors) under contract to the district administration. If you want more information please write to the manufacturers directly, mentioning the Vetiver Network.

SEE BACK PAGE FOR TABLE OF CONTENTS

We have had a few generous contributions from some of our members to help keep the network in operation. These donations have meant that we have been able to send technical material (videos slide sets etc. to those of you who can't afford them or cannot get foreign exchange. Some of the money will be used to make a professional technical video of the vetiver system using slides and photographs that many of you have generously sent me over the years. This 20 minute video should be completed by mid October and will be available in PAL or NTSC at about US $ 20 each.

We need more support from those of you who can afford to help. You will see from this newsletter that readers really appreciate the information that they receive through the network.

Photo 1. *His Majesty The King of Thailand with Her Royal Highness The Princess Mother viewing some quality vetiver planting material at Doi Tung.*

NGOs in particular are moving the technology fast. See the articles from David Connors, Kevin O'Sullivan, Shimelis Kebede, Alemu Mekonnen, Simon Ngwainmbi, David Harvey, Charlie Inggs, Bob Mann, and others. These NGOs need financial help. They obviously know how to use their scarce resources. If you can influence donor agencies, I suggest that you point them in this type of direction.

The Vetiver Network sadly has to report the death on July 18 of our oldest vetiver user and promoter, Her Royal Highness The Princess Mother of Thailand, at the age of 94. She was a great woman and much loved by the people of Thailand. She was famed for her establishment of the Flying Doctor Service. She did much for the socially poor, for those with leprosy, and for the crippled. She had great concern for the Hill Tribe people in the North East of Thailand and for the related environmental issues. During her last few years she took a great interest in vetiver grass, and had her own

development project at Doi Tung, near Chiang Rai, where vetiver was vigorously promoted. Her project will be the site for the "Vetiver: A Miracle Grass" conference — A befitting tribute to a great lady. I am sure that all Network members will join me in our condolences to the Thai Royal Family.

The Royal Development Projects Board of Thailand has announced that the International Conference on Vetiver grass "Vetiver : The Miracle Grass" plannned to be held in November 1995 has been postponed to the 4 - 8 February 1986. I hope that those of us who planned to attend the conference in November will be able to attend in February. I am sure that the Thais will put on a very good conference. They have a lot to show us, and there will be much exchange between participants. I believe some 300 "vetervites" will attend with at least 100 from overseas. We hope that the Board will publish a "proceedings' of all the works contributed to the conference, and that the proceedings will make it available to all network participants.

Once again I would remind you that your contributions and feedback are essential to our progress, those of you who have something useful to contribute to the next newsletter please write before by the end of January 1996.

Letters to the Network

From: **David Connors**, Project Manager, St. Joseph's Family Farm Project, Catholic Mission (Bwiam), P.O. Box 165, Banjul, The Gambia. Ph/Fax: 220489050

Thank you for the information you forwarded to me on the hand held site levels. They seem to be exactly what we want for our extension agents in the field to set out the contours on the farms. We are also training the farmers themselves to set out the contours using the 'A' frame.....We are a grass roots organization, working directly with the rural families. Our primary concern is in addressing the environmental issues which will, in time, lead to an increase in food production. We do this by educating the people at the grass roots because, after all, they are the people who count.

We are a charity organization relying on outside assistance for the operation of the project. But I think we are putting it to good use! Currently we have funding from the EC and the Irish government which will take us up to the end of 1996. Beyond that it is uncertain at this point. If you know of any organizations who are interested in funding environmental projects I would appreciate it if you could put me in touch with them when you have time to do so. I realize the Vetiver Network also seeks funds from donors, from reading your January '95 issue, and so I am certainly not asking you for anything in monetary terms. Your vetiver newsletters more than suffice in that respect. They make excellent reading and provide much needed technical information to interested people. We may even be in a position to make a small donation sometime.

We, at this project, realize the importance of vetiver grass in preventing soil erosion and have submitted a proposal to the National Environment Agency in The Gambia (Funded by United Nations Development Program) to establish about 15 vetiver nurseries in our area, which is about 70 km by 10 km. The planting stock will be provided to any farmers who practice contour farming.

I am enclosing a copy of that proposal for your interest and to let you know that vetiver is being promoted in West Africa. We are not sure how much vetiver there is in the country but apparently a lot of women have been using it in their rice fields for a long time. We plan to locate this local vetiver (don't know the technical name) and propagate it in nurseries. We already have 5 vetiver nurseries established, here at the project site and in schools (Vetiveria zizanioides, I think). How is it possible to determine the actual name / type of the vetiver?

We also want to establish a local vetiver network here in The Gambia and I will write to Jim Smyle to get the information from him about that.

That's about all I have to report. We are new to the Vetiver Network, and only heard about it late last year. We are delighted that such a network exists, which is a great assistance and support to us, and we will aid in getting this information to the people who matter, i.e. the farmers and rural people.....

From **Teoh Cheng Hai**, Golden Hope Plantations, Malaysia (fax 03 261 8221) ..... you will be pleased to note that the use of vetiver has become a standard management practice now. Although we produce vetiver planting material by micro propagation, it is mainly for in house use. However we have limited quantities available to people who are interested to evaluate vetiver...

From **Shimelis Kebede**, Finchaa Sugar Project, PO Box 101915, Addis Ababa, Ethiopia ..... After returning from Ghana (Wonder Grass Conference November 1994), I have continued planting vetiver grass on a 3 ha. vegetable farm for demonstration purposes, and the grass is silently doing its work ....The establishment of a National Vetiver Committee is in the pipeline ..... I have already submitted the draft statutes of the association to the Science and Technology Commission of Ethiopia. I have recently conducted a press conference about vetiver and our proposed Association. The Ministry of Natural Resources Development and Environmental Protection has promised further research and cooperation following my complaining to one of our newspapers! .....

From **Mr. Poul Richardt Jensen,** Royal Danish Embassy, Bangladesh ..... the National Herbarium of Bangladesh has been funded by Danida to under take a study on Vetiver in Bangladesh. The team leader is Dr. Matiur Rahman, Director of the Herbarium and grass specialist. The study will be in two parts, the first part will be completed this year and will be followed by a workshop in December .... *(Ed. We look forward to receiving news of the preliminary find-*

ings)

From **David Harvey**, Coordinator, FSP, Shiwa N'gandu, Mpika, Zambia .... My family has been involved in agriculture in northern Zambia for over 70 years. My father John Harvey imported vetiver from Madagascar in the hope of using it for essential oils ... I have planted out several hedges to see the results. Have been impressed, and am starting up some small nurseries, and so will have some vetiver for sale. The small NGO that has been set up to assist farmers within our area hopes to start a soil conservation component, particularly those who are farming on slopes of more than 15% *(Ed. I hope on slopes of less than 15% as well!!)*. We have also found that dairy cattle will graze it down in the dry season .....

From **Murray Fergusson** CEDEC, Casilla # 196, Sucre, Bolivia. Fax 591 64 32628 .... As part of my work I will be trying to promote the use of vetiver grass in this part of Bolivia and, if it proves successful, expand the use of the grass in coordination with CEDES' existing programs .... Here in Sucre I have made contact with Sn. Cresencio Callapino who is working with the NGO called Accion Cultural Loyola (ACLO). His address is in the network mailing list (page 7). ACLO has been working with vetiver since 1991 and currently has a nursery with several million slips for planting out and active projects in at least three communities. They have also produced 1000 copies of a 40 page cartoon booklet in Spanish on the use of vetiver in Bolivia called Protejamos Nuestros Suelos Usando Pasto Vetiver: Manual de Educacion Ambiental No. 2, 1994. It has good illustrations and seems to be aimed at a level somewhat between a technico and campesinos.....*(Ed ..... Murray, could you please let us have more about this program since I believe you visited ACLO. Thanks)*....

From **Ndong Joseph to Simon Ngwainmbi,** C/O PMB 42 via Bda, Mbingo Baptist Hospital, Mbingo, N.W Province, Cameroon .....I seize this opportunity on behalf of the Nbingo II Mens Group of the church to appreciate your efforts to supply us with books about vetiver grass. We have planted over 100 hedges of vetiver. After reading the booklet (Vetiver Grass A Hedge Against Erosion) members, who were reluctant, are now so impressed and are ready to transplant more of the vetiver around their compounds ..... I am appealing for more booklets for members who did not receive the first series that you sent. I am planning to introduce the vetiver grass to the Mens group of the association of churches as a special project.....*(Ed. Note the power of well written material, and proper training of farmers)*....

From **Glenn Allison,** Box 1481, Lilongwe, Malawi. There is keen interest in vetiver here. I have linked up with Francis Mbuka of the World Bank and Stephen Carr at Zomba. Implementation is very slow to date so I am endeavoring to establish commercial nurseries to bulk up planting material for faster than hitherto .... I like the comment from Fiji about the necessity for hedge maintenance seems to me to be a *sine qua non*! Most of the material available so far is Vetiveria nigratana . We are working towards bulking V. zizanioides.....

From **Charles Inggs**, Eastern Highlands Round Table No 35, PO Box 225, Chipinge, Zimbabwe ..... As an individual Table we have over the last two years been planting *(Ed. vetiver I presume)* the severely eroded Tanganda River catchment (a sub-catchment of the Save River), and are now gathering a tremendous response from the peasant plot holders. We have also successfully established vetiver nurseries at 10 schools in our District, supplied various agencies in ours and neighboring districts, and assisted in planting mine slimes dams. All this was done with voluntary donations of vetiver grass from **large scale commercial farmers**, with transport, labor and publicity costs financed by charitable contributions... *(Ed... when I visited Central American countries in 1993 I suggested that commercial farmers could help campesinos in this same way as is being done by commercial farmers in Zimbabwe, I wonder if anything came of it??)*..... Our Association has now adopted this project and at least 10 Table Clubs in Botswana and Zimbabwe are keen to, or have already started nurseries in their areas .....

From **Carlos Alberto Potes Roldan**, Decano, Fac. Ing Recursos Naturales y Medio ambiente, U. Central del Valle del Cauca, Apartado 303, Tulua-Valle, Colombia ..... I have received some planting material from Dr. Karl Mueller Seeman of CIAT and there are now four small propagation nurseries around the city of Tulua. The new Government of the city is interested in developing a vetiver program as a priority, for this, its agricultural extension and our local university is planning to make a special teacher and student project...

From **W.A.V.Wickramasinghe**, Ritz Towers, Ayala Avenue, Makati, Metro Manila, Philippines. ..The Department of Public Works and Highways is establishing a pilot project using vetiver. We plan to implement it as follows: (i) to popularize the technique of using vegetative measures to arrest erosion and stabilize unstable road embankments, and (ii) to establish the proper procedures and techniques into a standard item of road maintenance / rehabilitation works to be adopted in future projects executed on contract.....

From **S.R.Chalise**, ICIMOD, PO Box 3226, Katmandu, Nepal ..... We have introduced vetiver in a very degraded community forest land at an altitude of approx. 950 m a.s.l. in East Nepal on acid and hot/dry "red soil" area. The performance of vetiver is being monitored. We would be interested to hear from anyone who has tried vetiver in similar conditions. *(Ed.....The red soils of southern China are somewhat similar, similar altitude, rainfall of about 1,000 mm. year, long dry season, high summer temperatures, cool winter temperatures, pH of about 4.5... vetiver is doing very well under these conditions. For that matter vetiver grown in Karnataka, India seems to have some what similar conditions)*....

From **Bob Mann**, The Methodist

Church, 1 Central Buildings, London SW1H 9NH, UK. Fax 01717992153) ..... It is essential that all possible assistance be given to the people in Musiyo (Gwembe Valley, Zambia). and through out Gwembe South to help halt erosion and reclaim degraded areas. This is where the GSDP Agricultural Program has taken a step in the right direction encouraging people to start their own nurseries for vetiver grass....to stop erosion and give crops a better chance of survival in times of drought. There are presently some 31 farmers in the Musiyo area who have started vetiver nurseries

..... Mr. Lungu says that vetiver is a tough grass, drought resistant, and can tolerate grazing when once established .... The vetiver grass nursery established by John Jamanklwala in Siabaswi village was grazed down by livestock only a few months after planting, but the roots had become sufficiently well developed in that time to provide adequate anchorage for the vetiver clumps. The grazing has not damaged the nursery plants but had in fact improved the tillering and subsequent growth of young vetiver clumps ....

At Siabaswi village there is a good vetiver grass nursery started during the last rains by John Jamankwala, and in spite of the drought has grown well. In March 1995 the vetiver appeared to be under attack by termites, so Mr. Lungu made up a solution of crushed Neem leaves in water and sprayed part of the nursery as a trial. Two months later it is clearly seen that termites have left that part of the nursery sprayed with Neem-leaf solution.... *(Ed... great news, vetiver users in dry parts of Asia and Africa that have had problems with termites might want to try this use of Neem).*

Samuel Kuwandira of the Lungwalala Irrigation Scheme (Zimbabwe) showed us where they have used vetiver grass in the drainage channels to successfully stop erosion. There used to be gullies 1 meter deep, they planted vetiver in lines at intervals between 3 - 5 meters across the drainage channels and that prevented erosion and repaired the channels. Farmers then cut the vetiver and found it good for thatching. They have also found that it can shoot again without any problems if accidentally burnt by a bush fire. In the green stage vetiver grass has been found a palatable fodder for donkeys and oxen.....At Fambidzanai (Zimbabwe) vetiver grass is also being cut for mulch on garden beds and around trees, and it is also cut and mixed with Leuceana and Sesbania as a fodder for livestock. Cattle have been observed to eat vetiver in the green leaf stage in preference to other tough bush grasses.

From **Mark Dafforn** (mdafforn@nas.edu@INTERNET) .... Vetiver DNA profiling .... Great news! Robert Adams who used to work with NPI (now AgriDyne) is planning to do DNA fingerprinting of the entire genus Vetiveria! I've put him in touch with Steve Kresovich, who did the earlier work. I may ask you'all to put me in touch with people with different kinds of vetiver, but we've got some time. Adams' address is: Robert P. Adams, Plant Biotechnology Center, Baylor University, PO Box 669, Gruver, Texas 79040. Tel: 806 733-5558; fax 806 733-5606. rpadams@aol. com. *(Ed... anyone wanting to cooperate with Mr. Adams should contact him on Mark via Internet. I would imagine that he will be pleased to receive plant material from world wide sources).*

From **Norman Jones** - World Bank forester. ..... I have been meaning to contact you about an interesting chap who came to my office talking about Bioponics. In his brochure there are pictures of plants with absolutely vast root systems. The system recycles water (mixed with some chemical concoction) and plants just grow. It is used for raising vegetables in dry areas in the Western USA and I believe in one or two Middle Eastern countries. However, it struck me that anyone interested in the oil from vetiver roots could install one of these units and prune away to his hearts content without serious debilitating the plants. The price for these units range from $55,000 for a 20 sq. ft. adequate for 100,000 plants to $405,000 for 2,160 sq. ft. for a million plants (and a lot more for more!). The company is Bioponics International, 32 Galli Drive, Novato, California 94949 (Tel 415 883 3474; Fax 415 883 3776) .

From: **Alemu Mekonnen**, Head Ecological Dev't Dept. Menschen Fur Menschen (MfM), P.O. Box 45, Mettu, Ethiopia.... As you know, MfM, a local NGO, working in the South Western part of Ethiopia, is the only organization currently involving in vetiver grass promotion on a larger scale at farmers' level in the whole of the region and to that extent in the country. The success and the result in the transfer of vetiver technology is encouraging and appreciable. Today it is becoming very difficult to satisfy the increasing growing needs of farmers in the project area and outside the project as well. Currently we have 6 large nurseries (1-2.5 ha) established for vetiver grass propagation. Beside these we have also established four farmers' nurseries. Even these were not enough & farmers in the project areas are now propagating and planting from the already established hedge rows. All in all since the start of the project 1992, 811 ha. of land was treated & covered with vetiver hedge rows. Beside moisture & soil conservation, we have observed farmers are using the grass for: thatching material for huts; as mulch for vegetable beds; to cover the root zone of newly planted perennial crops (coffee & fruit); irrigation canal side stabilization; for coffee ceremony; on-farm grazing during off seasons & dry periods; and ornamental plantation in gardens etc. Further more, our project tried to introduce and supply the planting stock & technical support to government & non government institutions such as:- Japan voluntary service (NGO); Soil conservation research project (NGO); German Agro Action (NGO); Farm Africa (NGO); Ministry of Natural Resource & Environmental Protection; Ministry of Agriculture; and the Ministry of Tea & Coffee.

From **James Smyle & Joan Miller** (hamilton@sol . racsa . co. cr@INTERNET) ... I received a letter from a man in Guatemala: P. Agr. Romulo AlbrtO Ramirez G., Cordinador Regional, Proyecto

Conservacicn de Suelos, DIGESA Region II, Norte, Codigo postal 16801, Coban, A.V,Guatemala ..... points of interest are:

- the project has been working for 4 years with vetiver. They are also promoting green manure cropping, compost, agroforestry, and introduction of earthworms;

- their experience has been very positive with vetiver, especially since they have been promoting it as a multiple use grass barrier. They find that it works very well for: grass roofs, woven rugs, fans, brooms and supplemental cattle feed;

- they have 0.75 ha of nursery and currently about 20 ha of fields protected with vetiver. This covers 24 different areas and about 120 farmers are involved. They plan to expand the nurseries this year; and

- they are starting to do fertilizer trials (inorganic fertilizers) for nurserying of vetiver establishment in order to have a better understanding for proceeding with the promotion of vegetative propagation of vetiver.

Research topics

As I recall you had mentioned that you were interested in knowing some of the areas in which research on vetiver was yet needed for Central America. I can think of several, and will list them in no order of priority:

- We know very little about the vetiver populations in the region. There has been no collection of accessions, no genetic characterizations to establish similarities and differences, no physiological comparisons, etc. etc.. Obviously this makes it somewhat difficult to look at improving performance;

- Zamorano Ag. College in Honduras is now is bulking up an accession of the "Karnataka" or "farmer-selected" vetiver from India. We think that it is better quality fodder. Dr. Yoon in Malaysia found that it tended to out perform the other 8 or so accessions that he compared it against, in terms of characteristics desirable for rapid hedgerow formation. From reports we have had from our contacts in Honduras, while Zamarano has some interests in vetiver, it is apparently not yet fully committed to putting an effort into bulking up and testing this accession either for fodder value or for performance relative to the locally available accessions. Some cooperation with them on this might provide a needed incentive. *(Ed. note. Could those of you at Zamarano interested in vetiver give the above some thought, from all accounts this grass is becoming important in Central America),*

- Regional governments are beginning to heavily cut back on support (even little as it is now) to small farmers on so-called "marginal" lands or lands of "forestry vocation" Their technical criteria for doing is not very realistic and does not recognize the presence of some very good technologies available (such as vetiver) for hill slope farmers, which can sustain basic grain (beans & corn) production at a financially viable (and socially valuable) level. Empirical data with which to convince policy makers is missing. It is also missing to provide guidance to technicians on the conditions (slope, rainfall, soil depth) when more traditional hedgerow species (e.g. lemon grass, napier grass) no longer are technically desirable.

- Among some other soils, ultisols are a major problem within current small farmer technology menus as seemingly most extension efforts fail to recognize phosphorous deficiencies, and given the heavy emphasis on organic methods, they do not coincidentally have any significant impact on the problem. Given that maize is as yet the most common hills slope crop and that maize is quite sensitive to P deficiencies, yields are extremely low. Low yields translate to low input cropping, which translates into no soil conservation and higher erosion rates, etc. etc.. Given that the soils thus tend to be in pretty poor shape (biologically, chemically and physically) after a decade or two of such treatment, it would if possible that one part of the solution is to look at the mycorrhizal populations on maize crops. In Vetiver Newsletter #7 there is an article on "Mycorrhiza and Vetiver - Rehabilitating Degraded Lands" where the authors found that AMF commonly occurring on maize roots significantly increased vetiver growth under P deficit conditions and hypothesized that AMF inoculated vetiver hedgerows could serve as a reservoir of AMF for crops on degraded lands. *(Ed..... Readers any other research topic suggestions would be welcome)*

From **Richard Webb**, Hong Kong ..... A small part *(of the land reclaimed through the use of Acacia mangium and Vetiver — Ed)* was burned last year, but the vetiver grew away strongly after the fire, and after being released from the shade so that it quickly did its job before the Acacias leafed out again. The vetiver planted in the single rows, while providing some erosion control in the first year, did not thrive and is now dying back. I think that the "soil" is too poor, but Ron Hill at Hong Kong University is doing some soil nutrient tests, which may throw some light on the subject. However, I am not discouraged as the grass did an excellent job and improved the establishment of the trees ....

From: **S.P.Yadav**. Community Development and Welfare Society, Katmandu, Nepal. .... Some information about Vetiver on our farm at 6,000 ft. We started with few (7) seedlings of Vetiver in July 1992 out of my personal interest in it after hearing about its soil binding and erosion controlling characteristics. It was planted for fun in the worst location without any care and management. Observing its capacity to withstand even the worst condition and no management and still having the growth (vertical and horizontal) we planted it on terrace bunds in July 1993, but still limited in number. n July 1994 we counted the number of plants in a clump. On an average it has multiplied 38 times in a year having a maximum of 46 plants in a clump. 300 shoots were planted in three different terrace in July 1994. The multiplication count done on 24th July 1995 is 48 per clump. The number has grown

to 75 this year in a clump planted in July 1993. The plant height above the ground is around 110 cm. and the root length is 45 cm. We are still using it in our farm prominently to control the soil movement during the heavy rains. It looks quite appropriate planting material in order to check the soil erosion and land slides in the steep hill slopes and therefore we are multiplying the stock to be distributed to the farmers in our project area initially and later to others as well. The farmers coming to our farm for training and visits are being exposed to the importance and characteristics of Vetiver as it appears in our farm which has quite positive impact on the farmers and there is increasing interest for this material to extended in the larger areas. Let us see how it works in the days to come.

From: **Christoph Backhaus** (GTZ Team leader), North Western Province Dry Zone Participatory Development Project (DZP), New Secretariat Building, Dambulla Road, Kurunegala, Sri Lanka. Tel/Fax: 0094137122554+22203 writes .....After such a long time I am not sure whether or not you might still remember that we once met in Northern Thailand a few years ago (about 1991), where we had a good time together while you were visiting our project area (the Thai German Highland Development Program). In the meantime, I have started to operate as a team leader for a new GTZ-Project in the Dry Zone of Sri Lanka, which among other components is mainly focusing on Rainfed Upland Farming. We are adopting a "Participatory Technology Development Adaptation" approach, but are also increasingly involved in dissemination activities. The project (funded by FAD and GTZ) is working with small farmers in the Dry Zone in order to assist them in improving their self-help capabilities and upgrading their living standard and in developing and adopting natural resource management systems which are in a sustained balance with their natural environment.

Vetiver plays an important role in our program, as one of the most prominent species which we are offering to farmers for soil and water conservation purposes. We are determined not to promote anything, but just offer the chance to farmers to test some new technical options and incorporate them into their existing resource management systems. The response has been quite good so far, in each of the 30 villages where we are working so far (the project is only operating for 2 seasons yet) some farmers have picked up Vetiver, though on a small scale, and they are observing and comparing it with other S&WC options, such as alley cropping (mainly with Gliricidia), physical bunds etc. While the first Vetiver lines are closing and thus show what kind of effect they may have, some (but not all) farmers have indicated that they consider Vetiver as one of the more promising options for S&WC. In addition, we have trained the operators of private small-scale multipurpose nurseries to multiply Vetiver and they are doing a good job already. In the coming years the challenge for us will be to further develop the technologies in a way that they become manageable for the farmers, and to disseminate them through a farmer to farmer extension approach on a fairly large scale. The project is supposed to extend its services to 500 villages (in 7 years).

Photo 2. *Natal, South Africa. Well established and stabilized water course on sugar estate. Note the vetiver hedges on the contour in the sugar field*
Photo Credit Maxime Robert.

From: **Maxime Robert**, Vallonia Sugar Estate, P.O. Box 56, Umblali, Natal.4390.South Africa ..... Due to the good rains experienced in the months of March, April, and June, 1995 I am still at present planting vetiver even though we are in the middle of our winter season. The vetiver clumps have being dipped in water and planted immediately using 3-5 slips per station. Vetiver is an unbelievable plant that can take up to three months before growth is noticed especially during the winter months, but in the summer will show growth after only one week. The better the quality of the plant material the higher the survival percentage will be. The advantage of planting in winter, provided there is moisture in the soil, is that except for harvesting of sugar cane during this period, our labor force can be given alternate work with the vetiver program *(Ed. note that in the Himalayan region of India and Pakistan winter or early spring planting*

Photo 3. *Natal, South Africa. Four year old vetiver hedges in a sugar cane field in Natal. The sugar cane is 18 month plant cane. Note that there is virtually no damage caused by cane harvesting and transporting sytems*
Photo Credit. Maxime Robert.

snow melt is feasible and would reduce competition for labor).

The problems experienced are very limited compared to summer planted vetiver where newly planted material can he washed out after the heavy summer rains and even staking of clumps will be required. Gaps in the vetiver hedges are best planted using up to 10 slips as this will ensure no further replanting. Harvesting of sugar cane between the hedges using a tractor together with a side loader does not cause a problem. Where the tractor and trailer are forced to drive over the vetiver hedge, it is then advisable to cut the damaged hedge down the ground level as this will promote regrowth.

The negative aspects of vetiver that I have experienced are very limited: (i) mature vetiver burns quicker under dry conditions, and unless water is available can cause a problem; and (ii) around the laborers quarters, where soap detergents are constantly used and thrown over the grass, and compaction occurs, the grass will die. Therefore washing facilities and pathways are required to prevent this problem.

On the positive side the advantages far outweigh the negative aspects. The vetiver system is easy to implement, it is not expensive and not difficult to maintain. It will eventually increase crop yields and the overall farm management will be made easier and less expensive.

The vetiver system is a system that I believe in, found that it looks after itself, and found it most rewarding to work with.

From: **Paul Truong**, Queensland Australia. ..... I agree wholeheartedly with Dr Yoon on the high quality and standard of planting materials needed for stabilization of engineering projects as replanting is very expensive and sometimes impossible. However I wish to point out that we must not lose sight of the main reason that the Vetiver System is so widespread and popular is that it is a very practical, simple and low tech means of soil and water conservation. This is particularly important in developing countries and also under extensive land use systems.

To me the bare root planting should be the ultimate aim in general as it is the simplest and cheapest method of establishment. I have successfully used bare root method at many sites in Queensland, the critical requirements are: (i) fresh planting material, should be planted preferably on the same day of digging, but no more than 2 days maximum; (ii) slightly larger slip size, at least 3 green tillers; (iii) planting into wet soil or that to be irrigated within a couple of hours after planting with enough water to soak the soil around the roots; and (iv) keep soil wet for at least 2 weeks after planting.

As watering is often a limiting factor, timing is very important, plant only during the wettest part of the year if watering is not available. A small application of fertilizer or manure will promote early growth and better chance of survival later. These are my limited observations, and I think this is a very important area on which we need to focus. I am presently working on the clay dipping method where bare root slip are dipped into a mixture of bentonite clay, dried out, and then planted. Clay dipping is a common practice in forestry to plant bare root pine seedlings here in Queensland *(Ed..... and in China)*

From: **Mark Dafforn,** National Academy of Science, Washington .....on the "non-weediness" of vetiver.

Mark Dafforn was research associate for the 1993 National Research Council report, "Vetiver Grass: A Thin Green Line Against Erosion". The following comments are drawn from some of his early correspondence on potential vetiver seediness and pestiferousness.

Vegetative hedges have shown great results controlling erosion in field agriculture, as well as in civil engineering, landscape stabilization, rehabilitation, and the re-establishment of native vegetation. The potential invasiveness of the species was an initial concern in our study.

This diminished considerably as we

learned more about the plant. The vetiver used in erosion control is an essential-oil grass from South India, where it seems known only in cultivation. It is increasingly clear that most vetivers outside South Asia are these low fertility, essential-oil types that are never invasive and are unlikely to become pests. This domesticated form of vetiver has long been grown as a field crop for its oil, which is used in perfumes. For this reason the grass has been carried from place to place for centuries. It is now pantropical—in nearly 100 countries. Extensive experience and literature exist on the plant, and it is not considered a weed.

When selecting germplasm for erosion control, fertility should be monitored on a case-by-case basis. There seems a strong correlation between oil yield from the roots and what is termed "nonflowering". Thus, the most desirable plants for propagation and further introduction have also tended to be the most infertile. This selection pressure may explain why viable seeds (caryopses) are scarcely reported from elite cultivars. This is a common characteristic of plants domesticated for purposes other than seed production, such as potato and sugarcane (a close relative of vetiver). The sterility (due to various factors such as pollen sterility and embryo abortion) seems total in many vetiver genotypes, but of course cannot be absolutely proven. "Nonflowering", by the way, is a misnomer: inflorescences occasionally occur but they are sterile.

One conjectural ancestor of the cultivated essential-oil vetivers is the seedy vetiver from north India and adjacent areas. This is not widely disseminated but it has been introduced to South India and a few other places. Morphologically the two types are quite dissimilar: the North India phenotype is lax, weak stemmed, and shallow rooted (and thus unsuitable for forming hedges). These traits hold true regardless of where the plants are grown.

The oils vary chemically, they rotate polarized light in opposite directions, they smell differently, and are treated separately in commerce. Technically, the north Indian is "Khus Oil"; the South Indian, "Oil of Vetiver".

The two types also differ in flower structure. The differences fall within specific limits of the taxon, so the two are not at present considered separate species. The North India vetiver is fully fertile, as are other species of the genus. Since the time of Linnaeus, it has been proposed that the wild north India vetiver and the essential oil south India vetiver are separate species; this has not been separately examined. It should be noted in passing that, as a convenience, taxonomists have long lumped unassignable cultivated plants with nearby relatives. Nearly all vetivers with which I am familiar can be handily assigned to either the north India or south India group. The last treatment of Vetiveria was about 90 years ago, and systematists seem to agree the genus merits revision. Incidentally, 2 - 4 new Australian species have recently been described.

Initial DNA fingerprinting (RAPD RFLP) of several genotypes has shown north India seedy material to be quite heterozygous and genetically quite distinct from the south India materials. By comparison, the three "nonflowering" clones tested thus far are unusually homozygous among themselves. These were traced back as far as Louisiana, Guatemala, and—quite possibly—Jamaica. They are virtually identical by any genetic standard (as well as quite distinct from the seedy types of vetiver from northern India). Homozygosity such as this over a broad geographical area seems to indicate a long history of clonal propagation without sexual reproduction. None of these three accessions has seeded in more than 50 combined years of field growth.

The "vetiver system" is an innovative concept of great promise. Hundreds of people are now working with vetiver hedges in every clime; the knowledge base is exploding, still without signs of potential vetiver pestiferousness. Since our report, many locations have been found with very old vetiver hedges. None show signs of spreading either nearby or far downslope; they persist but have not naturalized. Watchfulness is, of course, called for. Experience also shows that, if desirable, vetiver is easy to eliminate either mechanically or chemically. Perniciousness is not a problem. Importantly, even seeding north India types are not reported invasive, although they are co-dominants in fluvial Ganges grasslands.

Other plants besides vetiver can be used in a vegetative hedge system; the concept of slowing runoff and dropping sediment remains the same. The drawback is that nothing has been found that does the job as well as vetiver."Analogues" have been less effective, or required more maintenance, or been more competitive with neighboring crops, etc. On the other hand, if mandated in critical areas, native grasses—given sufficient management—would probably work well enough.

I ask members of the Vetiver Network to contact me with their insights on vetiver's physiology, morphology, and ecology and—particularly—to correct misconceptions I may have. Mark Dafforn, Office of International Affairs, National Academy of Sciences, Washington, DC 20418; 202 334-2692; fax 202 334-2660; email mdafforn@nas.edu.

Newspaper Reports

Khus used to check erosion - The Times of India News Service SHIMLA, May 15 1995: **.....** The agricultural department here has found that the fragrant tropical grass, vetiver (KHUS), used for cooling rooms, is a good soil binder. The grass, which can be grown without the risk of turning into a menacing weed, has proved to be an inexpensive and practical solution for combating erosion - a chronic problem in the state (Himachal Pradesh). It can be successfully grown both in tropical and semi

arid regions. The agriculture department planted the grass in rows on the slopes in Sirmour district. The grass grew quickly forming narrow but dense hedges which not only blocked the passage of soil and debris from being washed away but also gave a better chance for the rain water to soak into the soil rather than run down the slope. Besides, once the grass hedges were formed, they did not spread and become a pest. As a result terraces arose as the soil accumulated behind them. The once fragile erodible slopes - were converted into stabilized terraces fit for cultivation or forestry. This has proved to be a boon for Himachal where a few hours of torrential rain can wash away major chunks of top soil from the land ..... According to an official spokesman, successful demonstrations have been given in and around the Shiwalik Hills region. These have motivated farmers to recognize, understand and adopt the grass along the periphery of their orchards and agricultural lands.

Photo 4. *Darling Downs, Queensland, Australia. A typical strip cropping layout on the flood plain, a sequence of different crops (corn, sorghum, cotton, sunflower and fallow) designed to protect crop/fallow from flood erosion. If proven, only one Vetiver hedge is needed to protect five of these 19 m strips.*

Photo Credit Paul Truong.

Vetiver Grass Being Trialled On Flood Plains Sunday Mail. Dec 18 1994. .....Vetiver grass hedges are being assessed for their effectiveness in spreading flood flows on flood plains by two Darling Downs landcare groups. Overseas studies have shown Vetiver grass to be effective in spreading water and conserving soil and water on sloping land. Trials in Queensland have shown it to be highly drought, heat, cold and salt tolerant and able to be established on a wide range of soil types. Vetiver's suitability is now being assessed on flood plains as a supplement to or, in some cases, an alternative to strip cropping, which at times provides little protection from erosion. This is particularly so during drought or when low stubble producing crops such as sunflower and cotton are grown in alternate strips. The Myall Creek/Blaxland Landcare Action Group and Jondaryan Landcare Group have initiated two Vetiver trial field sites. These have been set up by Paul Truong (Natural Resource Management Unit. DPI) and Rod Smith (Agricultural Engineering Department. Southern Queensland University). For the Myall Creek/Blaxland Group, Vetiver hedges were established across shallow gullies and depressions to supplement existing strips at Ken McRae's property. These hedges should spread flood flows and trap most of the eroded soil moving down the slope, gradually leveling the gullies and depressions. For the Jondaryan Landcare Group, Vetiver hedges were established at approximately 90 m intervals down a strip cropped slope on Mark Hensell's property on Evanslea Road. Flume tests on the site, conducted by Paul Dalton of the Agricultural Engineering Department, University of Southern Queensland, found that when fully established, the Vetiver hedges should provide adequate spreading of flood waters over the 90 m spacing, which is equivalent to five strips at this particular site. Stubble mulching would still be required to maximize erosion protection. If proven successful, the incorporation of Vetiver hedges as an alternative to strip cropping on flood plains should result in more flexibility, more easily managed land, and more effective spreading of flood flows in drought years and with low stubble producing crops. An added benefit is that the area cropped at any one time could be increased by up to 30%.

Vetiver Developments in Mexico. What two men with a mission can accomplish

Your Editor first heard from Kevin O'Sullivan less than a year ago. We have never met, but he is obviously a dynamic person with a mission in life. He got interested in Vetiver, and found it growing in Chiapas Region of Mexico. People often ask me how one can get a vetiver program started in a country. Kevin's approach is interesting and appears to create many initiatives. His story of how he is spreading the technology in southern Mexico is worth pondering and follows below:

From: **Kevin O'Sullivan. Mexico** Tel: 52

951 464 90 ..... A brief update on the status of vetiver in Oaxaca and other Mexican States as of the beginning of August 1995.

1. Institutions.

Instituto Tecnologico Agropequarto De Oaxaca (ITAO): Member organizing committee. - Ing. Francisco Marini. Now have a Vetiver nursery in Oaxaca. Approx 7000 tillers were brought from Chiapas, 6000 of which were planted in groups of 3 tillers, 30 cm. X 40 cm, unfortunately, under far from optimum conditions. ITAO has micro propagating facilities and is very interested in getting information on micro propagating techniques for Vetiver. Who would be the best people to approach ? *(Ed. I believe some of the best micro propagation work has been done in Thailand at the Doi Tung Royal Development Project at Chiang Rai).*

Centro Regional Universitario Sur (Crus Chapingo) Suelos Aguas Y Semillas De Oaxaca (SASO.Ac). Member organizing committee. - Ing.Efrain Paredes, Ing.Gabriel Narvaez. Efrain and Gabriel have been taking care of the plants I brought from Chiapas in January and the accessions we received in February from the Botanical Gardens, Jalapa, Veracruz. Both were very slow to start but with the advent of the rains, warmer temperatures and a little more care, sprang vigorously to life!!! They appear to be different varieties. The grass from Chiapas has grown very well. It has put out between 20-30 tillers since May with a strong, erect: habit; that from Veracruz has produced 15-20 tillers, is a lighter green in color, more "weepy" and looser in habit. We will get botanical identification as soon as we can. They have also taken 1000 tillers from our latest batch from Chiapas which they have planted in polybags. *(Ed. Kevin you might want to send your different cultivars to Robert Adams for DNA testing. See letters to Editor above).*

Instituto Politecnico National. Centro Interdiciplinario de Investigacion para el Desarollo Integral Regional. CIDIR - IPN - U. GAXACA. Ing. Cirenio Escamiros. Your slides are proving very useful. Efrain and I gave a presentation to a group of agronomists from CIIDIR. They were very enthusiastic. They are working with communities in the Mixteca Region, one of the most eroded parts of Mexico, if not of the world! They were curious to know if vetiver would grow faster under greenhouse conditions given the elevation (1500m.) and a cooler climate. Very keen to start a nursery.

Instituto National De Investigationes Forestal Y Agropequarto INIFAP. CEFAMOAX (Nochixtlan). - Ing. Efrain Cruz Cruz. Ing. Efrain Cruz has been working for some years with grasses, shrubs and trees in this very eroded area of Oaxaca. He is very well informed about the virtues of Vetiver but did not know it existed in Mexico. We will meet with him next week.

Universidad De La Mixteca. Member organizing committee - Ing. Juan Manuel Garcia. ..... Very keen to start a nursery for research purposes.

2. NGOS and Committies in Oaxaca:

Estudio Rurales Y Asesoria. AC. (ERA) Member organizing committee. - Ing. Carlos Vilchis. ERA has been working with Union Zapoteco Chinanteco - (UZACHI) on sustainable forestry for a number of years. UZACHI are very keen to use vetiver as part of their erosion prevention program. The nursery would be based at CAPULALPAM DE MENDEEZ. Region: Sierra Juarez. I am really impressed with their tecnicos; very keen and very committed to their work. The elevations 2400m.

Asesores Para El Advance Sociales. SC. (AAS) Member organizing committee. - Ing. Ricardo Diaz.AAS have been working on integrated projects (agriculture, health, education) in the region of the Mixteca Alta. They are keen to start vetiver nurseries in the area of SAN MARTIN PERAS on the border with the state of Guerrero, one of the most eroded parts of Mexico.

Santa Maria Tiltapec. Region: Mixteca Alta. A very interesting community in the valley of Nochixtlan where prehispanic forms of erosion control still survive. Two campesino friends, Don Betto and Don Saul, are very keen to try Vetiver both as an adjunct to and possible replacement for the very laborious but very effective traditional methods of check dams and terraces. They are also interested in Vetiver as a forage grass. Ing. Efrain Cruz has worked with this community for a number years.

Santa Maria Chilchotla. Region: Sierra Mazateco. This is a coffee producing area on the border with Veracruz. The people here are seeking to minimize their dependence on a monocrop. They had heard about vetiver oil and were looking to the plant as a generator of income. They obtained 3 or 4 slips from a campo experimental in Guadalajara, Jalisco. The campo experimental seems to have a few Vetiver plants as specimen/ornamentals as does the botanical gardens in Veracruz. The people of Chilchotla, having got their plants and didn't really know what to do with them. We gave them what literature we have in Spanish and explained our approach to Vetiver. This is a tropical, subtropical humid region of very steep slopes. Erosion is an increasingly serious problem. The two community representatives who came to see us will get in touch with us around the middle of August with their ideas for a Vetiver program.

La Esmeralda. Region: Isthmus of Tehuantepec. Gabriel and Efrain (CRUS) have been working with communities in this area for a number of years using the mucuna and canavalia beans as green manure/cover crop/ weed inhibitor. It is a tropical humid zone with deep rich soils. We would like to start a nursery here. We reckon the plants would reproduce rapidly under the nearly ideal conditions of good deep soils and good soil moisture throughout the dry season.

3. Vetiver In Other States.

Tabasco.

Centro De Capacitacion Agropequarlo Y Forestal. Macuspana, Tabasco. Dr. Arturo Romeo. Dr Romeo got in touch with us by telephone. He and his group are working with agroforestry programs on steep slopes on the Tabasco/Chiapas border. He is well informed about vetiver but was not able to identify it in Mexico. He tried importing vetiver from Guatemala (through SHARE, I think) but it did not survive. He was delighted to know that vetiver is available in Mexico and is very keen to work with it. We will exchange visits later in the month.

Veracruz.

Jardin Botanico. Jalapa, Veracruz. Biologist Mayte Lazcurain. This botanical garden has some well established vetiver plants as specimen/ornamentals. We obtained about 20 tillers from them in February. Comparing it with our accessions from Chiapas it appears to be a different variety. We will soon have botanical verification.

Inifap Campo Experimental El Palomar. Cordoba Veracruz. Ing. Victor Hugo Diaz. Ing. Victor Hugo has also been in touch. with us. He is working on slope agriculture and obtained 5 slips of vetiver from the botanical gardens in Jalapa which he hopes to reproduce. He was very pleased. to know other groups are beginning to work with Vetiver and more ample supplies might be available. I will visit him in the near future.

Jalisco.

Centro De Investigacion Y Asistencia En Tecnologia Y Diseno Del Del Estado De Jalisco. AC. (CIATEJ) Dr. Marco A Martinez. We know very little about this group except that they have some vetiver, apparently as specimens/ornamentals. They also have micro propagating facilities. CIATEJ provided the vetiver slips for the Union de Santa Maria Chilchotla but very little information. We will get in touch with this group very shortly.

Tlaxcala.

Carlos Vilchis of ERA. AC. (Oaxaca) tells me of communities in the state of Tlaxcala who are working with grasses for erosion control. He thinks they might be using vetiver. I will visit this area with him around l4th -l 5th August. It seems that in Mexico, there is vetiver (possibly 2 varieties) in at least 4 states, if in very small quantities. Our most plentiful source still seems to be the finca La Paz in Chiapas. Our main problem is and will continue to be lack of plants.

The vetiver program is linked into at least three of the major agricultural research institutions of the country. We are now hoping that some bright eager researchers will grasp the possibilities. Unfortuneatley, none of these institutions seem to have any money at all for research at present.

As for the small farmers, I believe that if we have enough material to do adequate demonstration by the beginning of the rainy season 1996, farmer acceptance of vetiver grass technology will speedily follow.

The question I am most frequently asked is, "is vetiver a good forage grass ?". Here is an immediate topic for research and development. Most farmers I know would jump at a technology that has dual benefits: a technology that not only conserves soil and moisture but also doubles as a forage or has some other economic benefit would be irresistibly attractive. *(Ed. ..... there are lots of examples in this news letter showing that vetiver is very much used as a fodder).*

At the end of the month I intend to go back to Chiapas if the finca La Paz is still in the hands of my friend Ricardo, to bring back as much vetiver as I can. We will distribute this to the interested groups and communities in the various regions and zones of Oaxaca with the aim of propagating the grass for regional demonstrations next year. We will also provide Tobasco and Veracruz with enough to plant their own nurseries. We are also considering starting a nursery in the deep soils and tropical humid zone of the Isthmus to insure safe supplies for the very uncertain future.

Very little funding has materialized so far but: some agencies are beginning to blow warmer and others have gone ice cold. UNDP and FAO seem to be really interested in the long term development (and perhaps amplification) of a Vetiver program. We certainly could do with a healthy injection of cash. There is an enormous amount of work to do and only two of us to do it.

David Leonard's advice from Honduras is, "propagate, propagate, propagate! The grass will then promote itself!!". He also sent us a magnificent volume on "sustainable soil management practices for slopes" which will be enormously useful here because it is largely based on campesino experience. I also visited very briefly David Arrivillaga of SHARE Guatemala. Unfortunately, I arrived at the beginning of a four day holiday so I wasn't able to any demonstrations; nonetheless, it is a useful contact for the future.

This is more or less the vetiver story so far here in Oaxaca, perhaps in Mexico. I find it quite surprising. First Chiapas, then Veracruz, and now Jalisco. In the next weeks or months perhaps more sources of vetiver will turn up and we won't have to be so anxious about losing our source in Chiapas. It does seem though, that with proper organization, sufficient personnel and adequate financing we could be at the beginning of introducing a major new technology. I guess we need to find a Mexican Dr. Yoon. There is so much to be explored. In particular given the Frequency of the question about forage. Are any groups actively researching this? I came across a reference to "hybrid 8" in the newsletter but much to my chagrin, I can't find it again! (*Ed. ..... Hybrid 8 is supposed to be a high yielding oil cultivar developed in India)*

We will be very appreciative of any ideas/advice you might have for us.

Thank you again for all your help so far.....

Accelerating Vetiver Developments In Africa

Ghana. Some feed back from the November 1994 Wonder Grass Conference

Billiton Bogosu Gold Ltd.

The Billiton Bogosu gold mining area in the Western region of Ghana, initiated a few years ago an intensive rehabilitation of mine dumps. In this process a wide range of grasses and plants were tested to see which of them are suitable as conservation measures. One of the main characteristics for this exercise is how to handle the soils with very low nutrient content. Vetiver grass is among the grasses being tested, both local and imported species are being grown. At the present stage nurseries have been set up to provide planting material. Vetiver has so far performed very promisingly compared to other plants, such as e.g. Leuceana sp., due to its strong root system which is very effective in the process of stabilizing slopes. Comparisons of the performance of the local species *(Ed. probably Vetiveria nigratana)* with the imported one (Vetiveria zizanioides) indicate that the latter is more suitable.

Establishment Of A Local Vetiver Grass Planting Material Base

Upon request for solutions from farmers facing serious erosion problems, the local species of vetiver grass has been established at the Crops Research Institute in Kumasi for further experiments and at the same time providing a planting material base

Agroforestry In The Volta Lake Area

In an attempt to solve the siltation problems in the Volta lake by the Akosombo dam as a result of serious erosion problems on the hilly sides surrounding it, an assessment of a possible use of agroforestry measures along the Volta river was carried out. In the process vetiver grass was identified as one of the possible means of preventing erosion and local species were discovered in various parts of the country including the Shai hills in Eastern Region and the Northern parts of the Volta Region.

Demonstration Of Erosion Control Measures At Bompata In The Ashanti Akim Ditrict

In connection with the celebration of the Africa Scientific Renaissance Day on 30th June, 1994, the Soil Research Institute (SRI), Building and Road Research Institute (BRRI), Crops Research Institute (CR1) and Forestry Research Institute of Ghana (FORIG) decided to address the settlement erosion problem affecting many communities in Ghana. The aim was:

- to adopt measures which could be implemented to check erosion problems at Bompata at the most economic level, and

- to implement some of these measures as demonstration exercise for the 30th June celebration, 1994.

Bompata being one of the major towns in the Ashanti Akim District is located in the moist, semi-deciduous zone with annual average rainfall of about 1200 mm. occurring usually in torrents. Soils are generally deep agricultural soils classified as sandy clay loams and clay loams. Control measures with special emphasis on vegetative cover were embarked upon in 1975, but due to health inspectors discouragement , considering it a malpractice encouraging weedy and insanitary surrounding of the town, the grasses were hoed out. Roads and houses are oriented along the slope with no drains, and rills and gullies dominate the landscape. The ground slope is around 20% on upper slopes and 2-5% on lower slopes where a lot of sand deposits have accumulated. The erosion problem has left many buildings, especially older ones, virtually hanging or sitting on pedestals and many are collapsing; even the newer buildings are being undermined gradually. Erosion in the area is a result of the soils' high susceptibility to erosion, heavy rainfalls, lack of land use planning creating pedestrian access roads facilitating further erosion as well as socio-economic factors. A number of measures were implemented around the houses such as:

- slowing down and diversion of velocity of runoff using bamboo, sticks, boulders/stones and sandbags;

- biological stabilization of the surface soils including the use of various grasses and fast growing trees

Vetiver grass was one of the grasses being test planted at the toe of a slope in order to arrest the movement of eroded soil. Preliminary results showed that the grass formed a very effective barrier sieving runoff and thereby causing soil particles to be deposited behind. Further studies are yet to be carried out to look at the grass' performance in the long term. **Some of the inhabitants of Bompata have however already started planting vetiver grass hedges around their houses in an attempt to control erosion.** *(Ed. It would seem that the potential users are already convinced, researchers should work with them and speed up the process of adoption).*

A Practical Look At Vetiver And Its Uses As Applied In The Republic Of South Africa

Tony Tantum, South Africa

It is not known when vetiver was first brought to South Africa from the East. The grass has been grown in the Transvaal since 1892. It was apparently brought from the Cape by a Voortrekker family, and was used for scenting kists (Meredith, 1955) .

Mine Dump Rehabilitation - Anglo-American Gold Tailings Slimes Dam. Vetiver hedges were planted in May 1992. The experiment showed that:

- the vetiver plant managed to establish itself prior to winter with a minimum of water;

- Vetiver survived the winter, but it also survived the hot winds of spring in the hostile environment of the slimes dam with a pH of approx. 3.3.

Not only did the vetiver hedges survive with no maintenance or fertilizer/watering but three years later they were still in-situ. The year 1993 was a bad drought year in the area, but over the three years a mortality rate of only 18% had been experienced. Through this experiment Welkom Mines have written vetiver into their specifications for the mines slime dam reclamation work over the next 15 years.

Kimberley (De Beers diamond mine dumps)

The vetiver hedges established easily on the dumps, and have also enabled (because of improved soil moisture) the local grasses to establish themselves between the hedges. The dumps range from rainfall areas as low as 300 mm. up to 1000 mm. Once again the droughts in South Africa have not affected the vetiver grass significantly. In any mining situation in areas where the rainfall is low and especially in Gold Tailings where pyrites are acid forming, irrigation is essential. Vetiver hedges planted across the slope then vegetates. A detailed plan on how this is done is available from Tony Tantum.

Road Stabilization

A road pass, called Oliviershoek, in the Drakensberg mountains in the region of Natal was stabilized by the Road Department. As an experiment, a portion of the pass was planted with vetiver grass. The objective was to see how the vetiver grass stood up to, and could be compared to the norm of guniting the slope (blowing concrete onto the slope). Three years after establishment the gunite was clean and intact where the hedges had been planted above, whereas the gunite was breaking down where there was no hedge protection. The gunite was full of holes and within a few years is expected to be replaced at a very high cost. Where gabions have been put in place mud slides are prevailing and the slope often collapses. Vetiver hedges at a much smaller cost could have done the job in the first instant with no subsequent maintenance.

If a little trouble is taken to establish vetiver hedges on any slope or gully prior to the rains there is no doubt the area concerned will be stabilized. No maintenance will be required. The establishment of vetiver hedges across waterways will stop silting of dams. In South Africa it has been proven that wherever vetiver hedges are used and no matter the circumstances, as long as it is properly established, the system works. Presently the plant is also being used for the following in South Africa: oil from roots; resale of crowns as planting stock for new planting; and for thatching, weaving and briquettes for cooking.

As one can see there are many uses of vetiver. Not only is vetiver a "Wonder Grass"; but it has become a household name especially in government and district country circles. If people in power are serious in their attempts to give people a sustainable living at the grass root level then a serious and positive look should be given to the "wonder grass" called vetiver.

Vetiver Grass As A Tool For Consideration In The Forestry Erosion Management Program. - Tony Tantum et al. South Africa.

While the erosion problems have largely been overcome within the forest plantation, the areas adjacent to the plantations have been overlooked. These areas include firebreaks, road cuttings, and drainage systems. Vegetative barriers of vetiver grass were planted on firebreaks and show much potential as a tool in the erosion management program. A suitable site was chosen on Bloemendal experimental farm where bands of vetiver grass were planted across a firebreak to test the grass' ability to filter out the sediment and retain it, in situ. The firebreak has a slope of 15% and is 9 m. wide. It is hoed clean. In October 1990 vetiver grass tillers were planted 5 cm. apart across the firebreak at 30 m. intervals perpendicular to the slope. Seven months later the grass had started to form a hedge and was effectively filtering out much of the sediment. A terrace had started to form from the filtered sediment above the hedge and the development of a gully which had started to form below the hedge was halted. It is expected that with time, the hedge will grow thicker and become more effective at filtering out sediment. To satisfy fire insurance requirement the grass must be burnt before the first season. Attempts were made to burn a hedge of vetiver grass in June 1990, but a satisfactory burn could not be obtained. It was then sprayed with a contact herbicide (Gramoxone) and two weeks later a satisfactory burn was obtained. The grass has subsequently recovered and new tiller development has been encouraged by burning. By devegetating firebreaks the erosion process is encouraged. The advantages and possibilities of vegetating firebreaks with fire resistant ground covers require further investigation. Ideally the ground cover should be frost resistant, competitive but not invasive, indigenous and of low growth habit. Certain succulent species have been identified and are presently being investigated.

The grass has fulfilled all expectations and observations made thus far are impressive. It has the potential for replacing mechanical methods of controlling erosion on forestry firebreaks. It is more cost effective than mechanical methods and requires less maintenance becoming more effective with time as the hedge grows thicker. It does not produce viable seed, and will not become a weed.

Prospects And Problems Associated With The Use Of Vetiver Grass As A Biological Mean Of Soil And Water Conservation In Lesotho Lowlands And Foothills - By A.B. Chaudhry, M. Petlane (Agronomist & Programme Coordinator, soil and Water Conservation and Agroforestry Programme (SWaCAP)), and N. Mota

(Chief Conservation Officer, Soil Conservation Division, Ministry of Agriculture, P.O. Box 24, Maseru 100, Lesotho).

Summary: Vetiver grass (Vetiveria zizanioides) was introduced into the farming systems in Lesotho lowlands and the foothills during 1990/91 summer season. Observations thus far have indicated that Vetiver grass has gone through the process of acclimatization and displayed its potential as a biological mean of soil and water conservation. Contrary to the earlier beliefs, Vetiver grass is palatable to the livestock and has survived below freezing point (around - I0° C) winter temperatures. However, the traditional practice of livestock grazing, and Vetiver grass' failure to withstand over grazing and compete with neighboring Bermuda grass (Cynodon dactylon) as well as Kikuyu grass (Pennisetum clandestine) seems to seriously restrict its scope for successful integration into the farming systems. *(Ed. ..... this may be a premature conclusion. In other countries vetiver will withstand very heavy grazing, and if planted at the right time will actually act as a preventative barrier to the afore mentioned creeping grasses)*.

Introduction: Lesotho's agro-ecosystem is characterized by wide spread erosion, shrinking land resources, low pH, biomass disequilibrium, and as a consequence, declining agricultural production (UNICEF, 1991, Harrison, 1989). There are over 30,000 gullies occupying 4% of the total arable land and millions of tonnes of top soil have been lost through erosion (Hall and Green, 1989, Harrison, 1989). An average rainfall of 740 mm should normally sufficient to ensure successful farming, however, with erratic rains the crop failures due to the drought conditions are a common phenomenon. Lesotho farming systems are based on comprehensive terracing which are more than 50 years old. Unfortunately most of the terraces at the moment are poorly aligned and in some cases banks have been slashed by the plough to be just rudimentary lines (*Ed. ..... also many of the waterways that take surplus runoff from the terraces have become major gullies due to concentrated water flows. It is my opinion that Lesotho's conservation systems are a classic case of systems that have actually enhanced the removal of scarce water resources from the land, and have contributed to furthering "drought" conditions and reduced ground water levels)*. Farmers are generally not too keen to upgrade their terraces due to the physical drudgery and controversial land tenure system. Under prevailing circumstances physical soil conservation structures need to be supplemented by appropriate biological means to effectively contain the situation. In this regard Vetiver grass was introduced from the Republic of South Africa (RSA) during 1990/91 summer season to ascertain it suitability for the existing farming systems in Lesotho.

Methodology: Vetiver planting material was imported from the RSA during December, 1990 at very high initial cost. In all >60 farmers were selected through consultation with the District Conservation Officer (DCO), Extension Agents (EAs) and the Village Development Committees (VDCs) to contain rill erosion in their farm lands. Sufficient material was provided to each farmer to establish a line or so across the run-off routes. Vetiver grass was used to establish border lines, measuring about I00 m, to protect a cut-off drain in the communal area. In addition Vetiver grass was tried in the agroforestry experimental plot for soil and water conservation. All the planting took place during December 1990/ January 1991.

Establishment of Vetiver grass nurseries: Part of the planting material was planted on an area of 0.40 ha for observation and multiplication. A research element was also introduced by employing two tillage systems i.e. traditional plough-plant system (control) and rip-line system, where in addition to ploughing, pre-planting rip-lines were established and necessary soil amendments, notably compound fertilizer 2:3:22 @ 100 kg/ha and farm yard manure @ 2t/ha were applied on the rip-lines. Ripping was carried out to eliminate the plough-pan. Later during 1993 another nursery was established on an area of 0.20 ha. For the first nursery, an arrangement has been made with a farmer having a cow and a heifer to monitor the fodder potential of Vetiver grass. The farmer regularly cuts the green fodder and feeds his animals. Necessary data is being recorded periodically using a questionnaire.

Propagation: During 1993/94 summer season efforts were made to establish Vetiver grass lines using bare root slips with disappointing results. At present the planting material is first time being planted in polybags to be transplanted in the field, later following the planting of field crops.

Observations:

On-farm observations: During 1990/91 summer season, out of 8543 Vetiver grass stands 56% successfully established. However, following 1991/92 harvesting of summer crops, the grazing livestock relished the fresh regrowth so much that they grazed it to extinction. It was more so because Vetiver grass puts up an accelerated growth at the inception of fall and pre-spring period, when in the fields nothing else is green. In the cut-off drain situation Vetiver grass initially put up a wonderful growth but it was soon over powered by the Bermuda and the Kikuyu grasses. The following year its token presence was felt and later it disappeared completely. In the agroforestry experimental plot Vetiver grass grew well and established in a short while. Half moon circles planted around some fruit trees for in situ water harvesting did not provide any evidence of competition between the trees and the grass. Vetiver grass hedges were trimmed twice a year, once before Fall and then in Spring. The hedges acted as windbreaks.

Establishment of Vetiver grass nurseries: The first Vetiver grass nursery was established during January, 1991 for a close observation. The plants responded to rip-line system (improved husbandry) favorably in terms number of slips/ clump and dry matter production. On an average there are 17 and 28 slips/ clump for traditional plough-

plant system (control) and rip-line system, respectively. The number of slips/ clump directly contributed towards the dry matter production.

Fodder production: The information regarding the Vetiver grass fodder production and utilization has thus far indicated that Vetiver grass did provide green fodder for supplementary feeding of the farmer's cow and a heifer. He reduced grazing time to four hours/ day and cut four sacks of green fodder daily. Vetiver put up an accelerated growth during prefall drop in temperature as well as early spring. Plant growth always slowed down during the extremes of winter and summer. Winter chill also led to a usual bronzing of vetiver foliage. Vetiver fodder reduced farmer's dependence on alfalfa hay selling at US$ 4-5 per bale. Farmer cut fodder assisted by his family. Despite the fact his cow was at the end of lactation period, he has been recording on an average 300 liters of milk/ cow/ month to be sold at US$ 0.50 per liter. He found one cut of 0.40 ha Vetiver grass plot sufficient to feed his cow and a heifer for up to 60 days, especially during the rainy season and recorded very minimal wastage on Vetiver grass fodder during stall feeding. Finally on palatability issue he pointed out that another farmer's cattle refused to eat Vetiver grass fodder, indicating that cattle have to develop a taste and get used to the new fodder. Otherwise frequent cutting of fodder strengthened the clumps and increased the number of slips/ clump.

Propagation: Bare root plantings displayed a modest success of around 60%. The gaps within the line rendered the hedges ineffective to successfully intercept the run-off. The planting of Vetiver grass slips in polybags seems to be the appropriate way to economize on the planting material and insure a uniform establishment (*Ed. ..... under farm conditions polybags are expensive. I would suggest that you look more carefully at bare root planting. Two points should be especially noted: (i) time of planting when the soil is wet after a good rain, and (ii) in India we have found that survival rates drop significantly if planting is done more than 24 hours after lifting the plants from the nursery).*

Discussion:

Lesotho according to Harrison (1989) is facing an environmental crisis of "massive proportion". There is no way how conventional, physical soil conservation structures alone could rescue the situation. The only way out seems to be an integrated approach. In this regard Vetiver grass has been proclaimed to be not only right, but indeed the only plant suitable for long term control of soil erosion and promoting in situ moisture conservation (Greenfield, 1988). With most soils in Lesotho being acidic. Vetiver grass' tolerance to low pH and particularly aluminum toxicity (Truong, 1993), makes it the most appropriate biological mean of soil and water conservation.

There is always an acute shortage of fodder in the country, as the carrying capacity of the range-land is extremely low. Vetiver grass is palatable. Its nutritive value has been reported to be between Napier grass (Pennisetum purpureum) and fresh corn stover (Vetiver Newsletter, 1990) *(Ed. .....if cut at regular intervals in the young green leaf stage)* In the light of the above facts, it is expected that Vetiver grass hedges within the farm land, around the gullies and even within the range land might be an answer to the current overstocking (Hall and Green, 1989, UNICEF, 1991). However, the socio-cultural tradition of livestock grazing is a big obstacle in the way of this positive development and has in fact been causing a havoc (Hall and Green, 1989).

Better Vetiver grass performance due to rip-line system is associated with the fact that most Lesotho soils are the victim of compaction of various degree. These observations are in line with other field crops' response to the rip-line system (Chaudhry, 1994). Vetiver grass planting material is scarce and extremely expensive, and with the erratic rains, planting of Vetiver grass in polybags seems to be a right approach.

Australian Pilot Programs Steam Ahead Under the Guidance of Paul Truong

Effectiveness Of The Vetiver Hedges In Soil Erosion And Sediment Control In Queensland. by Paul Truong, Queensland Department of Primary Industries.

A large number of field trials were carried out to verify the effectiveness of Monto Vetiver in soil erosion and sediment control in Queensland. The followings are results to date of some case studies:

Steep slope stabilization: Embankment of both cut and fill slopes can be effectively stabilized by establishing Vetiver on contour lines. The deep root system stabilizes the slope while the hedges reduce runoff, increase infiltration and trap sediment providing a very favourable environment for the colonization by local volunteer species. This is well illustrated in the following two examples.

A very steep (1:1) and highly erodible sodic soil on a railway embankment near Cairns collapsed and needed to be rebuilt after almost every wet season. Obviously, the solution to this problem is a very costly engineering structure. As a trial, six rows of Vetiver were established on mini benches (0.25m wide) on the slope at 1 m VI (Vertical Interval). A total of approximately 250 m embankment was stabilized with Vetiver in June 1992. The Vetiver established and grew well despite the dry season and by December 1992, the slope was reasonably stabilized by the young Vetiver plants and local species began to establish between the Vetiver rows. In March 1993, nine months later, the slope was completely covered with local vegetation between the Vetiver hedges. Fifteen months later the embankment was completely stabilized with a mixture of Vetiver and mature local grass species. This embankment has withstood up to the last three wet seasons.

On another site, an old quarry at Henlies Hill in Cairns, where the old rubble surface has remained bare of vegetation since the quarry operation stopped five years earlier. Four rows of Vetiver, established on an 80% slope at 1m VI. Despite the extremely poor and hostile conditions of the coarse gravely ground, Vetiver established well (with NPK fertilizer) and started trapping debris from upslope. The stiff stems of Vetiver provided a very effective barrier trapping debris and rocks up to 70 mm in diameter. Twelve months later the old gravely slope was 75% covered with local vegetation between the rows of Vetiver hedges which had grown to 1.2 m tall. Eighteen months later the slope was completely stabilized and revegetated with Vetiver and other local species including a pasture legume (Stylosanthes).

Filter strips : When established across drainage lines and water courses, Vetiver hedges filter and trap both coarse and fine sediment resulting in cleaner runof water. At Excel Quarry north of Brisbane, Vetiver was used to stabilize steep slopes of overburden and waterways. When planted across a long (500 m) and steep (20%) waterway, Vetiver hedges stopped the erosion on the waterway floor and trapped both coarse and fine sediment in runoff water from this working quarry. On another waterway leading to a dam, Vetiver hedges trapped most fine sediment resulting in less polluted water in the dam. Following the success of these trials, Vetiver is now being used as a standard method of trapping sediment and land stabilization at the quarry.

Gully stabilization: Vetiver hedges are very effective in stabilizing gully erosion. When planted on contour line above the gully head, Vetiver hedges will spread and slow down runoff water and stop the advancement of gully heads. This is well illustrated at a number of gullies in both cropping and grazing lands. Following the control of active erosion at the gully heads, gully floors are normally revegetated naturally with native species. On large and long gullies where active erosion occurs both on gully floors and walls, Vetiver hedges established on the gully floor will reduce flow velocity, trap sediment and reduce further erosion on the floor. At Ashall Creek, a very large gully system in the black earth on the Darling Downs, more than 0.3m of sediment was trapped by a series of 17 hedges over an area more than 400 m long and 50m wide during the 1994 summer.

Wave erosion control: Being able to establish and thrive under waterlogged conditions, Vetiver has proved to be very effective in reducing erosion caused by wave action on big farm dam walls. The erosion caused by wave action on the inside wall of a very big farm dam near Cloncurry was effectively controlled by establishing a Vetiver hedge along the high water mark.

Rehabilitation of mining waste and contaminated land: With its very wide range of tolerance to adverse soil conditions such as pH, soil salinity and mineral including heavy metal toxicities, Vetiver is highly suitable for the rehabilitation of mining waste and contaminated lands. Early results have shown that Vetiver is the most promising species grown on coal mine tailing in Central Queensland.

Photo 5. *Darling Downs, Queensland, Australia. Under dry (or drought) conditions, water competition occurred affecting establishment and yield of the first row (0.85 m from Vetiver hedge) but not the second.*

Photo Credit Paul Truong

India. Vetiver Has Found A Permanent Place In Land Management Practices.

Khus (Vetiveria zizanioides) in Watershed Development in Karnataka (India) by Prof. K.N. Ranganatha Sastry, Head of Department of Agricultural Economics, University of Agriculture, Bangalore, Karnataka.

Though Khus (vetiver grass) is a native grass in Karnataka the credit of introducing this in rainfed areas under Watershed Development Program for Rainfed Areas (WDPRA) in Karnataka goes to the World Bank in general, Mr. John Greenfield and Mr. Richard Grimshaw in particular. During 1985-86 a bag of khus slips was air lifted from Jhansi and planted in the prepared raised beds

in World Bank aided Kabbalanala Watershed. It is only after 4-5 years that the author and Dr. S. Subramanya were able to spot 3-4 locations in the southern part of Karnataka, mostly with red, red-laterite soils, where Khus was grown naturally as an indigenous grass. Most often used in small stretches or points wherever erosion was maximum. In Gundalpet area of Mysore District, khus had been grown on bunds for over 200 years (R. Grimshaw 1993).

This small note cannot justify the full extent of the features of the versatile Khus grass. In this note a features are highlighted through photographs rather than lengthy descriptions:

Photo 7. *Karnataka, India. Preparation of vetiver slips by farmer prior to field planting. These are good quality plants and should establish well.* **Photo Credit. K.N. Ranganatha Sastry**

Soil Conservation: Photograph 6 indicates the efficiency of khus in conserving soil in-situ, which an earthen bund cannot do satisfactorily over time. The strip in the upper reaches where the damage has been more with lot of rills is gradually getting protected with khus while the second strip is already protected satisfactorily as perceived by the absence of rills and uneven surface. The greenery is also uniform. In the third strip the green cover is more perfect. At the periphery one notices a small patch of exposed surface which was the mouth of the gully. Khus was able to protect the land which was earlier covered by rills and uneven surface leading to a gully. This was the state after two years. However, the entire plot was protected after 4-5 years.

Skill level: Since all the farmers are familiar in handling planting materials, they do not need any training in handling khus grass. All that they need is the information regarding its habits, planting methods, maintenance and so forth. Just like an Indian woman preparing the new food menu with mere explanation without requiring demonstration, even average farmers can pick up the technology of planting, maintaining and expanding Khus hedges. There were instances where even average farmers altered the planting distance and intensity to suit particular spots in the field and along the bunds. Photograph 7 shows the preparation of slips by a farmer for establishing hedgerows on his field.

Photo 6. *Karnataka, India. Erosion control on fallow land.*
Photo Credit K.N. Ranganatha Sastry

Fodder: The top portion of khus, after preparing slips, can be used as fodder supplement. Photograph 8 shows a heap left over after planting slip preparation. Since the women and children in rural areas participate in farming activities they are fully aware of khus technology. It is becoming a most familiar grass like an other crops. In the process they are acquiring knowledge about its contributions to soil and moisture conservation. They expressed the view that if Stylozanthus hamata is mixed with

Photo 8. *Karnataka, India. After the vetiver plants have been topped in the process of preparing planting slips, the residual leaf is used for fodder. Here farmers' wives get ready to head load the fodder to their farms.* **Photo Credit K.N. Ranganatha Sastry**

khus, the animals could get almost a balanced diet since the former is a leguminous plant. It is easily possible to get both if khus and hamata are grown as hedges and inter hedge spaces in public, non-arable, lands where forest is developed or on private marginal lands where forest or horticulture is practiced. In some of the cropped fields, where existing bunds were stabilized with khus hedges farmers had sown hamata on bunds. In a single harvest they were able to get both succulent cuttings of khus and hamata.

Fodder Bank: During shortage of fodder in 1986 -87, the farmers in Asundinala (Dharwad District) Watershed were asked to take khus by head loads from a forest nursery. All the poor farmers, who were having short supply of their traditional sorghum fodder were able to survive this crucial period. Photograph 9 shows the farmers, men, women, and children - carrying head loads of khus. In a fodder farm khus constitutes a main component along with Scabra, Hamata and other fodder species. Because fodder farms have the additional role of conserving soil and moisture in the they are usually established on problematic marginal non-arable lands.

Animal Food: Photograph 10 proves that bullocks (the most important draught power in Indian agriculture) will eat the succulent top portion of khus grass. If, as already mentioned, mixed with Hamata or Scabra it could form a regular fodder like an conventional grass. Since the live hedge rows should be trimmed periodically, the harvested top portions become an important by-product and has immediate use on the farm as an animal feed.

Gully Stabilization: Photograph 11 taken in Hirehalla (Raichur District) Watershed amply proves the necessity of bio-intervention. Most of the times the gully checks constructed with stones fail to provide sustained relief in checking gullies. The photograph reveals a few salient features of khus in the management of gullies. Two gullies joined and formed a bigger gully. Across both these gullies, at their mouth stone gully checks were constructed. One of them was also supplemented with khus on a small (not matching the size of the gully) scale. During high intensive rains, the check which was not supplemented with Khus was totally washed out, almost leaving the gully in a state as it was prior to treat-

Photo 9. *Karnataka, India. Farmers' wives and children headloading vetiver leaves to the farmstead for livestock feed.*
Photo Credit K.N. Ranganatha Sastry

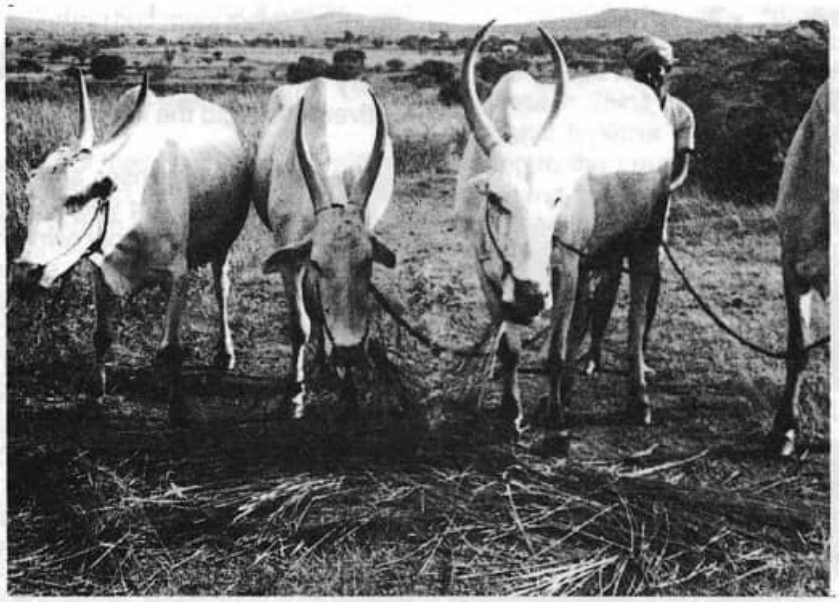

Photo 10. *Karnataka, India. Brahmin cattle eating vetiver leaves. If cut regularly vetiver leaves are good as a maintenance ration, better still if mixed with a legume.* **Photo Credit K.N. Ranganatha Sastry**

ment. The second gully check also was destabilized but the degree of damage was relatively less. During a site inspection and discussion, project personnel not only accepted the concept of vegetative stabilization but also considered that the second gully check would have remained intact if more lines of khus had been planted across the gully. It is a known fact that a gully check, on an average, costs Rs. 1500 (US $ 50). If a gully check cannot withstand even one monsoon season, the investments will not be justified. Apart from the cost, the farmers will loose confidence in any of the technologies adopted or disseminated by the government agencies. This may result in an increasing cost of dissemination, both for new and existing technologies, and may increase in the delay in acceptance if the confidence of the farming community is shaken.

Photo 11. *Karnataka, India. Gully stabilization using vetiver grass to provide added support to stone check structure.*
Photo Credit K.N. Ranganatha Sastry

Summary and Conclusions: This note is prepared to convey a few features of khus (Vetiveria zizanioides) grass, as experienced in the fields of Karnataka. The photographs were taken in the project watersheds. A few features: (a) effective soil conservation, (b) easiness in dissemination of skills, (c) a good fodder supplement, (d) a fodder that withstands drought, (f) acceptance of khus by animals and (g) a good supplement / replacement of earth, masonry structures have been highlighted. These features implicitly indicate positive physical, and financial benefits. Estimation of exact economic benefits is not this note this note. It is deferred for future papers.

Introduction of Vetiveria zizanioides in Phulbani District.

by H.S. Kumar, Project Manager Integrated Watershed Development (Plains) Project - Phulbani District, India.

At the outset, I feel that with all humbleness, I should admit on behalf of all members of my I.W.D.P. family that in March, 1992, when we started this World Bank aided project, the two words; "V-ditch" technology & "Vetiver" application were strange to us. Moreover, we had no idea how and from where to get such huge quantity of vetiver. In case of some of my project members, they did not know what vetiver was and how it looks like, let alone its procurement, propagation and contour planting. It was with lot of apprehension & fear of criticism from one and all, as well as the World Bank's first visit which was set for some time during September 1992, we started searching for vetiver. In the process of searching, many types of grasses were brought which people said was vetiver.

Photo 12. *Phulbani District, Orissa, India. A happy Mr. Kumar inspecting a "new species" of vetiver that can be grown in air on a tree. He and his colleagues are standing in one of the many vetiver nurseries developed under the project.* **Photo Credit H.S. Kumar**

But aroma of the root was not there. The search came to an end by locating Vetiver zizanioides in the Coastal areas of the State. Thus began our journey into the use and development of our own innovations into the various practices for using this wonder grass which was easy to use, for insitu soil & moisture conservation, for creating a thin Green Line for the future.

Phulbani District in Orissa is a varied land of forests, mountains, plateaus and sloping table lands, having an area of 4282 sq. miles and lies at the latitude of 19.36° N to 20.53° N & longitude of 83.33° E to 84.00° E, situated at an elevation of 650-750 meters. This District is a source of origin of several rivers of Orissa namely the Loharakhandi & the Badanadi which feed the Pushikulya in Ganjan District. The river Roul, the Jhirpani, the Khadaga & the Kalapani, eventually fall into the river Tel and this along with Paburia river & Bagha river fall into the basin of River Mahanadi. The district which originates so many important rivers and feed two of the main river systems of Orissa i.e. Pushikulya & Mahanadi is rightly selected for watershed management under Integrated Watershed Development (Plains) Project, with World Bank assistance.

The first 3 years of the Project were the pilot phase and the succeeding 4 years, up to 1997, the expansion phase. The total gross area envisaged to be treated, is 57,000 ha. covering arable & non-arable lands. To treat such a huge area with vetiver under different models, starting from ridge to toe basis, where soil conservation measures are taken up with brush wood check dams, small loose rock check dams, protected on either side by multiple rows of vetiver. Rills prevented from expansion by vetiver plugging. Forest areas with continuous "V" ditches along the contour reinforced with vetiver. Pasture grounds adopt the same "V"-ditch & Vetiver techniques for insitu soil & moisture conservation. Under arable land treatment vetiver is used in field planting along the contour in the property bunds.

For treatment of all these models, a lot of vetiver was required. To meet such huge annual requirement, it would not be possible to import annually 60 - 100 truck loads, as it (Vetiver) gets dried in the process of transit & survival comes down, also the transportation cost is very heavy. In the first year, vetiver was imported since it was not available locally and the Project identified potential locations in the Coastal districts, from where every alternate day, 2 truck loads of vetiver rolled into the Project area.

To cut down the expenses and to have a permanent supply of vetiver, the urgent necessity of raising our own mother nurseries of vetiver, was very essential. This district being a drought prone area, selection of sites posed a major problem. For the future requirement, it was not possible to have small nurseries. Sites having an area of 1.00 ha. or above, were only selected, having adequate water facility either in shape of perennial sources or canal facilities. By May 1992, selection of such sites were completed at 3 locations and the smaller existing nursery with an area of 0.5 ha. was also revived. The usual nursery techniques were followed during July '92: (i) Selection of sites having at least 1 Ha. area; (ii) ploughing & leveling; (iii) live fencing of the site; (iv) laying out of beds with inspection paths; (v) planting of vetiver slips @ one slip per every 40 cm; (vi) use of chemical fertilizers; (vii) as per vetiver guide lines, we used DAP as a basal dose @ 100 Kg. to 250 Kg. per Ha. Applied in split doses in 2-3 applications; (viii) nitrogen @ 100 to 250 Kg./Ha. after tillering started as top dressing, also in split doses & foliar spraying; (ix) in the initial stages the nurseries had the advantage of natural monsoons. Subsequently pump irrigation or flow irrigation from canal was carried out; (x) for pest control, BHC 10% @ 2.00 Qtls./ha. was used both as precautionary dose & when required; and (xi) other operations such as weeding, topping & fertilizer application & soil working were carried out at regular intervals.

I still remember, the first visit of the World Bank Mission when Mr. Jim Alexander & Mr. M.C.Lodha visited the first mother nursery at Nabaguba and inspected the layout. We had the utmost apprehension. At that time, the planting was hardly 35 days old. To add to our apprehension, Jim at random started trying to pull out the vetiver to see whether it was properly planted and root established. We had no idea about the root

system. Fortunately, not a single plant could be uprooted. When we heard the word 'GOOD' both from Jim & Lodha, all apprehension melted away!!

In course of their field visits, certain observations and suggestion were made relating to both arable & non-arable land, and the defects were also pointed out. Thus, we started improving on our own techniques, rectifying our earlier errors, creating our own designs to tackle the different types of terrain within the Project area irrespective of the site condition.

The low number of tillering in the nursery started worrying us, as the cost would increase. To find out the reasons for low tillering, soil testing was carried out. The observation from the three nurseries are as follows.

Nutrient content of soil ppm	Nabaguba	Kanbagedi	Dakapalla
Nitrogen	1.46	1.81	2.02
Phosphate	2.00	1.75	1.54
Potash 2.60	2.18	1.82	1.82
ppm	<6.5	<6.5	<6.5

From the above table it was observed that tillering was less probably for the following reasons: in acidic soil, the available phosphatic content of the soil is less due to phosphatic fixation by minerals; and waste land sites which were selected for nurseries, have been badly eroded due to over exposure for want to top cover & was devoid of any humus and biomass as a result of repeated erosion, thus have very low organic matter.

At the time of laying out of the beds, DAP & Urea were applied as per the prescribed doses. This was in keeping with the guide lines as circulated from time to time in the World Bank vetiver newsletter. Hence, it was high time that to cut down the overhead cost & improving the soil texture by addition of organic manure, in the form of farmyard manure was added to improve the soil texture which when added with judicious mixture of fertilizer already applied, was expected to increase the tillering.

This integrated nutrient management proved superior *(Ed ... we found similar results on the red acidic soils of Fujian Province in China back in 1989)* to use inorganic fertilizer alone & enhanced tillering to the tune of 110 to 120 slips per clump, bringing about 75-80% improvement. Thus, organic & inorganic sources influences physio-chemical & micro-biological properties of soil favorably to supply the additional major plant nutrients from inorganic sources & micro nutrients from organic sources. Farm yard manure improved aeration in the rhizosphere & secretion of growth promoting substances by the beneficial micro organisms. The result was better root proliferation, vigorous vegetative growth & doubling in rate of tillering. These above observation drastically made us change the nursery pattern, where organic & inorganic fertilizers were used in appropriate proportions as per the local site conditions.

The result of soil analysis samples from nursery areas and adjoining fallow sites confirms the above conclusion. Inside nursery, soil pH increased marginally from 5.7 to 5.9 and from 5.8 to 6.0 due to prevention of soil erosion and better retention of bases in the profile. Organic carbon content has increased significantly within the nursery from 0.22% to 0.28%, the reason could be attributed to addition of farmyard manure and leaf toppings of vetiver added to the soil. Increase in organic matter, status of the soil consequently increased soil moisture content from 12% to 18%. Soil potash status has declined from 350 to 400 kg/ha to 316 kg/ha. This is due to crop uptake and non-supply of potash fertilizers. A marginal decline in phosphorus status could be attributed to higher crop removal. By random sampling during April, 1993, 9 months after raising of the nursery, initially raised by planting one slip at 40 cm square & the count of maximum tillers per clump was 293 slips at Nabaguba and 327 at Kanbagadi. Before planting in June, a random counting was again conducted of the vetiver clumps & the average stood at 120-145 slips/clumps in all the location. Some observations were made as under:

- topping the vetiver slips merci-

Photo 13. *Phulbani District, Orissa, India. This area was a heavily eroded and gullied area devoid of all top soil. After two years the central gully is stable and the surrounding area has been rehabilitated using vetiver and other grasses and shrubs.* **Photo Credit H.S. Kumar**

Photo 14 *Phulbani District, Orissa, India. This scene is typical of the rehabilitation of non arble lands in the district. Vetiver hedgerows are the mainline of defence, once established other shrubs, trees and grasses are planted.*
Photo Credit H.S. Kumar

lessly up to 20 cm. height with soil working & weeding with usual root zone treatment encouraged tillering by 15-20 % after each topping;

- watering in the nursery by lift irrigation did not produce profuse tillering. The method was costly & time consuming, but could not be avoided. At Nabaguba, the nursery was irrigated by flow irrigation from the canal. This gave at least 20% more tillering than the lift method;

- for gap planting of failed clumps in the nursery or in the different field models, it was most successful when slips ware removed or adjoining clumps planted immediately in the gaps. The reason was quite obvious that the gaps were filled up by slips from the same age group & moisture loss was negligible; and

- irrespective of the irrigation systems adopted, to arrive at the break even stage by optimum tillering visa-via the cost per slip, it was observed that when the nursery receives natural rain irrigation with the onset of monsoon, for a period of 7-10 days, profuse tillering took place & thus reduced the cost of the nursery & increased the survival percentage in the field planting.

The Project further improved its techniques & started raising vetiver in polypots during 1993. Within the short span of March to June of that year, the polypots developed 15 - 25 tillers on average. The maximum count exceeded 31 slips in some polypots. To reduce the cost of polypot vetiver during l995, the project introduced smaller size polypots of 8" x 4" and it is expected that at the time of planting, minimum 15-18 slips would be present per polypot. At Lambagudari, the polypot vetiver nursery had 25 to 41 tillers per pot in July 10, 1995. Raising of polypot vetiver was new to the Project & some observations are as under:

- proper proportion of FYM with fertile & sandy soil in the proportion of 1:2, with 2 gm. of DAP is very essential for good tillering; and

- at best, the polypot can be topped only twice before transporting to the field. The height of the vetiver in the polypot in the nursery is on an average one meter, at the time of planting.

Under the planting technique, the Project has tried both planting the polypot with full length of the vetiver and planting the polypot by topping vetiver to a height of 20 - cm. In both the cases, there was no difficulty in tillering, because the polypot was planted with the exposed node on the surface of the polypot inside the pot & immediately sprouting started.

In case of the first planting method, drying up the of the slips in the polypot did not take place and thus the effectiveness of the staggered hedge planting for silt load arresting was remarkable. In the second case, silt load arresting occurred from the first day of planting, but by the time of tillering, the topped tillers had a dry appearance attracting termite attack till new tillering took place.

At the time of planting of slip & polypot respectively, a basal dose of DAP @ 5.00 gm. per hole, or 10 gm. per vetiver polypot pot, followed by regular topping after establishment & repeated at least 3 times up to the end of the monsoon, has created such density, that it was difficult to identify the slip from the polypot vetiver planting material.

Using polypot vetiver planting, soil loss & expansion of the eroded areas have been stopped over extreme slopes.

Under non-arable land treatment, vetiver is used widely under Silvipasture, Forestry & Drainage Line treatments. In all cases, this Project has successfully implemented vetiver planting taking into consideration the slope of the land. For less than 5% slope, slips have been planted @ 2-3 slips at every 10 cm in a furrow or V-ditch of one sq.ft.; the latter improves retention of moisture and thus reduces water stress at planting. In all cases, a judicious mixture of agave, hill broom, bamboo & forest species are planted to creating a green crown cover & to control the splash erosion.

On slopes of more than 10%, successful vetiver planting is executed by using vetiver polypots, planted in a staggered manner at optimum spacing of 3 polypots per meter. Mixture of bam-

boo, hill broom & tree species ware encouraged. With hill broom it was noticed at the time of inflorescence the local people cut the stems low down on the bush, for commercial purposes, and in 50% cases, due to extreme ground frost, as the temperature recorded during peak winter was 0˚ C followed by extreme summer temperatures of 45˚ C, heavy hill broom casualties are noticeable. On such slopes, it is now programmed to introduce by notching & sowing of various grass seeds and slips, as grasses would give a good ground surface cover and add to the biomass.

Under forestry models, gentle to steep slopes are present. On steep slopes of more than 10%, vetiver is planted at erosion prone locations, with hedge intervals of 4 to 8 m. between lines. The first "V" ditch row are planted with vetiver polypots and the second row planted with slips. In some cases, over extreme slopes, polypots are planted at the standard 3 per m., and in the gap in between each polypot, slips are planted at 10 cm. apart; the result is extremely encouraging.

For engineering structures, with low height loose rock check dams or brushwood check dams, vetiver filter strips with vegetative barriers such as bamboo & vitex, have bean planted on either side of the structure & it has been observed that, silt load has been arrested at stages upstream and after the water has passed over the structure, soil erosion by scouring on the down stream side has been prevented, by vetiver filter strips & vegetative aprons. Side slopes have also been prevented from erosion by multiple rows of vetiver mixed with vitax, bamboo, agave etc.

In Diversion Channels on the foot hills, vetiver slips have been planted inside the channel. Immediately after establishment, moisture retention is quite feasible, retaining moisture for at least 7-10 days more, excess water was allowed to flow through well protected aprons with filter strips to a stabilized natural drainage line. Thus ground water table is gradually restored.

Similar is the case studies relating to Forestry, Silvipastural & Horticulture, the V-ditch rows with vetiver, retain moisture for longer time. This has helped the plants and grasses to tide over the moisture stress condition during the short period when rain stops, and has resulted in good growth.

While using vetiver slips under arable land treatment, care had to be taken in selecting a cluster of beneficiaries who had proposed to take-up farming during the monsoon. At such sites vetiver is planted in 1 ft^2 "V" ditches. Only in such cases where grazing was prevented, during the time that the agriculture crop was raised was the vetiver sustained ; in other cases, where planting was done on fallow arable lands, vetiver was unable to properly establish due to the immediate grazing of the succulent tillers by cattle who uprooted newly planted tillers within 3-7 days of planting, and before root establishment took place. This Project has adopted selection of beneficiaries, taking into consideration the farming practices of the locality,

Table: Water Table Well Recordings Of I.W.D.P. Over Different Periods in feet.

Month	Nabaguba Water Table					Dutimendi Water Table					Nedisahi Water Table				
	DW	92	93	94	95	DW	92	93	94	95	DW	92	93	94	95
May	33.5	7	8'	9.5	18	30.5	Dry	1	2	16	31	1	2	2.5	17
June	33.5	11	12	13.5		30.5	12	13	13.5	13.5	31	13	14.5	15.5	15.5
Dec	33.5	15.5	16.5	18	N.A	30.5	10	11	12.5	NA	31	6	7	7.5	N.A

	Karuna Water Table					Charipada Water Table				
	DW	92	93	94	95	DW	92	93	94	95
May	20.5	1	2	2.5	2.5	20.5	Dry	1	2	5
June	20.5	3	4	5	5.5	20.5	2.5	3.5	5	5.5
Dec	20.5	4	4.5	5	5.5	20.5	10	11.5	12.5	N.A

DW = Depth of well when dry

Water table measurements = depth of water in well

where they take-up rotational cultivation, thus arable land treatment with vetiver has become successful.

The visit by Mr. Richard Grimshaw on March 23rd & 24th 1994, came as a real booster. After the extreme winter with the mercury touching 6° C with severe ground frost, with no summer showers, the vetiver clumps were in a very poor condition. The Project was not aware about the tolerance limits of vetiver & had pruned the vetiver before onset of winter. Practically, there was nothing to show except the existence of the pruned clumps. Lot of first hand and useful instructions were given during his field visits. The application of vetiver in the field and the model patterns, were well appreciated by him. After his detailed inspection of various nurseries & work sites of 1992 & 1993, this Project found place in the Search & Find Mission Report of the World Bank, which gave us the impetus to create our own innovated patterns & tackle the most impossible eroded site to the smallest rill formations with success.

Within the short tenure of the Project, the Project's M & E cell, recorded the water table of the open village wells, the rise of the water table over the last 3 years, during peak summer months and in winter is an indicator of improvement in the ground water table, mainly due to the V-ditch & vetiver technology.

Surrounded by high hills & deep valleys, with sloping table lands, the hills being devoid of the rich Shorearobusta(Sal) & other valuable compatible species, reduced to rooted wastes, due to over exploitation of the forest, age old and traditional shifting cultivation, great demand for forest material & such reasons, soil loss from the hill slopes is very heavy. Similar is the case in the foot hills, where the vegetation has disappeared & hamlets have encroached into forest lands. Over grazing in pasture lands by rapid increase in cattle population, irregular cropping pattern and reasons beyond human control, have resulted in fast degradation of the ecology and the environment. A single rain drop creates severe splash erosion and it could be wall imagined, as the district experiences the rainfall between 1200 - 2000 mm. annually, what would be the quantum of soil loss! Moreover with a number of rivers originating from the district, feeding two major river basins of the State, as to the quantum of siltation down stream when calculated would leave one awestruck. This being a Tribal district, sparsely populated by the local inhabitants, with low per capita income, the Project has come as a boon to the locality. With all round development of the degraded Forests and eroded sites by the local people, by the Project, continuous labor generation is ensured. Transfer of technology for the cost effective, easily replicable and sustainable models, have brought about all round development of the Community and the Environment within the Project area.

Thailand - A Visitor's View

Truong visits Thailand

P N Truong Principal Soil Conservationist (Natural Resource Management)

.... The few things that really stand out are:

Reclamation of degraded land. This works really well; all the sites I visited were grassed up within a year and tree crops (teak and neem) are much improved. The Thai attributed this solely to the water conservation aspect of the hedges but I suspect that keeping cattle out of their trial sites had a big effect on the grass cover. This happens here in Queensland all the time - we call it the "barbed-wire treatment!

Water Conservation around fruit trees. Most of the Thai works concentrate on this aspect and some with spectacular results that I have trouble accepting it purely on the water conservation basis. You know what I mean with the attached photos. I suggest that they have a closer look at it, the only think I can think which can give such spectacular results is some form of symbiosis such as Micorrhyzal effect.

Alley cropping. As expected, the effect of alley cropping on soil erosion in their research plots in the first two years was very good, as good as Vetiver with the added bonus of leguminous plants (Leucaena and pigeon peas). However it needs more works as pigeon peas have to be cut three times a year and put down as mulch. But the big difference is after two years, the pigeon peas are too tall with thin stems which give no protection at the ground level. This is in sharp contrast to VH as we know, resulting in very marked erosion, unless you can replant the pigeon peas again. So the Thai decide to replant the alley with Vetiver instead of pigeon peas, Vetiver was planted among old Leucaena bushes which makes a very good combination and works very well. Most of the old alley crops at the Thai-Canadian project near Chiang Rai have now replaced pigeon peas with Vetiver

Waterways stabilization: Most of the sites visited experienced some forms of erosion on their waterways when VH was planted across the flow. This is due mostly to the overall effect caused by a neatly trimmed single row. I suggest they plant more than one row, 0.5m intervals of 3 rows and do not trim their hedges as I noticed in our hydraulic tests in flume, water glides over the bent tops instead of tumbling over a rigidly trimmed hedge. They are experimenting with inverted 'V" shape hedges. This is quite a problem for them and for us here too, so I have asked our engineer friend to look into different shapes and size of the barrier across the flow.

Research Abstracts And Summaries

Aquacultural Sludge Stabilization Within Created Wetlands Bulletin #8 (last revised June 20, 1995). The Freshwater Institute, PO Box 1746, Shepherdstown, WV 25443 (304) 876-2815. A cooperative project between

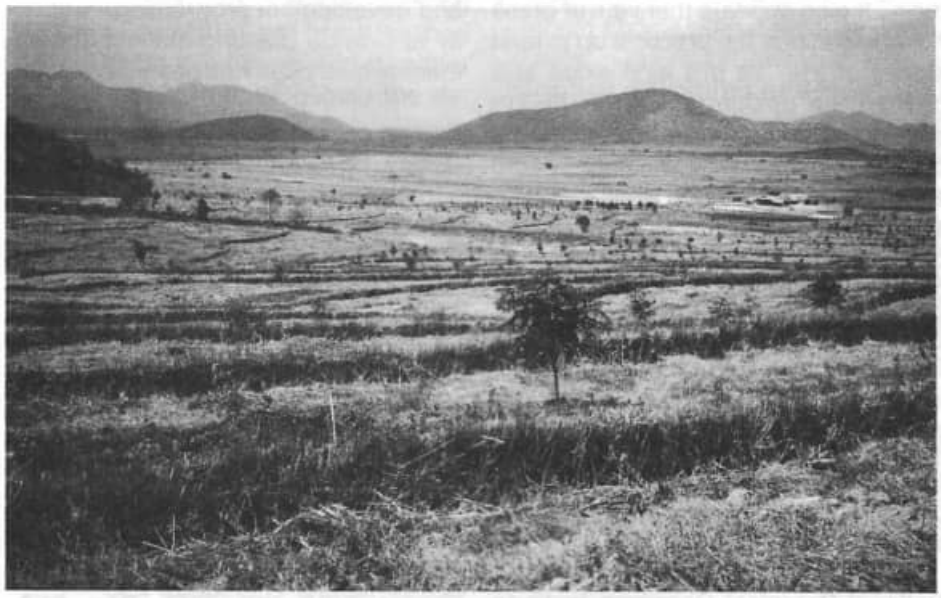

Photo 15. *Very good grass cover and Neem tree on the rehabilitation of degraded pineapple land near Hua Hin.* **Photo Credit Paul Truong**

the Freshwater Institute and the USDA IARS Appalachian Fruit Research Station. Funded by the USDA/ARS under a grant titled "Aquaculture Linked to Plant Culture: Products and Processes "(#0500-00022-003-00D) and a grant titled "Water Quality Control in Intensive Recycle/Reuse Aquaculture Production Systems" (#59-1931-3-012). Principle investigators are Dr. Steven Summerfelt (Fl) and Dr. Paul Adler (USDA/ARS).

Disposal of solids produced from an aquaculture operation is a serious is-

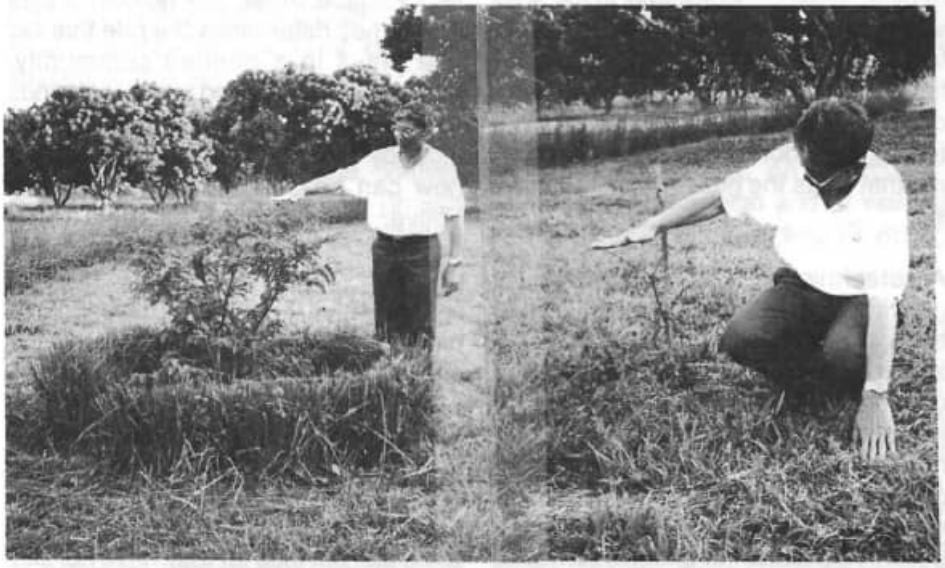

Photo 16. *Thailand. Water conservation insitu. Left - Lychee trees improved fruit setting compared with right the same age tree not surrounded by vetiver hedge. Note the size and poor conditions as compared to the tree surrounded with vetiver.* **Photo credit Paul Truong**

moval rates and efficiencies as well as levels of nutrients leaching from both wetland types. Preliminary results indicate that filtration and anaerobic digestion occurring within the vertical flow wetlands removes 90-98 percent of the total solids, a large fraction of the dissolved COD, and more than half of the percentage of volatile solids. The horizontal beds removed only 70% of the total solids and produced dissolved COD. The horizontal flow wetlands did not perform as well as the vertical flow wetlands, probably because (1) the hedges had not fully developed a stalk and root mass thick enough to trap solids and (2) the length (aspect ratio) and number of hedges were probably inadequate to provide the physical means for removing greater than 90% of the solids. Nutrient leaching data is not yet available.

Vertical flow wetlands have been used for more than 20 years to treat sludges at municipal wastewater facilities. When used for municipal treatment, vertical flow wetlands are typically planted with reeds or phragmites and are loaded with solids approximately once every 14 days, with 7 - 10 cm of 2% solids applied each load (about 30 kg/m2/yr). In this research, solids are loaded onto both horizontal and vertical wetland types at a rate of 30 kg/m^2/yr, six times a day, every day, year round. Semi-continuous application of sludge means that only a small volume of sludge, 0.5-1.0 % solids in this research, is distributed at any given application. Semi-continuous application also maintains saturated conditions that support anaerobic microbes in both the horizontal flow wetland and at the surface and sand layer of the vertical flow wetlands. Some aerobic treatment is provided in both wetland types through root transport of oxygen and by aeration within the gravel layers of the vertical flow wetlands, which are not saturated with water. A more aerobic environment helps to minimize odors, breaks down organic matter more rapidly, and makes phosphorus less susceptible to leaching than under anaerobic conditions. However, an anaerobic environment stabilizes sludge to the minimum solids mass.

Vertical flow wetlands are generally more expensive to construct than horizontal flow wetlands because vertical flow wetlands require more and much more complex distribution and drain piping as well as large quantities of sand and gravel. Horizontal flow wetlands are vertical flow wetlands because they can use the clay, gravel, or soil available on site.

Hydraulic Characteristics of Vetiver Hedges: An Engineering Design Approach to Flood Mitigation on a Cropped Flood Plain - P.A. Dalton, R.J. Smith and P.N. Truong, Faculty of Engineering and Surveying, University of Southern Queensland, Toowoomba, Qld. 4350, Australia. Resource Management Institute, Queensland, Department of Primary Industries, Indooroopilly, Qld. 4068, Australia.

Abstract. In this paper trials aimed at a quantitative description of the hydraulic characteristics of vetiver grass hedges are described. Three hedges were planted across a large outdoor flume, perpendicular to the flow. Trials were conducted at various discharges and depths and the discharge and depths upstream and downstream of each hedge were recorded. From this data an empirical hydraulic relationship was developed between the depths and the discharge. relationship was used to calculate the maximum vetiver grass hedge spacing required to control soil erosion on a cropped flood plain of low slope subject to deep erosive overland flows Finally an appropriate hedge spacing was calculated for a field site on the Darling Downs of Queensland Australia Hedges were planted at the appropriate spacing and flow retardance and sediment trapping were monitored for the validation of this theory.

Conclusions The flow of water through a hedge can be described by a simple equation relating discharge to the depths upstream and downstream of the hedge, with upwards of 90% of the variation in discharge described by the equation. Secondly it appears hydraulically feasible to use vetiver hedges to control flood flow and erosion on a cropped flood plain. It also appears that vetiver grass hedge spacings are practical up to land slopes of 2%. At this land slope and beyond the design for vetiver hedge spacing would require a different model of flow. Although flow discharge depth equation has only been applied to design spacings on a flood plain it might be assumed that the hydraulic equation could be applied to vetiver hedge spacing design for soil conservation on various topographical situations provided.

Vetiver For Sodic Land Reclamation H.M.Behl & A.K Singh Tree Biology, National Botanical Research Institute, Lucknow 226 001, India.

National Botanical Research Institute (then NBG), Lucknow in Uttar Pradesh was a pioneer for using vetiver (in 1956) for amelioration of sodic sites. However, it is only recently, after 40 years, that vetiver has again been opted for large scale trials under a World Bank program in the state (Uttar Pradesh). High concentration of salts in the root zone of soil limit the productivity of 950 million hectares of otherwise productive land around the world. In India alone, there are 8.1 million hectares of sodic land, where productivity is limited. We have been able to grow Vetiver successfully in the soils with high levels of echangeable sodium in the root zone with high pH (9 to 10.6) throughout the profile, poor water intake, occasional anaerobic stress due to water logging, poor availability of phosphorus that limits the growth, and low fertility.

Agrotechniques were developed for growing vetiver as hedgegrow on flat beds in barren uncovered lands. The agrotechniques included developing quality planting material selected for tolerance to high pH, optimum root formation, mycorrhizal association and vigorous vegetative growth. The nursery was raised in a polyhouse with mist irrigation. Application of endomycorrhizae cultures (Glomus fascicutlatum) facilitate root growth and P uptake. Such selected and tailored slips are being used for hedges under sodic land afforestation and development programing. Capacity to provide planting matinal in commercial quantities has been developed.

Farmer are yet slow to accept the technology, however, a marketing strategy with appropriate training is being planned. Initial training is provided,by "motivators" while technical tips are provided by experts. Key personal are being trained for faster dissemination to end users. Vetiver along with other aromatic grasses such as lemon grass and palma rosa are gradually gaining cognizance and acceptability.

Vetiver's Resistence to Damage by Native Pig in Papua New Guinea Allai R. Aina (Forester), PNG Forest Authority, P.O. Box 668, Kundiawa, Simbu Province, Papua New Guinea.

Papua New Guinea is a small country in the Pacific with more than 200 different languages and varied beliefs, even more complex are the varied traditional practices of maintaining soil fertility and conserving soil and moisture. The taming of the New Guinea native pig is a custom to most of the Highlands region of PNG, and in equally to be able to tame the native pig is considered to be the a very valuable asset. The number of pigs one tames determines the role that he/she plays in a defined community. Vetiver was introduced to the Highlands region, particularly in the Simbu Province, by Mr Allal Aina in 1989. Simbu now can boast in having the largest Vetiver nursery in the country (PNG). Over the years I have put some native pigs with vetiver plantings in various locations within the district (GUMINE) and have found out the following results:

- pigs tend to dig as close as possible around the Vetiver base but have not removed any clumps;
- pigs tend to dig down as deep as 30 cm. but thus far they have not fully exposed the roots or have completely dug out the plant (Vetiver);
- where pigs were left to plough

the whole area, and after 2 days of rain there was no sign of soil being washed down. There is a strong evidence that in PNG soil is trapped behind the dynamic plant (Vetiver);

- pigs were fed with vetiver grass together with sorgham or elephant grass. It was observed that pigs only ate the elephant grass and inever bothered to eat the vetiver grass.

Having witnessed the research I have the following comments:

- vetiver is truely a deep rooted plant that stabilizes the soil;it is resistent to ploughing by native pig;

- Soil trapping is a clear indication when the area was ploughed prior to heavy rainfall; and

- for now pigs don't eat the vetiver grass.

It is truely a dynamic plant and I will report any strange things when I come across one.

Salient Research Results on Vegetative Technology. Regional Research Station Kandi Area - Hoshiarpur, Punjab, India. Comparison with vetiver and other grasses. vetiver can be established as thick hedges in the area but are susceptable to termites.

Integrated watershed Development (Plains Project) Orissa State. Vetiver is a major component of this project along with the technology of "continuous contour trenches" Booklet describing project available from Watershed Planning & Coordination Organization, Directorate of Soil Conservation, Government of Orissa, Bhubaneshwar, 751 001, India.

Evaluation and Potential Uses of Vetiver Grass for Erosion Control and Soil Improvement, and Development of Adaptive Implementation Plan for Plantation and Soil Conservation Project Vinh Phu, Vietnam. By P.K.Yoon. Published by Vietnam Sweden Forestry Cooperative Programme. January 1994. Vetiver grass exists in Vietnam and has great potential in that country. This report analyses what is there, and establishes how to set up an effective and quality program. Report is very nicely illustrated with color photographs.

Vetiver As a Source of Soil and Moisture Conservation. Tamil Nadu Agricultural University. Experiments conducted at the Regional Research Station at Aruppukottai and at Kovilpatti in Tamil Nadu clearly revealed superiority of vetiver over other hedges in conserving soil moisture. A similar consistent influence of vetiver was observed from an Agricultural Engineering experiment over three years.

Continuing Studies of Over wintering Success Rates of Vetiver by the US Army Construction arid Engineering Research Laboratories at USACERL, Champaign, Illinois. From: Dr. Mohammed Sharif at 1-800-872-2375 ext.5519, Dick Gebhardt ext. 5475, Gwyn L. Howard ext. 5467 or Heidi R. Howard ext. 5205. US Army Construction arid Engineering Research Laboratories, Champaign, Illinois:

As mentioned in the January edition of the Vetiver Newsletter, the US Army Construction and Engineering Research Laboratories in Champaign, Illinois has been conducting an ongoing investigation into the uses of vetiver in controlling soil erosion Vetiver has been studied in plots located on USACERL grounds in Champaign and at several Army installations including Ft Bragg and Pt. Campbell.

During February of 1995 at the Ft. Bragg installation, experiments were conducted to determine vetiver's resistance to fire burning. It was found that burning enhanced plant vigor and fecundity of new shoots. Those subjected to fire burning were also observed to sprout more vigorously and earlier than those plants left untouched. However burning may not always be used when vetiver is employed as a filter strip for sedimentation trapping of soil runoff; this could defeat the purpose of the terrace-building effect of the grass strips

Winter climatic conditions at the Ft. Bragg area (Fayetteville NC), which is located on the northern border of the USDA Hardiness Zone of 8a, are suitable for an average to above average success rate of vetiver re growth. During the 1994-95 winter at Ft. Bragg, daily minimum temperatures were recorded and averaged to produce the following data:

Month	Averaged minimum Daily Temperature
September	62.50˚F
October	51.52˚F
November	45.60˚F
December	39.45˚F
January	35.03˚F
February	34.14˚F
March	42.68˚F
April	53.43˚F

Let it be noted that during d the month of January temperatures dropped below 20˚ F on 2 days and during February 3 days. After wintering, 90% of the vetiver plants survived to become healthy and vigorous plants for the Spring. All of these will remain in place for the determination of survival rates through the 1995-96 winter at Ft Bragg.

At the Ft. Campbell site, daily temperatures were also recorded. Ft. Campbell is located near Clarksville, Kentucky which is within the USDA Hardiness Zone 6b. It was noted, that on the average, the 4 local plots had above a 50% survival rate. interestingly enough, 2 of the sites which had not grown very well throughout the first growing season were flourishing during the second growing season. The remaining 2 sites which had performed superbly during the initial growing season were not performing as well for the second growing season. The reasons for the unusual growth patterns will be investigated further over the next year or more

Currently, we have 40% survival rate in the vetiver plot located at USACERL Champaign, Illinois, which is located in the USDA Hardiness Zone 5b; a total of

20 plants were left in the soil to over winter. The only precaution taken for exposure to winter extremes was coverage of the plants with a clear plastic tarp, of approximately 1 mm in thickness, which was secured with concrete blocks along the edges. Out of the 20 plants, two plants are sprouting vigorously, 6 are sprouting, but not with the same degree of vigor witnessed in the former, and the remaining 12 succumbed to the climate. Winter temperatures were very mild with lows reaching down to an average of l9.6˚ F for the month of January and 19.5˚F during February. The lowest temperature recorded during the season was -4˚F on January 5, 1995. Temperatures bounced back up to 17.0˚ F the following day. Consequently, results for our area may be skewed due to the unseasonably warm temperatures experienced during the 1994-5 winter.

Future endeavors will include analyzing the effects of an array of herbicides as a means to control and destroy vetiver.. The collection of climatic data will continue to be amassed for determination of the success rates for vetiver nationwide with regard to hardiness zones. Plots have recently been established at the following installations and experimental stations: Anniston Army Depot, Alabama; Ft. Chaffee and Pine Bluff Arsenal, Arkansas; USACERL, Champaign, Illinois; Ft. Leonardwood, Missouri; Ft. McAlester and Ft. Sill, Oklahoma, AP Hill, Virginia; arid Texas Tech University.

Vetiver Oil Extraction

Oil of Vetiver ***Paper written in 1949. Author unknown***

Essence de Vetiver Aceite Esencial Vetiver Vetiverröl Oleum Andropogoflis Muricati

Introduction. - The vetiver grass *Vetiveria zizanioides* Stapf *(Andropogon muricatus* Retz., *Anatherum zizanioides* [L] Hitchc. and Chase) occurs wild, semiwild and cultivated in many tropical and subtropical countries. The underground part of the plant consists of numerous fine rootlets, light yellow or gray to reddish in color, which contain a viscous essential oil of pleasant, persistent odor. The commercial oil of vetiver is obtained by distillation of the root. The root itself possesses a most agreeable aroma, for which reason the dried root is employed to scent linens, clothes, etc., either by itself or in the form of sachets. In the Orient the root has been used extensively since antiquity; it was described in the ancient Veda of the Hindus. From time immemorial the root has also been employed to make baskets, and to weave mats, which, sprinkled with water and hung like curtains in the house, cool the air and emanate a pleasant odor. In Java the root is often used to support the walls of fish ponds and to protect them against collapse. In Haiti the natives employ the overground part of the plant, the dried grass, for the thatching of their huts.

In Java the vetiver root is called "Akar wangi," in India "Cus-Cus" or "Khas-Khas," meaning "aromatic root." In its wild state the plant flourishes on the slopes of the Himalaya Mountains, in many parts of India, Ceylon, and Malaya. Vetiver is cultivated extensively in Java, on Réunion Island, in the Seychelles Islands, and in some parts of the Western Hemisphere - Louisiana (U.S.A.), and in Sao Paulo (Brazil), for example. Cultivation experiments (for the distillation of its oil) have been conducted in Honduras, Guatemala, and Mexico. In Haiti (West Indies) the plant escaped cultivation long ago, and now grows semiwild and scattered over wide areas.

The commercial vetiver oil is distilled from root material grown chiefly on plantations, the principal producing regions being Java, Reunion Island, and Haiti. The trade distinguishes the following types of vetiver oil:

Oils produced by modern methods in European and North American essential oil distilleries, from dried root material imported from Java. This type of oil is of excellent quality. Prior to World War II about 60 metric tons of vetiver root were exported annually from Java. Assuming that all of the exported root was used for distillation purposes, this quantity corresponds to an approximate annual production of 1,000 kg. of European or American distilled vetiver oil.

Oils distilled in Java from domestic root material. Owing to the strict analytical control exercised by the government of Indonesia (formerly the Netherlands East Indies) over all outgoing shipments, this type of oil is also of good quality. Prior to World War II, annual production amounted to about 20 metric tons of oil.

Oils distilled on Réunion Island from roots grown locally by small-scale planters, in large part sharecroppers. The oil is usually of excellent quality. Annual export figures have varied considerably (from 5 to 15 metric tons), depending upon competition from the Java type of vetiver oil.

Oils distilled chiefly in Haiti (West Indian islands) and to a small extent in Mexico, Central America (Guatemala and Honduras), and South America (State of Sao Paulo in Brazil). As we shall see below, this type of oil differs somewhat from the other types of vetiver oil; its quality depends upon the age of the root material and the method of distillation. Haiti has been producing the oil, but in limited quantities only. Production, however, could be increased substantially, should demand and market prices warrant it.

Hearsay reports from the interior of Java indicate that the principal (and quite modern) vetiver distillery was destroyed during the occupation by Japanese forces and many of the vetiver plantings have been discontinued in favor of other, more vital, crops. It will be quite some time before normal conditions are restored in Java. Shipments of Java vetiver oils reaching Europe and the United States at present, represent, in the main, old stocks accumulated here and there during the Japanese occupation. The following monograph on Java vetiver is, therefore, based chiefly upon conditions prevailing in Java prior to the outbreak of World War II, when the author had occasion to visit the island and

survey the vetiver producing regions. Undoubtedly the Java oil will again be offered in large quantities, when conditions on the island become normal.

As far as the American vetiver oil industry is concerned, it came into existence during the years of World War II, when the Java and Réunion oils were no longer available, and when very high prices encouraged the production of vetiver oil in certain parts of the Western Hemisphere. However, some of the new plantations were started without previous experience and in soils not for vetiver. The result was a very low yield of oil, and therefore an excessively high price. Potential production in the Western Hemisphere is large, but future developments will depend entirely upon the availability of the Java and Réunion oils (which are the most important types), and the price the oil brings on the world market. It should also be remembered that the use and consumption of vetiver oil are rather limited, and any over production will only cause ruinous competition. Moreover, vetiver root is difficult to distill, giving a great deal of trouble in the separation of the oil from the water, and the yield of oil in general is low. Therefore, any prospective grower of vetiver should first ascertain, by systematic distillation experiments, whether his root material will yield sufficient oil to make commercial exploitation worthwhile. The vetiver root grown in Louisiana (U.S.A.), for example, does not contain sufficient oil to permit distillation on a competitive basis. The Louisiana root is therefore sold as dried root, in small bundles for the scenting of linen in drawers and closets.

An English controlled company in the interior of the State of Sao Paulo (Brazil), during World War II, began extensive cultivation of the root on its vast properties (mostly coffee plantations), but it is doubtful if this potentially large vetiver industry can survive, once competition from Java is felt again.

Oil out of Java

Development. - Before World War I, Java exported large quantities of dried vetiver root to Europe, chiefly to Germany, France, and England, where the root was used either for the distillation of its oil, or in the form of sachets, for the scenting of closets, drawers, and chests. The year of 1917, however, brought about such a shortage in shipping space that much root material accumulated in the ports of Java. Since the warehouses were filled to capacity, this material could not even be properly stored. It was principally as a result of this situation that Hischmann conceived the idea of distilling the root material on the spot and of exporting the less bulky oil. Preliminary distillation experiments convinced Hischmann that the root should be distilled with direct steam, and a substantial quantity of the accumulated stocks were then processed in a distillery near Bandong. Owing to the fact that the root had already been stored and aged for almost two years, an oil of high specific gravity and very good quality was obtained. It found ready acceptance in Europe and America, and thus Java's vetiver oil industry came into being. Despite occasional setbacks the industry grew, and in 1935 Java surpassed Réunion Island in quantity of vetiver oil exported.

Producing Regions. - Java's main vetiver producing regions are near Garoet (western Java) and Wonosobo (central Java). Practically all of the root originates from scattered patch plantings and from small holdings, ranging from one-quarter of an acre to twenty acres in rare cases. The production of the root has always been in the hands of natives, few white planters growing vetiver on their estates.

Soil Conditions.- The most suitable soil for the successful growing of vetiver consists of loose sandy ground, or, even better, young volcanic ashes on the slopes of hills. The root can easily be pulled from such soils without parts of the thin rootlets adhering to the ground and being lost. Compact, heavy, loamy soil should be avoided, not only because the root cannot be pulled out readily, but also because root grown in such soil gives a lower yield of oil. Harvesting from heavy soils is a problem. If the root is planted in proper soil, the altitude does not matter. Young volcanic soils, however, do not occur in the plains of Java; but only on the slopes of volcanoes, usually at about 5,000 ft. above sea level. Good export root is often characterized by the presence of small, black cinders.

Planting.-"Akar wangi", the vetiver plant of Java, is a nonflowering variety of Andropogon muricatus Retz.

According to experiments carried out in Buitenzorg, vetiver should not he planted in shaded places, as shade will exert an unfavorable influence upon the development of the root system. Regular cutting of the grass seems to benefit the root.

As on Réunion Island (cf. the monograph on "Vetiver Oil Réunion"), vetiver is planted by root division. The planting takes place in the rainy season. Distance between the plants should be 2 to 3 ft., but, due to local conditions, is frequently irregular. The ground used in Java for the planting of vetiver seldom lends itself to the raising of other crops. It is not always possible to replant vetiver on the same field.

One hectare yields about 1,000 kg. of air-dried root, the quantity, of course, depending upon the soil and the general condition of the planting. Occasionally root fungus (the nature of which has not yet been established) damages the plants and lowers root yield.

Harvest - The harvesting period depends upon the weather. If the same field is to be replanted with vetiver roots can be extracted from the ground only during the rainy season, because the root stocks have to be divided and replanted immediately. However, if the field is to be used for some other crop, harvesting of the root will be more convenient during the dry season, not only because the earth can be shaken off the extracted root more easily, but also because the root will dry more quickly. Distillers prefer to purchase dry root material, to avoid any argument with the supplier over weight and water content. The collected root is first washed in a

river or fountain, and then dried in the sun, or preferably in the shade.

If intended for local distillation, the dried root is packed loosely, if intended for export, it is pressed into bales of 100 kg. and wrapped in jute bags.

The native growers sell their crop to middlemen, usually Chinese, from whom they have received advance payments. The middlemen, in turn, sell to the local distillers or to exporters in Batavia (Jakarta) and Surabaya.

Quality of the Root - If a fully developed root system and a high quality of oil are desired, the root should not be extracted from the ground earlier twenty-four months after planting. Young roots are tender, thin, almost hair-like; on pulling they break easily and stay in the ground. Furthermore, on distillation they yield an essential oil with a low specific gravity and low optical rotation. The odor of these "light" oils is "green," "earthy." Older, more developed, somewhat thicker root, on the other hand, yields an oil of better quality; its specific gravity and optical rotation are higher, the odor fuller, richer, more lasting. Oils derived from older root are usually of darker color than the oils distilled from younger root.

However, for obvious reasons, it is difficult to induce the natives to wait twenty-four months before harvesting the root. Always in need of cash, they are inclined to collect the root as early as eight months after planting; at any rate they expect at least a yearly crop from their vetiver fields.

Any experienced distiller will carefully examine a lot of root material before paying for it. Some "smart" natives or middlemen occasionally admix root that has previously served for mats or other purposes or has already been exhausted by steam distillation. A good quality of root, giving a high yield of oil, can usually be recognized by its slightly reddish-brown color. Very light, almost whitish root as a rule contains very little essential oil.

Distillation - Prior to World War II, there were in Java several vetiver oil distillers, a few of them Europeans, the others Chinese and Malayan. Two of the distilleries were of large size and equipped with efficient, specially designed stills and oil separators. The vetiver distilleries owned by the natives were not quite so advanced. A few producers used their citronella stills for distillation of vetiver, which explains why some lots of vetiver oil received abroad were contaminated by a slight by-odor of citronella.

Because of the high boiling points of its chief volatile constituents, and their high viscosity, the distillation of vetiver root is beset with considerable difficulties, particularly in regard to the separation of the oil from the distillation water.

Prior to distillation, the dried root material should be reduced to small pieces in a solidly constructed ensilage cutter. To prevent formation of dust, annoying to the workers, the root is first wetted by sprinkling with water.

Distillation is carried out with live steam of 4 to 5 atmospheres pressure (measured in the separate steam boiler). The stills should be well insulated, to prevent internal condensation and excessive wetting of the plant charge during the long hours of distillation. Depending upon the pressure and amount of steam injected, distillation of one charge requires 12 to 36 hr.

The oil distills over first as a fraction lighter-than-water, and toward the end of distillation as a fraction heavier than water. For a time the distillate may run in the form of a whitish milk like emulsion which has to be separated (1) by regulating (modifying) the temperature of water in the condenser, and (2) by using proper oil separators. Some distillers in Java employ a series of large tanks as oil separators. At the bottom of each tank is a narrow, tube like pocket in which the fraction heavier than water collects and from which it can be drawn off. The combined fractions of the oil are finally filtered warm in steam-jacketed filters; some producers use small centrifuges for the purpose.

Yield of Oil - Dried Java vetiver root of good quality, yields from 1.5 to 2 per cent, in rare cases as much as 3 percent, essential oil. Fresh (undried) root, of course gives a much smaller yield.

Quality of the Oil - The quality of vetiver oil depends not only upon the age of the root (see above), but also upon the length of distillation. The most valuable constituents of the oil, and most important in regard to odor, are high boiling and can be recovered only by prolonged distillation, which, obviously, means more steam consumption and a higher cost. By the use of slightly superheated steam toward the end of distillation, the hours of distillation may be shortened.

In order to produce vetiver oils of good quality the leading distilleries in Java, prior to World War II, stored, their root material for about six months before they processed it, and extended distillation to almost 36 hr. Such oils are quite dark in color, rather viscous and possess al high specific gravity and optical rotation. The odor of these "heavy" oils is full, rich, and very lasting, quite superior to that of "light" oils obtained either from young roots or by short distillation.

On aging, the odor of vetiver, in general, improves, freshly distilled oils exhibiting a somewhat "green" odor.

The oil is usually shipped in galvanized iron drums of 25, 50, or 100 kg. capacity. In normal times every shipment of Java vetiver oil must first be examined in the government laboratories of Buitenzorg before a certificate of purity is granted to the exporter.

Oil Of Vetiver Réunion

For years the oil of vetiver produced on the island of Réunion (located in the Indian Ocean, 400 miles east of Madagascar) has been noted for its good quality, a result of the care applied to the root material prior to distillation. The odor as well as the physicochemical properties of a vetiver oil depend greatly upon the age of the root, i.e., the time which elapses between planting and harvesting.

Producing Regions - The growing and producing regions on Réunion are located in the southern, eastern, and extreme southeastern parts of the island, the most important centers being La Petite Ile (in the southeast), Montvert (in the south), and Les Lianes (in the east).

These are mountainous sections of Réunion and abound with water, drawn from nearby springs or rivulets. This fact is important, as the distillation of vetiver root requires a great amount of water. Stills on Réunion are supplied with water by a system of simple bamboo tubes.

The plantings are located on the slopes of hills and mountains, above sea level, but well below altitudes at which geranium is grown.

Economic Setup.-The bulk of the oil is produced by settlers of French descent, who own large or medium sized tracts of land. With the help of employed labor they grow the crop and distill the root material in their own still. Often, however, the root is grown by sharecroppers and delivered to the landlord for distillation.

The annual production of vetiver is influenced by several economic factors: (1) the price of the oil on the world market which depends upon competition (chiefly from the Java oil); (2) the cost of labor, which is governed entirely by the social laws of France; (3) the price of sugar.

Since cane sugar and vetiver are grown on the same type of soil on Réunion Island, and at about the same altitudes, the two crops compete with one another, and obviously the planters are inclined to give preference to the more remunerative crop. Most of the sugar produced on Réunion, however, goes to France, where, after the leveling of a very high import duty, it has to compete with beet sugar, which crop fluctuates widely in France.

Planting, Cultivating, and Harvesting. Most vetiver plantings on Réunion Island are small, patch like, and widely scattered. The best soil consists of loose volcanic ashes, since the roots can be pulled easily from such soil, and without any portion of the fine roots remaining underground. Vetiver root grown on such soil can be cleaned quickly by simply shaking any adhering soil particles off the extracted root.

Whenever a new planting is started, fertilizer is applied in the form of ashes of residual vetiver root which has been distilled and used as fuel.

A new field is started on the same ground, immediately after, in fact simultaneously with the extraction of the old roots. Harvesting and planting take place from June to November. The leaves and stalks of the old plants are cut with machetes and the entire root system is pulled out of the ground by hand. The lower, fibrous parts of the root are cut off, and the remaining center parts of the root stocks (stools) are divided for replanting. The root segments are then planted out, 1 ft. apart, in rows also 1 ft. apart. The plants should be so close together that the roots, after growing, touch one another underground. This will facilitate extraction of the ensuing root crop.

Quality and Age of the Root The quality and the age (i.e. the length of time between planting and harvesting) of the root are of fundamental importance, and greatly influence the yield, physicochemical properties, and odor of the oil.

In poor soils the root will develop very little oil; hence the necessity of frequent manuring and fertilizing. After one year in the ground the root contains sufficient essential oil, but the oil will be of substandard quality. After two years in the ground, the root yields a little less essential oil, but the oil will be of excellent quality. Three-year-old root yields so little oil that distillation becomes uneconomical. It is questionable whether the content of oil actually decreases as the root stays in the ground. More likely the oil contained in old root is composed chiefly of high boiling constituents (sesquiterpene alcohols) which do not readily distill over, particularly in the low-pressure type of stills (water *and* steam distillation) used on Réunion Island.

Obviously, then, the best distillation material is two-year old root, and the distiller producers insist upon such root when purchasing from sharecroppers. The latter, however, are usually in need of cash, and like to reap a yearly crop from their fields. Producers, who have to depend for part of their root requirements upon other growers or sharecroppers, are, therefore, very careful in their selection of material, preferring to buy it from their neighbors, with whose fields they are well acquainted. Good root can be distinguished by very fine black rings, whereas superannuated root (yielding very little oil) possesses a dead, gray-brown color.

Distillation. - The root material grown on Réunion is not exported, but processed locally, in a number of rather primitive stills sheltered under simple roofs, or in wooden shacks, and distributed over the producing regions. The stills operate on the principle of water and steam distillation. Frequently, however, the water rises above the false bottom (usually made of wood) and immerses part of the charge, causing excessive wetting, which means that longer distillation is required.

Many stills are of relatively large capacity, one charge consisting of 300 to 400 kg. of root material, after it has been dried in the sun for one or two days. The water below the false bottom is brought to the boiling point with a fire kindled with wood or exhausted vetiver root. Distillation of one charge requires 36, or sometimes even 48 hr. Whenever the cost of wood is high, and the price of vetiver oil relatively low, some producers are tempted to shorten the distillation, to the detriment of the quality of the oil (cf. the section on "Distillation" in the monograph on "Oil of Vetiver Java"). Since the larger landowners and producers cannot personally supervise distillation for 36 to 48 hr., the Florentine flasks and oil receivers are sometimes enclosed in a special compartment of which the owner alone has the key. This protects against theft of oil by the laborers who, during

the night, must watch distillation, regulate the temperature of the condensers, and keep the fire burning.

In view of the difficulties connected with the distillation of vetiver, the visitor to Réunion is inclined to wonder how the distillers can produce such a good grade of oil with their primitive equipment. It is simply a matter of "know-how" acquired through many years of experience. No facilities for the automatic reflux of the distillation waters (cohobation) existing, the distillation waters are collected in barrels and used again (instead of fresh water) for the next charge. To prevent the flow of the distillate in the form of troublesome emulsions, the water inlet to the condenser is regulated so that the distillate (condensate) runs quite warm. Moreover, fuel will be saved if the warm distillation water is used again for a new batch of root in another still.

While practically all oil of vetiver in Réunion is produced in primitive direct-fire stills, there are on the island two steam distilleries, one in St. Paul, Piton, and the other one in nearby St. Paul, Grand Pourpier, which in years past produced limited quantities of vetiver oil by steam distillation. These oils, therefore, resembled the higher type of vetiver oil distilled in Europe and America from imported root material.

The process applied in the two plants in St. Paul is, in reality, a combined form of direct steam, and water and steam distillation. The root material is charged above a false bottom, and direct steam is injected through a steam coil. The distillation water is returned warm into the still, i.e., cohobated. When the water in the still reaches a certain level above the false bottom, the direct steam is turned off, and distillation is continued by indirect steam (steam jacket). Here, too, the distillation water is automatically cohobated. The proper quantity of water in the still and a warm flow of the distillate are of great importance for successful distillation. Distillation of one batch requires 24 hr., 15 of which are for actual distillation. Due to relatively high cost of labor and fuel, the two distilleries in St. Paul in 1935 discontinued production of vetiver oil, other products, such as cane sugar and rum, being more remunerative.

The small lots of oil produced in the various distillation posts are purchased by field brokers and sold to exporters in St. Denis, who first have to filter the oil, and free it of small quantities of water. Combined lots are analyzed in the official control laboratory in St. Denis and then shipped abroad.

Yield of Oil As was pointed out in the section on "Quantity and Age of the Root," the yield of oil depends upon the age of the root material. Two year-old root of best quality, distilled for 36 hr. in the primitive type of still used in Réunion, yields from 0.8 to 1 per cent of oil. The same root material, if processed in modern steam stills, may yield 1.5 to 2 per cent. In general, the yield of vetiver root oil in Réunion ranges from 0.6 to 1.2 percent.

Physicochemical Properties - Oils distilled from young (about one year old) roots exhibit a low specific gravity, a low optical rotation ($_{\infty}D$ + 13° to +17°), and a poor solubility, a result, probably, of the predominance of terpenes and sesquiterpenes, rather than of sesquiterpene alcohols (cf. "Chemical Composition of Vetiver Oil"). The odor of the oils distilled from young roots is "green", "earthy," and slightly harsh. Prior to World War II the government of the island, in collaboration with the Chamber of Commerce in St. Denis, enacted a ruling by which such oils, when exported, must be marked "substandard in regard to specific gravity" or "substandard in regard to optical rotation."

Adulteration. Vetiver oils imported from Réunion are usually pure, because the producers and exporters in Réunion are not familiar with the methods of "skillful" adulteration. Moreover, Réunion is a small island, and imports of any products which could be used for the purpose of essential oil adulteration would at once arouse the suspicion of the custom authorities. Dishonest field brokers and Chinese middlemen occasionally resort to alcohol, kerosene, or fatty oils as adulterants, but such additions are readily detected in the official control laboratory in St. Denis, which examines every outgoing shipment.

Total Production -prior to World War II, annual production of vetiver oil in Réunion varied from 5 to 12 metric tons, depending on the competition and the price of the Java oil. During World War II competition with Java was eliminated, and prices of the Reunion oil rose sharply. In December 1945, prices were as high as $75.00 per kg. of oil. In the same year Réunion produced about 15 tons of oil. The future development of the industry will depend upon the reappearance of the Java oil on the world market.

Chemical Composition of Vetiver Oil

The first investigations of the chemical composition of this important oil date back to the beginning of the twentieth century, when Theulier fractionated vetiver oils distilled in Grasse (A. M.), France, and on the Island of Réunion and studied the physicochemical properties of the fractions b_{25}) thus obtained. Other investigations were carried out by Franz Fritzche & Co.Genvresse and Langlois and Semmler, Risse and Schröter· However, in the light of the latest findings mentioned below, the conclusions reached by these authors cannot be fully accepted. Research on the chemical composition of this oil has been beset with considerable difficulties; and it is only lately that we have obtained a better, although still incomplete, insight into this complicated subject. Up to the present the following constituents have been identified in vetiver oil:

Alpha and beta Vetivone (Vetiverone). According to Pfau and Plattner, Java and Réunion vetiver oils contain from 7.8 to 35.1 percent (in most cases, from 15 to 27 percent) of ketones, determined by the hydroxylamine method. By oximation, Sabetay and Trahaud estimated a ketone content ranging from 12 to 13 percent. The odor of vetiver oil is due chiefly to the ketonic sesquiterpenes $C_{15}H_{22}O$ (bicyclic and alpha ethylenic), of which only alpha vetivone and

beta vetivone have so far been isolated. For details pertaining to these apparently stereoisomeric substances.

Vetivenols, (Vetiverols). The alcohols occurring in vetiver oil were investigated first by Franz Fritzsche & Co· later by Genvresse and Langlois but in both in instances with inconclusive results. According to our present knowledge, at least 60 per cent of the sesquiterpene alcohols occurring in Java vetiver oil seem to consist of a mixture of prirnary alcohols $C_{15}H_{22}O$, in which a tricyclic alcohol largely predominates, whereas the bicyclic alcohols amount to only about 10% of the mixture of primary sesquiterpene alcohols. The tertiary (bicyclic) sesquiterpene alcohols present in Java Vetiver oil also seem to be a mixture. They amount to about one third of the total Sesquiterpene alcohol fraction of the oil.

Réunion vetiver oil contains a similar mixture of sesquiterpene alcohols $C_{15}H_{22}O$, which consists of a primary bicyclic alcohol and a tertiary tricyclic alcohol. Depending upon their origin and quality, vetiver oils contain from 45 to 65 per cent of free sesquiterpene alcohols (observations in the laboratories of Fritzsche Brothers, Inc., New York).

Vetivenyl Vetivenate. In the fraction $b_{o.3}$ 170˚ - 250˚ of vetiver oil, Ruzicka, Capato and Huyser observed an ester which, on saponification with a 10 per cent alcoholic potassium hydroxide solution, yielded the tricyclic vetivenic acid, $C_{15}H_{22}O$, a viscous oil $d^{20/}{}_4$ 1.0748, $n^{20/}{}_D$ 1.5203. Treating the neutral saponificetion products with phthalic anhydride, these authors obtained a primary tricyclic sesquiterpene alcohol $C_{15}H_{22}O$, b_{12} 160˚-162˚, $d^{15/}{}_4$ 1.0186 $n^{15/}{}_D$ 1.5251.

Vetivenic acid had previously been observed in Vetiver oil by Semmler, Rinse and Schroter and before them by Genvresse' and Langlois and by Bacon. The proper empirical molecular formula, $C_{15}H_{22}O$ was established by Sesmmler and collaborators. Genvresse and Langlois expressed the opinion that the characteristic odor of vetiver oil is due to the ester which vetivenic acid forms with vetivenol. The ester readily hydrolyzes, even under the influence of water.

Palmitic Acid. In a vetiver oil which for a period of time had been stored in a tin-lined vessel, Schimmel & Co. observed the crystalline zinc salt of palmitic acid, which permits the conclusion that this acid is a constituent of vetiver oil.

Benzoic Acid. Bacon reported the presence, in a sample of vetiver oil, of considerable quantities of benzoic acid.

Oil of Vetiver Haiti

Chief producer of vetiver oil in the West Indies is the small Republic of Haiti, part of the historical island of Hispaniola where Columbus established his first settlement in the New World. Nothing is known about the introduction of vetiver to Haiti, but the root has been grown there for a long time. The plant has escaped cultivation and now grows wild and semi-wild over wide areas of the island *(Ed, ...I wonder if the cultivars originated from North India. It would be interesting to do some DNA testing on this material)*. It was formerly planted along roadsides and on the edges of fields. For generations the dried leaves (grassy part) have been used by the natives for the thatching of their huts, little attention being paid to the roots, except that occasionally they have been sold in the towns for the scenting of linen or as insect repellents. Most of the root material was allowed to remain in the ground, with the result that much of that collected today for oil distillation originates from very old plants. (As was explained in the monographs on "Oil of Vetiver Java" and "Oil of Vetiver Réunion, "the age of the root material exerts a considerable influence upon the quality of the oil.) Recently the importance of vetiver for soil conservation has been recognized in Haiti, and today vetiver is planted extensively as a protection against soil erosion. It is estimated that about 4,000 acres are now under cultivation on the island. These, about 600 acres have been planted on large fields for the special purpose of oil production, particularly on the small island of Ile à Vaches and in the Plaine des Cayes. Small peasant plantings are located in Kenscoff, Dondon, Plaisance, Limbé, La Vallee de Jacmel, Bainet, Dame-Marie, and Chambellan. At St. Michel de l'Attalaye small planting experiments are being conducted in heavy black soil.

Vetiver is planted by division of the root stocks (stools), from which three to six new plants can be obtained, depending upon the age of the old stock. The plants are set out 2 to 3 ft. apart. The most favorable time for planting is in the spring, i.e., in the rainy season. The root material is extracted from the ground, usually in the rainy season, at which time the earth is softer than in the dry season. Harvesting of the roots is a tedious task, particularly in heavy clay. The roots are dried in the shade sun-drying causing some loss of oil. Only the slender and fibrous parts of the root system are distilled. They are not triturated prior to distillation.

Distillation is carried out chiefly in two well equipped distilleries, one located in Maniche, the other in Ducis (Aux Cayes, in the southern part of Haiti). Care must be exercised not to pack the charge in the stills too tightly. Distillation of one charge lasts from 36 to 72 hr. The older the root material, the longer it has to be distilled. Young roots are exhausted after 12 to 16 hr., but they yield an oil of low specific gravity and "green" or 'earthy" odor. The heavy fractions of the oil are collected in large separating vats, arranged in sequence, to allow emulsified oil to separate at the bottom. After completion of the distillation, the lighter-than-water and heavier-than-water fractions are mixed and run through a centrifuge, to remove traces of water. After having been freed of water, the oil is once more centrifuged; traces of sediments are retained in the clarifying bowl. The final limpid oil exhibits a color ranging from light amber to almost black. The color depends upon the material of which the stills are constructed, and, according to Dejoie upon the iron content

of the soil in which the plants have been grown. As was pointed out in the monographs on Java and Réunion Vetiver Oils, only roots of a certain age develop the full fragrance of a high-grade vetiver oil, but such roots give a low yield of oil. Plants less than two years old should never be distilled.

As regards the yield of oil, experiments conducted by Dejoie in Aux Cayes indicate that fertility of the soil is the principal factor in successful vetiver oil production. The richer the soil, the higher will be the yield of oil per ton of root material. Vetiver grown in sandy seashore land does not yield more than 0.5 per cent of oil, not withstanding the size of the leafy over-ground part of the plant. (There is no relation between the size of the leaves and the content of oil in the roots.) In general, the yield of oil varies from 1 to 1.5 per cent. In roots from very rich soil it may occasionally reach 2 per cent; but in Haiti such fertile soils are usually planted with sugar cane or other staple food crops. Only the poorest (and particularly the eroded) sections are planted with vetiver. In consequence, root material collected from mountainous sections usually yields less oil than root from the plains. However, the quality of the former is often better, the oil possessing a higher specific gravity and a fuller, more lasting odor.

The vetiver oil produced in Haiti differs from those produced in Java and Réunion in regard to odor, physicochemical properties, and chemical composition. The Haitian oil is of very good quality; it has a high content of vetiverol, the principal constituent of all vetiver oils. For this reason the oil seems to be particularly useful as a starting material for the isolation of vetiverol and its conversion to vetiveryl acetate. The odor of the Haitian oil is rich, full, and lasting; its color usually dark. The properties characteristic of the Haitian oil are probably attributable to the unusual length of time the root has been permitted to remain in the ground (see above). The odor of the Haitian oil being somewhat different from that of the other types, the Haitian product cannot always replace the Java and Réunion oils in established perfume formulas. Preliminary experiments ought to be made whenever such a change is contemplated. In the author's opinion the Haiti oil should be marketed as a separate and distinct type of vetiver oil, the label indicating its origin.

Oil Of Vetiver Brazil

The development of the Brazilian vetiver oil industry resembles that of Brazilian lemon grass oil (cf. the monograph on "Oil of Lemongrass Brazilian"). The oil is produced on the same large estate in the State of Sao Paulo, and by similar modern methods. In the course of World War II the plantings were increased to several hundred acres, and the oil found a ready market in Brazil, Argentina, and other South American countries. The future development of the Brazilian vetiver oil industry will depend upon the demand for the oil as well as upon its price on the world market. The latter, of course, is influenced chiefly by the quantity of Java oil available, and to a lesser degree of the Réunion oil.

In the Araraquara region of Sao Paulo, soil and climatic conditions favor the growth of vetiver. Plants grown in light sandy soil yield a much larger proportion of fine roots than those grown in heavy "terra rocha" (red laterite). In the latter case a good part of the fibrous root will remain in the ground when the stocks are pulled out. Moreover, more water is required for the washing of the harvested root material when the root originates from a heavy soil. Only roots at least sixteen months old are dug up, which precaution, combined with the use of modern distilling equipment, assures the production of a high-grade oil.

Vetiver may be planted at any time of the year provided there is rain, but the most favorable months are November to February, when rainfall is assured. Furthermore, if set out during these months the plants will usually flower in the same season. Since the fine, hairy, oil-bearing rootlets develope only after the flowering period, some time will be saved by planting early in the rainy season; otherwise the plants tend to lie dormant or, at best, to produce only coarse roots which yield an inferior oil. Planting is done by subdivision of the root stocks. Most of the fine, hairy root system is separated and set aside for distillation, but some of the fine roots must be left on the stock for replanting. Planting stock may be stored in the shade until the root divisions can be set out in the fields, but exposure to the sunlight for a few days will do no harm as the plants are actually quite hardy. Since the grass tops have to be cut off, prior to planting, in any case, they can be used as cover and shade for the piles of root awaiting planting. The methods of planting resemble those employed with lemongrass. The grassy tops are cut off to within 6 or 9 in. of the root, the clumps are then split with a machete into divisions of 3 to 4 shoots each, after which the latter are set into holes previously dug with a crowbar or other implements. The distance between the plants is 0.5 m., that between the rows 1 m. The root divisions are firmed into the earth with a pole, or by treading with the feet.

Scarcity of agricultural labor in Brazil has made it necessary to mechanize the production of vetiver as much as possible. The primitive methods used in some parts of the world would not allow for a large acreage to be harvested within a few months. In Brazil vetiver producers follow this procedure: when about sixteen months old and 2 to 3 m. high, the grass is cut roughly with scythes, left in the field to dry for a few days, and then burned off. By this method, both the cut grass and that left protruding from the ground are disposed of. The ash serves as fertilizer. In dry weather the burning takes place so quickly that the flames have no time to heat up more than, say, 1 cm. of the surface earth, with the result that the roots are not damaged by heat. After the fire has died out, the hard cores protruding from the ground are chopped off level with the ground by means of mattocks, and cleaned away. The plantation, now clear of surface vegetation and trash, is plowed with a disc plow, tractor-drawn. The earth is turned over to a depth of about 35 cm.; it contains all the root material, with the exception of a few coarse taproots. Deeper plowing would not compensate

for the very small extra yield obtainable at, say, 40 cm. depth.

Once the plowing is finished, the loosened earth and freed root material are treated in batteries of shaking machines provided with screens. Mixed soil and earth are shoveled on top of the screens. The roots stay on the shaker screens, while the soil falls through the meshes and piles up beneath the machine. At intervals the root material is cleaned off the screens and collected in heaps. Being of light weight, the shaker machines are moved along the rows to continue operation. Four men accompany each machine, and about one dozen machines operate in a row. At the end of the day the collected roots are carted away, while the piles of sifted earth are leveled by tractors. All the work is done on a contract basis, and paid for per weight of dry, uncleaned root, as it comes from the field. Thus each day's harvest is weighed before further treatment.

On poor, highly acid soil the yield of root per alqueira paulista (1 alqueira paulista equals roughly 2.5 hectares or 6 acres) averages 700 kg., whereas on well-fertilized and irrigated soil it may be as high as 1,300 kg. The uncleaned root material is hauled from the fields to large concrete washing tanks, cleaned of adhering earth by washing, and spread on extensive "terreiros" or drying grounds made of bricks (such as are used for washing and drying of coffee). Here the root is turned over at regular intervals until dry, and any foreign matter is removed. The cleaned and dried roots are finally sacked for transportation to the distillery or storage shed, where they are allowed to mature (age).

Before distillation, the root is again weighed and passed through a motorized driven cutter which reduces the length of fiber to about 1 in. The stills, which hold about 600 kg. of dried root, are loaded, and the charge is tramped down evenly, during which time a stream of water plays on the material. After the charge has been soaked for a period, distillation is started, first with direct steam and later with indirect steam (by means of pressure steam coils), the pressure being varied and regulated as dictated by the progress of distillation. All the condensed water is cohobated and the oil collected in separating tanks. Distillation of one charge (600 kg. of dried root) requires about 36 hr. The lighter-than-water and heavier-than-water oil fractions are mixed and transferred, together with some water in emulsion form, to the separating room, where the oil is freed of water by centrifuging. The clear oil is then placed into cans of 5 0r 18 kg capacity, and whenever possible, left to age and mature.

It should be noted that aging for a period of six months improves the odor of the oil substantially; the harsh, "green" and earthy odor characteristics of the freshly distilled oil will disappear and develop into a fuller, heavier, and sweeter odor.

Young plants do not possess the same proportion of fine, hairy roots as do plants which have been in the ground more than sixteen months; on distillation roots from young plants give a low yield of oil. The color of such an oil is gene, the odor harsh, the specific gravity subnormal (low).

Oil of Vetiver India

In the Central Indian State of Uttar Pradesh (perhaps the most important area for vetiver production in the whole of India) no attempt is made to cultivate the roots. Roots growing wild in the extensive forest areas of the state are dug out and distilled insitu. Although these roots are said to yield only 0.2 to 0.3 percent oil, the industry has been able to operate profitably because there are few cultivation expenses beyond payment of a royalty to the state. *(Ed. ..... this vetiver is nowadays described as the north Indian cultivar - a seedy type, and different to that of south India)* The production of vetiver oil in India increased during World War II, due to the steep rise in price a result of the complete stoppage of imports from Java. This condition stimulated several private and state efforts toward a scientific study of the cultivation and distillation of this valuable and neglected crop. The most important work along these lines is that sanctioned by the Government of Madras, and carried out by the Kerala Soap Institute, Calicut.

According to Murti and Moosad, the white sandy soil on the west coast of southern India were first considered to be the best suited to the cultivation of this crop. Cultivation and distillation experiments carried out by Murti and Moosad, however, proved that pure (white) sandy soils not suited to the growing of vetiver. The root on distillation (for 16 hr.) yielded only 0.18 to 2.22 percent oil. Root grown in red laterite loam, on the other hand, yielded from 0.76 to 0.94 percent oil. Root grown on red laterite with very little sand yielded 1.02 percent oil. In all experiments root of 18 months was used. In two years of experimentation the roots produced in loamy soils were found to be thick and wiry, with only a small proportion of hairy rootlets, whereas the roots grown in sandy soil were thin and hairy.

So far as the maturity of the roots at harvest time is concerned, Murti and Moosad found by systematic experiments that the oil content increases progressively up to twenty-one months (yield 0.87 percent); at ten months it is 0.10 percent, at fifteen months 0.56 percent, at seventeen months 0.79 percent. It is definitely uneconomical to harvest before a minimum maturity of fifteen months, while a period of twenty-one or twenty-four months will also be uneconomical. A period of maturity of fifteen to eighteen months for the roots in the soil may be considered the optimum. In these experiments Murti and Moosad harvested the root during the dry period.

The same authors also found that at twenty-four and twenty-five months maturity the roots yield only 0.25 and 0.20 percent of oil, respectively. However, in these two cases the root was dug up during the rainy season. It may well be that the drop in oil content of the root, twenty-four and twenty five months old, was due to washing out of a part of the oil from the underground roots during heavy rains.

Data on manuring showed that fertilizing with ammonium sulfate, brine manure, and groundnut cake increases the oil content of the roots to some extent, but the increase is far less than that of roots cultivated in a good .....

[Article incomplete]

Large Scale Mechanized Runoff Water Harvesting: Prospects For Future R&D Activities.

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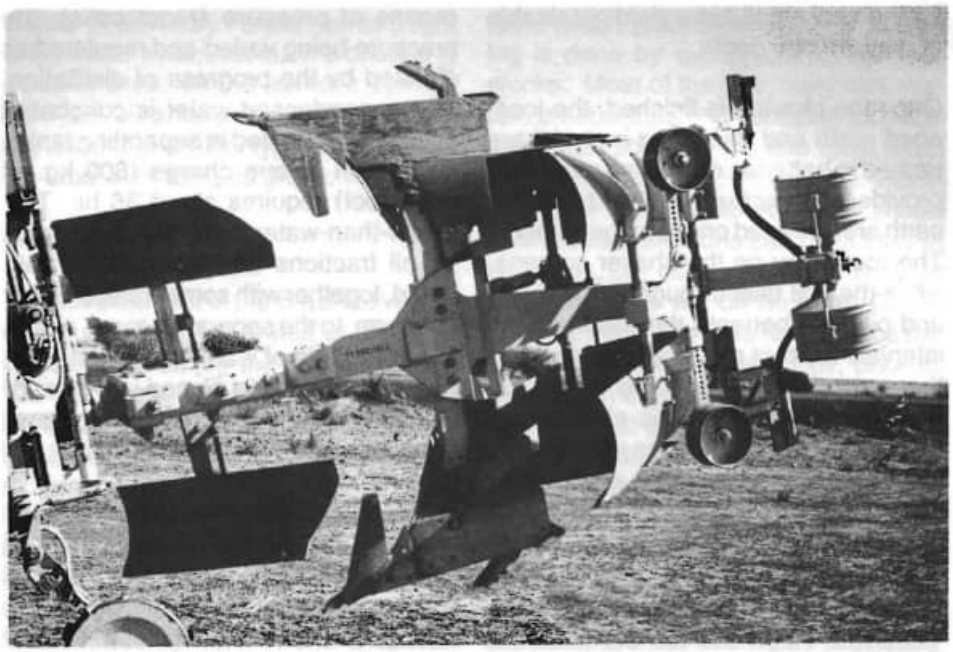

Photo 18. Reversable Dolphin plough. Close up view. Note seed drill at rear. **Photo credit. Domenico Bruzzone**

Brief presentation of the technique. Throughout the last decade, development of micro-catchment systems for runoff water harvesting purposes (runoff farming) was increasingly considered amongst the most suitable strategies for improving soil productivity in semi-arid and arid areas, where rangeland, fodder, trees, or crop production schemes are hampered by harsh soil and hydric conditions; on the other hand, implementation of efficient water harvesting systems represents sometimes a costly exercise, and can be of difficult optimization: thus, it is widely accepted that micro-catchment schemes and other water harvesting methods have to conform with a set of primary criteria, amongst which the essential are those related to land configuration and slope, soil characteristics and quality, economics of operation (1.).

Photo 17. Reversable Dolphin ploughin operation in Niger on black, flat and very dry soil conditions - "V" ditching. **Photo credit. Domenico Bruzzone**

New perspectives for optimized and economical runoff water harvesting practices were opened - after preliminary field trials (2., 3., 4.) by the application of specialized mechanization schemes to small-scale hand dug systems for semi-circular bunds making (the so-called demi-lunettes or croissant fertiles in most Sahelian Countries), which led to the design of a powerful system for large-scale applications of semi-circular bunds or discontinuous furrows making.

The ploughs prepare soil by a regular and sequential digging operation, either by excavating crescent-shaped micro-basins (i.e. the 'dolphin' -t ype ridger), or by digging discontinuous furrows (the 'train' type ridger) for runoff water harvesting. The "Dolphin" hydraulic, single-furrow plough for programmable, discontinuous ploughing, has been tested in afforestation schemes, reclamation trials of marginal lands and in trials for im-

proving pastures and rangelands; one plough device, combined with a 160 HP tractor, can treat up to 10-15 hectares per day after the digging operation of ca. 10-15 micro-pits per minute or, 4500-7000 micro-pits per day; the size of microbasins being of 5x0.5x0.45m (plus approx.20 cm of subsoiling). The potential of the technique, as compared with the traditional, small-scale hand dug is therefore impressive.

The technique allows the direct seeding operation of trees and shrubs, with improved rooting rates, that might disclose unprecedented prospects for reforestation and desert reclamation action programmes in arid and semi-arid areas, thus escaping the problems associated with seedlings transplantation processes: transplanting stress, curbed development of the rooting systems, and the associated reduction of plant resistance to drought.

The reversible, single-furrow plough for double-layer ploughing, with sub-soiler, was designed to prepare soil with furrows, excavated at intervals (discontinuous furrows): the plough is equipped with a device that aggregates and lays down into the furrow the fertile top soil layer separated during the ploughing process; the plough has been tested for improving lands within agro-sylvo-pastoral schemes and for afforestation trials on plain, hard soils of colluvial origin, or slightly sloping soils, on contour lines. The plough allows large-scale optimum tillage of soil surfaces under conditions of poor rainfall and soil fertility, after recovery and concentration of the top-soil layer, gathered in the furrows and by promoting the sinking process of runoff water within the furrows, at a rate directly related with the extent of the uncultivated soil strip.

A ripper is also designed for the improvement of natural pasture lands and an injection seeding device is allowing to carry out direct seeding of shrubs and trees seeds, thus promoting pre-germination and early development of tap roots.

Due to the potential and considerable technical interest displayed after the first trials, a similar project device, clearly inspired to the dolphin-type plough concept was designed and constructed in the frame of a separate research project (5.).

The direct seeding operation is conceived as a key developmental issue in the greening process of the mechanized micro-catchment system, for it can allow skirting the nursery and transplanting operation, with important effect on plant biology (tolerance quality) and on the economy of the process.

The technique was tested in the frame of major integrated rural development schemes and related operations, after the first trials carried out in the Department of Zinder (Niger), at the Projet Intégré de Réhabilitation du Damergou (PIRD), financed by the former Italian Authority for Development Co-operation, Fondo Aiuti Italiani - FAI, 1986-1988.

Conclusions.

The building of micro-catchment systems by the special ploughs technique allows mechanical treatment of vast land surfaces so as to convey, gather and concentrate the runoff water within the room of the excavated pits or furrows, where sowing or transplanting of vegetation can be carried out adopting annual or perennial plant species; it is reported (6.) that the performance of this technique, coupled with adequate standards of field operation management and control, resulted, under favorable conditions, in impressive biomass production; in the same account, information is provided on the costs involved with the adoption of this technique.

Very schematically, it can be stated that the technique appears to offer the prospects for developing micro-catchment systems for large-scale runoff water harvesting, with low-cost equipment, economic operation, minor manpower requirement and, with a direct-seeding system, avoidance of the costly nursery and transplanting operations.

While ploughing trials appeared impressive in most cases, and extremely encouraging in some other circumstances, as it has been documented, and the technical package has displayed its potential for practical application, the output results of trials were not duly appraised by the classical probability analysis methods and experimental design, assessment with data from control areas, and after application of standard schemes for the monitoring of figures. Therefore, a considerable share of the available technical information, is only descriptive or anecdotal, with monitoring data limited to some basic assessments on vegetation patterns resulting from plough testing.

A detailed analysis of the Dolphin and train plough application has been conducted in the frame of a GTZ financed project in Niger - the Projet de Développement Rural Tahoua (PDRT) where some economic considerations on the technique have been taken into account.

Technical specifications of ploughs

Technical specifications of the dolphin hydraulic single-furrow plough for discontinuous ploughing (Mod 40 MI/CM): micro-pits size: length: 3-5 m; width: 40-60 cm; depth: 40-50 cm; programmable distance of pits along the row: l-2 m; subsoiling beyond furrow bottom: 15-25 cm; working speed: 50-70m1/min (tractor power: 160-180 HP).

Technical specifications of the train reversible single-furrow plough for double-layer ploughing, with subsoiler (Mod Por 130-119 Mz/RCM): furrow size: depth: 40-50 cm; width: 45-50 cm; surface fertile layer tillage: depth: 5-10 cm; width: 45-50 cm; sub-soiling beyond furrow bottom: 15-20 cm; deployment of fertile topsoil at programmable intervals, from2.5 to 5 m; tractor power: 160 -180 HP.

Photo 19. *The All American Disc for reclaiming road shoulders shown here attached to a farm tractor.*
Photo Credit. Bill Doyle

Shoulder Reclaimer Saves Time, Money.

by *Thomas 0. Zimmerman Highway maintenance supervisor Wisdom District, Minnesota*

Each spring many gravel road shoulders must be reconstructed ridges and ruts removed, inslopes reshaped, among other things to reverse the effects of the previous winter. Standard repair methods require a virtual parade of graders, rollers, mixers, and other equipment (and sometimes thousands of yards of new aggregate), all at considerable expense. To help streamline this process and reduce costs, Minnesota Department of Transportation (Mn/DOT) is testing a new wing-mounted disc designed to eliminate the outside ridge that develops from routine blading and "reclaim" gravel from that portion of the roadway. In one particular operation, the shoulder reclaimer saved Mn/DOT over $2,400 per mile compared with the previous method, while accomplishing the same result. The cost of the disc-approximately $5,000 was recovered in just a little over two miles of shoulder reconstruction.

The Windom District purchased the new disc in spring 1992 using funds from Mn/DOT's Maintenance Operations and Research Division experimental equipment initiative. The disc consists of 12 disc plates mounted on a very heavy duty frame (see photo). Although it requires no modifications for mounting, the Windom district did modify the unit by adding chain links between the discs, to prevent dirt and mud build-up.

Better Results, Less Equipment

The first usage of the disc was on Minnesota TH60 just west of the Brewster city limits, in spring 1992. The previous year (1991) Mn/DOT had narrowed the inslope of the shoulders and reclaimed gravel that had been thrown into the ditch by snowplows. The operation consisted of two and sometimes three motor graders, two rubber tire rollers, three loader tractors, a Ceman mixer, a water truck, and one person for traffic control. Between a quarter and a half mile were reclaimed per day. The motor graders first windrowed the gravel along the edge of the roadway, then proceeded to move the dirt from the ditch bottom up the slope to the edge of the shoulder. When the blades created a windrow, the mixer would go across it to break up the clumps of dirt and sod. This was necessary to properly shape and compact the new inslope. The cost of this operation was $2291.92 per mile on one side only. In 1992 Windom again repaired the shoulders on TH60, this time with the new disc mounted on a motor grader In contrast to the old method, only two motor graders, one roller, and one person for traffic control were needed. With the disc, the roller operator did not have to wait for the mixer to cross The windrows, which enabled the roller to operate more frequently. This in turn meant one roller was eliminated from the operation. After some experience with the disc, workers were able to reclaim one mile of shoulder per day in one direction, with more time and practice this rate could possibly increase by about another mile on both sides per day. We were unable to confirm this in 1993 because the extreme moisture prevented us from performing this type of operation, but we will resume testing this spring, weather permitting. The cost of the operation with this equipment was $963.60 per mile.

The Windom District used the disc chiefly on narrow gravel shoulders. A typical operation had previously taken three days for 48 lane miles of shoulders, resulting in a shoulder full of clumps and grass. With the disc the same road is reclaimed in one day with much better results a shoulder with no trough, and the grass and sod chopped up-leaving an attractive shoulder. The disc has worked well for other uses, such as eliminating ridges on wide shoulders, minor narrowing of wide shoulders, re-establishing water flow in the bottom of ditches, and removing ruts left by trucks along interstate ramps.

Conclusion

The Windom District has been able to maintain more shoulders with the new disc simply because of the resulting time savings. In the past some shoulders had been difficult due to excessive sod build up, last year we were able to disc them two to three times because we were able to cover more ground more frequently.

Other districts have also tested the disc, with very positive reports to date. If you would like further information or wish to borrow a video tape of the disk please contact Doyle Incorporated Equipmen, PO Box 89947, Sioux Falls, South Dakota 57105, USA. at (612) 890-3326, or (800) 658-5491. *(Ed. .... Note, Bill Doyle manufactures the equipment to fit on the three point hitch of a farm tractor. It could therefore be easily used in most parts of the developing world with good effect)*

Spanish Readers Column

The following paper was presented in English at the International Soils Congress in Mexico in July 1994. Kevin O'Sullivan had it translated into Spanish for his associates in southern Mexico. I have copied it to the newsletter so that those growing number of vetiver uses in Spanish speaking countries can take advantage of its content.

Articulo presentado en el Congreso Internacional sobre Suelos que se llevó a cabo en Acapulco, México, en julio de 1994.

El papel del Pasto Vetiver en el sostenimiento de la productividad agrícola

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Sumario

El artículo resume los resultados experimentales y observaciones de campo del uso del pasto vetiver, Vetiveria zizanioides, y señala su uso como un importante y efectivo seto vegetativo que, cuando crece en el contorno, reduce significativamente el flujo de sedimento de sitios en erosión y reduce el desagúe, ambos simultaneamente y a bajo costo, comparado con las practicas de ingeniería tradicionales. El pasto vetiver posee características únicas. El articulo también muestra evidencias de que el pasto vetiver crece en un amplio rango de condiciones locales; no compite con cultivos contiguos; no es una mala hierba; resiste las plagas y enfermedades; es utilizado como forraje para el ganado; es usado para estabilizar terraplenes, lineas de drenaje, caminos, etc.; resiste al fuego y se sabe que es repelente de roedores; y requiere de un mínimo de mantenimiento. El principal obstculo para extender su utilización y aplicación se debe a un pobre sistema de transferencia de tecnología y a la falta de entrenamiento de granjeros y técnicos.

Introducción

El presente artículo resume los descubrimientos experimentales y las observaciones del escritor en el resurgimiento del uso del pasto vetiver como una tecnología importante en el sostenimiento de la productividad agrícola en tierras tropicales y semitropicales. Como resultado de una precoz iniciativa del Banco Mundial [1], el pasto vetiver fue introducido a los proyectos de desarrollo en la India como un sistema vegetativo de bajo costo para la conservación del agua y el suelo.
Su utilidad y potencial fue ampliado aún mas en posteriores artículos [2, 3, 4, 5 y 6]. Este artículo se dedica a resumir los hallazgos de un creciente número de científicos independientes y usuarios del pasto vetiver quienes, en años recientes, han demostrado la singularidad del pasto y su utilidad como una tecnología formidable para incrementar la humedad de la tierra y en la conservación del suelo.

El mantenimiento de la fertilidad del suelo y la disponibilidad de humedad en la tierra son los dos mas importantes elementos críticos para la producción agrícola sostenible. La prioridad dada a estas dos actividades durante los últimos cuatro mil años ha permitido a China sobrevivir y alimentar a su enorme población [7], en el pasado lo mismo que en la actualidad, mientras otras sociedades se han desmoronado por no haber mantenido estas actividades clave. En un tiempo en que se presta una gran atención a la tecnología simple de bajo costo para la agricultura sostenible, el pasto vetiver ofrece una tecnología muy buena, amplia y fácilmente aplicable que es practica, probada, efectiva y beneficiosa.

La Tecnología del Pasto Vetiver (VCT), en su forma mas común, es simplemente el establecimiento de una barrera viva, estrecha (de menos de un metro de ancho) y firme de pasto, en forma de seto vivo, a lo largo de la pendiente de un terreno. Cuando se aplica correctamente, esta tecnología es efectiva en pendientes de menos de 1% y hasta de 100% de inclinación. Un seto de pasto vetiver bien establecido retardará el agua rodada, esparciéndolo uniformemente, y atrapará los sedimentos del agua rodada para crear terrazas naturales. Todo esto es posible sin el uso de complejos detalles y diseño hidrológicos y sin necesidad de caros consultores y topógrafos. Es una tecnología realmente de los campesinos, creada por los campesinos; una tecnología que pasó desapercibida por la mayoría de los desarrolladores y científicos. Su singularidad radica en las características de la planta.

Material y métodos

La hipótesis que sustenta el uso de VCT fue establecida en un pequeño manual para campesinos, ahora en su tercera edición, "Vetiver Crass (Vetiveria zizanioides). A Method of Soil and Moisture Conservation" [8 y 9]. Las afirmaciones que fueron hechas a la VCT en esa primera edición, lo mismo que en las subsecuentes [10], fueron en ocasiones refutadas por los investigadores, y como resultado, han sido y continúan siendo intensamente investigadas por numerosos científicos y campesinos. Este artículo tiene su origen en estos trabajos, y es respaldado por las propias observaciones del autor en países de Asia, Africa, Centroamérica y el Caribe. Describe los resultados de las pruebas y experimentos, y cita a los autores. En ocasiones el artículo reporta observaciones que no están respaldadas por una investigación, pero son conclusivas por su sola existencia bajo las condiciones descritas.

Resultados y discusión

Denuncia núm. 1. Un seto de pasto vetiver es una medida efectiva par la conservación del suelo y la humedad.

En investigaciones en ICRISAT, India [11], se comparó la VCT con barreras de piedra, té limón y la tierra descubierta (como control) bajo condiciones de lluvia naturales (precipitación total de 689 mm) y artificiales. En todos los casos la VCT fue la tecnología más efectiva para reducir la pérdida de tierra y agua. La VCT redujo 57% las corrientes de agua rodada y más del 80% la pérdida de suelo. Los resultados mostraron claramente a partir de la hidrografía experimental el mayor retardo en la liberación del agua rodada de las parcelas de vetiver, una interesante característica que podría ser aplicada como medida superior de control de crecientes. El mismo equipo de investigadores [12] confirmó que al siguiente año el vetiver tuvo un desempeño aún mejor. El vetiver muestra una distinta mejoría en su eficiencia cuando los setos envejecen y son más densos. En CIAT, Colombia [13], el vetiver fue comparado con otros sistemas vegetativos que fueron crecidos junto con yuca. A los 11 meses (con una precipitación de 1240 mm) los setos de vetiver redujeron la pérdida de suelo de 142 toneladas por hectárea en una tierra descanpada en descanso, a 1.3 toneladas por hectárea para la yuca cultivada entre setos de vetiver. El agua rodada se redujo de 11.6% a 3.6%. Otros investigadores han reportado resultados similares. La evidencia [14] muestra una fuerte correlación positiva entre la pérdida de suelo y la reducción de agua rodada cuando la VGT se aplica al Vertisol negro en India occidental, y la VCT es significativamente superior a otros tipos de setos. En Louisiana [15], las demostraciones muestran de manera conclusiva el impacto de los setos de vetiver en la retención de sedimentos. En Malasia [16], experimentos a gran escala han demostrado que hay depósitos de sedimento sustanciales detrás de los setos de vetiver, en un caso de cerca de un metro en un año.

Los campesinos han reportado en prácticamente todos los casos el uso favorable de la VGT. Un campesino [17] ha usado el vetiver en la granja familiar de caña de azúcar en Natal, Sudáfrica, por más de 70 años como una herramienta para estabilizar los costados de los caminos. Desde 1989 ha protegido 186 hectáreas de su granja con setos de vetiver. Las pérdidas por erosión se han reducido sustancialmente y el agua rodada disminuyó al grado que en una tremenda sequía en 1992, ninguno de sus jóvenes árboles de litchi se perdió. Los usuarios de vetiver en Centroamérica, entre ellos los de Honduras [18], confirman que los setos de vetiver son el método efectivo más costeable para la conservación del suelo, como lo han hecho usuarios [19] de Etiopía y otros paises africanos. La retroalimentación de 17 granjeros en Layete, Filipinas [20], indica claramente el impacto de la VGT y su superioridad sobre otros sistemas. Debe resaltarse que el pasto vetiver puede regenerarse a partir de nudos en el tallo. Esto significa que mientras el sedimento se forma detrás y en el interior del seto de vetiver para formar una terraza, el pasto crecerá junto con la terraza - en Fidji, bajo ciertas condiciones, se han formado terrazas naturales de 3 metros de altura.

No hay evidencia que permita demostrar que los setos de pasto vetiver son inferiores a otros tipos de seto. Por el contrario, la evidencia sugiere que los setos de vetiver constituyen la barrera vegetativa más efectiva.

Afirmación núm. 2. El pasto vetiver puede crecer en una gran variedad de condiciones locales.

Investigaciones con vetiver bao condiciones salinas y sódicas en Australia, han demostratado que el pasto muestra tolerancia a elevados índices de salinidad, de hasta ECse de 15 mScm-l sin una reducción apreciable en el rendimiento de materia seca. Se han realizado investigaciones sobre la tolerancia del vetiver a un espectro de pH del suelo [22], y en ellas se ha demostrado la tolerancia del vetiver a niveles de pH tan bajos como 3.8, con niveles de toxicidad por aluminio en el suelo de 68% -según indicaciones, el vetiver puede ser una de las especies de cultivo más tolerantes (¿junto con la pastura?) a la toxicidad por aluminio. También se demostró que el vetiver podía establecerse en suelos con pH de 9.9, y que sobrevivía bien cuando se suministraban niveles apropiados de fósforo y nitrógeno. Se ha demostrado que el pasto vetiver puede crecer bajo una gran variedad de tipos, profundidades y estructuras de suelo. Se comparó el crecimiento del vetiver en cinco diferentes tipos de suelo en Malasia [23]; y aunque el crecimiento del vetiver difería de un tipo de suelo a otro, en todos los casos creció razonablemente bien. También se demostró que el vetiver puede establecerse en terrenos donde funcionaban minas de estaño, lo que lleva a la rehabilitación de esa tierra degradada. En India, el vetiver crece vigorosamente en los Vertisoles negros lo mismo que lo hace en los Alfisoles.
El vetiver crece bien en tierras altas lo mismo que en condiciones pantanosas, lo que demuestra sus características xerófitas e hidrófitas [23]. El límite de tolerancia del vetiver al frío se encuentra alrededor de los 9.5C bajo cero [24], aunque algunas plantas han logrado sobrevivir cortos períodos a l5C bajo cero [25].

La mayor limitante para el crecimiento del vetiver es la lluvia. Crece en áreas con escasa precipitación, de 300 a 400 mm, pero requiere de mayor atención. Bajo estas condiciones es más difícil que se establezca el vetiver, y debido a los extremos estacionales, causados por el sobrepastoreo, las sequías periódicas, etc., el vetiver sufre al igual que otras plantas. Como una regla empírica, el vetiver crece bajo más condiciones locales a lo largo de tierras tropicales y semitropicales. Lo hace mejor en suelos bien drenados. No crece en áreas con heladas invernales, y donde existan condiciones de escarcha permanente. Excepto por efecto de la temperatura, el vetiver puede crecer en la mayoría de las altitudes. En Honduras [18] el

vetiver crece muy bien a dos mil 800 metros. Se han establecido setos de vetiver en el occidente de Etiopía a dos mil metros [26]. El vetiver ha sobrevivido en la nieve a tres mil metros en Lesotho [27]. El vetiver tiene un gran potencial para crecer en áreas salinas [28] en Australia, y fue utilizado con éxito en la rehabilitación de tierras sódicas abandonadas en Ussar, al noroeste de la India [6].

Toda la evidencia apunta a la tolerancia del vetiver a una amplia gama de condiciones locales, incluyendo aquellas que pueden ser consideradas extremadamente hostiles para el crecimiento de la planta. El vetiver será aún mas adaptable a diferenes sitios cuando sean identificadas condiciones más específicas a las condiciones locales.

Afirmación núm. 3. El pasto vetiver no compite con los cultivos adyacentes.

La mayoría de la evidencia indica que el vetiver no reduce de manera significativa el rendimiento de los cultivos adyacentes. Experimentos en Colombia [13] señalan que no hay pérdida de rendimiento de yuca cuando se cultiva junto con setos de vetiver, mientras que hay una reducción del 33% con setos de pasto elefante (Pannisetum purpureum). Se han demostrado resultados experimentales semejantes en Maharashtra, India [30] y Malasia [16], que han sido confirmados por campesinos desde el sur de India hasta Fidji. Los productores de azúcar de Natal, Sudáfrica [17] y Fidji [8] reportan ganancias en la producción.

Investigaciones llevadas a cabo entre 1989 y 1991 en Akola, Maharashtra, India, en Lithic Ustorthent suelos con una precipitación promedio de 840 mm [31], muestran que los cultivos crecidos en asociación con los setos de vetiver alcanzaban niveles superiores de producción. La producción total promedio fue 17.1% y 32.3% superior en los cultivos crecidos en parcelas protegidas con vetiver, en comparación con los cultivos crecidos en terrenos con bordos y con los cultivos en pendiente, respectivamente. La mayor ganancia monetaria se registró en cultivos asociados al vetiver -6,833 rupias-, comparada con 5,969 y 5,065 rupias para graded bunds y cultivo en pendiente. La eficiencia en el uso de la humedad fue mas alta en las parcelas de vetiver, lo mismo que el nivel de nutrientes residuales. Los investigadores también compararon la eficiencia del pasto vetiver con otras barreras vegetativas. En total se hicieron cuatro comparaciones - Vetiveria zizanioides (pasto vetiver), Leucaena leucocephala (subabul), Cymbopogon flexuosus (té limón) y Chrysopogon martini (Tikhada). Los rendimientos de semilla de algodón fueron 25.5% superiores con vetiver que con el control sin tratamiento, en comparación con 24%, 15% y 11% de la Leucaena, el té limón y el Chrysopogon, respectivamente. En todos los casos, los mayores porcentajes de humedad promedio, perfil y disponibilidad del almacenamiento de la humedad, se registraron con el vetiver. Los campesinos en Filipinas señalan que el maíz y el arroz plantados cerca del seto de Mura (vetiver) se comportaron mejor [20]. Un experimento de un año en suelo rojo en ICRISAT, Hyderabad, India [12], apunta evidencia contraria que señala que el maíz, cuando se cultiva en asociación con setos de vetiver, tiene un rendimiento en grano reducido, aunque la biomasa total no se afecta. Observaciones posteriores en esas mismas parcelas podrán resolver esas contradicciones, y también podría ser más apropiado usar cultivos, como sorgo y mijo, mas comunes en el área que el maíz.

Aunque en algunos casos hay evidencia de competencia con el surco de cultivo inmediatamente adyacente a la barrera de vetiver, la mayoría de los resultados experimentales, junto con un número abrumador de reportes de campesinos señalan que no hay cambios negativos de rendimiento, y que por el contrario, la mayoría de los cultivos muestran respuestas positivas a las barreras de vetiver. Debe notarse que los setos de vetiver usan menos tierra que otros sistemas de barreras, por lo que (si todas las demás condiciones permanecen sin cambio) el rendimiento global por unidad de área debe esperarse que sea mayor.

Afirmación núm. 4. El pasto vetiver no es una mala hierba, no es invasor.

No hay pruebas de que el vetiver sea invasor en tierras altas de temporal [6]. Hay alguna evidencia de dispersión natural bajo
condiciones pantanosas [32 y 33]. En ningún lugar se le ha visto como una mala hierba amenazadora (nótese que este no es el caso de otras especies de setos, como Leuciana sp., que puede convertirse en una maleza mayor si no es manejada apropiadamente). Sus raíces no son estoloníferas, algunos de los tipos originadas en el sur de la India rara vez florean, y si lo hacen las semillas son en su mayoría estériles. Un vetiver, probablemente originario de Guatemala, cultivado ahora en Louisiana, ha estado sin floración en un mismo lugar por 25 años [34]. El vetiver se propaga vegetativamente. En Zambia, los setos de vetiver de Msamfu Research Station han permanecido intactos por mas de 60 años [8].

Uno de los principales objetivos de la revisión del National Research Council [6] del vetiver, era verificar donde podía el vetiver ser una amenaza como una mala hierba potencial. La revisión encontró que en la mayoría de los casos el vetiver no era invasor, pero recomendaba vehementemente que sólo se usaran los tipos sin semilla. La evidencia sugiere que los tipos introducidas de India a las estaciones ARS en Mississippi resultaron muy fértiles y germinaron vigorosamente. No parece ser el caso de las accessions de Le Blanc, cerca de Baton Rouge, Louisiana, ni de Boucard [35], en Leakey, Texas. Se necesita más investigación sobre los hábitos de floración del vetiver en relación al cultivo, el clima, la lluvia y la duración del día. Un diagnóstico molecular [36] vinculado con análisis biométricos rigurosos fue utilizado para identificar las relaciones entre los diferentes linajes de vetiver. Se extrajo

DNA de tejido folicular joven. Se encontró que la Coucard accession, y la que se conoce como Hauffman accession (que se cree es originaria de Guatemala) tenían esencialmente el mismo genotipo, y que eran muy diferentes de los tres tipos recibidos de la India. Se cree que mas de 20 tipos de pasto vetiver han sido introducidos a Estados Unidos. Los diagnósticos moleculares ofrecen una herramienta para identificar las diferentes tipos y para correlacionar características biológicas positivas relevantes de estos. Esto deberá llevar a un uso mas científico y controlado del vetiver, con resultados potencialmente mejores.

En Tailandia [37], mas de 30 diferentes tipos de Vetiver han sido identificados. Estos a menudo difieren marcadamente en carácter, e incluyen seis tipos de especies de vetiver identificadas como Vetiveria nemoralis. Estos incluyen algunos que tienen floración, pero que producen semillas estériles, y otras cuyas semillas germinan más libremente.

Una conclusión mas general es que en la mayoría de los lugares rara vez se ha reportado al vetiver como invasor, y si se encuentran plantas de semillas germinadas, pueden ser fácilmente removidas mediante la labranza (esta es probablemente una razón por la cual los campesinos nunca lo han visto como un problema). Hay claras diferencias entre tipos, que deben ser mejor identificadas, para que en el largo plazo puedan ser caracterizados los mas apropiados, de acuerdo a las necesidades locales.

Afirmación núm. 5. El pasto vetiver es extremadamente resistente a las plagas y enfermedades.

El vetiver es extremadamente resistente a las plagas de insectos y las enfermedades [23 y 24]. Hay evidencias de la India [38] que muestran que cuando una planta muerta de vetiver es atacada por las termitas, puede dar lugar a una reacción alelopática que evita el resurgimiento del vetiver a partir del centro de la planta, y bajo condiciones de sequía severa, los retoños de la periferia de la planta son rozados y la planta muere. De manera alternativa, y mas probablemente, el retoño es demasiado correoso para que la termita cast pueda penetrarlo. La quema puede erradicar este problema. Reportes de Brasil [39] sugieren que el vetiver es resistente a Meloidogyne javanica y M. incógnita raza 1 (nematodos de los nodos de la raíz), ambos nematodos de la raíz del tabaco. Existen reportes de China en el sentido de que el vetiver ha sido afectado por el barrenador del tallo del arroz [24], y aunque no ha afectado el crecimiento del vetiver, el último puede actuar como planta hospedera. Sin embargo, en Fujian (en el sureste de China), donde el vetiver ha sido cultivado en asociación con el arroz por muchos años, éste no parece ser un problema. En la mayoría de los casos las plagas y enfermedades del vetiver pueden ser meor controladas mediante la quema, y como se notará mas adelante en este artículo, la quema puede tener un lugar importante en el manejo general de los setos de vetiver.

La evidencia actual indica que sobretodo, el vetiver es resistente a las plagas y enfermedades, y no es vista como una planta hospedera importante.

Afirmación núm. 6. El pasto vetiver no es alimento del ganado.

Donde hay pastos más apetitosos, el pasto vetiver es normalmente ignorado por el ganado, esta es una característica importante si los setos de pasto deben permanecer intactos por muchos años. Se ha llevado a cabo muy poca investigación sobre el manejo y el valor alimenticio del vetiver como forraje. En numerosas ocasiones se ha observado, bajo condiciones agrícolas, que si el seto es manejado correctamente, es posible cosechar regularmente las hojas jóvenes, que proveen una racion de alimento. En Malasia las ovejas no comerán el vetiver en el campo si hay abundancia de especies mas apetitosas, pero las puntas recortadas fueron ávidamente consumidas cuando se ofrecieron a ovejas en cautiverio. En China y Malasia el vetiver ha sido utilizado con éxito como alimento para la cara rass. Al este de Indonesia, bajo condiciones sumamente secas, el vetiver fue comido por vacas y caballos. Con un buen manejo, las hojas jóvenes de vetiver tienen un valor nutritivo similar al pasto naperiano, con niveles de proteína cruda de alrededor del 7.0%. Bajo condiciones adecuadas, grandes volúmenes de hoja verde se encuentran disponibles. En Texas [35], en condiciones de riego, se ha alcanzado una producción de materia seca de mas de 100 toneladas por ha. al año, equivalente a alrededor de 350 toneladas de hoja fresca. Reportes de China [40] indican una producción de mulch de vetiver de 11.4, 14.7 y 17.8 toneladas de peso verde por 100 metros cuadrados de seto por tres años consecutivos. Nótese que en este caso, 100 metros cuadrados equivaldría a 230 metros lineales de seto. Hay poca duda en que, mejorando un poco su manejo, el vetiver sería un forraje adecuado para la sequía, particularmente si se le combina con otro forraje de alto contenido de proteína. Los campesinos de Gundalpet, India, han utilizado el vetiver por siglos como división entre parcelas, y como forraje en donde se corta una vez cada tres semanas, durante la temporada de crecimiento. Hay reportes de muchos otros países sobre su uso como forraje, incluyendo China, Guatemala, Honduras, Nigeria y Mali. Se sabe que algunos tipos son mas apetitosos -i.e. las así llamadas "farmer" cultivar de Karnataka, que han sido seleccionadas por los campesinos por décadas como un cultivar mas suave y apetitoso.

En áreas donde hay especies de pastos mas apetitosas como forraje, o donde no hay ganado, y quienes necesiten de un pasto inerte que pueda crecer con un manejo mínimo deberían fijarse en el vetiver. Hay excelentes ejemplos de esta aplicación en Costa Rica [41] para la protección de huertos de mango en pendientes pronunciadas.

Dónde el vetiver pueda ser usado como forraje, será determinado por los objetivos del usuario y del manejo que se le de. Algo que se necesita es la identificación y selección de los tipos

mas apetitosos y manejables como un propósito dual de conservación y de planta forrajera.

Afirmación núm. 7. El pasto vetiver puede ser usado para fortalecer estructuralmente terraplenes, líneas de drenaje, caminos, canales controladores, etc.

Hay evidencias en todo el mundo que respaldan el uso del vetiver para la estabilización de terraplenes [9, 10, 17, 27, 42]. Ha sido utilizado con éxito en Malasia, India, Sudáfrica, Indias Occidentales y Brasil en la estabilización de los márgenes de carreteras. El vetiver ha sido utilizado junto con aplicaciones geotécnicas para la estabilización de terraplenes en Nepal. Ha sido probado con éxito [27] en la estabilización de desechos de minas de oro en Sudáfrica. También ha sido utilizado para estabilizar represas de inundación, de ríos y canales en Bangladesh. Por su gran fuerza y capacidad para absorber sacudidas, el vetiver tiene potencial en la estabilización de las riberas de canales contra la fuerza y el choque de los barcos -de ahí que la Comisión del Canal de Panamá muestre interés en la aplicación del vetiver en el Canal.

La Vetiver Network ha recibido reportes positivos del uso del vetiver para reducir la erosión en vertederos de pequeñas presas en Zimbawe [39], arroyos en Fidji [8] y canales de drenaje en Guatemala, Sudáfrica, Malasia y Nepal [16, 17, 41, 42]. Se han recibido reportes mas recientes de que el vetiver está siendo usado para la protección de terrenos de construcción localizados en áreas con pendientes [27].

El VGT puede ser usado de manera efectiva en la estabilización de canales de irrigación [43]. En experimentos en los que se utilizaron canales de irrigación con pendientes verticales, se comparó el vetiver con pendientes no canalizadas, con el vetiver en pendientes canalizadas con polietileno. Las pendientes donde se plantó vetiver con los canales entubados con polietileno permanecieron verticales, y prácticamente igual en las pendientes no canalizadas. Los resultados muestran la gran habilidad del vetiver para amarrar el suelo (una arcilla arenosa), y el potencial para el diseño de canales propensos a deslaves, con el consecuente ahorro en área de terreno.

El VGT ha sido usado en muchos paises como una herramienta efectiva para el control de escorrentias. Debido a su fortaleza, el vetiver puede resistir corrientes de agua de gran velocidad en los arroyos, y puede crecer y acumular profundos depósitos de sedimento que se forman tras los setos de vetiver establecidos en los arroyos. Como resultado, se forman escalones naturales en los arroyos. Donde se usan gaviones para la estabilización de arroyos y canales de agua, el vetiver, si se planta en asociación con las estructuras, ayudará a estabilizarías. En lugares donde se pueden esperar altas velocidades del agua, el vetiver puede ser plantado mejor embolsado para asegurar su rápido establecimiento, y puede necesitar durante el primer año protección mediante bolsas de arena, así como la fijación con estacas de bambú.

Es probable que el vetiver sea mas ampliamente usado para la estabilización de terraplenes cuando los ingenieros se den cuenta de su potencial. Ya que es muy importante para el control de escurrimientos en áreas no cultivabables.

Afirmación núm. 8. El pasto vetiver resiste el fuego y ahuyenta roedores y otros animales.

El vetiver es bien conocido por su resistencia al fuego. Esta resistencia ha dado como resultado su sobrevivencia en campos cañeros que son quemados antes de la cosecha. En Sudáfrica el vetiver es usado para proteger las barreras contra incendio de la erosión [27], y este método es aceptado por las compañías aseguradoras forestales. El vetiver joven calcinado (calcinado como resultado del corte y secado de una masa) en las condiciones prevalecientes en Malasia, se recupera totalmente en cuatro semanas [16]. Pastores históricamente nómadas con grandes rebaños en planicies rozadas del Río Níger en Mali, Africa Occidental, queman el vetiver para obtener un crecimiento rápido del pasto. La resistencia y rápida recuperación del vetiver del fuego se debe principalmente a su corona protegida y a su profundo sistema de raíces y el depósito de nutrientes asociado, lo que permite el rápido restablecimiento. Estas mismas características permiten que el fuego sea utilizado como un sistema de mantenimiento del vetiver en áreas secas donde grandes cantidades de hojas se acumulan en los setos de vetiver, quemándose los claros, y reduciendo la incidencia de la infestación por termitas.

Hay conflicto en cuanto a la efectividad del vetiver para alejar roedores y otros animales. Los campesinos reportan continuamente que, aparentemente, las ratas son repelidas por el vetiver y no se amadrigan en el sistema radicular. En efecto, en los sistemas de irrigación de Nepal muchos campesinos han plantado vetiver en terrenos entre sus límites, con el propósito de reducir la infestación por ratas [42]. Recientemente, un silvicultor de Papúa Nueva Guinea reportó [44] que en tres años, el cerdo de monte no ha desarraigado los setos del pasto.

Afirmación núm. 9. El pasto vetiver no requiere mantenimiento o manejo.

Inicialmente, en la diseminación de la VGT, la afirmación de un mínimo o ningún manejo se basaba en su uso en áreas de elevada precipitación pluvial, como Fidji y las Indias Occidentales. En estas áreas, la experiencia mostraba que en tierras cultivadas el vetiver se conservaba en buenas condiciones por sí mismo, siendo su único mantenimiento un corte anual. Después de introducirlo a condiciones climáticas menos favorables, como las áreas semiáridas del centro de la India (con precipitaciones de 500 a 600 mm anuales), se ha observado que al seleccionar material de buena calidad

para el transplante, su plantación se debe hacer en el tiempo correcto (bajo condiciones climáticas como esas, donde el tiempo de plantación es extremadamente corto), rellenar los claros durante el primer año al menos, plantar utilizando bolsas de plástico (como contenedoras de la planta) bajo condiciones extremadamente difíciles, el uso del fuego como una herramienta para erradicar el exceso de plantas muertas, etc., y el uso de diferentes técnicas de plantación para conjugar diferentes condiciones locales. Son todos aspectos importantes de manejo que requieren un buen criterio práctico. Se ha demostrado experimentalmente [15, 16, 23 y 30] que el manejo juega un papel importante en el nivel de éxito de los setos de vetiver como sistemas para el control de la erosión. Hay evidencia conclusiva de que "plantar el pasto y olvidarse de él" a menudo no lleva al éxito, es por ello que la mayoría de las tecnologías fracasan cuando se sigue este camino.

Estudios en Andhra Pradesh [45] y Filipinas [20] muestran que cuando los campesinos han entendido la tecnología y la aplican y manejan adecuadamente, el sistema es efectivo. Cuando el gobierno hace el trabajo en lugar del campesino, hemos encontrado que el campesino se compromete menos con la VGT; no se lleva a cabo el mantenimiento y el sistema de setos se degenera. Por otro lado, la VGT aplicada en un huerto de cítricos en Costa Rica [41] (libre de ganado) no mostró signos de deterioro después de cinco años de no haber recibido mantenimiento. Otro estudio [46] muestra que en granjas muy pequeñas (de menos de media hectárea), los granjeros están renuentes a poner cualquier barrera en su tierra, ya que les quitan áreas potenciales para el cultivo de alimentos. En estos casos debemos conocer mejor las prácticas campesinas y alentar a los campesinos a usar la VGT como demarcación de límites, tal como ha sido practicado por siglos por campesinos en Gundalpet, al sur de India, y por miles de campesinos en las afueras de la ciudad de Kano, al norte de Nigeria.

Afirmación núm. 10. El pasto vetiver es un sistema de bajo costo para la conservación del suelo y la humedad.

En un análisis económico [3, 47] se comparó el establecimiento de setos de pasto vetiver por menos de $30 US dlls. por hectárea, con más de $500 US dlls. por hectárea de los sistemas de ingeniería convencionales. Los índices económicos de recuperación en el segundo caso se ubican alrededor del 20%, comparado con más de 90% para el vetiver. El costo del establecimiento de setos de vetiver varía de un sitio a otro. En terrenos con poca pendiente los setos pueden ubicarse a 50 m uno de otro, por lo que sólo se requieren 100 m de seto por hectárea de terreno protegido. En terrenos empinados con 60% de inclinación, la distancia entre los setos puede ser de cuatro metros o menos, necesitándose dos mil 500 metros de seto por hectárea. El costo de la planta varía dependiendo de la forma en que se produce. Costará mas si se propaga a mano en un vivero comercial, y menos por métodos mecanizados, como hacen los hermanos Boucard en Texas, y aún menos si los setos existentes en granjas se dividen para trasplantarse como nuevos setos. En la India, un campesino puede excavar y plantar 200 metros diarios -con un costo de $3 US dlls. al día. Los viveros "comerciales" de vetiver en la India cobraban en 1987 alrededor de 0.01 rupias por esqueje plantado. Con tres esquejes por excavación, las plántulas costarían alrededor de 300 rupias ($10 US dlls. por kilómetro de seto plantado). En 1993, en Tailandia se pagaba productores de esquejes a raíz desnuda y de buena calidad $2,600 US dlls. por hectárea, lo que, con un millón 25 mil esquejes por hectárea equivale a 0.2 centavos de dólar por esqueje, y $60 US dlls. por kilómetro. En Tailandia se producen bolsas con vetiver, que se plantan por 62 centavos de dólar el metro. El costo mecanizado de la plantación de vetiver, incluyendo el costo de la plántula, se estima en alrededor de $175 US dlls. por milla. En Estados Unidos, proteger una hectárea de terreno con una pendiente de 4% costaría, utilizando seis líneas de seto vivo, alrededor de $90 US dlls.

Es más difícil determinar los beneficios que representa el uso de setos de pasto vetiver. En la mayoría de los casos, la pérdida de suelo disminuye rápida y permanentemente, y se reduce la pérdida por erosión de 143 a 1.3 toneladas por hectárea al año [3]. Se han demostrado ganancias a corto plazo en la India [31], dando como resultado relaciones costo-beneficio de más de 2:1.

Algunos campesinos en la India han reportado que no sufren pérdidas de cultivos en años de sequía cuando usan el vetiver, mientras sus vecinos han perdido sus cultivos desprotegidos. Otros beneficios que deberían ser cuantificados incluyen el valor del vetiver como paja (en China, cuesta 2 centavos de dólar el kilogramo), como combustible (el vetiver tiene un valor energético de alrededor del 55% de el del carbón) y como forraje. Los beneficios indirectos incluyen el valor y los nutrientes del suelo que de otra forma se perderían, el valor del incremento de la recarga de agua en la tierra, su valor en la protección contra las fuertes inundaciones y la reducción del costo de mantenimiento de terraplenes. Si se asume que los beneficios de los sistemas de ingeniería y del pasto vetiver son los mismos (que no lo son - los beneficios del vetiver son superiores), el bajo costo del vetiver comparado con aquéllos (alrededor de una quinta parte) debería ubicar a la VGT como una prioridad tecnológica. Los costos detallados del desarrollo de setos de vetiver [3] muestran su superioridad sobre otros sistemas, incluyendo estructuras de ingeniería, en términos de la relación costo-beneficio.

Conclusiones

Lo anterior establece una fuerte evidencia de que el vetiver reúne los requisitos de una tecnología vegetativa de largo plazo y bajo costo para la conservación del suelo y la humedad, como se establece en la primera

edición del manual "Vetiver Grass (Vetiveria zizanioides) A Method of Vegetative Soil and Moisture Conservation1'" [9]. La prueba no descansa tan sólo en los resultados experimentales mencionados anteriormente, sino en un número cada vez mayor de usuarios alrededor del mundo, quienes parecen estar votando a favor de la inclusión de la VGT como parte de sus prácticas campesinas. En ningún lugar se demuestra esto en una forma tan vívida como durante la introducción masiva de VGT en Tailandia en los últimos dos años [37, 48]. La educación de los campesinos para la conservación del suelo es un proceso lento que no debe ser acelerado. El pasto vetiver es otra de las herramientas que pueden ser usadas, junto con otros métodos (labranza en contorno, cero labranza, cultivos apropiados para la fijación de nitrógeno, etc.), para reducir la erosión del suelo. El vetiver tiene méritos especiales por sus características que lo hacen durable, relativamente inerte y un pasto altamente efectivo que cuando crece como seto vivo, detiene el flujo de sedimentos y reduce la pérdida de agua de la lluvia.

The Last Word From The Editor

On reading through the text and other documents not presented in this newsletter I believe that I should draw your attention to the difference between the north India vetiver (possibly Vetiveria lawsoni) and that of south India (Vetiveria zianioides). It seems increasingly clear that the north Indian vetiver is less robust, is "weedy" to a certain extent, produces less oil, and produces smaller, shallower, and has a less dense root system. I suspect that sometimes users in north India, Nepal and Pakistan are disappointed with their results with vetiver because they are using the "north Indian type". Elsewhere in the world the vetiver that seems most common is that from south India that produces a heavier oil from a more robust and stronger plant. The south Indian vetivers rarely flower, and do not display weediness. Those of you using north Indian vetivers are advised to try out the south Indian vetivers. I urge you to participate in Mr. Adams' DNA testing program for vetiver, just to see the relationships between the vetivers and thus further expand our knowledge about this remarkable plant.

Table of Contents

Editor's Page 1
Letters to the Network.....2
NewspaperReports 8
Vetiver Developments in Mexico.. 9
What two men with a mission can accomplish.....9
Accelerating Vetiver Developments In Africa.....12
A Practical Look At Vetiver And Its Uses As Applied In The Republic Of South Africa.....12
Vetiver Grass As A Tool For Consideration In The Forestry Erosion Management Program.....13
Prospects And Problems Associated With The Use Of Vetiver Grass As A Biological Mean Of Soil And Water Conservation In Lesotho Lowlands And Foothills.....13
Australian Pilot Programs Steam Ahead 15
Effectiveness Of The Vetiver Hedges In Soil Erosion And Sediment Control In Queensland.....15
India. Vetiver Has Found A Permanent Place In Land Management Practices.....16
Khus (Vetiveria zizanioides) in Watershed Development in Karnataka.....16
Introduction of Vetiveria zizanioides in Phulbani District.....19
Thailand - A Visitor's View.....24
Research Abstracts and Summaries.....24
Vetiver Oil Extraction.....28
Shoulder Reclaimer Saves Time, Money.....38
Spanish Readers Column.....39
El papel del Pasto Vetiver en el sostenimiento de la productividad agrícola.....39
The Last Word From The Editor.....45

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VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER NETWORK
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News Line

The First International Vetiver Conference, "Vetiver - A Miracle Grass"

The Conference, hosted by the Government of Thailand, The Chaipattana Foundation, Ma Fah Luang Foundation, Office of the Royal Development Projects Board, and the Land Development Board was held at Chiang Rai from February 5 - 8 1996. It was attended by about 300 persons, 100 of which came from 40 countries. We learned much from each others experiences, (detailed in this newsletter) some was confirmation and reinforcement of what we knew already, and some was new. In total we received confirmation that Vetiver grass is indeed a "miracle" grass — a miracle grass, not that it is the only grass (there are other grasses that can be used effectively under conditions not suitable for vetiver) for forming stiff grass barriers for soil and water conservation, but rather what is emerging is its potential range of uses for biological engineering and economic uses over a very wide area of eco-adaptability. This is likely to expand as new cultivars are identified, and vetiver grass breeders start selecting and improving the grass not only for its aromatic oil (as in the past), but also for its other traits. Lest we forget, let me list 31 uses of vetiver:

SEE BACK PAGE FOR TABLE OF CONTENTS

Natural Resources
- On farm soil and water conservation*
- Ground water recharge*
- Wasteland rehabilitation*
- Gully control*
- Drainage stabilization*
- Wind erosion control*
- Flood plain stabilization*
- Inhibitor to movement of excess soil chemicals*
- River bank stabilization*
- Permanent boundary demarcation*

Construction and Engineering
- Embankment and cut stabilization*
- Construction site stabilization*
- Mine dump stabilization and rehabilitation*

Pollution control
- Tolerance to high levels of toxic metals*
- Inhibitor to toxic metal movement+
- Municipal and industrial waste dump stabilization*
- Excess herbicide and pesticide clean up+
- Clean up of brackish water fishery wastes+
- Waste water cleanup+

Economic uses
- Mulch*
- Livestock fodder*
- Crop yield enhancement*
- Compost*
- Aromatic oil*
- Medicinal*
- Thatch*
- Fuel*
- Handicrafts*
- Natural herbicides and pesticides*+
- Paper manufacturing*
- Mushroom substrate*

Vetiveria zizanioides. Water color by Anita Cooper

* proven; + under investigation, early results promising

It is little wonder that the farmers of northern Nigeria, for generations, have called the grass "Wonderful Grass".

From our work with vetiver we find some interesting pointers that government technical transfer systems are not working too well. Too often the initiative of introducing new technology is not being properly administered, and seems often to be done better by NGOs. Even the latter need help. Extension and conservation staff are not properly trained, dissemination aids (books, slides, videos) are not available; and linked

to this, farmers are not properly trained in use of technology nor are they involved enough with the planning and evaluation of research and technology dissemination. This not only applies to vetiver, but to many other technologies as well, particularly those relating to long term natural resources sustainability. It is also evident that the success of land use policy will depend directly to a land users willingness to look after the long term needs of the land. There is a lot to do.

Funding Support For The Vetiver Network

The Vetiver Network needs **your** financial support to keep the Network alive and strong. As you can see from the above list of potential uses there are many areas that need information and support. There is a limit to what the Network can do, but in the area of information collection and dissemination of information about vetiver we can do a lot.

Currently, The Network has prepared a funding proposal, "The Vetiver Network Support Project", which is being sent to potential donors around the world. The project consists of a request for funds for a three year period:

- Establishment of at least five regional/ national networks.
- Start up support to NGOs to develop vetiver programs.
- Awards for good research.
- Development of new technical videos.
- Revising and publishing "Vetiver Grass - A Hedge Against Erosion"
- Printing and mailing of Vetiver Newsletters
- Administrative cost support for The Network.

The total cost is estimated at US $500,000. We hope to obtain most of the funds from major donors, but we need support from those users that can afford it, so if you think that the Network serves a useful purpose please help. If anyone needs a copy of the funding proposal please let us know, and The Network will send you a copy.

The Vetiver Network has now been established as a non profit charitable organization, with a board of 8 directors, and has US Internal Revenue Service approval as a tax exempt organization under Code 501 (c) (3). Thus for US citizens your contribution is tax deductible.

A Call For Help from The Land of the People of Kom -- Cameroon, West Africa

For three years now the Network has been in regular correspondence with Mr. Ngwainmbi Simon who works at the Medical Centers of West Africa, Maroua, BP 382, Cameroon. He, with virtually no help, has started vetiver programs with farmers. The man is tested, he is committed to working with vetiver to help his people reduce erosion. If any of you, particularly those that have operations in Cameroon, who read this newsletter feel that you would like to support Ngwainmbi Simon please get in touch with him at the above address. I want to share part of his most recent letter to me:

".....I learned a lot from your newsletters; I wish people could aid the project that I want to start. In Bamenda it is all hills and it is not easy for farmers. Rain water has washed away all the top soil. The hills (land) from which farmers used to have 10 bags (400 kg) of maize can now can only produce half to one bag (20 - 40 kg). This has resulted in some poor families having to go 30 km in search of farms. The new farms have again started producing less and less. This area is in trouble. Women will go out of their homes to stay out on their farms for one week, only to come home once a week to rest with the family. This happens every year from March to June. Again from October to December during the harvest time. These same women have to carry the maize 30 - 40 km to their homes — what a problem!

I am sure that I have the answers to this area, and that is Vetiver. I did try a section on the hill near the compound and it is doing very well now. Again I have traveled to get Vetiver from this part of Cameroon (Maroua). It is more than 1,500 km from Bamenda, it takes two days and two nights to get from Maroua to Bamenda. My problem now is where to get a four wheel truck to carry these seedlings to Bamenda. If we can start this project and I use the seedlings to carry out small experimental plots for 4 - 5 years, I am sure, God willing, the land of the people of "Kom" will be useful again. Are there people who are willing to aid us? is it possible for the World Bank to give us a loan or give a grant for such a project. I would be very happy to have an assistant from overseas who is willing to come to aid me in this development project. If at the conference in Thailand (4 -8 Feb. 1996) you could announce that (FARDP) Family Association Rural Development Project needs funds, transport, and volunteers who can come to aid in the soil conservation work in Bamenda (Kom) North West Province of Cameroon I shall be very happy....."

We received this letter after the Thailand conference. If you can, and are interested, please help.

Regional Networks

Regional Networks are being established for Latin America and Europe:

The first formal network is now under establishment in Costa Rica and will serve Spanish speakers in Central and South America. It will be known as "The Latin America Vetiver Network". Detailed information is available in English and Spanish. The Network will be managed and coordinated by Jim Smyle and his wife Joan Miller. Jim was very instrumental in the production of vetiver newsletters when he worked in Washington. He is also a director of the Vetiver Network.

Another formal network is under establishment in Europe. It will be known as "European Vetiver Network" (EVN). In cooperation with the Servizi Informatici Area di Milano of the Italian National Research Council, EVN provides the mirroring of the Vetiver Network WWW pages at the URL: **www.siam.mi.cnr.it/Vetiver**. European users are invited to connect directly to the mirror. For further information please contact the EVN coordinators Marco Troglia (E.mail: **tecnagrind@popmail.iol.it**) and Fulvio Naldi E.mail: **naldi@siam.mi.cnr.it.**

Marco Troglia is managing a demonstration project in Murcia (Spain) using the Vetiver grass for soil erosion control; the project started in 1993, thanks to the finan-

cial contribution of the European Union, General Direction VI-Agriculture. Fulvio Naldi is chief technologist at the Italian National Research Council and works in the field of networking and documentation.

Anyone interested in establishing a formal regional Vetiver Network please contact The Vetiver Network.

Red Del Vetiver Latinoamericana

(*Pidiendo perdón de todos aquellos quienes escriben español gramático)*

Receintemente hemos inaugarado la Red Latinoamericana De Vetiver, con el sede ubicado en San José, Costa Rica. La red será manejada por Jim Smyle y Joan Miller; Joan funcionará como coordinadora. El objectivo principal de la red es servir y informar a todos usuarios quienes hablan español. Nuestra herramienta principal realizar este objetivo será un boletín escrito en español. El boletín permitirá a usuarios e investigadores de tecnología vetiver compartir sus conocimientos y experiencias con los demas en America Latina y para ampliar el uso adecuado de vetiver para la conservación de suelos, aguas y infraestructura rural.

Por difundir información y ejemplos (exitos y fracasos) de la tecnología vetiver en latinoamericano, tanto como el resto del mundo, esperamos educar a usuarios y usuarios potenticiales de vetiver sobre el mundo de posibilidades que existen para su aplicación. Además esperamos a que la red servirá aumentar participación y número de miembros en la red del vetiver mundial. El Vetiver Boletín; será gratis a todos aquellos quienes quieren recibirlo. Tambien, la red servirá como un centro para todos que necesitan información individual sobre el uso y aplicación de la tecnología de vetiver. Y caso-por-caso, proveeremos asimismo información sobre otras tecnologías y sistemas innovadores para el manejo de recursos naturales bajo uso o apropriado para uso en America Latina.

La Red Del Vetiver Latinoamericana esta planificando publicar su primer boletín por los principios de 1996. Si se quiere recibir una copia o comunicar con la red, nuestra dirección es:

Joan Miller
Coordinadora de la Red del Vetiver
Apdo. 173-2020
Centro Postal Zapote
San José, Costa Rica
Tel: 506 255 4011
E.mail: hamilton@sol.racsa.co.cr

En anticipación de nuestro primer boletín, querríamos solicitar apoyo en lo siguiente:

- Necesitamos articulos escritos por usuarios de vetiver en America Latina. Publicarámos cualquier información que sea util. Y cuando sea posible, favor de incluir fotos. Les volveremos a todas fotografías si así pide.

- Necesitamos desarrollar un base de datos de usuarios quienes pueden proveer plantulas de vetiver a usuarios nuevos; sea en cantidades grandes o pequeñas. Favor de ayudarnos con éste por informarnos en caso que tiene acceso a vetiver.

- Y quizas ustedes han dado cuenta que nuestras habilidades de escribir en español son algo debiles. Por consiguiente, si querría ofrecer su tiempo ayudar redacta nuestro material, favor de contactarnos.

The Vetiver Network Homepage on the Internet

The Homepage is up and running. It publishes most of the information that we receive from you from time to time. You can find it at **http://www.vetiver.com**

Change of Address

Because of the large number of people living in Northern Virginia the Post Office will on July 1 1996 change the Zip code of The Vetiver Network from 22075 to 20176.

Mailing address:

The Vetiver Network,
15 Wirt Street NW,
Leesburg,
Virginia 20176 USA

Letters to the Editor

.....Many thanks for your mail. I am primarily involved in research group of soil amoebae called cellular slime molds. They are social also! Regarding Vetiver — I plan to use the extracts of vetiver & look for their anti-fungal activity (primarily on plant pathogenic fungi). In my own home — we use Vetiver extensively for two purposes: to add the gentle aroma of Vetiver in drinking water, we put dried roots in the water; and we also use it along with *Shikakai*, the natural shampoo. A soap is also available with Vetiver aroma, called *Moti*.

With regard to technology adoption — Whenever I chance upon farmers I urge them to cultivate Vetiver as hedges. They are bit reluctant at first, because it doesn't give any commercial value as other crops. But if I explain with photographs, they are taking initiatives.

Now the source — Many of the farmers feel that it is not available freely — which is true. The agriculture department here doesn't give much importance to Vetiver. Moreover the farmer has a concern that there will be lot of snakes. So some of the farmers try to remove Vetiver rather than cultivate them. Another interesting aspect which I plan to embark on is — whether Vetiver competes for resources with other plants - especially with weeds (*Parthenium* etc.).
R.Baskar, Karnataka, India
E.mail:
jatinder@vigyan.iisc.emet.in

***

I read the Vetiver Newsletter in our library. I am assigned as program field coordinator of our institute. Our farmers have been planting vetiver grass (locally named *Mura*) since 1991 when our soil and water conservation project started.

I am interested to have my own copy of the Vetiver book and the Technical Publication "Vetiver Grass for Soil and Water Conservation, Land Rehabilitation and Embankment Stabilization". Also, I am applying to be a member of the Network. We are now on the process of getting farmers' testimonies of the benefits of using vetiver in controlling soil erosion. We have trained about 200 farmers in SWC with *Mura* as the foun-

dation hedgerow. I have a plan to produce a simple brochure in Cebuano dialect about Vetiver and some of the testimonies of our farmers. Can you give me advice for possible source of funds. I need about US $1,000 for the project. Thank you very much and more power.

Edwin A. Balbarino, Farmi-Visca, Baybay, Leyte 6521-A, Philippines
Email: v+visca@ sat.vitanet.org

If anybody with an interest in the Philippines would like to help Edwin publish a book on vetiver in the local dialect please get in touch with him. I can vouch for Farmi-Visca, your money won't be wasted, and we will get some interesting results for all to share. Ed.

***

Yesterday we returned from a four day trip, locating vetiver for the Panama project. We found some very interesting stuff (as well as the planting material). The best of it is at a coffee finca (farm) (Rio Negro) that is owned by a Swiss company and operated by Costa Ricans. Since they purchased the finca and its 200 ha of coffee five years ago, they have rehabilitated 60 ha and protected them with vetiver hedges associated with drainage canals (they are in a 3,800 mm rainfall zone). The story of how they got on to the vetiver is interesting. The finca was started in the early 1950's by a Chinese (Taiwanese?) family named "Wachong". They planted all the roadsides with vetiver to stabilize them (we have pictures of the 30 plus year old roadsides), but nothing in the coffee. They even planted the coffee up & down slope! When the Swiss bought it, the consultants they hired to do the initial planning recommended getting rid of the vetiver on the roadsides as "it served no purpose and took up space". However, the fellow charged with managing the fields had, in about 1988 or 1989, received one of the green books on vetiver while working with the government's Agricultural Development Institute; he also said that he had heard about vetiver in some soil conservation courses. So he decided to use the roadside plantings to begin establishing hedges in the plantations. Five years later it looks good, the rehabilitated coffee is on the contour, the hedges are well-planted, dense and thriving, and well-maintained. It never ceases to amaze me how well the word on vetiver has spread.

Jim Smyle E.mail:
hamilton@sol.racsa.co.cr

Photo 1: *Vetiver hedges used on coffee just farm in Panama, adjacent to the area Jim Smyle writes about in Costa Rica. In this instance the hedge is two years old and is protecting the interface of a field and road.*

Photo credit: Dick Grimshaw

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I am delighted to hear that vetiver will soon be on the internet. I came across a terrific site, The International Arid Lands Consortium — I don't know if you are familiar with them. They are a jumping off point for all sites to do with arid lands and land resources. Fantastic! They are actively seeking sites to connect with them so it would be a great place to register the vetiver site. The address is: **http://ag.arizona.edu/OALS/IALC/Home.html** (*I have checked this site, it's good, and I have registered our home page with them...Ed)*

I will certainly send you an update of our activities with seabuckthorn. It is an extremely exciting plant and there is as much activity around it as with vetiver. Colin will be attending a conference in Beijing in December on seabuckthorn. The Chinese have over 100,000 hectares of badly eroded lands planted to seabuckthorn now, and are producing over 200 products from the berries. However, seabuckthorn is much more intrusive than vetiver as it sends up shoots from the roots after about four years. For the Chinese this is great as they can cover huge tracts of land this way. Especially steep mountain slopes. We have a video made for ICIMOD in Nepal. If you would like a copy please let me know and I will send one to you.

Susan McLoughlin. E.mail:
sam@wimsey.com

(I have worked with seabuckthorn in China. It is very good for wasteland rehabilitation, and is particularly useful in climates that are too cold and too dry for vetiver. If you want more information contact...Ed)

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A consistent problem for us V.Es. (Vetiver-Enthusiasts) is the poor performance of most varieties of Vetiver under shade. Even under the partial shade of coconuts and rubber, Vetiver planted with great care gradually dies out; and this is a severe constraint as it is often that these plantation crops are grown on slopes which need protection of the soil below them.

Another instance of Vetiver dying out under shade occurs when it is planted to protect road banks, and then shade trees develop overhead.

I feel sure that amongst the many varieties of Vetiver, there must be some which have adapted to growth under shade, and I wonder whether there is any source of research information to which we may go for guidance towards such shade-tolerant varieties. Have these various varieties of Vetiver been classified (perhaps numbered) according to their particular characteristics and adaptabilites? If not.... here is a **VERY** urgent area for research.

You may recall that interest in *Leucaena* was for many years mainly emotional.... enthusiasm without much REAL research backing. Then a pest appeared (Psyllid) which wiped out much of the *Leucaena* in the world. It was then found that certain *Leucaena* trees were resistant and from this arose very extensive research into the characteristics of the various varieties of *Leucaena*, and interest in *Leucaena* revived.

I shall appreciate your own views on this proposal.... or must we wait for a pest?

Ray Wijewardene DSc.

Tel: Colombo (94-1) 421881

Has any reader got any ideas for Ray regarding shade tolerance. I know that in Karnataka, India, some cultivars are know for being "forest types". In Panama and Guatemala vetiver hedges grow well under light coffee plantation shade. If anyone can help Ray, please get in touch with him. Bob Adams will be undertaking DNA classification of vetiver, this should be a start, but much more needs to be done. Mark Dafforn is trying to coordinate some of this work for the Network. If anyone wants to help Mark please get in touch with him at: mdafforn@nas.edu ...*Ed*

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I am pleased to say that at long last Vetiver is gaining the approval of more and more people around us here in Zimbabwe.

As a consequence of the two workshops I held on the farm with section managers of the large Hippo Valley Sugar Estates (Triangle) management has embarked on a major exercise in accordance with the Anglo American Corporation Zimbabwe Environmental Management Code of Practice. They have planted out Vetiver grass along 191 km of rivers and drains with a further 122 km identified for future planting.

Furthermore they have embarked on what is known as the "Magudu Vetiver Outreach Project" involving the local Chief, the District Administrator, and Agritex (Government extension and research service) officials. In February 1,400 meters of vetiver was planted, and watered by local people carrying 20 litre tins of water from the nearby dam. The grass in fact started catching the top soil when heavy rains fell shortly afterwards. Once again the primary objective of this exercise is to teach the communal farmers to conserve soil, and to see the many other advantages of vetiver i.e. thatching, mulch etc.

On the 28th October a Zimbabwe Sugar Symposium was held at Triangle, and I was invited to give a presentation on vetiver. I gave a short talk accompanied by a slide show on the grass itself, its uses on sugarcane farms, dam walls, and drains. It was well received by most of the 193 delegates some of which came from Malawi and Swaziland. There were also representatives from a major local chemical company who sought me afterwards for additional information.

I must say that all this is most encouraging and with the rainy season about to start we hope there will be more vetiver planted and more soil saved! Water situation, at present in the country generally, and more particularly in the Lowveld is critical.....I often receive letters from Agritex personnel requesting information to help them study the value of vetiver. In fact I am running out of the little green booklets fast .....
Jano Labat, Chiware Holdings Pvt Ltd. P.O. Box 14, Chiredzi, Zimbabwe.

***

I just got the vetivers from Panama and Costa Rica! I'll stick them in the freezer. They look fine for DNA extraction. It will be about April before I have a student to start. Hopefully I will have lots of samples by then.

I have Vetiver newsletter #14 and note that on p. 28 (Vetiver Oil Extraction) is by an unknown author. The article was copied from "The Essential Oils, Vol IV" by Ernest Guenther, pp. 156-180. Robert E. Kneger Publ. Co. NY (1977 reprint from 1950 original edition book by Litton Educational Pub., Inc.). The technical specifications on oil density, etc. were omitted, but otherwise the article is a word for word copy of the original. Your article ends on page 179 (of the book). The last page of the treatment of Vetiver by Guenther is p. 180 and contains two paragraphs on "Use of Vetiver Oil". You should probably note this source in another newsletter (else you might be sued for copyright infringement). There were several very useful bits of info. in newsletter #14.
Bob Adams
E.mail: rpadams@aol.com

Thanks Bob, readers please note the source of the article that he refers to. Bob needs all of you who can and are interested to send in a few small leaf pieces (10-15 cm long) of your locally grown vetiver for his DNA vetiver classification work. This work should result in a clearer picture of which vetivers are related, seediness of vetiver, and any other traits, such as shade tolerance, winter hardiness etc. He will share his results with you all through the Network. All you have to do is to dry the piece of leaf in the shade or deep freeze it for a couple of days, so as to kill the leaf quickly (without rotting). Put it in an envelope together with information of where it comes from, and any unusual characteristics, such as shade tolerance and send it to him at: **Dr. R.P. Adams, Plant Biotechnology Center, Baylor University, Box 669, Gruver, Texas 79040 USA.** *With regard to US customs, you should put a label on the envelope with the words "Dried Botanical Specimen (Genus Vetiveria) for destructive testing. Phytosanitary Permit/ Quarantine* ***Not*** *required. Please expedite"..ED*

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For about three years now I have been interested in Vetiver as a means of protection against erosion in a mountainous region of Colombia, S.A. I first obtained material from CIAT (Cali, Colombia) and planted the slips on rich fertile soil. The percentage of survival was fairly high, considering that the farm where planting was carried out, is located on a plateau (Sabana de Bogota) 2,630 meters above sea level, with a mean annual temperature of 15˚C in the Andes mountain range of Colombia.

Development of the plants was relatively slow, due to climatic conditions - I presume - but after 1 year the leaves had a length of about 3 feet, and clusters were increasing in size at an appreciable rate. The leaves, by the way, turned a reddish color from the middle up to the tips. Is this caused by ambient temperature? (*probably cold winter temperatures ....Ed*)

After two years I started using this material to plant it in a region of different soil and climatic conditions (clay soils, altitude of 1,000 meters above sea level, temperature of 26˚ C). Two and three slips per site were planted under different local conditions, (some were planted under shady conditions in a coffee plantation while others were planted on the bank of a water reservoir). Slip survival was somewhere around 70% but after about 5 months, growth is rather slow *(may be a shade problem....Ed)*; the plants do not show a vigorous development, as you would expect under the new climatic conditions (rains started after planting); they are thin single or double leaf shoots with no tillering showing. It is important to mention that at planting the slips were put into a mixture of black soil, water and 15:15:15 fertilizer. Some of the plants located on the banks of the water reservoir have flowered; this never happened at the higher altitude farm where these plants came from. The flowered plants do show a

somewhat better growth than the others, but they still seem weaker than the mother plants. I will be testing the seeds for fertility. My next step is to plant some of the materials in polybags to be transplanted at a later date in the field.

Hernando Gutierrez De La Roche - Ph.D. Carrera 20 # 86a - 16 Apt. 301 Santafe De Bogota, Colombia S.A.

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I am regularly receiving your Vetiver Newsletter and find it a very useful publication. The place where I am located is situated between 20˚ 15' and 21˚ 23' N latitude while 70˚ 33' and 74˚ 23' E longitude with the elevation ranging from sea level to 800 m. This region is characterized by heavy rainfall (1,500 to 2,500 mm), moderately cool winters and hot summers. A huge area in this region has been subjected to soil erosion due to deforestation, faulty tillage practices, heavy rainfall and unavailability of appropriate soil conservation technology. When I got your first newsletter, that was about 2 years ago, I contacted Gujarat Land Development Corporation, which is handling the watershed management projects and obtained 5 seedlings of vetiver from them. I multiplied them to initiate the following two experiments:

- spacing requirement of vetiver for obtaining maximum number of tillers; and
- optimization of contour width using vetiver on lands having 5% slope.

The first experiment is in second year while the second experiment has completed just one season. I am also thinking of initiating another experiment. The details of which would be communicated to you in my next letter.

Meanwhile we have taken up a multiplication program to distribute the seedlings to the farmers, as many of the farmers of this area have shown interest. Few of them have already got 10 to 15 seedlings each from our farm for further multiplication. I am intending to involve some non-government organizations for further multiplication programs to meet the farmers' need of their area. I will use this opportunity to explore if you know of any agency which is financing research projects on vetiver.

R.P.S Ahlawat University Office: Sardarkrushinagar.385506 Banaskantha District, Maharashtra, India,

Photo 2: *China. Guangdong Province. A slipping highway cut just planted to vetiver.*

Photo credit: Xia Hanping

(Mr. Ahlawat has subsequently written to say that his research has been funded, he is also interested in testing out vetiver for flood plain conservation...Ed)

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I was very glad that one of our staff members, Mr. Habtamu Wubshet, was invited to attend the International Conference on Vetiver grass : "Vetiver: The Miracle Grass" held in Thailand from February 5 - 8 1996. He is one of the promoters of vetiver grass among the peasant farmers as a major means of biological soil conservation. His immediate boss is of course Mr. Alemu Mekonnen, Head of our Agro-Ecology Development Department. Mr. Habtamu, although very busy this time of the year in preparing terraces, etc. is preparing to brief us about the conference. In the mean time our GM after seeing the Thai experiences has instructed me and the Women's Department + Mr. Alemu to see if vetiver leaves and roots can be used for small handicrafts like baskets, hats, etc. It would be helpful if we got the experiences of other countries through Vetiver Network or you personally. (*if anyone can pass some ideas to MfM please write direct... Ed)*.

Well coming to myself, I was employed by Menschen fur Menschen Foundation as a Deputy GM of Illubabor Projects as of July 1995. This means that I am closely working with the two vetiver promoters, Alemu and Habtamu. I have personally witnessed that vetiver is really a "miracle grass" against soil erosion. The methods that we use to promote vetiver among the farmers is simple extension approach.

Alemu, Habtamu and myself are of opinion that from the experiences of MfM, it would be possible to aggressively promote vetiver throughout Illubabor Administrative Zone, where our project is operating. However, as a small NGO, MfM is limited to its own concentration areas (project areas) and can't support the extension services of Illubabor Agricultural Development Department, the service responsible for extension services in the Zone. Is it possible for the latter to get financial, material and technical support if they prepared a project promoting vetiver for the control of soil erosion? As far sharing experiences is concerned, MfM is willing in all respects. *(another challenge, any aid agency interested in working in Illubabor, Ethiopia??....MfM has done a top class job on their project ..... Ed)*

Debela Dinka, MfM, P.O. Box 120372, Addis Ababa, Ethiopia

***

Thank you for your letter of May 5. We have

Photo 3: *China. Guangdong Province. A slipping highway cut fully stabilized 6 months after planting vetiver grass*

Photo credit: Xia Hanping

made new progress in our vetiver projects this year. Do you still remember what I said - the local road and railway departments are not willing to accept the practice of planting vetiver along the both sides of highways and railways - in my letter of March 5th to you? However we never lose heart. Later, my colleagues and I took a lot of material on vetiver, especially those you sent to me, to the Guangdong Provincial Highway Administrative Bureau (GPHAB) again and again, and related and showed the excellent effects of vetiver on controlling erosion and landslide, to the leaders and staff members of GPHAB. Constant effort yields sure success. At last, we convinced them, and started to collaborate with the Bureau. The two photos are just from one of 4 sites GPHAB offered us for carrying out the trials. Photo 2 is the background, and the part exterior after vetiver being just planted (May 4 - 5th). Note the severe landslip, almost total exposition, and piling silt on the road. We made the second observation to the experimental sites on September 19. It is very clear from the photo 3 that vetiver has formed dense lines and almost completely controlled the erosion in only four and a half months! Note among the lines there have been overgrown with some "weeds", one of which is mostly *Isachne indicum.* It indicates that "weeds" can grow once a sliding slope is held up. Obviously, these "weeds" are very helpful to control erosion. Currently, both sides express satisfaction with the experimental result, and are willing to continue cooperating in next years. Because of a great scarcity of funds, however, we feel quite difficult in enlarging the trial's scale. We are looking for resource of funds. Of course, we wish you and Vetiver Network could aid our this project financially. Thank you very much!
Xia Hanping South China Institute of Botany, Academia Sinica, Guanzhou, China

(another very good research group doing practical research and testing of vetiver. Any funding support to this group will give excellent returns and will have a wide range of applications. Ed)

Thailand First International Vetiver Conference "Vetiver: A Miracle Grass"

Draft Conference Resolution

This draft was prepared by the Vetiver Network and left with the organizers of the Conference. It reflects the general views of those who attended. The recommendation for the Second International Conference to be held in South Africa in the year 2000 was a recommendation of a special conference committee (the one and only committee established under the Chairmanship of Mr. Narong of FAO)

Preamble.

1. The conference recognizes the extraordinary leadership of His Majesty The King of Thailand in His Vetiver Grass Initiative and to the agencies that responded to His Initiative on June 21 1991 . This initiative comprising research, field testing and demonstration impacted on a wide range of applications covering soil and water conservation, road and pond stabilization, pollution control, and handicrafts in the Kingdom of Thailand.

2. The initiative that was primarily a Research and Development Program carried out by Chaipattana Foundation, Ma Fah Luang Foundation, Office of the Royal Development Projects Board, and the Land Development Board in conjunction with other various government departments has over a period of five years developed and identified techniques in the application of the vetiver grass hedge technology (VGHT) and has confirmed that VGHT involving the unique grass - *Vetiveria zizanioides* - has a very wide application throughout the tropics, and semi tropics for low cost soil and moisture conservation, and for other biological engineering purposes including land rehabilitation and stabilization, flood control, and for remediation of a range of pollution related problems.

3. The conference recognizes the efforts and contributions made by individual user, scientists, and government and non government agencies in over 100 countries in their contribution to the development and extension of new knowledge and information relating to VGHT.

Technical application

4. In summary VGHT has some very clear uses and advantages for the stabilization of the world's land and water resources that are located primarily between latitudes 30 degrees north and south of the equator. The technology is user friendly, low cost, and has wide adaptability over a range of ecological conditions. The conference confirms that nowhere is the grass seen as an

invasive weed, even in its natural habitat (wet lands).

5. VGHT when applied correctly has proven to:

- reduce the movement and loss of soil from lands protected with vetiver grass hedgerows;
- significantly reduce rainfall runoff losses, with the consequent positive impact on improved soil moisture content and ground water recharge;
- recycle plant nutrients;
- under conditions of water stress has generally resulted in significant crop yield increases;
- provide for a low cost and effective means for stabilizing earth fill and cuts in relation to roads, drainage and irrigation works;
- stabilize and rehabilitate mining sites;
- stabilize river and pond banks;
- tolerate heavy metals and other toxic minerals and chemicals at higher levels than most other plants, and thus has potential in the prevention and clean up of polluted sites that might include municipal waste dumps, mine dumps etc.; and
- have important byproducts including: thatch, fodder, mulch, aromatic oil production, medicinal products, fuel, and as a material for handicrafts.

6. The above uses and applications have been confirmed by research and practice in Thailand and in other countries in Asia, Africa, and Latin America over the past 10 years.

Future Directions and Applications

7. The Conference endorses the use of vetiver grass for such purposes as outlined above, and recommends that individuals, private agencies, governments and international agencies extend the use of vetiver grass on a wider basis and accelerated time frame. The conference noted the integrated and well coordinated efforts of Thai agencies in the development of a strategic approach to resource conservation using VGHT. Other Asian, African and Latin American countries could well use this approach for the introduction of this low cost technology, as an important environmental measure for the stabilization of agricultural lands that would result, in conjunction with other management practices, in improved incomes of the rural poor, and in reducing the pressure on adjacent forest lands where relevant. VGHT should be used more often in watershed conservation for improving ground water recharge and the resultant positive impact on rural water supplies. It was noted that VGHT has potential as a measure to reduce sediment flows that would normally be detrimental to the life of reservoirs and to the good health of coastal reefs and fisheries.

8. The conference recommends that efforts are intensified to use VGHT for stabilization of engineered works, phyto-remedial uses, and for biomass production.

9. The conference urges that funding for research and technology transfer be improved. In particular, research and testing efforts should be intensified in:

- the identification of the different vetiver species and cultivars in the world, their relations to one another, and their different physiology and potential uses;
- the efficient propagation and handling methods for the rapid multiplication of vetiver grass;
- the development of different architecture required for various bioengineering;
- the field management practices of vetiver grass hedgerows to assure long term maintenance at minimum cost;
- phytoremediation practices that could be used for environmental mitigation of problems relating to pollution; and
- the selection and development of appropriate vetiver cultivars for fodder and other biomass purposes, and for the use of handicrafts and other potential uses.

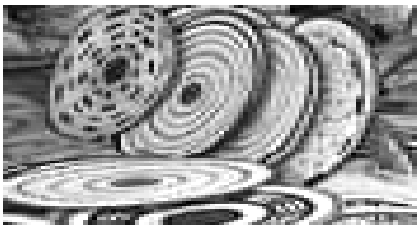
10. In Thailand and in other countries that are currently using VGHT there is a need to think through appropriate measures to assure effective transfer of the technology to users, and to put them into place. In all cases the end user must be involved in the planning process and should receive adequate support and training to allow such strategies to be properly executed. Greater use should be made of public news media, handbooks, audio visuals etc.

11. The conference urges land development planners, executing agencies and engineering consultants to initiate programs that include VGHT technology. In particular to provide funds for technology transfer and research, and for the initial production of plant material for distribution to users.

12. The conference supports the need to expand the free transfer of information by continued support for The Vetiver Network and for the establishment of independent regional and or national networks. At this time it is recommended that networks are established for the Pacific rim, for south Asia, for west and southern Africa, and for Latin America and Europe. These networks, to be effective, should retain close ties, should be operated at minimum cost, and should cater to potential participants without hindrance or bias.

13. The conference urges governments and agencies to provide small grants to bonefide non government agencies for start up VGHT programs. In addition the conference recommends that international and bilateral agencies that are already helping to promote the technology should continue, but on an accelerated time frame.

14. The conference believes that VGHT will, in the 21st century, become a major biological technology for the mitigation of a wide range of environmental problems. To this end: (a) research and testing programs should be accelerated, and (b) the Second International Vetiver Conference should be held in South Africa in the year 2,000.



Abstracts Of Selected Research Papers Presented At The Conference

SOCIO-ECONOMIC ASPECTS

Status Of Vetiver Grass In Upland Farming Development In Indonesia (Contradiction Between Soil Conservation And Farmers' Utility Orientation)

Agus Hermawan. *Institute for the Assessment of Agricultural Technology Agency for Agricultural Research and Development (IAAT-AARD), Indonesia.*

There are two kinds of soil conservation techniques developed by Farming Systems Research (FSR) component of Agency for Agricultural Research and Development (AARD) of Indonesia, i.e. mechanical and vegetative. Vegetative soil conservation includes cropping pattern arrangement, tree plantation, grasses and legumes as terraces strengthen on strips and alley cropping systems. In that case, vetiver as grass barrier could control run off and decrease 'CP' factor and land erodability lower than control plot, as well as increase organic matter on soil. On alley system, vetiver could control erosion to 13.21 and 0.56 ton at second and third years respectively (on the average erosion on control plot was 120.08 ton/year), while height of ridge soil at third year was 29.7 cm lower than Flemingia (38.9 cm) and Caliandra (39.7 cm). But, adoption by upland farmers of vetiver plantation was low. Resources limitation of upland farmers led them on short term orientation, and they only adopt technologies that give direct benefit. In that case, farmers more prefer plant other grasses (such as king grass, elephant grass and setaria) or legumes (Fiemingia, Gliricidia, Leucaena, etc.) on alley system. Grasses and legumes were planted by famers for fodder and fuel wood, but not for soil conservation orientation., lower forage production and poorer palatability of vetiver grass, compared with other grasses and legumes, being the cause.

The Adoption Of Vetiver Extension For Highland Farmers

Vitat Tachaboon. *Hill-tribe Welfare Division, Public Welfare Department, Thailand.*

The objective of this study is to investigate the adoption behavior and the cultivation of Vetiver by farmers in the highlands by collecting data from the areas under the responsibility of the Hill Tribe Development Centers, covering 14 provinces with a sampling of 1,433 farmers.

It was found that 401 farmers or 27.98 percent of the sampled farmers had grown Vetiver since 1992, which occupied 35.45 percent of the holding areas of the Vetiver growing farmers. There were 18.70 percent of Vetiver growing farmers planning to grow more Vetiver in 1995.

As for the reasons to participate in the Vetiver growing project, 74.81 percent of farmers claimed that the reason was from the introduction of the project officials, there were 14.96 per cent wished to replace other alley crops, 66.58 percent to reduce soil erosion, 47.88 per cent to improve soil fertility and 17.95 per cent wish to keep using their land forever. Besides, there were 30.17 percent of farmers who joined the Vetiver growing project in order to obtain land ownership or land rights.

Studying the use of land between the Vetiver rows revealed that most farmers were using every field every year. For the use of Vetiver, 45.14 percent of Vetiver growing farmers made use of it, commonly used for feeding animals. Besides, 33.67 percent of growers also introduced Vetiver growing to the other persons, mainly their neighbors and relatives.

In terms of farmers' attitudes towards the effect of Vetiver growing; the study showed that both the Vetiver growers and non Vetiver growers had similar opinions that vetiver required more labour and time management.

The analysis of relationship between the adoption of Vetiver and certain socio-economic factors using Chi-square test revealed that the differences of ethnicity, social status, number of family labour and sources of information were significantly correlated with growing Vetiver. It was also found that the farmers who used to grow other alley crops grew higher proportion of Vetiver than the ones who had never grown alley crops before.

Studying the relationship between the information transferred from various sources and the reasons to participate in Vetiver cultivation showed that the farmers who received the information from the other sources that were not persons or that were not involved with persons had a smaller proportion of land use between the Vetiver row than the ones who received from the persons knowing vetiver. It was also found that the farmers who participate in the Vetiver project concerning erosion control had a higher proportion of land use under Vetiver than those who joined the project for other reasons.

Environment And Socio-Economic Values Of Vetiver; A Miracle Grass.

MD. Faziul Huq. *Proshika 1/1 -9A, Section -2, Mirpur-2, Dhaka- 1216, Bangladesh*

Vetiver is a familiar grass growing on the flood plain soil of Bangladesh. It is commonly grown as a fodder in the rural areas. In the rural condition, this grass has high economic value. Vetiver is a fast growing species of indigenous fodder. The plants become 2-3 feet high with leaves and soft body. The leaves and stems are soft and palatable to the animals. T he marshy and wet land is favorable for vetiver cultivation. The small scale dairy and livestock farmer cultivate this grass in their limited agricultural land in between two principal crops. Sometimes Vetiver is cultivated as a relay crop. The vetiver has high nutritive value for Dairy cattle and Beef fattening animals. The goat and sheep herders also use the fodder as a popular forage. The animals with other balanced feed and vetiver show a remarkable body of gain within a short period. Small scale farmers benefit both socially and economically. The cultivation of vetiver helps both soil erosion and fertility of the land which gives environmental protection. So the socio-economic value of vetiver is quite satisfactory for the poor farmers in a country like Bangladesh.

Socio-Economic Dimensions Of Vetiver In Rainfed Areas Of Karnataka (India)

K.N. Ranganatha Sastry. State Government of Karnataka, India

The vegetative measures for soil and moisture conservation is most warranted for various reasons like protection of ecology and environment, cost effectiveness, sustenance, simplicity in adoption, familiarity

Photo 4: *Nigeria, Bauchi State. Vetiver grass, Vetiveria nigritana, used for making handicrafts.*

Photo credit: Ahmed U Ibrahim

of operations among the farming community. This is being increasingly felt at academic, policy and planning levels. There is a need to translate this concept sufficiently at the execution level. Among the various species available for vegetative approach, Khus *(Vetiveria zizanioides)* has various uses because of its versatile features. It can function as an independent measure, can initiate vegetative measures with other species, supplement other species in vegetative measures. Because of simultaneous existence of xerophytic and hydrophytic characters (as revealed by structure of its tissues), it can adapt under various agro-climatic settings. The cost of multiplication of slips, planting, developing into a hedge and maintenance is far less compared to earthen and masonry measures. Once introduced into a region and the farmers are convinced, it can expand without the intervention of government agencies. These facts have been supported by tables, photographs and slides as experienced in Karnataka (India).

Uses Of *Vetiveria nigritana* In Northern Nigeria — A Case Study Of Bauchi State.
Ahmed U. Ibrahim. Bauchi State Agricultural Development Programme, Soil Conservation /Agroforestry Component, Nigeria.

The paper high lights the uses which *Vetiveria nigritana* is put to in Northern Nigeria. The locally available grass species in the region is known by the local farmers as a gift of nature to settle farm boundary disputes from many centuries ago.

The uses of the grass include, hedge rows, farm boundaries demarcation, thatch, mat, mulen, rope, hand crafts, and pest repellent. Supporting evidence with film slides and some empirical data are provided. *Vetiveria nigritana* has established it's potentials from it's vast uses as important in both soil/moisture conservation and source of revenue generation to the African peasant farmer.

Farm Household Center: A Basis For Extension And Transfer Of Vetiver Technology.
Kuscahyo Budi Prayogo. Agricultural Information Center, Central Java., Indonesia.

The existing situation related to vetiver extension activities in Central Java is discussed. Although Java is the leading producer of vetiver oil, in some places people are convinced that vetiver actually causes erosion. Farmers themselves think that vetiver is not profitable economically. These problems basically show t**he failure in executing extension and research approaches.** Upland watershed farming system need to be approached and analyzed from three key perspectives, i.e. technical factor, socioeconomic factors and agroecological factors.

Socioeconomic factors have great influence in determining farmers preferences in doing their farming system. Vetiver, as a single plant is considered unprofitable. That is the reason that farm household living in upland watershed are more likely to choose other grasses. However, as an integral part of an upland farming development, vetiver has the best role in controlling soil and water erosion. It is essential to reconsider the way researchers and extension workers do their activities in upland watershed.

Cost Comparison In Producing Vetiver Grass From Different Methods Of Production
Sumol Sopakorn, Wichai Suwanakert and Darunee Kaewvichien. Land Development Department, Ministry of Agricultural and Cooperatives, Bangkok, Thailand.

According to the high demand of using vetiver grass for soil and water conservation from many government agencies, it is necessary to find the best and quickest method of producing vetiver grass for good quality, low cost etc.

The study was carried out into 2 steps:

- planting vetiver directly into the plastic

Photo 5: *Nigeria, Bauchi State. The wall of this grain store is made of vetiver grass, Vetiveria nigritana. The roof is made from Andropogan gayanus.*

Photo credit: Ahmed U Ibrahim

bag, the field and greenhouse.

- After the first step dividing the tillers of vetiver grass from the plastic bag, field and greenhouse and replanting in the plastic bag.

The results from the study showed that the cost of producing vetiver grass were:

Cost for the first step.

- Cost of producing vetiver's shoot in the plastic bag was 0.12 Baht.
- Cost of producing vetiver's shoot in the field was 0.08 Baht.
- Cost of producing vetiver's shoot in the greenhouse was 0.20 Baht.

Cost for the second step.

- Cost of producing vetiver's shoot again from the plastic bag was 1.65 Baht.
- Cost of producing vetiver's shoot again from the field was 1.61 Baht.
- Cost of producing vetiver's shoot again from the green house was 1.73 Baht.

Note 1 US$ = Baht 25

Alternative Dissemination Bridging The Gap

Stephen Rwangyezi. Ndere Troupe, Cultural Performers and Promoters, Offices at National Theatre Building, Uganda.

The Educational methods that were introduced in Africa during the second half of the 19th century by the first missionaries and which formed the basis for schools, were completely different from those that tradition had developed since the existence of the African continent.

Whereas in traditional Africa, education was informal-learning through work. play or conversation, and where every body was a teacher-at any time and anywhere, (except for specialised education like medicine which was done through apprenticeship), the European education emphasised selection and isolation of learners, keeping them in partial prisons called schools, run by "artificial creatures" code-named teachers, who were slaves to books called syllabi and to a bell that signified change of periods and subjects irrespective of whether the previous ones had been understood or not. Only the financially capable parents managed to send their children to these privileged Centres-Schools.

The result of the collision of these two completely different educational systems was class creation. The "Modern" system produced a powerful minority group of "social misfits" that control political power from remote centres called towns and cities. These people, unfortunately disregard the vast "Unschooled" rural based majority as primitive, obstinate, fatalistic, retrogressive and peculiarly impervious to any form of civilization-a condemned group to be ignored until they die off.

Far from dying off, however, the rural majority, interact with nature. Using crude methods, they produce the food and the children that keep feeding the cities and the whole country. They, however, view the elites as an unrealistic and not down-to-earth lot.

The mutual suspicion that developed between the products of the two educational systems is, in our opinion largely responsible for the gross lack of complimentality in addressing Africa's problems such as malnutrition, high mortality rates, political confusion, wars etc. etc.

If, therefore, we are to talk about development that is environmentally friendly, then we must talk about effective COMMUNICATION and DIALOGUE with the rural population. But since the majority of them neither read nor write, given that radio and television, leave alone electric power, are a luxury of the rich city dwellers, considering that the rural peasant is depending on their muscle power therefore with serious time constraints (cannot afford the luxury of spending 'endless' hours in boring lectures and seminars) we must find in *interesting, familiar* and *friendly* method to disseminate vital information and *stimulate* open and sincere *dialogue.*

Farmer Participatory Selection Of Vetiver Grass And The Most Effective Way To Control Erosion In Cassava-Based Cropping Systems In Vietnam And Thailand.

Reinhardt Howeler, CIAT, Thailand

Research has identified various effective ways to reduce erosion in cassava-based cropping systems, including the use of vetiver grass. However, few of these practices are presently used by farmers. To enhance the adoption of soil conservation practices by cassava farmers, a Farmer Participatory Research (FPR) methodology was used in two pilot sites each in Thailand, Vietnam, China and Indonesia to test and select the most effective practices. Farmers in Thailand and Vietnam selected vetiver grass contour barriers as one of 4 - 5 treatments they wanted to test on their own fields. After harvesting all trials and discussing the results, farmers in all three villages in Vietnam selected the vetiver grass treatment as the most effective in increasing income and reducing erosion. Although the trials in Thailand have not yet been harvested, farmers already observed that the vetiver grass treatment was the most effective in reducing erosion. In both countries, participating farmers, after seeing the benefits of vetiver grass, requested additional planting material to plant in their fields.

TOLERANCE OF VETIVER TO TOXIC CHEMICALS

Vetiver Hedgerows And Agrochemical Residues: A Case Study In The Cabbage Fields At Nong Hoi Development Center Chiang Mai, Northern Thailand.

J.Pinthong[1], S. Imphitaks[2], M. Udomchoke[2], A. Ramlee[1]
[1]Research Division, Royal Project Foundation
[2]Department of Agriculture Technology, THAILAND

The main objectives are to investigate the fate of agrochemicals used for growing cabbage in between the vetiver hedgerows (VHRs) and to evaluate the effectiveness of hedges in reducing the over supply amount of pesticides and nitrate fertilizer. The experiment has been conducted in the area of 15 x 72 square meters on 60 per cent slope. Split-plot in randomized complete block is assigned with three replications (blocks). Each block consists of six plots with and without VHRs at 3 and 6 meter vertical intervals and also agrochemicals at zero, one and double doses were applied. Seedlings were transplanted on July 13, and harvested in September 29. Random samplings were later taken from the lowest VHRs of the three whole plants at each plot; and from soils to one meter depth in between and at one meter behind the lowest VHRs. Included were sediments from the collection tanks below. From the

analytical data, the three pesticides were taken up into vetiver grass at different rate and contents. Those applied were in soil cooperated as Carbofuran insecticides. Alachlor herbicides sprayed 7 days after planting cabbages and Monocrotophos spraying twice at 34 and 42 day during the growing stage. Carbofuran was found in vetiver grass about 0.001 - 0.006 per cent; Alachlor 0.01 - 0.08, and Monocrotophos 0.19 - 0.53 per cent of the total fresh weight. In soils, only Alachlor has been detected around 3.38 to 7.69 per cent. It is believed that over 90 per cent of Carbofuran and Monocrotophos had decomposed and could have not been detected by the method employed. Probably, the same decomposition happened for Alachlor after spray to harvesting when the cabbage was about 78 days old. Alachlor and Monocrotophos were found both below and over Maximum Residue Limit, i.e.>0.02 and 0.20 ppm respectively. Carbofuran at normal and double close was lower according to FAO/WHO CODEX (<0.5 ppm). Losses of soil through VHRs of 5 months old found at the moderate rate of 22.4 ton per hectare. There was only Alachlor found in sediments about 0.02-0.5 per cent. The influence of nitrate fertilizer could not be possible as to have been detected by this period. A conclusion can be made at this stage that VHRs have substantially contributed to a process of captivating over supplying of agrochemicals as the living walls. As a result detoxification should have been possible and the better downstream water quality. This study is a preliminary one, thus it still needs further detailed investigation.

The Capability Of Vetiver Hedgerows On Decontamination Of Agrochemical Residues: A Case Study On The Production Of Cabbage At Nong Hoi Development Center Chiang Mai, Thailand.

Pinthong J.[1], Impithuksa S[2]., Udomchoke M[2]., Ramlee A.[1].1 Research Division, Royal Project Foundation.
2 Division of Agricultural Toxic Substances, Department of Agriculture.

The study was conducted in a cabbage field at Nong Hoi Development Center, Chiang Mai, in order to determine the movement and degradation of agrochemicals applied on cabbage which focused on their impacts on soil sediment and especially in vetiver. Split-plots in RCB was designed in the area of 15x72 in^2 at sixty per cent slope. Each block consisted of cabbage and vetiver hedgerows (VHRs) lined vertically at 3 and 6 m apart. Before and after transplanted on July 13, the pesticides, i.e. carbofuran, monocrotophos, and alachlor were applied in single and double doses. On September 29, an approximate 78 days after transplanted the cabbages were harvested and were brought to the laboratory together with soil, sediment (from the small reservoir below the experimental plots). and vetiver grass for analysis.

The analytical data revealed that most of the tested pesticides applied on cabbages could be translocated and up taken by crops, adsorbed by soil as well as sediment in different amounts. The vetiver was capable of pesticide absorption as indicating by the residues of carbofuran, monocrotophos and alachlor found at the percentage of 0.001 - 0.006, 0.09 - 0.25 and 0.01 - 0.08 of the total amount of active ingredient application, respectively. In soil, only alachlor was detected between 3.69 - 7.56 per cent. While, the percentage of residues found in cabbage for carbofuran, monocrotophos and alachlor were 0.005 - 0.01, 0.75 - 0.91 and 0.01 - 0.09, respectively. Moreover, alachlor residues detected from the single and double doses were exceeded the maximum residue limit (MRL). This event was also occurred in the cabbage applied with the double dose of monocrotophos. The loss of surface soil by run-off which could be evaluated in term of sediment was at the medium level 22.5 ton per hectare. Aside from the rate of leaching the sediment was also an accumulation site for alachlor and carbofuran residues at the percentage of 0.02 - 0.5 and 0.002 of the total active ingredient admitted, respectively. No data were available for the absorption of nitrate fertilizer by vetiver in the experiment. The study concluded that the vetiver hedgerows played an important role in contribution to the process of captivity as well as decontamination of agrochemicals especially pesticides and preventing them from contamination and accumulating in crops, streams and other ecosystems. Due to the lacking of data upon the relationship between vetiver and agrochemicals, altogether with this study which is a preliminary one, therefore further study for more details is still needed.

In Vitro Induction Of Salt Tolerance In Vetiver Grass

M. Nanakorn[1], S. Surawattananon[1], C. Wongwattana[2]
K. Namwongprom[1] and S. Suwannachitr[1]
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[2]Department of Biology, Faculty of Science, Srinakharinwirot University, Bangkok, THAILAND.

Vetiver grass (*Vetiveria zizanioides* Nash) ecotype Sri Lanka was induced for salt tolerance by culturing calli from young inflorescence on MS medium supplemented with 5 μ M 2,4- D and 0.5 -3.0% NaCI, at 0.5% intervals for 45 days. At 0.5-1.5% NaCI, 100% of calli survived. At 2, 2.5, and 3.0% NaCI, their survival percentage dropped to 82.5, 25, and 0%, respectively. The surviving calli regenerated to plantlets when transferred to hormone and NaCI free MS medium for 30 days. However, the regeneration percentage declined with an increased concentration of NaCI. The 1.0 - 2.0% NaCI treated calli regenerated only 10 - 20% while there was no regeneration in 2.5% NaCI. All obtained plantlets were tested for their salt tolerance by culturing on MS medium with NaCI at the same level as their calli were treated, in comparison with the untreated plantlets. The result showed that the survival percentage of treated plantlets at each concentration of NaCI was higher. They tolerate up to 15% NaCI while the normal plant can tolerate nothing higher than 1.0% NaCI.

Effects Of Some Adverse Soil Conditions On The Growth Of *Vetiver Zizanioides* L.

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It has been widely reported that vetiver grass can be established and flourish under a wide range of conditions including some very hostile environments. However very few quantitative data have been reported to support these anecdotal observations. In a series of glasshouse and field experiments, it was shown that vetiver can thrive under a wide range of pH, it is highly tolerant to saline and sodic soil conditions, and Al and Mn toxicities. When adequately supply with N and P fertilizers, Vetiver can flourish between pH 3.3 and 9.5. The saline threshold level is ECse = 8 dS/m and for 50% yield reduction, ECse = 17.5 dS/m. These results include vetiver in a group

of highly salt tolerant crop and pasture species grown in Australia. Its growth was also not adversely affected by soil with exchangeable sodium percentage of 33%. With adequate moisture, N and P supply vetiver can flourish at soil Al and Mn higher than 68% saturation and 578 ppm respectively.

These results support observations that vetiver can be established under highly hostile environment and indicating that it is highly suitable for land stabilization and reclamation of extremely hostile environment such as mining and industrial wastes.

In Vitro Selection Of NaCl Tolerance In Vetiveria Species

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[2]Department of Biology, Faculty of Science, Chiang Mai University, Chiang Mai, THAILAND.

The NaCl tolerance of vetiver grasses were examined in vitro. There were 5 ecotypes of *Vetiveria zizanioides* Nash: Surat Thani, Songkhla 3, Chiang Rai, Sri Lanka and Indonesia; and 5 ecotypes of *V. nemoralis* A. Cam US: Kampaeng Phet 1, Prachuap Kin Khan, Nakhon Sawan, Huay Diag and Gudbaak. The calli from young inflorescence were cultured on MS medium supplemented with 5 ILM 2,4-D and 0-4% NaCl at 1 % interval for 45 days. The Kampaeng Phet 1 clearly showed maximum degree of salt tolerance. The NaCl concentration that gave 50% reduction in callus growth was 1.95% and followed by Prachuap Kin Khan at 1.31 %. The surviving calli of the Kampaeng Phet 1 were regenerated to plantlets on hormone and NaCl free MS medium for retesting of NaCl tolerance.

Vetiver For Sodic Land Reclamation

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226 001, India

National Botanical Research Institute (then NBG), Lucknow in Uttar Pradesh was a pioneer for using vetiver (in 1956) for amelioration of sodic sites. However, it is only recently, after 40 years, that vetiver has again been opted for large scale trials under a World Bank programme in the state. High concentration of salts in the root zone of soil limit the productivity of 950 million hectares of otherwise productive land around the world. In India alone, there are 8.1 million hectares of sodic land, where productivity is limited. We have been able to grow Vetiver successfully in the soils with high levels of exchangeable sodium in the root zone with high pH (9 to 10.6) throughout the profile, poor water intake, occasional anaerobic stress due to water logging, poor availability of phosphorus that limits the growth, and low fertility.

Agro-techniques were developed for growing vetiver as hedgerow and flat beds in barren uncovered lands. The agro-techniques included developing quality planting material selected for tolerance to high pH, optimum root formation, mycorrhizal association and vigorous vegetative growth. The nursery was raised in a poly house with mist irrigation. Application of endomycorrhizae cultures *(Glomus fasciculatum)* facilitated root growth and P uptake. Such selected and tailored slips are being used for hedge under sodic land afforestation and development programme. Capacity to provide planting material in commercial quantities has been developed. Farmers are slow to accept the technology, however, a marketing strategy with appropriate training is being planned. Initial training is provided by "motivators" while technical tips are provided by experts. Key persons are being trained for faster dissemination to end users. Vetiver along with other aromatic grasses such as lemon grass and palma rosa are gradually gaining cognizance and acceptability.

***Photo 6**: Newly planted vetiver on cut section above canal in Mindanao, The Philippines, used for bank stabilization and control of debris.*

Photo credit: Francisco E. Garrido

BIO-ENGINEERING ASPECTS

Hydraulic Characteristics Of Vetiver Hedges:
An Engineering Design Approach To Flood Mitigation On A Cropped Flood Plain.

P.A. Dalton, R.J. Smith and P.N.V. Truong
University of Southern Queensland and Queensland Department of Primary Industries, AUSTRALIA

Although the Vetiver system has been used worldwide, few studies described the hydraulic characteristics of Vetiver hedges quantitatively. This paper describes the effectiveness of the Vetiver system in a quantitative hydraulic manner beyond the well documented anecdotal evidence.

The hydraulic characteristics of Vetiver hedges were first determined in a testing flume. From the data collected an empirical hydraulic relationship was developed between the depths and discharge. This relationship was used to calculate the maximum Vetiver grass hedge spacing required to control soil erosion on a flood plain.

From the model of flow through Vetiver hedges, design hedge spacing were selected for a field site in Queensland. The various catchment and farm characteristics

Photo 8: *Queensland, Australia. Vetiver hedge on Darling Downs Close up of photo 7. Note how the vetiver remains erect.*

Photo credit: Paul Truong

were considered before a hedge spacing of 91.5m was selected for the site. Six rows of Vetiver totaling over 3,000 m were planted on the contour at this spacing.
Flood discharges and depths and sediment movement are being monitored at this site to validate the above theory and quantification of Vetiver on the flood plain and to monitor the effectiveness of the hedges. Early results from a small flow over the site show that the hedges reduce significantly the depth and therefore energy of flow through the hedges. At a low depression. 7.25 tonnes of sediment was trapped.

Vetiver In A Southern African Context

Anthony Tantum Specialized Soil Stabilization CC, P.O. Box 167, Howick, 3290, South Africa

Vetiver grass has been promoted and researched extensively in Southern Africa with considerable success. As a consequence it is being used in a range of applications including; combating of soil erosion, in farming and forestry, commercial planting for generation of essential oil, slope stability on engineering sites, and most significantly as stabilization hedges on slimes dams in the gold and diamond industry.

South Africa has numerous very large slimes dams which represent a by-product of deep level gold mining. These dams consist of an extremely sterile, highly acidic rock flour which becomes encrusted with salts in the near surface layers. Aside from being hostile to plant growth, the slimes dams present severe dust, aesthetic, and acid mine drainage environmental problems. These dams are also located in harsh climatic conditions including low rainfall and temperatures which range from -5˚ C in winter to plus 30˚ C in the summer. Trial survival planting has shown that Vetiver represents an ideal plant material for stabilization of gold mine and slimes dams. Vetiver has survived successfully for nearly 4 years on slimes dams in Welkom with minimal maintenance. Its use as a stabilization medium is now accepted by the Gold Mining Industry, and aside from the above, other commercial aspects (e.g. mulching, thatch grass, weaving material) applications are being widely considered in the new South Africa.

Slope Stabilization: Vetiver Application In Bio-Engineering Aspect

Karn Trisophon and M.R. Samjamjaras Rajanee, Department of Land Development, Thailand.

Tremendous earth work during the construction of Noppamaetaneedol and Noppapol Phumisiri Pagoda at Intanon summit has caused substantial change in the relief on the construction site. Falling earthwork had formed a steeper slope which was stable enough to sustain itself during the dry season. But in the rainy season, infiltrated water which was contributed by subsurface flow had gradually increased pore pressure and subsequently overcame shear stress of the soil. This caused slope failure. In order to reduce pore pressure, strips of gravel pit were built so as to induce inflow from the excess moisture content of the soil. The excess water was then drained into concrete dikes next to each pit. Even though most of the excess water was drained out, what was left was enough to make the portion of slope adjacent to the dikes become unstable. To remove this problem a row of vetiver was planted on the outer bank of each dike. Vetiver's outstanding root system had two roles. The first was to mesh up and mechanically add stability to the slope. The second role was to suck up the excess water and dissipate it via evapotranspiration process.

An Assessment Of Strength Properties Of Vetiver Grass Roots In Relation To Slope Stabilization

Diti Hengchaovanich and Nimal Santha, Nilaweera Erocon Sdn Bhd, Kuala Lumpur, Malaysia.

It is well reported that the root properties of vetiver grass can help reduce soil erosion and enhance slope stability when properly planted on soil slopes. In general the root properties can be subdivided into root strength properties and root morphological parameters. Some previous studies on vetiver plant have elaborated the root morphological parameters qualitatively.

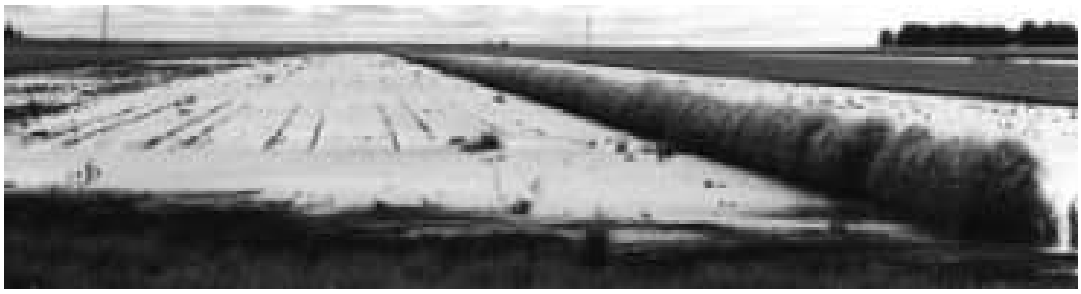

Photo 7: *Queensland, Australia. Vetiver hedge on Darling Downs (black soils, flat plain, subject to serious erosion when not protected. Vetiver hedges slow down flood velocity, and reduce erosion and crop and crp dammage.*

Photo credit: Paul Truong

However, the strength properties of vetiver roots, which also play a significant role in terms of erosion control and slope stabilization, have not yet been understood adequately. Vetiver is considered as a very deep-rooted penetrating grass variety which develops a fibrous profusely grown root system. The root penetration is mainly vertical and sometimes up to 3.6 m deep depending on the soil conditions. When a root penetrate across a potential shear surface in a soil profile the distortion of the shear zone develops tension in the root; the component of this tension tangential to the shear zone directly resist shear, while the normal component increases the confining pressure on the shear plane. Therefore, it is essential to understand about the root tensile properties in the process of evaluating a plant species as a component of slope stabilization.

This paper intends to discuss about root tensile strength of vetiver grass and its contribution to soil strength increase by means of experiments on root tensile strength determinations and root permeated soil shearing, which is a part of an ongoing research work specially design to assess both root strength properties and root morphological parameters in relation to slope stability and erosion control. Unbranched sections of vetiver roots in different diameter classes up to about the average maximum root diameter (3.5 mm) were tested in order to determine the tensile strength. The results were compared with the root tensile strengths of other tree species which were obtained from previous studies, and the effect of root diameter on the tensile strength of vetiver roots was established. To obtain the contribution of root tensile strength to the shear strength of soil, large scale direct shear tests were performed in 0.5 x 0.5 x 0.5 m^3 root permeated soil blocks along with root free soil blocks with same soil properties. The difference between the shear strength values of root permeated and root free soils, the shear strength increase due to the presence of roots, were then analyzed with the root area ratio, root diameter, root orientation and eventually with the root tensile strength to elaborate the significance of root tensile strength of vetiver grass and its influence in soil strength increase.

Calibration Of Rusle With Vetiver Grass As Live Sediment Filter In The Hills Of Puerto Rico.

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Vetiver is being evaluated and considered, along with other conservation practices, as a viable alternative for erosion control and reforestation of large clear areas. Research to calibrate the performance of vetiver as a live sediment filter is in progress; the Revised Universal Soil Loss Equation (RUSLE) is being used as the prediction model in very steep slopes subject to several management practices including denuded areas.

Vetiver barriers have been planted at 30 foot intervals in a 100 percent slope planted in an intercrop of pigeon pea and celery in the town of Jayuya, Puerto Rico. A sediment collection equipment was designed, built and installed before and after each vetiver barrier. Sediment accumulation behind the barrier is measured after every rain event with surveying equipment. The farmer has collaborated in all aspects of the work from planning. contouring, planting to data collection.

The result of this experimental work will be used to develop guidelines for use of vetiver in the hills of Puerto Rico and other tropical islands with similar ecosystems and under agriculture and in construction sites and along road banks to reduce the high level of sediment yields from most agricultural watersheds in tropical environments.

Root Characteristics And Root Distribution Studies Of Some Vetiver Grass *(Vetiveria zizanioides* L, Nash And *Vetiveria Nemoralis* A. Camus) In Thailand By Using P-3z Tracer Technique

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The root performances at different growth stages of some local vetiver grass was conducted at different experimental sites within the Royal Doi Tung project area. Soil injection technique with P-32 at various distances and depths of a vetiver plant hill was used. Radio activity of P-32 was monitored from the leaves at growth stages to evaluate rooting characteristics and pattern of root system.

Under field trial for studying root characteristics at Doi Tung Vetiver Crass Research and Development Centre, 2 vetiver grasses originated from Surat Thanee (*Vetiveria zizanioides* L, Nash) and Pimai (*Vetiveria memoralis* A. Camus) were studied. It was observed that at 1 and 2 1/2 month after planting of a Slip of vetiver grass, roots of both vetiver plants were found at 150 and 250 cm depths respectively. However, more root density was found at the depth 30 -100 cm. At 9.6 months growth stage of both vetiver plants, roots were found at soil depth 400 cm. and the highest root density was at the depth of 150, 250 and 350 cm. respectively. It was also found the roots of both vetiver grasses at the depth of 500 cm. when observation was made at 25 months old.

Vetiver grass, Viangchai, from Chiangrai was grown at side slope for the purpose of soil erosion control. Root systems was not extensive due to inadequate nutrients which was shown by the handed growth of vetiver plants. However, roots penetrating were as deep as 400 cm. when the plants were 17.6 months old. The results of root density were vague.

Vetiver grass from tissue culture from Surat-Thanee and Hua Ka Kaengere were used to study root distribution at field trial. It can be concluded that on the average root development of vetiver grass studies of Surat-Thanee would distribute horizontally from the plant hill 60 cm. (soil depth 80-90 cm.) at the age of 6 months. At 8 -10 months old the distribution was between 80-140 cm. (30-120 cm. depth) respectively. The root could spread in between 70-100 cm. apart from the testing at the depth of 150 cm. It could be observed that at 180 cm. depth, the root could distribute to the distant of 80 cm. away from the testing hill. For Hua Ka Kaeng the root distribution was not as good as that at Surat-Thanee. The root could spread uniformly between 40-60 cm. on average away from the testing grass (6 -10 months old).

The Introduction, Early Results And Potential Uses Of Vetiver Grass Hedge Row (VGHR) In the Mediterranean Region.

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The establishment and growth of VGHR were tested in the hostile, aerial and edaphic environment of Murcia, Spain. The climatic condition consists of hot summer, cold winter with sub-zero temperatures, low precipitation and negative water balance over more than half a year. The soil is calcareous, mostly clayey. Hilly topography is common with serious erosion rates of more than 5000 Tm/km^2 per annum.

The experimental sites were in El Chopillo with 300 plants and in Lorca with 32,498 plants on 5 trials testing soil protection and moisture conservation under different conditions. Despite cold winter with frost, trials established by container plants, from December 1994, had overall transplanting success of 95.9%.

Harvesting of plant tops in El Chopillo, produced 55 tiller and 1033 gm/plants after 14 months. In San Julian, the Malaysian and American Cultivar produced 304 and 377 gm/plant with 45 and 79 tillers respectively after 9 months.

Excavation showed that the root system in El Chopillo had reached a depth of 2.6 m. In San Julian, the Malaysian and American Vetiver had produced roots reaching down to 2.1 m. and 1.7 m. respectively. In all cases, the major root masses were at the top 0.5 m. In a 45% slope of 11 meter height, 2 blocks of 20 meters were planted with VGHR at 1 metre vertical interval in January 1995. The in-between block, left unplanted as control, suffered severe erosion by September 1995 despite the low rainfall. Significant soil had been trapped by the VGHRs.

Sub-zero temperatures in winter killed exposed tops but the buried crowns survived. In early spring, new tillers were formed, followed by good and vigorous growth in Summer and Autumn. The plant's response to the seasonal weather condition suggests 4 distinct phases:

- Frost injury and dormancy.
- Awakening and tillering.
- Rapid growth and biomass production.
- Slow growth or sustenance period.

The tropical Vetiver Grass adapted well to the weather conditions and appeared to behave like a temperate plant. This, and the good growth and root system suggest potential uses for Vetiver in the Mediterranean Regions. It also suggests that Vetiver could be established in the highlands of the tropics and the subtropics.

AGRICULTURAL USES OF VETIVER

Nutritive Value Of Vetiver Grass Silage Supplement With Some Silage Additive

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To improve the nutritive value of Vetiver grass, cv. Ratchaburi using a 30 day cutting interval, was ensiled by adding 0.5% urea (Treatment 2), 10% molasses (Treatment 3), 1 5% mixed ground cassava chip (Treatment 4), 0.5% urea + 10% molasses (Treatment 5), 0.5% urea + 1 5% mixed ground cassava chip (Treatment 6) and compared with untreated Vetiver grass (Treatment 1 as Control). After 30 days, the result was that Treatment 3, 4 and 5 had good quality in terms of palatability, pH, and percentages of dry matter, lactic acid, butyric acid, nutritive value and dry matter digestibility. Treatment 6 was judged of fair quality due to higher percentages of butyric acid. Treatment 1 and 2 were of poor quality.

Vettiver Grass (*Vetiveria Nemoralis*) As Substrate For Mushroom Cultivation.

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Preliminary study on the cultivation of four different species of mushroom (Genus *Pleurotus*) using dried vetiver grass (*Vetiveria nemoralis*) as substrate, was conducted during March 1994 - January 1995 at Som Dej Pra Sri Nakarin Royal Garden, Huai Sai Royal Development Center, Petchaburi Province. They are *Pleurotus sp*. Florida (Hed Hang Rom Kao), *Pleurotus sp*. from Hungary (Hed Nang Rom Hungary), *Pleurotus sp*. (Hed Bhuthan), and *P. abalonus* (Hed Pao Hu). Pasteurization and non-pasteurization methods were applied. Two formulae of the first method used for substrate preparation were : Coarse ground vetiver grass mixed with rice bran, sugar, magnesium sulphate (100 kg.: 4 kg.: 2 kg.: 0.2 kg.) and water as needed (mic 60-65%) and cut vetiver grass composted with 7% with rice bran. These mixtures were bagged, pasteurized and spawned.

It was observed that the first method produced higher yield in every species. The second method (non pasteurized), where cut soaked vetiver grass was bagged and spawned simultaneously produced fruiting bodies on only two mushroom species *Plourotus sp*. Florida and *Pleurotus sp*. from Hungary.

Vetiver (*Vetiveria zizanioides)* Straw For The Cultivation Of Oyster Mushroom (*Pleurotus Spp*)

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Possibility of utilizing vetiver (*Vetiveria zizanioides)* grass for the cultivation of *Pleurotus euos* (serk) Sacc., *P. salmoneo* - Stramineus L. Vass., *P. citrinopileatus* (Fr) Singer, P. Sajorcaju (Fr) Singer: *P. platypus* (Cooke and masee) sacc., was explored. *P. euos*, *P.salmoneo* - Stramineus and *P. Platypus* colonised the vetiver straw early (within 13 days) and yielded 355 to 405 g of mushroom/bed (Bio-efficiency ranged from 70 to 80 per cent). Paddy straw and paddy straw + Vetiver grass (1:1 w/w) gave significantly higher yields (437.1 and 434.7 g/bed respectively) than vetiver alone (385.9 g/bed).

Allelopathic Effects Of Vetiver Grass On Weeds

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Vetiver is a tropical perennial grass, widely distributed thoughout Thailand. Vetiver is cultivated for erosion control as well as a sort of barrier to prevent the invasion of weeds. Experiments were performed to investigate allopathic effects of vetiver grass on weeds. Methanol extract of ground dried stems and roots of 3 vetiver ecotypes were tested on 10 common weed species. It was found that root and stem extracts from 3 Vetiver ecotypes: Ratchaburi, Suratthani and Indonesia strongly inhibited seed germination and seedling growth of *Amaranthus gracilis*

Desf., *Abutilon hirtum* Sweet, *Pennisetum polystachyon* Schult, *Melochia corchorifolia* Linn. and *Ruellia tuberosa* Linn.. The degree of inhibition depended on the vetiver ecotypes, concentration of the extracts, and weed species dependent. The study also suggests the possibility of developing a natural herbicide from vetiver grass which will leave hopefully little or no toxic residue harmful to the environment.

Study On Compost Making From Vetiver Grass

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The studies on compost making from vetiver grass were carried out at 5 sites: namely Ratchaburi, Srisaket, Chiang Mai Land Development Station, Khao Hin Sorn and Pikun Thong Royal Development Study Centre. The design was observation trial with 4 treatments. The treatments were:

1 Making compost on the ground with LDI rhizobium and turn over.

2 Making compost in the hole with LDI rhizobium and turn over.

3 Making compost on the ground with high tech rhizobium.

4 Making compost in the hole with high tech rhizobium.

After 150 days the results showed that the ratio between carbon and nitrogen from treatment 1 is the best, followed by treatment 2,4 and 3 with the ratio of 20, 23, 26 and 29 respectively. It also found that the chemical and physical properties of T1 is the best followed by T2, T4 and T3. The pH value ranging between 6.9 - 7.2.

VETIVER AGRONOMY

A Comparative Study On Growth, Rooting System And Yield Of Difference Ecotypes Of Vetiver Grass.

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The comparative study on growth, rooting system, and yield of 10 ecotypes of vetiver namely Songkla 3, Sri Lanka, Kamphaeng Phet 1, Ratchaburi, Loei, Su rat Thani, Kamphaeng Phet 2, Naskorn Sawan, Prachuap Khiri khan and Roi Et was conducted at Amphur Muang, Narathiwat Province on Kho Hong soil series. The study showed that Ratchaburi gave the best performance in term of height tillering and crop yield followed by Prachuap Khiri Khan and Songkla 3.

A Global Perspective Of Vetiver

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The potential role of Vetiver grass in modifying unwanted effects of land-use-change and burning of fossil fuel is presented. In this century we have witnessed large scale soil erosion and climate changes. In the next century soil erosion and climate change are expected to be even more damaging to the well-being of mankind.

The role of Vetiver grass hedges in restricting the world wide soil erosion is outlined. Means of restricting global warming by increasing the carbon transfer from the global atmosphere to the vadose and phreaticenes using deep-rooted plants like Vetiver is outlined.

Various techniques for improving Vetiver plant survival in cold, saline and arid conditions are presented.

Genomic Manipulation For Eco- Friendly Plantation And Enhanced Productivity Of Essential Oil In Vetiver

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Profuse seed formation enriches vetiver population in its natural habitat but leads to a heterogenous mix of in-built genetic variability that may not be always desirable. Nevertheless, the vegetative mode of propagation attendant in this species promises a distinct advantage for realising uniform population and the resultant plant products. But this does not take care of the menace that is likely to take place on account of seed dispersal, disturbing genetic purity of the growing population as well as spread of vetiver to undesired destinations, lest the flowering tops are excised before seed-set. Therefore, an eco-friendly approach should aim at isolating the desired plant types that either do not bloom or bear only infertile seeds.

In India, tremendous amount of genetic variability exists in vetiver that can be clustered into five distinct groups on account of karyomorphological characteristics and 2C nuclear DNA content (range 2.0 to 2.6 pg). Although, non flowering/infertile plant types naturally occur in southern parts of India, their genetic manipulation to attain desirable attributes is greatly handicapped for lack of an amenable reproductive system. Therefore, resorting to artificial polyploidy is the obvious choice to meet the twin objectives of genetic manipulation for bringing a desirable change in agrobiological characteristics as well as causing a breakdown in sexual reproductive system.

Curiously, the artificial autotetraploids developed in this species have shown their superiority over diploid progenitors with respect to economic yield by 60% and enhanced soil binding capacity on account of thicker roots. The seed sterility associated with such autotetraploids and the expected triploids would not only restrict their unwanted spread, but facilitate channelisation of saved biological resource of the plant towards vegetative vigour and secondary metabolism.

Vetiver Grass In India

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ABSTRACT - 1

The paper summarises research results of the use of vetiver grass to improve the water holding capacity and moisture percentage of soil in wastelands. Water holding capacity and moisture percentage are the two important soil factors governing the productivity. Vetiver grass was grown in an area with known water holding capacity and soil moisture percentage for 20 months. A control plot was maintained without vetiver grass. Soil samples were collected once in a month in control and treated plots. Water holding capacity and soil moisture percentage were determined

by standardized methods. When compared with control plots, the treated plots show 20% increase in water holding capacity & soil moisture percentage over control. Positive correlation were made between root biomass and the two soil parameters studied.

ABSTRACT - 2

Fine roots significantly influence soil organic matter accumulation and nutrient cycling. Characterization of the activity of the fine roots is therefore a key approach to the understanding of the below ground system (Singh). At the global level, fine root production represents a large and relatively unknown portion of the production/decomposition carbon balance. Despite the central importance of fine root dynamics neither a clear and consistent pattern of fine root dynamics in communities nor an understanding of factors controlling those dynamics has emerged (Aber). Very little information is available on this subject. The present study on fine root productivity of vetiver was designed to unravel temporal and spatial patterns of their size distribution, growth, decomposition and overall role in the functioning of the below ground system.

Root sampling. involved collection of replicate soil cores, hand washing and sorting of roots from the soil matrix. Collections were made at monthly intervals. Ten randomly spaced samples (1.9 cm in diameter and to a depth of 15 cm) were collected separately in the study area. (l8 months old stand of vetiver). Annual fine root production of vetiver is estimated by max-min method of McClagherty et al (1982)

The annual fine root biomass was 190 kg/ha. Positive correlation was obtained between fine root biomass and organic carbon content of soil.

ABSTRACT - 3

The paper presents the impact of R D M (Rock Dust Mineralisation) technology on the biomass production of vetiver grass. The positive impact of R D M technology was well studied and well reported in many forest tree species and vegetable crops (Joanna Camp). The technology is simple, cost effective and environmental friendly. As far as known to us this study is the first research effort made on the impact of R D M technology in the productivity of vetiver grass.

The study was carried out in earthen pots. Twenty five pots were kept without R D M treatment (control) and twenty five pots were treated with R D M treatment. Biomass (Root & Shoot) production was estimated after 120 days. Productivity of vetiver in control pot is 0.225g/day and 0.383g/day in treated pots. Significant increase in the biomass was noticed in the treated plants. Since this was only a pilot study carried out for practical application the conclusion is tentative and R D M technology needs further investigation.

Effect Of Soil Water Levels And Nitrogen Fertilizer On Growth Of Vetiver Grown On Three Major Soil Series Of Northeast, Thailand.

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Experiments were conducted in greenhouse and in the field to elucidate the effect of soil water and nitrogen fertilizer levels on growth of vetiver on three major soil series of the Northeast, Thailand, namely: Satuk (Oxic Paleustults), Nampong (Ustoxic Quartzipsamments) and Roi-et (Aeric Paleaquults at Khon Kaen Province during 1993-1994).

For the greenhouse study, four levels of soil water (100, 80, 60 and 40% of field capacity) were applied with each level of 0, 2.5, 5 and 10 kg. nitrogen fertilizer per rai. three weeks old Songkla-3 vetiver seedlings were transferred into 5 kg. capacity pots. Soils were treated with respective levels of water and nitrogen. Experimental design was factorial in CRD. Plants were observed for growth and harvested at 3 months.

Roi-et soils gave the highest shoot dry matter followed by Nampong and Satuk soils. In general, increase in soil water as well as nitrogen fertilizer levels resulted in increase in shoot dry matter for all soils. There was no interaction between soil water and nitrogen fertilizer levels for Satuk and Nampong but Roi-et soils.

For field study, three soil series with three different locations were surveyed and selected. For each soil, 2 levels of soil water (control and irrigation) were applied with each level of nitrogen fertilizer (0 and 10 kg. N per rai). Plot size were 4 x 6 m. with 1 x 1 m. spacing. Experimental design was in RCBD with 3 replications. Growth was observed and measured. The plants were harvested when they were 8-10 months old. Shoot dry matter as well as other parameters were determined. In general, increase in soil water levels as well as nitrogen fertilizer resulted in increase shoot dry matter. Nampong soils gave the highest shoot dry matter followed by Satuk and Roi-et soils respectively. For Nampong soils, the effect of irrigation was extremely high for shoot dry matter when compared to the effect of nitrogen fertilizer where as on the other soils, the effect from both treatments were more or less similar.

Varietal Selection For High Root Biomass And Oil Yield In Vetiver

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Soil-erosion is a serious cause of ecological disturbances and environmental degradation. Its impact is more distressing in resource-poor countries which can hardly afford mechanical control of soil-remediation. Vetiver — a perennial grass with its fibrous roots offers an inexpensive yet effective and eco-friendly tool to combat soil erosion. Axiomatically, the larger its root volume, better is the capacity to conserve soil and soil moisture both. Besides, larger root volume will also ensure higher (dried) root yield which has multiple economic uses including those related to aroma and essential oil, the world renowned Khus oil (oil of vetiver). With this in view, we screened 45 indigenous germplasm collections of vetiver for fresh and dry root biomass, oil content and oil yield. Sixteen clones/lines were found to be promising. They were evaluated in initial station trial, where the best five strains (BDP-1, BMH-1, MBR-5, BMH-3 and MBP-6) were shortlisted and elevated to bench scale trial (BST). The elite strain BDP-1 had the largest root-volume (dry root yield = 97.0 q/ha) followed by BMH-1 (56.2 q/ha), BMH-3 (33.3 q/ha) and MBR-5 (28.7 q/ha), all registering 12 to 3.6 times more root yield than the commercial checks in BST. Fortunately, the oil content in their roots was also high, hence economically most viable. Thus BDP-1 with its largest root volume can serve as an excellent soil-binder besides being the most productive

oil strain of vetiver.

VETIVER GRASS HEDGE ROW TECHNOLOGY

Studies On The Effect Of Contour Vegetative Hedges On Moisture Conservation, Growth And Yield Attributes Of Millets, Cotton And Pulses Under Rainfed Conditions.

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To ascertain the performance of pulses, millets and cotton with different hedging systems on a slopey land under rainfed condition, a study was conducted with vetiver, subabul, cenchrus grass and desmathus as hedges. The results revealed that the growth of the cotton, redgram and greengram were best influenced by cenchrus hedge followed by vetiver hedges. Vetiver hedging system has shown very good effect on the yield of annual crops. The vetiver hedges conserved 21.80%, 20.98%, and 19.77% soil moisture at various stages of growth, and thereby helped all annual crops to produce higher yield. In dryland farming, hedging with vetiver is recommended for moisture conservation and higher yield of the intercrops.

Suitable Techniques For Establishment Of Vetiver Hedgerows In Semi-Arid Region Of Rajasthan-India

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Investigations were carried out in semi-arid region at Udaipur during 1991-1995 to study the effect of plant spacing, densities, polymers, manures, planting methods and time gap between uprooting from nursery and planting in field for effective establishment of Vetiver hedgerows on alfisols belonging to land use capability Class VI (non arable). and Class IV (arable). The soils are low in N, medium in P and rich in K content. Wider spaced (15 to 20 cm) planting proved significantly superior in respect to growth compared to 10 cm: presently in operation. Planting of 2 or more than 2 slips/hill recorded highest increase in survival and growth. Among the polymers and manures. application of agrosoke polymer 30 g/m row length in furrows at planting recorded highest survival (95%) and significantly higher number of tillers/plant (116) and clump girth (79 cm): closely followed by FYM application - 600 g/m row length. Planting of vetiver in furrows opened at bottom of 'V' ditch is found suitable method as it recorded maximum survival as compared to planting on top of bund of 'V' ditch and on berm. Planting of polybag raised vetiver recorded maximum survival (98%) over field nursery raised (17%). Polybag raised vetiver also gave significantly better growth. In a two year (1992 & 1993) study planting of vetiver immediately or within 24-36 hours after uprooting from nurseries was found effective in better establishment of vetiver hedgerows.

Effect Of Applying Vetiver Grass On Sloping Lands In China.

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Planting grasses or shrubs along the contours is extremely effective for erosion control on slopes. In order to explore measures for speeding up the growth of vetiver grass, a fertilizer trial was conducted. According to observations, the growth of vetiver grass in the first year after being transplanted could the divided into three stages: the recovery stage, the rapid-growth stage and the trimming and gathering stage.

On farmland, the vetiver grass in the control plots survived very well and formed hedgerows rapidly, whereas the treatment of applying fertilizer showed no obvious effect. As most fertilizer disturbed the recovery of vetiver, if we must apply some fertilizer to farmland in order to multiply seedlings of vetiver, we had better use fertilizer after manure.

On sloping bare land, the organic manure is better than the chemical fertilizer, and treatment NPK + FYM had a more obvious effect. The lack of phosphorus would seriously disturb the survival, growth and grass-yield of vetiver. If we apply the NPK fertilizers, we had better apply them in split applications which is better than applying the whole NPK at transplanting.

Comparative Study Of *Vetiveria zizanioides*, *Vetiveria nigritana*, And *Andropogon gayanus* In A Trial Of Soil And Water Conservation.

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Using vegetation in a trial of soil and water conservation is an important challenge in arid and semi-arid zones. The objective of the study is to obtain data on the comportment of three grass species, *V. zizanioides* (unknown in the country), the local Vetiver *(V.nigritana)* and *A. gayanus*. On a bare ferrugineous soil (Lixisol), three stone lines were built along the micro-topography with a distance of 33 meters. The three species were used for vegetatization of the stone lines.

The results obtained show a few mortality of *V. zizanioides* (3%) compared to the local grass (18% for *V.nigritana* and 34% for *A.gayanus)* in terms of growing after plantation. Concerning plant height, local grass *(A. gayanus)* have a total longer of 203 cm when Vetiver grass (local and exotic) have just 103, 5 cm after 103 days. The weight of dried material is respectively 7570 g for *Andropogon*, 3548 g for *V. zizanioides* and 866 g for *V. nigritana.* The coverage of the soil in amount of the stone line is about 80 - 90% for Andropogon and 50 to 60% for Vetiver grass. The soil moisture evaluate ponderal method is twice more under *A. gayanus* comparatively to *V. nigritana. V. zizanioides* maintained more moisture in the soil than the local Vetiver. These data revealed the potential of *Vetiveria zizanioides* growing in soudano-sahelian zone and the possibility to use it for stone line vegetalization to combat erosion.

Studies On A Biological Erosion Control System Integrating Tree And Grasses To Manage Degraded Soils Of Foot-Hill Himalayas.

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Soil erosion is the single largest factor responsible for degrading quality and productivity of land in India. It is estimated that 45% of forest, 56% of farm, 86% of cultivable wastes and 95% of pasture lands suffer from erosion related problems. Though 39 million hectares have since been treated in the last 30 years, but each year area degraded far exceeds the area rehabilitated. Unless massive efforts are

made to mobilize farming communities, the march of degradation cannot be contained. This would, however, require the development of cost effective and easily adaptable packages linking conservation and production to motivate farmers. High cost and questionable performance of mechanical measures have also shifted emphasis to biological measures of land amelioration. It is planned that 40 million ha of wastelands be developed with vegetation models designed for each agro-ecological region integrating multi purpose trees and sod-farming, conservation effective perennial grasses having inherent ability to thrive on degraded sites and provide usable biomass and economic returns.

In the Himalayan foot-hill ecosystem of north India, *Acacia nilotica* is the most favored multipurpose tree species, Bhabar *(Eubiopsis binata)* and Kana *(Saccharum munja)* are important sod forming natural perennial grasses. Dub grass *(Cynodon dactylon)* also commonly thrives and meet conservation and forage needs. Vetiver grass *(Vetiver zizanioides)* occurs naturally in wet pockets and was strongly recommended in many of the internationally funded projects on conservation of natural resources. The research information on the integration of these remarkable plant species in a silvipasture system was lacking. Hence the study.

In a replicated and randomized field experiment started in July 1990 on a 1.2 ha of degraded gravelly soil near Chandigarh (30˚ - 45' N, 76˚ - 15' E, 350 m MSL) typically representing semi-arid climate; *Acacia nilotica* was uniformly planted from nursery raised tube plants at 8m x 5m spacing in 30 cm^3 pits. Four understorey grasses namely Bhabar, Vetiver (0.5m x 0.5m), Kana (1 m x 1 m), natural dub grass were raised in the interspace and compared with control having no grass. Interplot earthen bunds of 20 cm height were made to conserve rainwater. Runoff and soil loss was measured using Ramser samplers. The root system of the 3 planted grasses was studied by excavating soil monoliths at one and two years of age. Grasses were harvested twice a year in June and November and air dry weights recorded.

All the four understorey grasses affected the survival (except Vetiver) and growth of *Acacia nilotica* seedlings as compared with no grass treatment (Table 1). The depressing effect amongst grasses were non-significant. All grasses tended to reduce runoff and hence soil loss. The lowest water loss (2.2%) was recorded under natural grass followed by planted Vetiver grass (5.8%). The residual soil moisture left in 0 - 30 cm soil profile at harvest was highest (9.1%) in Vetiver grass. S. *munja* provided the maximum biomass, when Bhabar and Vetiver were almost at par. The roots of Kana were relatively more sturdy and thick but the root density was low. The roots of Bhabar and Vetiver grass were more fine, spongy, larger in number and hence their root density was much higher. The results of 3 years of study indicated that Vetiver was more conservation effective, Sacrum gave more biomass and Bhabar grass provided more of economic returns. The emergence of clear picture about their relative merits would take few more years of study.

Comparative Study Of Hedgerow Of Vetiver And Other Grasses With Mechanical Measures On Erosion Losses At 4% Runoff Plots

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Mechanical measures namely bunding (earthen embankment), terracing, trenching etc. used to stabilize high slopes have been found costly, area consuming and unstable structures needing maintenance cost on agriculture lands up to 4 percent slope. Therefore, erosion control measures of conservation agronomy and grass barrier were tried on runoff plots (l00 x 20m) on 4 percent slope equipped with H flume, stage level recorder and Coshocton Silt Sampler. Three grasses namely, Khus grass *(Vetiveria zizanioides),* Bhabar grass *(Eulaliopsis binata)* and Guinea grass *(Panicum maximum)* were planted in 60 cm wide strips on contour at 100 cm vertical interval. The soil loss (52 t/ha) and runoff (45%) of rainfall from cultivated fallow were reduced to 18 t/ha and 51 percent respectively by following contour cultivation of corn. There was further reduction in soil loss (10-12 t/ha) and runoff (40 %) by adopting strip cropping, intercropping, zero tillage and bunding. Introduction of vegetative barriers (live bund) gave and average (7 years) soil loss 5-6 t/ha and runoff 33% of rainfall. The performance of bhabar grass was comparatively poor. Corn yield in most cases remained unaffected (23-24 q/ha) due to minor variations in erosion losses. Dry matter production was highest from guinea grass (1540 kg/ha). The yield of following rainfed wheat was visibly higher in the upper reaches up to 5 m. due to deposition of fertile sediment (40 t/ha) and better moisture regime. Thus grass barriers were more effective than other measures of conservation agronomy and engineering. There is a tendency to change the slope into Puerto Rican terraces due to grass barriers.

Performance Of *Vetiveria zizanioides* In Rainfed Areas Of Vindhyan Plateau Of Madhya Pradesh, India.

Khandwe, Rupendra; Vyas, M.D. and Saran, R.N. J.N. Krishi Vishwa Vidyalaya, Jabalpur, India.

The seven year study since 1987-1994, on the performance of vetiver was carried out under World Bank aided Watershed Development Project at Rafi Ahmad Kidwai College of Agriculture, Sehore (M.P.) India. The seeds of vetiver from different locations in different years were tested under laboratory and field conditions for their germination. The viability of vetiver seeds reduce as the increase in storage period. Relatively higher germination 28.33% was observed in laboratory compare to 11.66% in field condition. The naturally germinated number of vetiver plants was observed 16.22 and 17.44/m^2 with up and down stream on existing vetiver hedge row respectively when the field was cultivated during winter and rainy season. While in uncultivated field during both crop season, the vetiver plant was 48/m^2.

In a study on application of fertilizer doses on the establishment of vetiver hedgerow. It was found that the application of 20 kg N + 20 kg P_20_5/ha as basal dose was most effective. The vetiver barrier caused higher soil deposition in upstream with the average soil deposition from 6.78 cm in two rainy season to maximum of 21.15 cm in seven rainy seasons. Four to five percent higher moisture conservation on upstream was recorded than the down stream.

In the screening of various locally available grasses in comparison to vetiver for establishing soil and moisture conservation. It was found that the vetiver recorded higher survival percent and higher soil particle binding capacity.

Environmental Considerations In Erosion Control: Use Of Vetiver Grass In Soil Moisture Conservation Program In Sardar Sarovar (Narmada River) Catchment In India.

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Soil and land form an integral part of the fragile life supporting system basic to mans existence. However excessive soil erosion with consequent high rate of sedimentation in the man made water bodies and decreased land fertility have become serious environmental problems with disastrous socio economic consequences. For reversing the trend, there is an urgent need for adapting economically viable techniques of soil moisture conservation. Quick method of erosion control through construction of engineering structures have neither significantly stopped erosion nor have significantly increased yields of crops through improved moisture conservation. They also do not work in the long run. While vegetative systems in conjunction with appropriate cultivation practices were in most cases found suitable.

The present paper discusses the use of Vetiver as an economically viable method in erosion control of arable lands and its usage in catchment area treatment program in Narmada river basin in India where 175,000 ha area is being treated with erosion control measures. Socio-economic problems associated with planting of vetiver on large scale in Narmada river basin are analyzed. Based on the experiences drawn, planting, of vetiver as an integral component of interactive subwatershed planning, is recommended for low cost erosion control in extensive areas of a river basin to mitigate the stresses on the local environment.

Use Of Vetiver Grass As A Filter In The Process Of Ground Water Recharge Through Open Wells.

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3 Chief Engineer, Public Health Engineering Department, Indore Zone, Indore, INDIA.

To solve the vital problem of constantly receding ground water in the plateau regions of Malwa & Nimar (Western Madhya Pradesh), an attempt has been made to collect surface runoff water filtering the water at various stages in to an unconfined aquifer specifically by passing through the network of vetiver grasses provided as biological filter on the bed and side of the drains. The studies were performed from 1990-95 at Jawaharlal Nehru Agricultural University campus Indore. Integrated Soil & Water Conservation Techniques were used to maintain the water level in the open wells viz., technique of water spreading and recharge through direct water injection. Water spreading techniques contributed 23% to the ground water recharge while injective techniques contributed 77%. An average annual recharge for the five hydrologic years (1990 - 91 to 1994 - 95) was 60308 m^3. Total amount of water drawn from the ground water sources (average annual value was 56554 m^3) for an average annual rainfall 0.977m during this period. Similarly. two year's average annual rainfall and draft of water from ground water sources recorded during 1988 - 89 to 1989 - 90 was 852 m^3 and 21710 m^3 respectively. After adoption of integrated water conservation techniques 34844 m^3, about **1.6 times increase** in the water reserves in the wells was achieved. It was found that out of 50308 m^3 water additionally recharged 34844 m^3 could be recouped which forms 69% of the average recharge value. Vetiver grass has provided an excellent filtering effect.

Constraints Of Using Vetiver In Watershed Management In Sub-Mountain And Scarcity Zone Case Study Of Nashik District (India).

Prakash Pawar. Government of Maharashtra, Department of Soil & Water Conservation, India.

Soil and water are the most vital natural resources for the survival of mankind. Proper management of this natural resources on watershed basis gives excellent results. Engineering structure for managing, is expensive. Vegetative measures by use of Vetiver is quite inexpensive and it is promoted in a centrally sponsored scheme in India. Accordingly, twelve watersheds comprising two Agro Climatic Zones are undertaken in Nashik District, with a geographical area 52,952 Ha. Since 1991 - 92, 4855 tonnes of Vetiver slips *(Vetiveria zizanioides)* are used for drainage line and land treatment of watershed management. A case study of Vetiver in the use of soil and water conservation attributes are taken up.

The results of the case study indicate that the establishment of Vetiver and its survival percentage are directly correlated to rainy days, depth of soil and other managerial factors like, the problem of stray cattle. In scarcity zone the use of Vetiver as a conservation measure failed except in a few drainage line treatments. In sub-mountain zone drainage line treatments like live check dam and loose boulder structure show excellent results while land treatment has only limited success. Instead of planting vetiver merely as a barrier, a minor engineering support would give better result.

In sub-mountain zone, the survival percentage of Vetiver is the highest in live check dam, supported by minor engineering structure (65.50%). It is followed by loose boulder structure which is reinforced by Vetiver at 47.75%. Thirdly, land treatments named as contour vegetative hedges give the lowest survival at 41.50%. From the case study it is clearly observed that planting material plays an important role in the survival of Vetiver, in addition to managerial factors like the problem of stray cattle. The overall conclusion is that dry spell adversely affects the survival percentage of vetiver. The average rainy days in sub-mountain zone are 75 while in scarcity zone it is only 25. The dry spell thereafter and the problem of stray cattle causes the mortality of vetiver. However, vetiver in good survival situations gives excellent results in terms of soil erosion control and moisture conservation, which account for good land returns i.e. crop production.

An attempt is made in this case study to compile all available information and its correlation to field situation.

Effect Of Vetiver Hedge On Runoff, Soil Loss, Soil Moisture And Yield Of Rainfed Crops In Alfisol Watersheds Of Southern India

C.Nagender Rao, M. Singa Rao, A. *Padma Raju and R. Prabhu Prasadini. Division of Soil Science, Andhra Pradesh Agricultural University, Rajendra Nagar, Hyderabad - 500 030, India.*

Runoff and soil loss are the twin problems threatening the security and sustainability of crop production in the Deccan plateau of Peninsular India. Low cost and easily adoptable technologies need to be devel-

oped for conservation of natural resources. Experiments were conducted on shallow gravelly *Alfisol* having 2.5% slope during 1990 - 95 to study the effect of vetiver *(Vetiveria zizanioides)* hedges on soil and water conservation, and yield of rainfed crops, sorghum + redgram and castor. Vetiver hedge on contour reduced the runoff and soil loss by 65.75 and 75.59% (1993-94) and 66.65 and 76.98% (1994-95), respectively over contour cultivation alone. Vetiver + dead furrows (deep furrows) at 3.6 m interval reduced runoff and soil loss by 56.33 and 70.48% (1993-94) and 58.33 and 70.77% (1994 - 95), respectively over dead furrows alone. Vetiver hedge on contours increased mean soil moisture (up to 45 cm depth) by 5.13 to 8.55% over contour cultivation alone. The increase in soil moisture content with vetiver + dead furrows was 6.96 to 10.85% over dead furrows alone. The average soil moisture content 2 m above vetiver hedge was higher by 8.61 to 16.25%, compared to the soil moisture below (2m) Vetiver hedge. The percent increase crop yields due to vetiver hedge ranged from 7.04 to 22.37 over that of contour cultivation. Vetiver + dead furrows recorded 3.79 to 8.29% increased yields over dead furrows alone. The crop yield above vetiver hedge was higher by 15.55 to 17.98% over that below the vetiver hedge.

Growing of vetiver hedges on contours and adopting conservation tillage practices between them can thus be an effective method to reduce runoff and soil loss, and increase *in-situ* moisture thereby obtain higher crop yields in rainfed Alfisols of the central parts of Southern India.

Vetiver Vis-A-Vis Indigenous Plant Species For Conserving Soil And Water In Arid Lands

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Study on the performance of contour vegetative barriers as soil and water conservation measures has been initiated during 1991 on the farmer's field covering an area of about 50 ha near Jodhpur. The area receives an average rainfall of 360 mm per annum. Eight species of grasses, 3 shrubs and 3 under shrubs were tried on contours at 1 m vertical interval in 3% slopey fields. Vetiver was used as control. This grass though survived on few fields but failed to make an effective barrier due to adverse climatic and edaphic conditions. Locally adapted grasses such as *Cymbopogon jwarancusa*, *Cenchrus ciliaris* and *Cenchrus setigerus* performed exceedingly well and formed effective barriers against soil erosion in a span of 2 years.

Significant reduction in peak flow and runoff volume have been recorded in the barrier fields over control. The runoff volume reduced between 22 and 71 %. The barriers do not channelise runoff and allow greater opportunity time for the rainwater infiltration. The barrier fields store 12 to 16% of soil moisture as against 6 to 10% in the control fields. The soil loss reduced from 530 kg /ha in the barrier fields. Also the sheet and rill erosion were checked to a greater extent. All these resulted between 37 and 51% more yield of guar (*Cyamopsis tetragonoloba*) over control.

The contour vegetative barriers of local grasses were more acceptable to the farmers as these are less expensive, easy to raise, less labor intensive and provide fodder in the lean period.

The Function Of Vetiver In Agriculture Ecosystem

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The experimental results showed that vetiver could efficiently ameliorate many properties of soil. For example, it could lower the acidity and exchangeable Al of strongly acid soil by 0.5 - 0.7 and 0.3 - 0.6 cmol.kg, respectively. A significant increase in soil organic matter, total N, available N and K, and porosity was found after planting vetiver for 29 months. However, vetiver didn't enhance soil P. After vetiver was established, the moisture of soil was increased by 20.3 - 42.3% in 0 - 20 cm depth and by 4.2 - 13.4% in 20 - 40 cm depth, respectively. Furthermore, vetiver distinctly slowed down the dropping speed of soil moisture. The vetiver treatment averaged 60% and 93% less runoff and soil loss than the control, respectively, in 2 years. Vetiver also improved the microclimate of agricultural ecosystem, which increased the relative humidity by approximately 5%, and declined the air temperature by 1 - 2˚ C.

Studies On The Effects Of The Soil And Water Conservation Of *Vetiveria Zizanioides* In Eucalyptus Plantations

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In the new afforestation land of Eucalyptus ABL No.12 plantation, at Yangxi county, Guangdong Province, China, three experiment plots, included a row of vetiver grass in two rows of trees, a row of stylo grass in two rows of trees and only trees without any grass (the control plot) were set up in April 1991. The runoff plot had been established in each plot and the laws of changes in rain, height, surface loss rate of soil and water were observed and studied. The three-year observation results indicated that the surface runoff rate in vetiver grass was 20351 t/hm^2, which was 15.2% lower than that of stylo grass and 58.5% lower than of the control plot. The soil loss was 68.2 t/hm^2, which was 28.2% lower than that of stylo grass and 51.1% lower than that of the control plot. The loss rate of the solid and liquid nutrients were also much lower than that of the stylo grass and control plot. The vetiver grass hedge can not only resist erosion, but promotes tree growth as well.

Hedgerows And Mulch As Soil Conservation Measures On Steep Lands.

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A summary of the experience with vetiver and other grasses used in soil erosion research in Venezuela is presented. The need for accelerated data production through simulated tests in the field is highlighted. Four experiments were conducted under field simulated rainfall conditions at 1800 masl. in the mountain coastal range of Venezuela, with 5 m length and 0.5m width plots and an average rainfall intensity of 556 mm/h using a double nozzle rainfall simulator, on an Aquic Paleudult soil with different humidity contents and two 15% and 26% slopes respectively. In order to evaluate the efficiency of five different hedgerow conditions: 50 cm wide *Vetiveria zizanioides* 0 (Vetiver), *Agapanthus africanus* (Lily). *Nephrolepis sp.* (Fern). *Andropogon citraturn* (Lemon grass) and no hedgerow. and five levels of pine needles: 0 Mg/ha. 0.5 Mg/ha. 1.5 Mg/ha, 3 Mg/ha and 5 Mg/ha used as a mulch. Over-

land flow was simulated in order to obtain equivalent slope lengths using a 01/min, a 21/min, a 61/min and a 141/min flow, representing a 21/min flow equal to an 80% rainstorm runoff similar to that obtained under humid and saturated conditions on a 5 m length bare plot.

Hedgerows and mulch are good conservation measures, especially when they are combined. The residue requirements are less when the slope is protected by hedgerows. and larger intervals between hedgerows are possible provided there is mulch on the surface of the soil between hedgerows. Soil losses in wet conditions were reduced to less than 1 Mg/ha by combining any residue cover and a Vetiver hedgerow against almost 8 Mg/ha on the bare 5 m length plot. Equivalent slope lengths increased soil losses up 25 Mg/ha on a 40m equivalent length bare plot. For the same slope equivalent length condition there was a soil loss of only between 1- 2 Mg/ha with the highest residue level applied and a loss less than 1 Mg/ha when the residues and the hedgerows were combined. Vetiver grass and Nephrolepis (Fern) were the most efficient hedgerows because of their high density vegetative structure. Under dry soil and humid soil, slope effect was considerable but under saturated soil the slope effect was not evident. Runoff was also diminished by the residue cover and hedgerows but efficiency was poor under saturated conditions. Simulated rainfall allowed to reduce time and costs of exp eriments as compared with natural rain. A table is presented as a semi-quantitative model to design spacing between hedgerows taking into account rainfall erosivity, soil erodibility, crop-management intensity and a minimum distance between hedgerows of 10 m.

A Test Of Planting Vetiver Grass At Different Vertical Intervals Of Soil And Water Conservation On Sloping Land.

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The study of planting vetiver grass at 7 different vertical intervals for soil and water conservation was conducted in Huay Sai Royal Development Centre, Petchaburi Province on Hup Kapong soil series at 5% slope. It was found that when planting vetiver grass at the vertical interval of 0.5, 1 and 2 m. compared with no vetiver grass treatment, vetiver grass treatments can reduced soil loss to 43.55, 39.72 and 22.89% respectively. However they can reduced soil loss up to 53.98, 50.85 and 37.13% when comparing vetiver grass treatments with the treatment of planting cassava up and down slope after land preparation.

Establishing Vetiver Hedges To Alleviate Soil Erosion In The Rubber Replanting Area Of Southern Thailand

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A rapid increase in rubber plantation in southern Thailand, has lead to the movement of plantation area on marginal land, often steep land where the damage of soil erosion is great during heavy rainfall. To alleviate this impact, an experiment was established in a farmer's rubber-replanting area under traditional intercropping in Songkhla Province. Rubber seedlings are grown (spacing 3 x 7 m.) on a highly erodible sandy loam soil on land with slope of 12%. A randomized block design was used with 5 treatments (1 - sole cropping of rubbers or control; 2 - establishing vetiver hedges between rows of rubbers (R+V); 3- rubbers intercropped with upland-rice (R+P); 4 - establishing vetiver hedges between rows of rubbers intercropped with upland-rice (R+V+R); and 5 - establishing vetiver hedges between rows of rubbers intercropped with *Pueraria phaseoloides)* and (P + V + P) in 3 replications. Total plots were 15, each plot (5 x 1 2 m) consisted of 4 rubber seedlings. During the experimental period (October - December 1993) there was heavy rainfall of 1061 mm. In the control treatment, amount of runoff (649.88 lit/m and eroded soil (3.40 t/ha.) were highest, and they was a significant difference from the remaining treatments. There were no significant differences among the treatments of P + V, H + P, H + V + H and P + V + P. The highest percentage of the reduction of runoff and eroded soil occurred in the treatment of H+V+P, and they were 40% and 52%, respectively. Analysis of nitrogen (N). phosphorus (P) and potassium (K) in eroded soil, results showed that the removal of N and K were significantly highest in the control treatment. The results of the tests suggested that the occurrence of surface runoff during the rainy season should be counteracted by establishing vetiver hedges and adequate plant cover.

Effects Of Vetiver Grass And Leucaena For Soil Erosion Control In Sugarcane, Maize And Cassava Crop Practices

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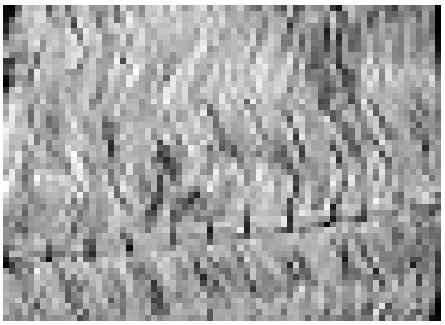
Four experiments on the effects of vetiver grass and leucaena in sugarcane, maize and cassava (grown early and at nearly the end of rainy season) crop practices were conducted during 1993-1995 in a farmer's field at Tambon Huai Bong, Amphoe Dan Khun Thot, Changwat Nakhon Ratchasima. The experimental plots were in a soil with sandy loam surface on three, four, five and six percent slope respectively. The experimental design of all experiments was randomized complete block with four replications. Each replication consisted of four treatments: one and two-rows of vetiver grass strip, one-row of leucaena strip and the control.

Results obtained from the experiments revealed no significant difference among treatments in the amount of soil loss due to erosion in the first and second year in sugarcane. On the other hand, in maize, the control treatment showed the highest amount of soil loss with an average of 7.236 ton/ha which was significantly higher than that of the one-row of vetiver grass strip treatment in the first year. In the second



QUIZ.

US $50 to the first person to quess correctly what the above photo is. Send your answer and some news about what you are doing with vetiver to Dick Grimshaw

year, the control still showed the highest amount of soil loss with an average of 16.753 ton/ha. This was highly significant different from all other treatments. For cassava grown in early rainy season, the different treatments did not show any significant difference in the amount of soil loss in the first year. However, in second year the amount of soil loss obtained from the control was 44.107 ton/ha which was about six times higher than that from the other treatments. In another cassava plot grown near the end of rainy season, the data showed no significant difference in the first year, however, in the second year the control gave the highest soil loss with an average of 23.03 ton/ha. This was significantly higher than that of the two-row of vetiver strip treatment. In these experiments it was found that the yields of sugarcane, maize and cassava in different treatments were not significantly different.

Vetiver Grass Hedgerows For Soil And Water Conservation In Tea Lands In Sri Lanka — A Success Story

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Soil erosion is severe in high rainfall Mid and Upland regions of Sri Lanka where the major crop is tea; 80% of this is seedling tea (tea from seeds). The old 'Up and Down' planting system adopted and absence of vegetative protection to existing mechanical measures results in severe soil erosion. Studies reveal 115 cm top soil lost during last century. This relates to 40 MT/Ha/yr. Unplanned land clearing causes 250 MT/Ha/yr soil loss. Land rested 2 yr. under Managrass (*Cympobogon confertiflorus*) without mulching results in 120-160 MT/Ha/yr. soil loss. New contour planted VP tea during 4 year growth exhibits 75 MT/Ha/yr. to 20 MT/Ha/Yr. soil loss mainly due to insufficient mulching.

Mechanical measures are generally not accepted due to high cost, repeated reconstruction, high maintenance, while Vetiver grass hedgerows popularly accepted due to low cost, easy application, low maintenance, permanency once established. No detailed research done on Vetiver hedge rows in tea, but significant results visually observed in its high efficiency of soil and water conservation. This is proved by its increasing adoption by tea estates for this purpose in Sri Lanka.

Vetiver — A Promising Grass For Soil Conservation In Vietnam

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In Vietnam the upland areas account for 25 million ha, which are located mainly on slopes of 25% to 45%. So soil erosion presents a real threat for agricultural production and environment. on the upland.

Studies showed that the anti-erosive measures based on imported "modern techniques" appeared to be less acceptable by farmers than improved traditional ones using living barriers. Among the plants used for this purpose, Vetiver is considered one of the most suitable one.

This poster paper describes the present status of Vetiver use for soil and water conservation.

Both advantages and disadvantages of this plant are also discussed based on the farmer feedback and field observations.

In Vietnam Vetiver can be grown either from seeds or by vetiver "splits", but the latter way vetiver is propagated vegetatively, by "splits" and not by seeds.

Vetiver is planted along the contour at 15 - 20 cm interval of the sloping land. The vetiver grass grows very fast and does not compete with trees for nutrients. Within two to tree years the plant grow together, forming vegetative hedge. Vetiver puts down a dense curtain of deep roots and, being so well anchored, a hedge can withstand even a shed of water flowing over it. Vetiver hedge can block the passage of soil, keep topsoil in site limit runoff, and over time, retard most surface erosion and in many cases can filter out the soil particles.

Since most of cropping systems on the upland retrieve nitrogen amendment, growing vetiver in mixing with some leguminous ones is highly recommended.

A Test On The Use Of Vetiver Grass With Some Soil Conservation And Improvement Measures For Sustainability In Cassava Based Cropping (Sword Bean)

Chumpol Konsilp and Adul Srisupan . Land Development Department, Ministry of Agricultural and Cooperatives, Bangkok, Thailand.

The test on the use of vetiver grass with some soil conservation and improvement measures for sustainability in cassava based cropping was carried out on Nam Pong soil series at Mahasarakam Province during 1993-1995. The treatments were: (1) Cassava without any soil conservation or improvement measure: (2) Cassava with sword bean as cover crop; (3) Cassava with sword bean and vetiver grass without seedbed; (4) Cassava with sword bean and vetiver grass with seedbed; (5) Cassava with sword bean and mango in vetiver row without seedbed; and (6) Cassava with sword bean and mango in vetiver row with seedbed.

The results indicated that treatment 3 and 4 which including soil conservation by vetiver grass and soil improvement by sword bean showed good result in reducing soil loss and increased the cassava's yield from 30 - 43% in the first year and 46 - 48% in the second year. There was a potential to plant mango in the system but termites had to be controlled.

Study On Optimum Rows And Different Plant Spacings Of Vetiver Grass For Soil Erosion Control On Sloping Land.

Wenus Charoenrungrat, Nakorn Thawornwong, Anusornjit Sangknamarn, Solot Sae-Lim and Surawuth Klinkhajai. Land Development Department, Ministry of Agricultural and Cooperatives, Bangkok, Thailand.

The experiment was conducted in Saraburi Province during August 1993 - March 1995, at about 10% slope on Muak Lek soil series which is shallow and erosive soil. The treatments were comparing between with and without vetiver grass as soil erosion control. The results showed that there were significant differences in reducing soil loss and crop yield between with and without vetiver grass, but there were not significantly difference in reducing soil loss and crop yield among difference spacing of vetiver.

Vetiver Grass As Erosion And Land Productivity Control

Syahrul Donie and R Sudradjat. Watershed Management Technology Center, Indonesia

The use of vetiver as erosion and land productivity control was investigated in Boyolali

(Central Java) from 1990 to 1992. The method used were:

(1) Grass barrier with *Vetiveria zizanioides*; (2) Grass barrier with S*etaria spacelata;* (3) Bench terrace with *Setaria spacelata;* and (4) Control : Bench terrace without grass barrier.

Those treatments used as a strip cropping along border line of 1500 m plot area for each treatment. Corn, *Sesamur indicum* and bean were planted for two harvesting periods in the plot area. The result showed that the use of vetiver as a grass barrier could reduce erosion of 72.7% and stream coefficient of 12.5% compared to control. Moreover, corn production was increased by 104.7% at harvesting period I and 122% at harvesting period II, as for *Sesamur indicum*, it increased by 89.3% and bean production by 142.9%. Among the three grass barriers, only vetiver could produce brangkasan mucuna and give the highest grass height.

Use Of Vetiver In Soil Conservation In The Black And Red Soil Areas Of India.

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Mr. Greenfield of the World Bank initiated the 'Vetiver technology' of soil and water conservation in 1986, on the Black (Vertisol) and the Red (Alfisol) soils of India, which cover more than 15 million ha of arable land and which for generations, have been subject to severe erosion (6 to 15 T/ha annually). Since then, through a series of field studies, the characteris tics of this grass and the effectiveness of the technology have been evaluated. As compared to the existing technology (bunding), the Vetiver technology was observed to reduce soil erosion up to 65 percent, reduce run off loss from 50 to 60 percent and increase crop yields up to 25 percent, apart from being the cheapest.

However, even with all the ideal characteristics of the plant itself and the evidences in favor of the technology, it is not getting acceptance in the officially sponsored soil conservation programs in India. It is believed that the real causes are the extensive field coverage needed to achieve annual financial targets and the reduced scope for 'cuts' by officials. and contractors. Extensive awareness campaign among farmers and adoption of group farming system are suggested.

Field Reports

South Africa

The Use of Vetiver grass in the Revegetation of Kimberlite Spoils in respect to South African Diamond Mining.

Dr. M. P. S. Berry, Group Ecologist, De Beers Consolidated Mines Ltd.

Introduction

Spoils from diamond mining and processing of Kimberlite may be either a coarse fraction of tailings or a fine fraction known as slimes. Tailings dumps may cover an area of 100 to 200 ha and be as much as 80 meters high with a natural angle of repose of between 30˚ and 35˚. Slimes dams may cover an area of similar size with walls 20 m high and a slope of 20˚.

Kimberlite by nature is dark in color, easily weathered, high in smectite clays and may be high in sodium. These chemical and physical characteristics make slopes of kimberlite spoil dumps highly erodible, hostile for pant: growth and consequently difficult to revegetate. The problem is further exacerbated by the fact that many diamond mines are situated in semi-arid environments that are subject to temperature extremes and low and unpredictable rainfall. Furthermore, some exotic plant species are well adapted to these harsh conditions and establish comparatively easily to the exclusion of preferred indigenous species.

Vegetation trials

Vegetation trials with a suite of different indigenous grass species have been disappointing. Germination tends to be *low* and seedling mortality extremely high due to high ground temperatures, inadequate moisture availability and constant erosion of substrate surface. Some success was obtained where kimberlite spoils were top dressed with soil to stabilize slope and provide a better growth medium. However, this is extremely costly and in many instances not possible due to the lack of soil and inaccessibility of mid-slopes.

Vetiver Trials

Trials with Vetiver have been conducted on both tailings dumps and slimes dumps at several different sites. In all instances where plants were successfully established, vetiver has been found to grow vigorously on kimberlite spoils and met both the mechanical and vegetative requirements for rehabilitation. More particularly:

- Rows of vetiver planted at appropriate intervals contained runoff and arrested erosion. Consequently costly mechanical contouring of slopes was not necessary.
- Deep rooting Vetiver was able to obtain sufficient moisture from kimberlite spoils and survive extended drought periods.
- Vetiver withstood ground surface temperatures of more than 50˚ C in summer and over wintered sub-zero temperatures.
- Vetiver was well adapted to growing in alkaline kimberlite soils high in sodium.
- Dense tall tufts of vetiver trapped organic matter and created an ideal micro-habitat (suitable substrate and shade) for the establishment of indigenous grass species.
- Vegetative propagation of vetiver ensures that there is no threat of the species escaping to become an exotic weed.

Conclusion

In conclusion vetiver has been found to have the necessary attributes for self-sustainable growth on kimberlite tailings dumps and slimes dams. The species is likely to play an increasingly important role in the rehabilitation of kimberlite spoils. As such nurseries are being established at several mines to meet expected future demand.

Fiji

Back From The Future: Do's and Don'ts After 50 years of Vetiver Utilization in Fiji.

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Abstract

The concept of using Vetiver grass for soil and water conservation purposes instead of conventional structures was first developed for the sugar industry in Fiji more than 50 years ago. The Vetiver system is now widely used as a standard practice for soil and water conservation, particularly on small farms. The Vetiver system is very effective in erosion control and it is well accepted that when properly implemented the system can improve sugar cane yield up to 55%. Over a 40 year period terraces formed from eroded soil upslope are up to 1.5 m high. However farmers are now reluctant to implement the Vetiver system and in some cases are removing the well established system, resulting in massive erosion and production loss. The reasons for low adoption, and in some cases rejection, are complex but include socio-economic, land use policy and agronomic practices. Problems associated with these issues are identified and possible solutions are proposed.

Introduction

Vetiver grass was first used for soil and water conservation purpose in the Fiji sugar industry early in the 1950's. The success of the Vetiver system is highly visible in the form of 1 to 1.5m high terraces built up from trapped sediment on numerous canefields on the west coast of Fiji. However, despite this highly effective means of soil and productivity conservation, farmers are now reluctant to implement the Vetiver system.

The Fijian experience provides an extremely rare opportunity to observe with reality, not by modeling, but with actual outcomes, what is the impact of the Vetiver system after 50 years of application. Lessons to be learnt and pitfalls avoided, so that this new technology continues to protect our environment and conserve our limited' resources for future generations.

Historical Background

Vetiver grass was first introduced to Fiji from India probably late in the 1800's to provide thatching material for houses and it is still being used for roofing and walls. Although it was commonly used to stabilize embankments, terraces and to delineate farm boundaries, its application as a soil conservation measure as we know today was developed early in the 1950's. On Viti Levu, which is the main island, the Fijian sugar industry concentrated along the west coast where suitable low slope land is very limited. As the sugar industry expanded, the main sugar production company, Colonial Sugar Refinery (CSR) was faced with a very severe soil erosion problem on sloping lands, particularly on the north western area around Rakiraki, where the land is very steep and rainfall is often of very high intensity.

A team of research agronomists and soil conservationists including John Greenfield at the CSR Agricultural Experimental Station first tried the accepted methods - engineered contour banks, diversion banks, leading to grassed waterways, but under tropical rainfall conditions these structures did not last a season. The search then turned to vegetative systems. Of the 19 plant species tested only Vetiver grass was selected and developed to an effective soil and water conservation system. This system was very practical and easily implemented (Fijian agricultural systems being labor intensive rather than mechanized) and very effective as a soil conservation measure. Vetiver also conserved water increasing subsurface recharge as runoff water slowly seeped through the hedge instead of being diverted off the field. This greater accession to subsurface and ground water has probably led to productivity improvements and an improved overall water management system with greater stream persistence in the dry season.

CSR rigorously enforced this soil conservation technique on all sloping lands until the company left Fiji early in the 1970's. Since then this system has not been enforced under the present land use policy of the Government, despite steeper lands (up to 66% slope) being used for sugar cane production.

Official records show that the first Vetiver contour hedge was established in 1952 in the Penang Mill area, near Rakiraki, and hedges over 40 years old are quite common in the area, but farmers have used Vetiver for slope and batters stabilization for more than 50 years.

Current Application and Effectiveness of the Vetiver System in Fiji

Vetiver grass is widely used in Fiji from simple road embankment and stream bank stabilization, to contour hedges in sugar cane lands, and slashed and burnt plots on the east coast. It is a common practice for farmers to plant Vetiver to stabilize farm roads, across depressions, to spread and slow down runoff water, and most often on contour lines to protect their vegetable crops from rill erosion. According to local farm advisers of the Penang Mill, Rakiraki, 'Vetiver grass Systems' provide a very simple and practical solution to the soil erosion problem on small farms where both educational and technological knowledge is minimal and labor intensive activities dominate.

In all sugar cane growing areas, from the low slope fields around Lautoka to very steep hillsides around Rakiraki, terraces formed by Vetiver hedges up to 1.5 m high are quite common. These terraces were formed by soil erosion upslope and subsequent trapping by Vetiver hedges downslope over a 25 - 40 year period. The spacings between hedges are relatively close (averaging 30 - 40 m apart). The quantity of soil eroded and then trapped by the Vetiver hedge to form these terraces clearly demonstrates the effectiveness of the Vetiver hedge systems and the huge soil losses that would otherwise have occurred off those steeply sloping lands.

In general, fields protected by Vetiver hedges often have higher productivity than those unprotected by the hedges. On the average, where the practice is used on steep cane lands in the Rakiraki region, good yields can be expected for up to 7 to 8 ratoon crops. The number of ratoon crops in unprotected fields is generally lower and yields are reduced. Farm advisers attributed the loss of production to both soil and water losses on unprotected fields. In a simple demonstration trial, sugar cane yield of 48 tons per ha from a field protected by Vetiver hedges, and was reduced to 31

tons per ha from unprotected fields. This represents a 55% loss in production.

With the clearly demonstrated benefit of the Vetiver hedges in existence for the last 40 years, it is of interest to note that Vetiver has not become a weed. In addition to the provision of thatching materials, far mers still are very reluctant to establish new Vetiver hedges. In some cases they have removed old, well established hedges, resulting in massive soil erosion and drastic reduction in yield and within a few years the once productive land was covered with weeds and stones. Reasons given for these actions varied but the central theme pointed to these three concerns:

- Vetiver hedges take up too much land;
- terraces formed by the hedges hinder farm machinery operation; and
- the hedges sometimes harbor pests such as rats.

On closer examination, the real reasons are probably more complex than these three superficial concerns.

1. **Land shortage**. After 40 years where hedges were not properly maintained, the single row of Vetiver spread from 0.3 - 0.4 m to more than 2.5m width. Depending on the land slope and the original spacing, cropping areas sometimes were reduced to 4 - 5 m between hedges. In addition the trapped sediment formed terraces up to l.5 m high, hindering farm machinery operations. As with other developing nations, Fiji is faced with a severe shortage of agricultural lands, so it is obvious and understandable that farmers are concerned about the loss of productive land, where the cropping area of an average sugar cane farm is only 4 ha.

2. **Land ownership**. In addition to land shortage, land ownership is also an important issue. Under the present system, most Fijian farm lands belong to the Native Land Trust Board which administers the lease of the land to farmers for agricultural use. As the case of most lease land, farmers are not often very receptive to long term soil conservation measures where benefits are not often apparent in the short run.

3. **Land use policy**. Under the CSR policy, sugar mills enforced strict land use guidelines. Mills only accepted sugar cane from farms that implemented soil conservation guidelines recommended for the districts. For example, Vetiver hedges system was recommended for farms with land slopes of 12% or more. The spacing of the hedges was determined by soil type and land slope. Under the present Government policy sugar mills cannot enforce these guidelines, and farm advisers can only "advise" farmers to implement soil conservation measures which are often ignored, the few exceptions being new farmers where soil conservation and other agronomic advice is well received.

4. **Inflexibility of the existing system** Although the present system still provides a very effective water conservation method, it was designed over 40 years ago when the main power source was draught animals. As farming practices have increasingly relied on modern technology, including farm machinery, the existing system in general can cause hindrance to farming operations. For example, draught animals can walk around or climb over an overgrown hedge and terrace, whereas tillage and harvesting machinery can not. Redistribution of trapped sediment upslope is a major task, if it is done manually but with the availability of tractors the job can be carried out much faster.

5. **Lack of development and extension support.** There has been very little support to assist farmers in overcoming problems associated with the implementation of the Vetiver hedge system. The three major concerns expressed by farmers, namely the loss of productive land, hindrance to machinery operation and harboring pests, can be all resolved if an effective hedge maintenance program was carried out. If the hedges were trimmed and accumulated sediment was redistributed every few years, the spreading of the hedges and the build up of terrace would be very effectively controlled. As a result of the above actions, thin and well trimmed hedges are less likely to harbor rats and other pests. In addition, the general extension effort regarding the benefit and impact of a soil conservation system such as Vetiver hedges has been very limited due to the shortage of well trained extension staff.

In summary, the pitfalls DON'TS listed above range from technical (Research, Development and Extension) to political (Land Use policy) and socio-economic issues (land shortage and ownership).

Proposed Do's

From the above summary it can be seen that solutions to these shortcomings range from fairly simple technical issues to complex socio-economic ones which require both economic resources and political will. While some of these can be solved satisfactorily, others will be slow and difficult to solve and those, which involve cultural, ethnic and political issues probably can never be resolved satisfactorily. However if these issues are known and properly dealt with now, most of the pitfalls mentioned above can be avoided.

If the Fijian experience can be used as a model, the following three issues deserve utmost and urgent attention:

Research, Development and Extension. The conventional engineering soil and water conservation systems such as contour and diversion banks, and waterways etc. have been adopted and implemented worldwide for a long time, but these systems still require continuing research, development and extension efforts to improve and to gain farmers acceptance. Likewise, a new concept and technology such as the Vetiver system will need these supports for a long time. Some of the topics that have to be taken into account are:

- **Suitable cultivars**. There are a vast number of different species, sub-species of the Vetiveria genus, and an enormous range of *V. zizanioides* cultivars that are grown worldwide. They should be screened and selected for various applications. The Thai Department of Land Development has done an excellent job in collecting and screening more than 40 Vetiver cultivars and species for regional applications, but it is suggested that they should go one step further by selecting suitable cultivars for different crops and applications. For example shade tolerant cultivars are needed for tree crop and orchards, tolerance to salt and heavy metal toxicities for land reclamation, non-seeding cultivars for agricultural crops, fast regrowth and tolerance to grazing pressure for pastures and rot resistance for thatching, just to mention a few. In short the selection program needs to be purpose-oriented.

- **Propagation and Establishment**. Although potting gives excellent results, it is slow and costly and should be limited to high value projects to ensure fast, reliable

establishment and growth. Direct planting is the method farmers would prefer, and it should receive full research, development and extension attention. Detailed guidelines such as slip size, age, hormone treatment, soil moisture, seasonal conditions (rainfall and temperature). Obviously different guidelines are needed for different crops and applications.

- **Maintenance**. In. the long term, maintenance is the most important aspect which greatly influence the acceptance of the Vetiver by farmers. As mentioned previously the concerns expressed by Fijian farmers relate to the lack of a proper maintenance program. For example, for sugar cane crop, Fijian farm advisers recommend that hedges should be slashed twice a year, one early in the wet season to encourage growth and once towards the end of the wet or the beginning of the dry season to remove excess material which encourages rats. Trimming is required every 3, 4 years and trapped top soil should be spread up hill during replanting (5-7 years). Alternatively, every second hedge can be taken out, trapped top soil respread, and replant Vetiver with each cane replant cycle. The maintenance guidelines should also include recommended methods of controlling unwanted Vetiver plants. Again maintenance programs need to be developed for each application.

- **Design layout for various crops and applications**. Design layout should be flexible enough to take into account different cropping practices and regional variations. Wherever possible likely future changes in practice and crop production should also be considered. In addition, having understood the function and potential of Vetiver hedges, its applications should be extended to other non-conventional areas, both in agricultural and non agricultural sectors, such as mine rehabilitation, water quality improvement and toxic wastes management. A good example of a further application in soil and water conservation, the Thai Department of Land Development work on the incorporation of Vetiver into a Leuceana-pigeon peas alley cropping system and water harvesting design for fruit trees in Chiang Rai.

- **Extension**. An extensive extension service is needed to ensure long term success. Extension staff should not only be competent in soil erosion and sediment control matters but also in the agronomy, tolerance and adaptability of Vetiver grass. But most importantly, the final application and layout should be a compromise between farmers' needs and the recommended standard design.

Land Use Policy.

Lessons drawn from the Fijian experience strongly indicate that a firm land use policy is required for long term success. As pointed out above, when CSR was responsible for a large part of the sugar industry in Fiji in the 1950's strict soil conservation guidelines were applied. CSR sugar mills only accepted crops from farmers that complied with the company guidelines. With well trained and a supportive team of farm advisers, farmers were happy to implement these guidelines and CSR was able to maintain the productivity of these highly erodible lands.

Land use policy guidelines need to be developed for each agricultural industry such as sugar cane, rice, horticultural crops, pastures etc. taking into account topographic, edaphic, rainfall erosivity characteristics as well as the farming practice of each region. When properly developed and supported by extensive extension/education program, most farmers would accept it. However, to be effective, legislative support is often required. For example, to obtain a contract to grow sugar cane on lands with slope exceeding 15%, farmers in southern Queensland, Australia, have to implement green cane harvesting, trash retention practices — a soil conservation practice where the crop is mechanically harvested unburnt and retaining the trash all year round.

Land ownership. This involves' the highly volatile socio-ethnic-economic-political issues associated with any land reform program which require firm commitment from political leaders. It will be slow and difficult, but it should be considered as a long term goal. People will be more willing to take better care of properties they own, particularly in societies where land ownership is linked with cultural and spiritual values.

Conclusion

Although the Vetiver soil and water conservation system has clearly demonstrated its effectiveness and benefit to the sugar industry in Fiji, its acceptance by farmers is not guaranteed. To ensure its long term success, continued input into the development and adaptation of the system to changing needs of various agricultural industries is required.

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Zimbabwe

The Hippo Valley Estates Magudu Vetiver Outreach Project

The Vetiver Outreach Project is perhaps the most, shining example of what purposeful environmental conservation can achieve. The Magudu area through which the Tokwane irrigation water flows, has through this project, been transformed into a lush green water course over a very short space of time. Communal farmers have been introduced to this scheme and they are very enthusiastic about the benefits it will produce.

For the benefit of those who are not abreast with current affairs in this area, the Vetiver Outreach Project is a soil conservation project which is being implemented on the Tokwane River in the neighboring Magudu Area. The aim of this project is to plant the fast growing vetiver grass on the river banks to pr event soil from being lost through erosion. It. is hoped that the communal farmers will learn from this project and implement it in their own areas. The benefits of this environmental conservation scheme are tremendous, and in particular the people in Magudu will receive more effective rainfall when there is less runoff, but greater infiltration.

This project started early this year. As part of the necessary groundwork, the local Chief, the District Administrator and Agitex officials were informed about this project, and they all agreed that this is a good project. The land was surveyed and Mr. Muyangani's 3.4 hectare plot was identified as the most suitable site for the project. The perimeter and contours were pegged,

***Photo 9**: Vetiver hedges on small farmers fields near Zomba, Malawi. Note that the field cultrivation is also on the contour.*

Photo credit: Glenn Allison

and a stretch of 1400 meters was planted with vetiver grass when the first rains fell in February. Two local people were then employed to water the young grass using 20 litre tins to carry water from the nearby dam, and all the grass which was planted germinated, survived and in fact even started catching the top soil when heavy rains fell shortly after the planting.

Our primary objective in this project is to teach the communal farmers to conserve soil, and indications are that many have been sold to the idea. A few have however appreciated the project. more because it will produce a good supply of grass for thatching than the fact that it will help in environmental conservation. This may be the other motive, but Hippo is not deterred and it will continue to reach out to the people as the name of the project. implies.

In the next stage, Hippo will supply "seed" to the local Agritex official who will set up a 0.1 ha vetiver grass nursery in his irrigation scheme and hopefully provide the local people with a source of seed to plant.

Papua New Guinea

The Establishment and Management of Vetiver Grass within the Traditional Garden System of Papua New Guinea.

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Vetiver grass was introduced to *PNG* in the late 1980's and established on a Department of Agriculture and Livestock (DAL) Research Station in the coastal lowlands. All the planting material used in the PNG Highlands originated from this plot. Nursery blocks were established on Government Stations in a number of rural areas of Simbu Province by Extension Officers of the Provincial Department of Primary Industries (DPI). To date, the only on-farm plantings of vetiver grass in the highlands have been in about 40 gardens in Simbu Province.

Vetiver grass extension in Simbu Province prior to 1994.

There was little information available on the culture of vetiver grass to the DAL Extension Officers who made the first on-farm plantings of vetiver grass in Simbu in l993/94. The slips were planted at 30 to 50 cm centers in straight lines across the gardens, most of which have slopes over 40% The lines were not planted on the contour. Slips that died were not replaced. Few of the clumps of grass in these plantings have formed complete hedges and many gaps still remain. Their effectiveness in preventing soil loss has been minimal. The growth rate of the grass was satisfactory on fertile soils, but slow on shallow soils. Little follow up extension was given to farmers to encourage them to persist with the grass or manage it in any way as DAL Extension Officers were provided with few resources for this purpose.

CARE Australia's program with vetiver grass extension since June 1994.

The Simbu Agroforestry and Land Use Project, is managed by CARE Australia on behalf of the Australian Government Aid Agency, Aus Aid. One of it's components *is* to investigate ways *to* use vetiver in gardens in the Province. After a review of the literature, observation of the plots already established, and discussions with officers of the DAL and village farmers, a vetiver grass extension program was commenced. On-farm plots were established and follow-up extension visits are made on a regular basis.

The extension message is constantly reviewed in the light of the increasing practical experience. Texts in Tok Pigin, a commonly spoken language throughout PNG, are being prepared to provide farmers with information about all aspects of vetiver grass culture and management.

The extension methods used.

- The extension effort emphasizes the grass's likely benefits to the farmer and to the gardening system. No funding is allocated by Government or SALUP to provide incentives for farmers to plant the grass.
- Few farmers have access to capital for the purchase of inputs such as fertilizer, or labor. Establishment and management methods that need no cash and little extra labor are emphasized.
- Farmers are taken to visit already established plots, on-farm field days

and discussions are held, radio programs on vetiver grass are broadcasts, and follow up farm visits are made so that farmers have all the information they need to incorporate the grass into their garden system successfully.

- Farmers are supplied with limited amounts of free planting material and encouraged to establish their own nurseries as existing nursery areas are small.

- Papua New Guineans are very innovative gardeners and will adapt and adopt worthwhile new technologies to suit their situation, if they have all the information they need.

- Women have a major role in garden management. and all extension effort must include them.

Recommendations for establishment and management of the grass.

Preparations prior to planting.

Diversion drain: If there is a long slope without tree cover above it diversion drains should be dug to protect the garden from large flows of surface runoff that may run across it while the grass is establishing itself. Serious loss of soil and landslides occurred in a number of gardens which had no protection from this type of surface runoff. The hedges were still in the establishment phase. It is likely that less damage would have occurred to the garden if diversion drains had been dug above them. Care must be taken to ensure that the diversion drain itself does not cause erosion at its outlet.

QUIZ.

$30 to the first person to quess correctly what and where the above scene is. Send your answer and some news about what you are doing with vetiver to Dick Grimshaw

Contouring: The vetiver grass slips should be planted on the contour if possible. Some washing of soil has been noticed from high points to low points along terraces about 1 m wide, formed behind hedges that were not planted on the contour. As the hedges are likely to last for many years and form sizable terraces, the extra trouble taken to mark out contours during the initial establishment is considered worthwhile and does not need to be repeated in later years as the hedges are permanent. Lines of crop plants will also be planted parallel to the hedges, on the contour and will contribute to erosion control. The contour can be marked out using a simple "A" Frame. It is a technology that can be mastered by local gardeners, with minimum of training.

Soil retention barriers

Soil retention barriers are a useful tool when establishing vetiver grass, particularly in very steep gardens. These barriers are built after the initial clearing of the garden and before planting of the crop. They are temporary structures that rot within 6 to 9 months of their construction, when soil accumulated on their up-slope side is normally lost down the slope. Vetiver grass slips are provided with an ideal seed bed for their establishment when they are planted in this accumulated soil and their roots prevent it's loss when the barrier rots. Some gardeners, against recommendations by SALUP, planted the vetiver grass hedges on the lower side of the soil retention barriers. Grass growth was satisfactory, but when the barrier rotted, soil held by the barrier fell on top of the grass and some was lost down the slope. It is too early yet to determine if the grass will survive this treatment. They are most effective if they are established on the contour at 2 m vertical intervals.

Vertical interval between hedges

The ideal is to plant the lines of vetiver grass at no more than 2 m vertical interval. I f the vertical interval between hedges is more than 2 m, the velocity of runoff water on steep slopes during heavy rain is likely to cause heavy rilling and scouring which can lead to land slides in extreme cases. A 2 m. vertical interval on a 45% slope allows a surface distance of only 2.8 m between hedges. Most gardeners consider this is too narrow a space to crop and a compromise must be made between the ideal and the practical. On the steeper plots farmers have accepted vertical intervals of up to 3 m.

Planting

Season Planting of vetiver grass should take place early in the wet season, if possible. Vetiver grass hedges have been planted throughout the year. While most slips survive when planted during periods of drought (usually less than 3 weeks in PNG), their growth is minimal and some deaths occur. Slips planted when there is regular rain establish much faster.

Timing in the gardening cycle Planting of the vetiver grass in a garden should take place just before the crop is planted. At this time conditions are ideal for quick establishment of the grass as competition from weeds is at a minimum, and the farmer can observe the grass regularly when caring for the crop. By the time the garden is fallowed the grass should be well established so that it can compete successfully with invading volunteer species and still be present when the garden is re cultivated.

Vetiver grass can be planted into stands of Kunai (*Imperata cylindrica)* (the most common local grass) by cultivating a narrow strip where the slips are to be planted. Kunai is an aggressive species and while most of the vetiver grass survives, its growth is very slow unless the kunai is regularly cut. Few farmers are prepared to invest the time and effort required. It is also difficult to separate the kunai from the vetiver grass when the garden is cultivated later. As very little erosion occurs in established stands of kunai, there appears to be no advantage in planting vetiver grass into such swards. Established hedges should be able to compete successfully with kunai that grows during the fallow period.

Spacing The effectiveness of vetiver grass in controlling erosion depends largely on it's ability to form a complete hedge without gaps, across the slope. If the gaps between the clumps of vetiver grass are to close quickly, under conditions in Simbu, the slips must be planted at no more than 10 cm centers. Given reasonable growing conditions, most of the gaps will close within 12 months. Slips planted at 30 to 50 cm centers still have gaps after 2.5 years of growth.

Mulching A mulch of leaves, dead grass, etc. should be placed around the slips when they are planted, particularly in dry weather. The mulch prevents the soil from drying out, keeps the surface cool, retains some soil, and generally improves conditions for the establishment of the grass.

Use of leguminous coppices A line of *Leucaena spp*. trees, which will be coppiced when they have grown, planted parallel to the vetiver grass hedge, will help to improve soil fertility in the garden. The trees which have been planted at 50 cm centers in a line 50 cm to 1 m from the hedge, have a threefold benefit. They contribute nitrogen directly to the soil from their roots and indirectly through the coppiced material which is used as a mulch, their roots help to hold the soil on steep slopes, and the trunks and larger branches of the plants can be used for firewood or construction timber. The traditional nitrogen fixing tree used in PNG is *Casuarina oligodon*. It cannot survive coppicing, though it can be pollarded. Its use is generally as a tree cover/soil improver during longer fallow periods. Coppicing is a new technique in the Highlands and more research needs to be done into the best species and methods to use. An extension program will be needed if it is to gain widespread acceptance as a worthwhile practice.

Hedge Maintenance.

Replacement of slips that die Any slips in the hedge that die should be replaced as soon as possible. The gaps left in the hedge take a long time close up as replacement slips suffer from heavy competition from already established clumps if replanting is not done quickly. Trimming existing clumps will help. Ensuring that the original planting material is of good quality will reduce the number of dead slips. To date, no culms over 20 cm long, that could be used layered in these gaps, have been observed on any clumps.

Trimming Occasional trimming of the hedge will increase the number of tillers in the clumps of grass. A simple experiment to test the effect of trimming the leaves of clumps at 10 cm above the ground was conducted. It indicated that tillering increased significantly as a result of cutting. The trimmed leaves can be used as mulch or as thatch. The large majority of houses in rural areas still have thatched roofs.

Landslips

After prolonged periods of rain in steep gardens some vetiver grass hedges have been lost through land slips. Experience in Simbu is too recent to know how effective the grass will be in preventing landslides once it has a fully developed root system. The soil in many gardens overlays rock or clay, conditions that restrict root growth and are highly conducive to land slides, particularly when the soil is saturated.

The future for vetiver grass.

Much has been learnt in the last three and a half years but more experience must be gained before a definitive answer about the place of vetiver grass in the traditional garden system can be given. Villagers from one of the areas where the vetiver grass has been planted said, when they were interviewed recently, that they needed to observe the grass for a longer period before they were prepared to form a definite opinion about it's usefulness. However, requests for vetiver grass planting material continue to be received from other farmers in this area, and most seem confident that it will be a useful tool in making sure that their children will inherit land suitable for growing their future food needs.

Vetiver grass has a place within the gardening system, but will only be one of a number of technologies that must be mobilized to ensure that crops will continue to be produced given the extreme terrain encountered in this region of the world. Miracles are needed, vetiver could well be one of them.

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Photo 10: *Filter strips in a quarry in Queensland, Australia, filtering sediment from water being discharged into a dam.*

Photo: Credit Paul Truong

Australia

Effectiveness Of The Vetiver Hedges In Soil Erosion And Sediment Control In Queensland

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A large number of field trials were carried out to verify the effectiveness of Monto Vetiver in soil erosion and sediment control in Queensland. The followings are results to date of some case studies:

Steep slope stabilization:

Embankment of both cut and fill slopes can be effectively stabilized by establishing Vetiver on contour lines. The deep root system stabilizes the slope while the hedges reduce runoff, increase infiltration and trap sediment providing a very favorable environment for the colonization by local volunteer species. This is well illustrated in the following two examples.

A very steep (1:1) and highly erodible sodic soil on a railway embankment near Cairns collapsed and needed to be rebuilt after almost every wet season. Obviously, the solution to this problem is a very costly engineering structure. As a trial, six rows of Vetiver were established on mini benches (0.25m wide) on the slope at l m VI (Vertical Interval). A total of approximately 250 m embankment was stabilized with Vetiver in June 1992. The Vetiver established and grew well despite the dry season and by December 1992, the slope was reasonably stabilized by the young Vetiver plants and local species began to establish between the Vetiver rows. In March 1993, nine months later, the slope was completely covered with local vegetation between the Vetiver hedges. Fifteen months later the embankment was completely stabilized with a mixture of Vetiver and mature local grass species. This embankment has withstood up to the last three wet seasons.

On another site, an old quarry at Henlies Hill in Cairns where the old rubble surface has remained bare of vegetation since the quarry operation stopped five years earlier. Four rows of Vetiver, established on an 80% slope at 1 m VI. Despite the extremely poor and hostile conditions of the coarse gravelly ground, Vetiver established well (with NPK fertilizer) and started trapping debris from upslope. The stiff stems of Vetiver provided a very effective barrier trapping debris and rocks up to 70 mm in diameter. Twelve months later the old gravelly slope was 75% covered with local vegetation between the rows of Vetiver hedges which had grown to 1- 2 m tall. Eighteen months later the slope was completely stabilized and revegetated with Vetiver and other local species including a pasture legume (*Stylosanthes*).

Filter strips:

When established across drainage lines and water courses, Vetiver hedges filter and trap both coarse and fine sediment resulting in cleaner runoff water. At Excel Quarry north of Brisbane, Vetiver was used to stabilize steep slopes of overburden and waterways. When planted across a long (500 m) and steep (20%) waterway, Vetiver hedges stopped the erosion on the waterway floor and trapped both coarse and fine sediment in runoff water from this working quarry. On another waterway leading to a dam, Vetiver hedges trapped most fine sediment resulting in less polluted water in the dam. Following the success of these trials, Vetiver is now being used as a standard method of trapping sediment and land stabilization at the quarry.

Gully stabilization:

Vetiver hedges are very effective in stabilizing gully erosion. When planted on contour line above gully head, Vetiver hedges will spread and slow down runoff water and stop the advancement of gully heads. This is well illustrated at a number of gullies in both cropping and grazing lands. Following the control of active erosion at the gully heads, gully floors are normally revegetated naturally with native species.

On large and long gullies where active erosion occurs both on gully floors and walls, Vetiver hedges established on gully floor will reduce flow velocity, trap sediment and reduce further erosion on the floor. At Ashall Creek, a very large gully system in the black earth on the Darling Downs, more than 0.3m of sediment was trapped by a series of 17 hedges over an area more than 400 m long and 50 m wide during the 1994 summer.

Wave erosion control:

Being able to establish and thrive under waterlogged conditions, Vetiver has proved to be very effective in reducing erosion caused by wave action on big farm dam walls. The erosion caused by wave action on the inside wall of a ve ry big farm dam near Cloncurry was effectively controlled by establishing a Vetiver hedge along the high water mark.

Rehabilitation of mining waste and contaminated land:

With its very wide range of tolerance to adverse soil conditions such as pH, soil salinity and mineral including heavy metal toxicities, Vetiver is highly suitable for the rehabilitation of mining waste and contaminated lands. Early results have shown that Vetiver is the most promising species grown on coal mine tailing in Central Queensland (Radloff pers. comm.).

CONCLUSION

With its wide ranging tolerance of adverse climatic and edaphic conditions the Vetiver hedge system offers a simple and low cost alternative to constructed soil erosion and sediment control measures.

On disturbed lands, where conventional methods of stabilization and reclamation are limited and costly, the Vetiver system offers a unique means of rehabilitation of these highly erodible lands.

More specifically with its high level of tolerance to extreme soil pH, soil salinity, Al and Mn toxicities, Monto Vetiver has great potential for reclamation work in **mining** and other industrial waste and contaminated lands.

Effects of Heavy Metals Toxicities on Vetiver Growth

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Abstract

Environmentalists are increasingly concerned with problems caused by contaminated land to the environment. Land con-

Photo 11: *Queensland, Australia. Rehabilitation of toxic municipal waste dump using vetiver grass.*

Photo credit: Paul Truong

taminated by heavy metals, as results of mining and industrial and urban wastes, require effective erosion and sediment control measures to stop its offsite pollution. Vetiver grass which is known to have high tolerance levels to some extreme soil and climatic conditions, is tested for its tolerance to a number of heavy metals common in mining and industrial wastes in Queensland. Results indicate that Vetiver is highly tolerant to high arsenic, cadmium, chromium, copper and nickel levels in the soil. Therefore Vetiver is highly suitable for the rehabilitation/reclamation of lands contaminated by these elements.

Table 1: Investigation Thresholds For Contaminants In Soils
Australian and New Zealand Guidelines for Assessment and Management of Contaminated Sites, January 1992 (ANZECC/NHMRC)

	THRESHOLDS (mg/kg)	
HEAVY METALS	**Environmental Investigation**	**Healthbased Investigation**
Antimony (Sb)	20	-
Barium (Ba)	-	-
Cadmium (C)	3	2
Chromium (Cr)	50	-
Cobalt (Co)	-	-
Copper (Cu)	60	-
Lead (Pb)	300	300
Manganese (Mn)	500	-
Mercury (Hg)	1	-
Molybdenum (Mo)	-	-
Nickel (Ni)	60	-
Tin (Sn)	50	-
Zinc (Zn)	200	-

Introduction

In recent years, environmentalists have been increasingly critical of the contamination of the environment by by-products of industrial and mining industries. The majority of these contaminations have been caused by high levels of heavy metals which can affect flora, fauna and human population living in areas in the vicinity of or downstream from the contaminated sites. Table 1 shows the levels of heavy metals required environmental and health investigations set out by the Australian and New Zealand authorities.

These concerns have resulted in strict guidelines to prevent the spreading of these contaminations and in some cases have delayed and even stopped some industrial and mining projects, until appropriate methods of decontamination / rehabilitation are implemented. High levels of heavy metals in the by products are unavoidable but they must be contained or at least preventing from spreading downstream.

The usual methods of decontamination are to treat the contaminants chemically or to physically remove them from sites. Both methods are often expensive and at time impos sible to carry out as the volume of contaminated materials can be very large, as in the case of gold and coal mine tailings.

If these wastes cannot be economically treated or removed, they must be prevented from spreading out. Wind and water erosions and leaching are the usual causes of off-site contaminations. Therefore, an effective erosion and sediment control program is needed and rehabilitation with suitable vegetation is the most practical and economical method. However, revegetation on these sites are often very difficult and slow due to their highly adverse growing conditions including toxic levels of heavy metals.

As Vetiver is capable of growing in a wide range of adverse conditions such as toxicities of Al and Mn, highly acidic, alkaline, saline and sodic conditions, this trial was set up to establish its tolerance to a number of heavy metals commonly occurred in mining and industrial wastes in Australia. These include arsenic, cadmium, chromium, copper and nickel

Table 2: Treatment Levels And Chemicals Used

Treatment	Heavy Metals ppm				
	As(1)	Cd(2)	Cr(3)	Cu(4)	Ni(S)
Control	0	0	0	0	0
1	100	5	50	25	100
2	250	10	10	50	200
3	500	20	200	100	300
4	750	60	600	200	400
5	-	120	-	-	500

(1) As Di sodium methyl arsenate (DSMA)
(2) As Cadmium sulphate (Cd S04)
(3) As Dipotassium chromate (K2CrO4)
(4) As Copper Sulphate (Cu S04)
(5) As Nickel Chloride 9NiC12)

Table 4: Toxicity Levels In The Soil Of Some Heavy Metals (Baker And Eldershaw, 1993).

Heavy Metals	Toxic Threshold(ppm)
Arsenic	2.0
Cadmium	1.5
Nickel	7.0 - 10.0

Table 5: Dry Matter Yield Of Vetiver As Affected By Various Levels Of Arsenic In The Soil

Soil Concentration (ppm)	Dry Matter Yield (g/pot)	Relative Yield (%)
Control 0	43.85 a*	100
100	43.51 a	99
250	18.93 b	43
500	5.56 c	13
750	0d	0
LSD (5%)	2.95	

* Treatments with the same letters are not significantly different.

metals can affect plant growth by interfering with enzyme activities or preventing the absorption of essential nutrients. Many plants are sensitive to heavy metals, those which are tolerant are generally tolerant of most heavy metals. Tolerant plants can be divided into three groups *(Robbeta*l. 1983):

- excluder, plants with restricted transport
- index plants are those reflect soil concentration
- accumulation species which have higher concentration than the soil

Materials and Methods

A pot trial was carried out under glass house conditions over a period of 10 weeks. Table 2 shows the treatment levels in the soil of the five heavy metals used. These levels were chosen as they represent the range com monly found in contaminated sites in Queensland.

A complete nutrient solution was applied at the beginning and after 5 weeks to ensure adequate supply of nutrients to Vetiver growth. A close system was used and pots were watered to field capacity daily with de-ionized water. Tops and roots were harvested for yield and chemical analyses.

Results and Discussion

Heavy metals are generally found naturally only at very low concentrations. Elevated concentrations are commonly associated with pollution from human activities. Heavy

In general, results of this series of trial indicate that Vetiver is highly tolerant to this group of heavy metals. In a hydroponic trial, Bowen (1979) found that most vascular plants are highly sensitive to heavy metals toxicity (Table 3). Baker and Eldershaw (1993) also reported very low toxic threshold levels in the soil for As, Cd and Ni (Table 4).

Table 6: Dry Matter Yield Of Vetiver As Affected By Various Levels Of Cadmium In The Soil.

Soil Concentration (ppm)	Dry Matter Yield (g/pot)	Relative Yield (%)
Control 0	43.8 a*	100
5	37.86 a	86
10	34.08 a	78
20	33.50 a	76
60	21.06 b	48
120	12.24 c	28
LSD (5%)	11.59	

* Treatments with the same letters are not significantly different.

Table 3: Toxic Thresholds Of The Heavy Metals Used In This Trial Under Hydroponic Conditions (Bowen, 1979).

Heavy Metals	Toxic Thresholds to Plant Growth (ppm)
Arsenic	0.02 - 7.5
Cadmium	0.2 - 9.0
Chromium	0.5 - 10.0
Copper	0.5 - 8.0
Nickel	0.5 - 2.0

Although no distinctive symptoms were recorded in this trial, leaf tips of all affected plants became chlorotic first and the chlorosis gradually spread to the whole leaf. In the cases of As and Cd the leaf tips first became red then chlorotic.

Arsenic:
Results shown in Table 5 shows that Vetiver yield was significantly reduced when soil arsenic level is at 250 ppm and higher. Although these results did not establish the exact toxic thresh old level for Vetiver, which is most likely between 100 and 250 ppm, this level is extremely high as compared with the threshold of 0.02 - 7.5 ppm (Tables 3 and 4). As arsenic soil levels at 20 ppm and 100 ppm may require rehabilitation (Table 1). Vetiver is a highly suitable species for reclaiming these sites.

Literature indicated that high level of As in the plant interferes with S and P metabolism (Kabata and Pendias, 1984).

Cadmium

Although results from Table 6 indicates that Vetiver growth was significantly affected by soil Cd level at and higher than 20 ppm which is extremely high as compared with the threshold shown in Tables 3 and 4.

Table 7: Effects Of Soil Chromium Levels On Vetiver Growth

Soil Concentration (ppm)	Dry Matter Yield (g/pot)	Relative Yield (%)
Control 0	33.29a*	100
50	28.71 a	81
100	34.64 a	98
200	25.80 a	73
600	4.68 b	13
LSD (5%)	10.75	

* Treatments with the same letters are not significantly different.

Although at much reduced growth (48%), Vetiver maintained slow but continual growth at 60 ppm. At this level Vetiver can be established in most contaminated industrial wastes and gold mine tailing with the highest Cd contamination in Queensland.

These results again indicated that Vetiver's highly suitable for rehabilitation of Cd contaminated land as sites with soil levels of 3 ppm and 20 ppm may require rehabilitation (Table 1).

Chromium:

Table 7 shows Vetiver growth is not significantly affected until soil Cr exceeds 200 ppm and the toxic threshold level is between 200 and 600 ppm. This level is extraordinary high as compared with the threshold of between 0.5 and 10.0 ppm shown in Table 3.

Vetiver is therefore highly suitable for reclamation of Cr contaminated lands as sites with soil levels at 50 ppm may require rehabilitation (Table 1).

Copper

Copper is a micro nutrient for plant, but it is highly toxic to plant at higher levels in the soil. Results of Table 8 indicate that the critical toxic level for Vetiver is between 50 and 100 ppm which is very high compared with the threshold shown in Table 3. However, reasonable growth *(*56%*)* continued at soil Cu level of 100 ppm. Sites with soil Cu level at 60 ppm may require rehabilitation (Table 1).

Table 8: Effects Of Soil Copper Levels On Vetiver Growth.

Soil Concentration (ppm)	Dry Matter Yield (g/pot)	Relative Yield (%)
Control 0	20.53 a*	100
25	17.89 a	87
50	18.87 a	92
100	11.42 b	56
150	4.58 c	22
200	3.80 c	19
LSD (5%)	5.54	

* Treatments with the same letters are not significantly different.

Nickel

Although Nickel is considered a trace element for most plants and is a constituent of the important enzyme urease, but it is extremely toxic to plant at high concentration (Kabata and Pendias, 1984). Baker and Eldershaw (1993) reported the toxic threshold level of Ni in the soil is between 7 and 10 ppm for most plants, but from our trials, 58% of growth can still be obtained at the soil level of 100 ppm. At this level Vetiver is highly suitable for the rehabilitation of Ni contaminated lands which has 60 ppm of Ni or higher (Table 1).

General Discussion and Conclusion

Although results of chemical analyses of plant material are not available at the time of preparing this paper, yield data have clearly demonstrated that Vetiver is highly tolerant to this group of heavy metals and therefore a highly suitable species for the rehabilitation of contaminated lands.

Table 9: Effects Of Soil Nickel Levels On Vetiver Growth.

Soil Concentration (ppm)	Dry Matter Yield (g/pot)	Relative Yield (%)
Control 0	35.29 a*	100
100	20.56 b	58
200	3.21 c	9
300	7.32 c	21
400	1.31 c	4
500	0.90 c	3
LSD (5%)	10.01	

* Treatments with the same letters are not significantly different.

Results of chemical analyses will establish whether Vetiver is an excluder an index plant or an accumulator. If Vetiver is an index plant or an accumulator with high level of heavy metals in the shoots, then the use of Vetiver in the rehabilitation of the contaminated sites will have certain implications.

On the positive side, Vetiver will not only provide a very effective means of erosion and sediment control at these sites, when harvested and removed from the sites and disposed off safely elsewhere, the level of heavy metals in the soil can be gradually lowered with time.

On the negative side, these heavy metals in the plant shoots can enter the food chain and would become a health risk if animals are allowed to grazed on the rehabilitated sites.

More research is needed to investigate the tolerance of Vetiver to mixtures of a number of heavy metals as under field conditions high heavy metal contaminations often occur in combination with others. Literature indicates that interactions between themselves and other plant nutrients can affect plant tolerant level greatly (Bowen, 1979; Kabata and Pendias, 1984; Lepp, 1981).

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Resistance Of Vetiver Grass To Infection By Root-Knot Nematodes *(Meloidogyne* Spp)

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Introduction

Vetiver grass *(Vetiveria zizanioides)* is well known for its tolerance to adverse soil conditions and is used as a contour hedge to prevent soil erosion on steep slopes in some countries. Anecdotal evidence also indicates that when grown adja cent to orchard trees for soil and water conservation purposes, Vetiver appears to improve tree growth.

In Queensland, Vetiver grass is being used to stabilize soil on slopes in sugarcane and pineapple plantations. Since root-knot nematodes *(Meloidogyne* spp.) can be a problem on both crops (Spaull & Cadet 1990, Caswell et all 1990), the status of Vetiver as a host of root-knot nematode was of interest. This work aimed to answer that question.

Materials and Methods

Two Vetiver varieties were screened for resistance against five root-knot nematode populations. The populations are representative of the main genetic groups of *Meloidogyne* in Australia and consist of four species (viz. *M. arenaria, M. incognita* [populations B 1 and B2], *M. javanica* and *M. hapla).* They were identified using DNA technology (Hugall et al 1994). The two Vetiver varieties used were Monto, a sterile selection, and a non-sterile type from Western Australia. The test plants were grown in the glasshouse in 200 mm pots in a sterile sand mix. Once they were established, five replicate plants were inoc ulated with 10,000 root-knot nematode eggs. A susceptible tomato cultivar (cv. Tiny Tim) was used as a standard for comparative purposes. Plants were harvested 6 weeks after inoculation, when egg masses on tomatoes were mature. Roots washed free of soil were immersed in a 1% NaOCl solution for three minutes and eggs were collected on a 38µm sieve and counted.

Results and Discussion

Both Vetiver varieties were highly resistant to all five root-knot nematode populations. Reproduction was approximately 1000-fold less than on the susceptible tomato. Vetiver also compared favorably with other grasses that have been found to be resistant to root-knot nematode in similar tests. Our results confirmed those of de Moura et al (1990) who found that Vetiver was "immune" to both *M. incognita* race 1 and *M. javanica.*

Conclusion

Since the grass was resistant to all major species of *Meloidogyne,* Vetiver is unlikely to exacerbate problems caused by root-knot nematodes when used as a cover, companion or hedgerow crop.

Soil Moisture And Sorghum Yield As Affected Vetiver Hedges Under Irrigated And Dryland Conditions.

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Soil moisture competition between Vetiver hedges and crop could affect crop yield. To date conflicting results have been stated and very few quantitative studies on this topic have been reported.

This paper presents the effects of Vetiver hedges on soil moisture and sorghum yield under various growing conditions. Treatments include hedge maturity (mature and newly planted), soil types (Vertisol and Alfisol) and moisture regimes (dryland and irrigated).

Gravimetric soil moisture and sorghum yield was recorded for each single row.

Under irrigated conditions on both soil types, mature hedges depleted more soil moisture than the sorghum crop and newly established hedges, but sorghum yield was

not significantly affected by the presence of either mature or young Vetiver hedges.

Under dryland conditions on Vertisol soil, the presence of a mature hedge significantly depressed sorghum yield of the first two rows adjacent to the hedges. Yield of row 3 and further was not affected.

The above results indicate that moisture competition does occur between mature hedge and the first few rows. However crop yield is only affected when soil moisture availability is very low. Under irrigation or adequate soil moisture conditions, yield of adjacent rows was not adversely affected by Vetiver hedges.

Panama

Report on visit to Western Panama

R.G.Grimshaw. The Vetiver Network

Regions of Western Panama have been identified as sites for soil and water conservation programs that will involve erosion reduction measures using biological systems. These include the use of grass hedge rows - primarily vetiver grass; on farm cultivation practices - primarily contour cultivation, and soil fertility and insitu conservation measures that focus on green manuring and leguminous cover crops - particularly applicable to the maize crop. This note will focus primarily on the use of vetiver grass as a hedgerow barrier.

***Photo #13**: Panama, Cerro Punta. This hedge was established on 100% slope to stabilize farm land in an area adjacent to the Amisconde National Forest. The system works and the farmer is happy with the results. Note how crops are now cultivated on the contour.*

Photo Credit: Dick Grimshaw

Existing uses of Vetiver in western Panama

In all the regions (Chiriqui, Veraguas, Herrea, Los Santos, Coclé and western Panama), see attached map, visited there was evidence of the existence of Vetiver grass (*Vetiveria zizanioides*). In most instances it can be found on household plots as single clumps of grass used for medicinal purposes. In fact it is apparent that in the past few years a large number of households have heard of the grass and have acquired it for this purpose. The local name is “Secate Valeriana”. It was probably introduced from neighboring Costa Rica or Honduras. Some folk have had the grass for fifteen years or more. It should be noted that in no instance was vetiver reported as invasive, it was certainly not considered a weed, and no one had ever seen it flower. Many farmers showed very good powers of observation as to the grass’s growing habits.

***Photo #12:** Panama, Los Santos Region. 2year old vetiver grass used for medicinal purposes.*

Photo credit: Dick Grimshaw

At Cerro Punta, in Chiriqui Region, the NGO group, AMISCONDE, was introducing vetiver grass for soil and water conservation. AMISCONDE had brought the planting material in from a coffee farm in nearby Costa Rica, and had established a small demonstration plot near its office. The Cerro Punta area is characterized by very steep hills., intensively cultivated with vegetable crops. Much of the cultivation is down the slope, and erosion studies indicate soil losses of more than 200 tons per annum. Much of this soil loss could be reduced if vetiver hedges were established on the contour across the slope. **Photo 13** shows one such hedge on a 100% slope. In this instance the farmer with the help of AMISCONDE technicians established a hedge on the lip of a small terrace. The hedge, about one year old is

well established and the farmer reports significant soil loss reduction, and much reduced rainfall runoff. The scene also shows how the farmer has developed vegetable beds on the contour. The farmer also cuts the hedge from time to time and use the cuttings as a mulch. These farmers are very much aware of potential soil loss as some of them dig small pits to trap sediment which they then dig and spread on their fields. The farmer is extending his hedge row plantings by using material from existing hedges and from additional material from Costa Rica.

Vetiver has been used to protect an irrigation pipes on steep hills. Many of these pipes, if unprotected, end up hanging in the air due to the erosion of the soil on which they originally rested. The hedge will also stop the pathways from eroding. Another use of the hedge rows on steep slopes is that they make a strong and stable pathway for farmers to get to their crops.

At Rio Sereno y Caizán a coffee farmer was using vetiver for stabilizing the edge of the coffee fields and the plantation roadsides. The growth of vetiver at these sites was extraordinarily good. It was all less than two years old, and had very good growth rates, probably due to the trapping of excess fertilizer from the adjacent coffee fields. The altitude was about 1,000 meters and rainfall about 1500 mm over a period of about 7 months. The coffee plantation owner was agreeable to set up a nursery for the up coming project. All the farmers and users of vetiver were information starved!! They were happy to be given copies of the Spanish edition of "Vetiver Grass - A Hedge Against Erosion" This booklet should be widely distributed in Panama as part of the soil and water conservation program.

On one occasion in Chiriqui vetiver had been damaged by a very large rodent (the size of a cane rat). The rodent had burrowed along side a row of vetiver in an effort to find a weak spot to traverse the vetiver line. In doing so it cut many of the vetiver roots. It is surmised that when fully mature hedge rows have been established it will be very difficult for the rat to penetrate the hedges, and therefore that latter might turn out to be an effective barrier against in field crop damage.

Proposed uses of Vetiver

On farm soil and water conservation. There are abundant opportunities to extend the practices just started in Cerro Punt to conserve the steeply cultivated lands that support high value vegetable and beverage crops. A 3 hectare site near Boquete that has slopes over 100%. Some large banks have been built across the slope to remove excess water, but these eventually fail with devastating results. This could be prevented if slopes were protected with vetiver. The vetiver lines would be planted about 10 meters apart, on the contour, starting from the top of the slope. These hedges, if planted 15 cm apart within the line, would be effective within a year, and would result in a slow down of runoff, and the retention of sediment and nutrients. Erosion would be further reduced by improved in field practices including mulching and across the slope cultivation. Water would no longer be concentrated and would be dispersed gradually across the slope.

Photo #14: *Panama, Cerro Punta. This scene is on the other side of the valley from that shown in photo 13. Note how crops are generally not cultivated on the contour. Slopes are over 100% and are eroding fast at an estimated rate of 500 tons of soil per ha per year.*
Photo Credit: Dick Grimshaw

In other areas such as Los Santos and Herrea soil slips are frequent due to shallow soils on a rather impermeable subsoil. These lands will erode rapidly and will slip. Vetiver grass hedge rows planted on the contour will prevent these problems. The predominant crop is maize. If the a leguminous cover crop of beans were planted with the maize then it would be possible to improve soil fertility substantially - as demonstrated in Honduras. The combination of vetiver hedgerows and leguminous cover crops would probably result in complete stabilization and soil fertility maintenance. Erosion would be reduced to less than 3 tons per ha, and run off would also be reduced. The result would be that current labor intensive slash and burn farming systems would be minimized, farms would be stabilized, land slips would no longer occur, and sediment loads in the streams and rivers would be very much reduced. Crop yields and incomes would improve substantially.

Waste land stabilization Vetiver has a good chance of growing on the hostile salt degraded soils near Chitré. These flat tidal areas have become totally denuded and are effected by wind and rainfall erosion. Vetiver should be test planted. If it grows, then vetiver hedges could be planted 50 meters apart. The effect would be to slow down runoff, improve infiltration and probably improve the washing out of salts. Grasses and other species are expected to establish naturally between the hedges. Trees such as Cassurina, and shrubs such as Atriplex (salt bush) should also be test planted to determine survival and growth rates.

Land slippage Most areas suffer from land slippage. Some are massive others are slight but could get very much worse. Some large slips have produced a massive amount of sediment directly into the rivers, and have been caused by deforestation for coffee, and further aggravated, in some cases by an unprotected road cuts. These slips could have been prevented if the land had not been deforested. Further soil losses could be prevented by planting vetiver hedges to stabilize the slip. A slip in Los Santos was probably caused by cultivation. This massive slip landed up in a nearby stream — just another example of

Photo #15: *This scene shows how the land in photo #14 could be laid out with vetiver hedges. The hedges should be placed 6 - 10 meters apart in the first instance.*

Photo credit: Dick Grimshaw

Photo #16: *Panama, Boquete area. This land slope was more than 100% (note the angle of the trees!!), cultivated to vegetables under a 2,000 mm rainfall regime. Vetiver hedge rows are the only way to stabilize slopes such as this one.*

Photo Credit: Dick Grimshaw

"point source erosion" The slipped area has naturally re vegetated, but could have been done quicker with the aid of vetiver grass hedgerows. In this case these slips were due to over grazing and the slip started probably along a cattle path. If these slips are not checked, massive sliding can occur at a later date. Vetiver grass hedges might stop this slippage, as the hedge roots could pin the shallow overlying top soil to the underlying parent material. Research needs to be carried out to determine hedgerow effectiveness and hedgerow architecture under different circumstances.

Stabilization of roads and river banks
Vetiver grass has been used for years in the Caribbean, Guatemala, Brazil, Bangladesh and Natal (South Africa) to stabilize road sides, drains, and river banks. In western Panama much of the sediment flow in rivers can be traced back to point source erosion sites. The collapse of a river bank or the fill area of a road will add tons of sediment to nearby streams and waterways. This has been identified in foregoing paragraphs in relation to land slips. A road side near Boquete that had collapsed and rebuilt could have been stabilized with vetiver to prevent slippage at a later date. A typical road site in the Chiriqui area has eroding side drains and rock debris fill from above. Much of this could be prevented if vetiver hedge rows were planted along the up side edge of the drain. The hedge would trap falling debris, and would keep the drain clean. Road drains erode because existing miter drains either don't exist or don't work. Often where they do exist they create gullying in the land adjacent to the road. This can be prevented by cutting a miter drain in the correct place, placing a vetiver hedge on the down side of the drain and extending it across the road side lateral drain (to act as a diversion), and protect the exit of the miter drain with vetiver hedges to prevent erosion.

River bank erosion can cause damage to property and structures. A property owner at the picturesque tourist town of El Valle had attempted to protect the garden from river damage using oil drums and concrete — not a very pleasing sight! and probably not a long lasting solution. Using containerized plants vetiver grass would probably provide a long lasting solution, and would look much nicer. River flow can also do great damage to road structures and can easily wash away gabbions. For long term stabilization river banks should be "graded" and planted to vetiver hedgerows using containerized plants. The gabbions and concrete should also be protected with vetiver. On the down stream side of the bridge there was a real mess caused by uncontrolled stream flow. Stream flow could be harnessed over a period of time by placing vetiver hedge rows (containerized plants) along what should be the stream bank. Over time sediment deposits would build up in front of the vetiver, and the vetiver would grow up through the sediment to form a new bank. Note planting of containerized plants should be at the end of the wet season when no further flooding is expected.

Readers should note that what is possible in Panama is possible through out all of the Central American countries. and is essential for farm land stabilization, if tropical forests such as the Amiscobe Forest is to be preserved.

USA

The following article is included to recognize the hard work put in by a team of scientists working for USDA to develop stiff grass hedge technologies for those parts

(the majority) of theUSA that is too cold for vetiver. It is believed that the standards set out in the following article have now been approved by USDA for farmer use.

Guidelines for the Establishment of Warm Season Grass Hedges for Erosion Control

C. L. Dewald, Jim Henry, Steve Bruckerhoff, Jerry Ritchie, Seth Dabney, Dan Shepherd, Joel Douglas, Dale Wolf. USDA/ARS/SCS

Soil erosion is a major problem around the world (3). An economical method to slow runoff and reduce soil loss is stiff, erect, densely-tillered narrow grass hedges. Such grass hedges are widely used in India, the West Indies, and other countries to reduce soil loss (10). The concept of using grass barriers for erosion control was proposed by USDA Soil Conservation Service (SCS) about 40 years ago in the United States but for a variety of reasons was not adopted.

In recent years there has been a renewed interest in the use of narrow stiff grass hedges as a conservation practice (7). Research has been done on application of grass barriers to reduce water (4) and wind (1, 11) erosion. Research has shown grass hedges to slow runoff, trap sediment, prevent gullying (4, 9), and enhance terrace formation (1). They are an inexpensive, biological, conservation technology compatible with current tillage systems (8).

In 1991 the USDA Agricultural Research Service (ARS) and the USDA Soil Conservation Service (S CS), now the Natural Resource Conservation Service (RCS) along with several universities initiated a program to study grass hedges to control runoff and reduce soil loss. In 1994, the SCS initiated a three-year evaluation of a national interim practice standard for the design and implementation of grass hedges as an accepted conservation practice.

Grass hedges differ from other common types of grass strips (i.e. buffer strips, filter strips) because they are narrow, planted with stiff, erect grasses, and capitalize on, rather than minimize, the formation of berms by deposited sediment. A dense uniform stand of coarse stems slows concentra ted runoff, causing backwaters as deep as 12 to 16" and allows time for deposition of eroded sediments. The deposited sediment fills in low spots in fields so that future runoff is more broadly dispersed and less erosive. The general concept of this technology is that narrow rows of grass hedges are planted in parallel lines across and perpendicular to the dominant slope of the field (7) (Fig. 1). The design, spacing and lateral extent for vegetative barriers in concentrated flow zones depends on anticipated runoff rates, topography, and other factors which have been detailed previously (4, 7).

Factors which influence the success of grass hedge plantings includes selection of the proper grass, use of high quality seed, proper seedbed preparation, precision planting, optimum timing and sound management practices during and following establishment.

Grass selection

Research has shown that a variety of perennial grasses that have coarse stems will work as hedges if they can be established as a uniform and dense hedge, and are tolerant of silt deposition. Warm-season grasses are probably better candidates for hedges because they are generally more robust and tend to have stiffer stems and, increased tillering within the hedge than most cool-season grasses. Grass hedges should consist of stiff, erect, perennial grasses which are adapted to local soil and climatic conditions. Grass barriers must have sufficient stem strength to remain erect against expected water flows.

Suitable barrier plants must satisfy several criteria. They must be tolerant to: (a) herbicides used on adjacent cultivated crops; (b) partial shading from cultivated crops; (c) inundation by sediment; (d) local climatic extremes (wetness, drought, freezing temperatures, etc.); and, (e) easily established from available materials; (f) long lived and manageable as a narrow strip; (g) non-weedy and not too competitive with adjacent cultivated crops; and (1) relatively tolerant to defoliation if crop residues are grazed. Switchgrass (Panicum virgatum L.) and eastern gamagrass (Tripsacum dactyloides L.) are two warm season, perennial native, non-weedy species with potential as hedges in much of the United States.

Switchgrass has a wide area of adaptation, determinate seeding habit, smooth (non-chaffy) seed characteristics for ease of handling, and prolific' production of coarse durable vegetation making it a leading candidate for use in grass hedges for erosion control. Research on switchgrass improvement has been conducted for many years and has resulted in no less than a dozen released improved varieties which has increased the adaptation potential of the species considerably (12). State Extension and/or local NRCS personnel should be consulted to determine the variety best adapted to a particular site and situation.

Eastern gamagrass has recently received considerable attention for use in grass hedges for erosion control. Problems inherent to the species, including indeterminant low seed production, seed dormancy and resulting problems in stand establishment (2) have slowed the progress in eastern gamagrass variety development, but the erosion resistance potential of the grass merits further research. The crowns of eastern gamagrass are formed by a proliferation of compact shoots consisting of vegetative and reproductive tillers in various stages of development (5). Shoots are interconnected through several tiller generations by a thick (1/2 to 1") woody proaxis (stembase) chain network which remains intact for several years acting as a considerable deterrent to erosion. The dynamic crown has the capacity to elevate coarse aerial foliage above sediment coverage and to anchor the plant in place with stout (1/16 to 1/8" diameter) brace roots.

Seedbed preparation

Poor seedbed preparation is a major cause of stand failures in grass plantings and therefore seedbed preparation should be planned and initiated well ahead of planting. Methods of seedbed preparation (the cultural treatments needed to produce a suitable medium for optimum germination and seedling emergence) will depend largely on the condition of the site to be seeded.

No-till seeding can be ideal, provided the seedbed allows the placement of seed at an optimum depth and the planting operation is capable of firming the soil above and around the seed to obtain good seed-soil contact which is necessary for retention of soil moisture in direct contact with seeds during the germination process.

No-till seeding into areas with excessive surface residues (50% or more of the soil surface covered) or with weed competition

is not recommended. Excessive surface residues and weed competition can often be reduced by mechanical means, burning and/or the use of broad spectrum herbicides prior to grass seeding. In cases where such remedial practices are not feasible it will be necessary to resort to tilled seedbed preparation methods.

Tilled seedbeds have the same rigid requirements for, successful grass hedge establishment as outlined for no-till seedbeds. An ideal seedbed will result in optimum soil-moisture-seed relationships during seed germination and early seedling establishment. A firm smooth soil surface, not excessively compacted, is required to facilitate precision planting and to optimize soil-moisture-seed relationships. The disk, offset or tandem, is probably the most common tool used for seedbed preparation when site conditions allow for its effective use. Harrowing and cultipacking following disking helps smooth and firm the seedbed.

Excessively loose and rough seedbeds hamper seeding success because seeding depths cannot be controlled accurately. Soils should not be worked when excessively wet, and any operation which results in the formation of clods should be avoided. Grass seeds are small and must be planted relatively shallow in order for the energy stored within the small seed to power the seedling emergence process. Firm seedbeds are essential as loose porous seedbeds do not provide adequate contact between seeds and the underlying soil water needed to ensure germination of seeds placed near the soil surface.

Use good quality seed

The use of good quality seed is essential to allow for precision planting and to help ensure success of grass hedge establishment. Seed should be purchased from a reputable seed source on a pure live seed (PLS) basis. The seed tag should list the percentage purity, other crop, inert, weed seed, germination, hard seed, dormant seed, and total germination of the product. It is very important to plant seed with high purity as this reduces the percentage of detrimental materials, (i.e., inert which interferes with planting efficiency, and other crop and weed seed which can compete with the grass seedlings during establishment). Most seed tags include percentage hard and/or dormant seed which are seed determined to be viable, but which fail to germinate following standardized preconditioning treatments. Percent germination, firm seed and/or dormant seed are summed and reported as total germination. Pure live seed is determined by multiplying the decimal value of % purity by % total germination. A high percentage PLS is an indication of over all seed quality.

Stratification by moist prechill occurs in nature as seeds fall from the grass plant in the Fall and lay dormant on or in the soil throughout the winter until soil temperatures are conducive for germination the following Spring. The natural stratification process is short circuited when seeds are harvested from the plant, stored dry over winter and planted in warm soil the following spring. In laboratory tests seeds of switchgrass and eastern gamagrass are subjected to standardized moist prechill (stratification) treatments designed to break dormancy and enhance germination. A do-it-yourself germination test that measures actual germination without artificial stratification is often more meaningful than laboratory tests. A “ragdoll” test can be conducted by placing 100 seed on the right half of a wet paper towel, folding the left half of the towel over the seed, and rolling it into a tight tube. Excess water should be allowed to drain from the ragdoll which can then be sealed in a plastic sandwich bag to prevent excessive drying. The ragdoll should be kept in a warm (70-85˚ F) place until germination counts are made 7 days later. Placing some seed you know will germinate (alfalfa, millet, clover) in a similar ragdoll will confirm that the test conditions are suitable for proper germination. The number of seed which germinate in the ragdoll is equivalent to actual % germination and can be multiplied by % purity, expressed as a decimal value, to calculate pure actual germination (PAG). Pounds of seed/A on a PAG basis can be calculated by dividing the laboratory PLS by the obtained PAG and multiplying by lb PLS recommended per acre. This usually amounts to an increase in seeding rate which gives added insurance for rapid establishment of a thick grass stand.

Eastern gamagrass seeds consist of grain (caryopses) enclosed in a hard woody fruit case which protects the grain and inhibits germination of the grain until stratification is induced (2). The protective fruit case makes up about 70% of the total weight of good quality gamagrass seed and a much higher percentage of poor quality seed weights. Good quality eastern gamagrass seed should have at least 95% purity, a PLS of 80% or better and 6000 or less seeds per pound. Stratified seed (i.e., moist prechill at 35 to 45˚ F for at least 6 weeks) should be purchased from reputable dealers to increase the success of grass hedge establishment.

When to plant

Spring planting should be done as soon as the soil temperature warms up to the point required for optimum germination of the seed being planted and if possible just prior to the greatest probability of substantial or prolonged rainfall. In some areas these two factors may not coincide, thus a compromise may be necessary.

Switchgrass and eastern gamagrass should be planted when soil temperatures stabilize in the range of 65 to 80˚ F at a 1" depth-below the soil surface. Faster germination and seedling emergence will occur w hen soil temperatures are near the upper limits of the temperature range (80 to 85˚ F) when soil moisture is not limiting. Planting dates will vary depending on locations but are generally between March 15 and May 15 in the South and May 1 to June 15 in the northern states. In relation to other crops, the warm season grasses should be planted later than corn, but prior to cotton or soybean planting time.

In general, later planting dates will allow more time for weed emergence and weed control prior to grass hedge planting, but this must be considered in relation to timing of rainfall probabilities. In more arid areas it may be better to plant as soon as the 1" soil temperature reaches 65˚ F; whereas later plantings are preferable in more humid zones.

Planting rates

Planting rates for grass hedge establishment should be two to four times more than rates recommended for pasture plantings because grass hedges are planted in narrow strips with their function requiring a rapid development of a dense stand of grass.

Switchgrass planting rates should approximate the critical area stabilization rate (i.e. about twice that of pasture plantings) which translates to a minimum of 44 potential

seedlings per square ft. of the planted area. This is equivalent to 8 to 10 lb. PLS per acre, but if a ragdoll test shows that actual germination is overstated on the seed tag, the seeding' rate should be adjusted upward accordingly. Grass hedges occupy only a small percentage of the total field area so that increased seeding rates are usually cost effective.

Eastern gamagrass should be planted at the rate of 10 to 12 lb. PLS/row mile of hedge and lb./A will vary depending on the row spacing to be used. The 10 to 12 lb. PLS/row/mile will be equivalent to 9 to 13 pure live seed per linear ft of row. The amount of seed needed can be determined by multi plying the miles of hedge rows to be planted times 10 to 12 lb. PLS (i.e., 1 mile of 2 row hedge 1 x 2 x 10 to 12 = 20 to 24 lb. PLS needed).

Planting procedures

Width of grass hedges should be a least 1 to 2 ft. wide to a maximum of five ft. Wider strips can be narrowed down with cultivation once the hedge plants are well established (Fig. 2 and 3). A single row of a dense grass stand is usually adequa te except in concentrated flow areas where at least two rows are required.

Switchgrass is usually drill seeded in rows 6 to 8" apart at a depth of 1/4 to 1/2". Seed placement should be uniform in rows with drills having a small seed attachment. Drills equipped with double-disk openers with proper depth bands facilitate placement of seed at the proper depth (Fig. 4). The depth bands should be secured to the disk openers at a distance of 1/2" from the cutting edge of the disk. Tension on the disk openers should be such that the depth bands roll on the soil surface and do not become submerged nor ride above the soil surface. Packer wheels on the drill which firm the soil over the planted seed are also very beneficial. Drag chains, though inferior to packer wheels, may also be used to cover and firm the soil around the seed, and a cultipacker or roller may be used immediately following planting if needed to firm the soil.

Stratified seed of eastern gamagrass should be planted 1 to 1-1/2" deep. Planting in deep furrows in soils subject to washing should be avoided as seed can be covered too deep. Planting shallower than 1" will have less favorable moisture - seed relations and emergence may be delayed. Row planters (corn, cotton, peanut, etc.) are easily adjusted to plant gamagrass in rows. The row planter furrowing out shovels or disk openers can be set to push away dry surface soil and insure the placement of the grass seed in a moist environment. The covering device should be set to cover the seed with moist soil and the packer wheel adjusted to firm the soil over the seed row. Stratified seed has increased weight due to extra moisture content and calibration is best done by counting the seed to determine the number dispensed per linear ft of row (i.e. 9 to 13 pure live seed/ linear ft of row is recommended).

Management practices

Washout or other problems may cause voids or skips in the grass hedge which require replanting. Reseeding by hand broadcasting and covering the seed by a hand rake may be practical for reseeding small voids. In concentrated flow areas, replanting washouts with veg etative transplants may be more effective than reseeding as transplants provide quicker cover and provide protection sooner than seedlings.

Both switchgrass and eastern gamagrass can be established vegetatively from crown material transplanted during the dormant season prior to spring green-up (6). Propagules can be obtained from adjacent established plants by splitting off portions of crown material with a shovel and replanting the crown material in the voids. Individual transplanting units of switchgrass should have at l east 4 to 5 viable shoots (stem base) while eastern gamagrass should have at least 3. The transplants should be spaced no more than 6" apart in the row to create a dense hedge.

Fertility levels of phosphorus (P) and potassium (K) which promote good growth of the companion cultivated crop will be adequate for grass hedges. Soil tests are required to determine P and K needs if they haven't been applied recently in the crop management program. Nitrogen should not be applied until after a good grass stand is obtained and plants have reached a height of at least 4" because N promotes weed growth and competition. After the grass is established it should be fertilized annually with 60 lb actual N/A preferably in April or early May.
Mowing at a 10 to 12" height is a good practice for control of tall weeds during establishment and for hedge maintenance thereafter. Usually an early-summer mowing is needed to prevent the grass hedge from lodging on the adjacent crop rows. Grass hedges should not be mowed shorter than 10-12" as this is a minimum height for hedge efficiency and lower cuttings during periods of active growth may severely reduce the vigor of the grass.

Burning can be an effective tool for grass hedge management, but the timing of burning is critical. Winter burning is not recommended as the dormant hedge still maintains a high degree of its water impounding function during this period (Fig. 5). Burning just prior to spring greenup of the hedge would reduce the time that the hedge would lose effectiveness and should be considered in relation to period of probable runoff. Burning stimulates grass hedge tillering and vigor, but caution in its use is recommended.

Summary

Grass hedges can be a relatively economical means to slow runoff water and reduce soil loss. There are several factors which will influence the success of grass hedge establishment including grass selection, seed quality, seedbed preparation, planting procedures, timing and management practices during and following establishment. Failure to consider any one of these factors may jeopardize the success of grass hedge establishment. Grass hedge establishment is not simple nor easy, but the rewards from a well established grass hedge should offset the effort. Good Luck.

(if readers would like to learn more about this technology, contact:
dabney@gis.sedlab.olemiss.edu
....Ed)

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QUIZ

US $20 for the first correct answer as to what the above image represents. Don't forget to send in a piece about what you are doing with vetiver grass along with your answer to Dick Grimshaw at the The Vetiver Network

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FOR SALE

Video Films: Vetiver Grass - A Hedge Against Erosion. 28 minute video comprising 128 scenes of vetiver technology. Available in English or Spanish, and in PAL or NTSC formats. Price US $25 including shipping.

Slide set: (65 transparencies)of vetiver technology + write up in English. Price US $65 including shipping and handling

Available from The Vetiver Network.

Table of Contents

News Line
- The First International Vetiver Conference,"Vetiver - A Miracle Grass" 1
- Funding Support For The Vetiver Network 2
- A Call For Help from Cameroon! 2
- Regional Networks 2
  - Red Del Vetiver Latinoamericana 2
- The Vetiver Network Homepage on the Internet 3
- Change of Address 3

Letters to the Editor 3

Thailand - First International Vetiver Conference
- Draft Conference Resolution 7
- Abstracts Of Selected Research Papers 9
  - SOCIO-ECONOMIC ASPECTS 9
  - TOLERANCE OF VETIVER TO TOXIC CHEMICALS 11
  - BIO-ENGINEERING ASPECTS 13
  - AGRICULTURAL USES OF VETIVER 16
  - VETIVER AGRONOMY 17
  - VETIVER GRASS HEDGE ROW TECHNOLOGY 19

Field Reports
- South Africa
  - The Use of Vetiver grass in the Revegetation of Kimberlite Spoil in Respect to South African Diamond Mining. 25
- Fiji
  - Back From The Future: Do's and Don'ts After 50 years of Vetiver Utilization in Fiji. 26
- Zimbabwe
  - The Hippo Valley Estates Magudu Vetiver Outreach Project 28
- Papua New Guinea
  - The Establishment and Management of Vetiver Grass within the Traditional Garden System of Papua New Guinea. 29
- Australia
  - Effectiveness Of The Vetiver Hedges In Soil Erosion And Sediment Control In Queensland 32
  - Effects of Heavy Metals Toxicities on Vetiver Growth 32
  - Resistance Of Vetiver Grass To Infection By Root-Knot Nematodes(Meloidogyne Spp) 36
  - Soil Moisture And Sorghum Yield As Affected Vetiver Hedges Under Irrigated And Dryland Conditions. 36
- Panama
  - Report on visit to Western Panama 37
- USA
  - Guidelines for the Establishment of Warm Season Grass Hedge for Erosion Control 40

The Vetiver Network Addresses of Directors and Officials 43

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER NETWORK
NUMBER 16 NOVEMBER 1996

CONSERVATION GRASS WINS MONSANTO'S "JOHN FRANZ SUSTAINABILITY AWARD"

ST. LOUIS, Oct. 22, 1996 — A non-profit organization promoting novel uses for tropical grass for conserving soil and water and other environmentally beneficial applications was today named the winner of Monsanto Company's John Franz Sustainability Award. The winning organization — The Vetiver Network, headquarted in Leesburg, Va. — supports a worldwide network of 4,000 participants who use the technology to increase sustainable development in more than 100 countries.

Last December, Monsanto announced the $100,000 award to accelerate the development of new technologies and systems to improve world environmental and economic sustainability. The Vetiver Network was selected from more than 75 proposals as the most promising system for advancing global sustainability.

The announcement of the today's winner was made at a meeting of Monsanto's Sustainability Team, a group of more than 100 employees representing the company's 12 busi-

SEE PAGE 83 & 84 FOR TABLE OF CONTENTS

Editorial *The Vetiver Network has come of age. It is now in a position to execute a comprehensive $500,000 program over the next two years that will not only provide information, but will encourage through the provision of financial assistance to vetiver user groups the promotion of the technology at regional, national, and local levels. It will reinstate its research and development awards program and it will provide new and up to date publications and videos about the technology.*

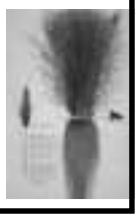
Our purpose in the last years of this century must be to continue to create, but at an accelerated rate, the awareness of the potential of vetiver grass as a unique and effective way of sustaining the worlds land resource, particularly in "tropical" countries. We have to also create the means to do this. The Vetiver Network cannot do this latter task alone. We invite governments, corporations and other institutions and agencies, however big or small, to take a serious look at the vetiver hedgerow technology, determine its usefullness, and then find the means to apply it.

During the next few years we expect to see Vetiver grass use expanded for bio-remediation and other puposes for cleansing the mess resulting from land fills, mine dumps, and other centers of toxic waste.

We also expect to see an expanded use of vetiver and other stiff grass hedges as a means of reducing nitrate and phosphate leaching to our natural water supply systems. This extraordinary grass, being a hydrophyte, has great potential asa component of a wetlands technology

We believe there will be an increased acceptance of the technology by engineers for use in embankment and other stabilization applications. It is an indeed an exciting plant and an exciting time to be working with the technology.

Earlier this year The Vetiver Network sent to many agencies a request for funding to enable us to expand our work. We thank those who responded, particularly The Royal Danish Government who gave us a generous grant. We would ask those who did not respond to reconsider, and provide us with funds. The Vetiver Network has no salaried staff and has minimal overheads. Thus funds go to where they can be effectively used -- in the field. We also ask vetiver users who can afford it, to contribute as well. Its your network, help to make it work!



We congratulate Jim Smyle and Joan Miller for establishing The Latin America Vetiver Network, and this year they have published two excellent newsletters in Spanish.

This Newsletter, #16 , has some interesting articles and deserves careful reading.

ness units who are dedicated to coordinating Monsanto's efforts to advance global sustainable development.

Monsanto received entries in the areas of resource conservation, technological innovation and educational programs from individuals, research institutions, and private and governmental organizations in 12 nations.

"The well-being of humanity depends on a healthy and sustainable planet," said Robert B. Shapiro, Monsanto Chairman and Chief Executive Officer. "Moving in the direction of sustainability will require new technologies and practices to spur the necessary innovation. We're working to develop some of these technologies, and we hope promising programs like the Vetiver Network will set a precedent for further advancement."

The winning proposal was selected by a panel of independent judges who are experts in different areas of sustainability. The panel of judges included Dian Cohen, the president of DC Productions Limited in Canada; John Hebblethwaite, the executive director of the Conservation Technology Information Center; Uma Lele, an Advisor in the Agricultural Research Department in the World Bankís Vice Presidency on Environmentally Sustainable Development; Manfred Wirth, the Director of Dow Europe's Environmental programs; and representatives from Interface, Inc., a company that provides high-quality, sustainable, commercial floorcovering products.

The Vetiver Network developed a method of using vetiver grass to conserve soil and water; to stabilize embankments, wastelands, landfills and mine dumps; and for flood control and groundwater recharge. The program is used in more than 100 tropical and semi-tropical countries through its 4,000-member communication network.

While effective in tropical climates, vetiver grass cannot survive extreme and continuous freezing temperatures typical of most of the continental United States.

Vetiver grass has a very deep and massive root system that extends more than five meters under the ground. Planted across the slope of the land as hedgerow, the Vetiver Grass Hedgerow Technology (VGHT) seems to be the most effective biological system of soil and water conservation.

Soil losses are reduced by 70 to 90 percent, while crop yields are increased by as much as 50 percent because of the preservation of sediment and nutrients on natural terraces. Vetiver grass is also tolerant to fire, drought, grazing, and high levels of toxic metals.
The advantages of VGHT, make vetiver grass a sustainable answer to many of the environmental dilemmas of the tropical world. For instance, highways in tropical countries are renowned as point source erosion sites that cause serious down stream contamination of water supplies. Used correctly, VGHT can virtually end forever sediment flows from such sites.

Other demonstration sites have proven vetiver grass as an effective means of stabilizing toxic dumps, controlling floods as well as a variety of other practical uses.

The Vetiver Network will use the $100,000 award to fund the continued operation and expansion of the project, including the preparation of educational films, publication of a new handbook and establishment of five regional networks to support further development of VGHT.

Monsanto is a science-based company involved in improving the quality of life through agricultural systems, pharmaceutical and food products and high performance chemicals.

The John Franz Award is named after the inventor of Roundup herbicide — which has contributed to agricultural sustainability worldwide through its use with conservation tillage systems. The announcement of the award in December of last year coincided with the 25th anniversary celebration of Roundup as a product.

VETIVER NETWORK FUNDED FOR 1997 and 1998.

The John Franz Sustainability Award to the Vetiver Network of $100,000, together with the generosity of the Royal Danish Government and the Amberstone Trust, assures that The Vetiver Network has sufficient funds to: support the establishment of Regional Networks (about $120,000), support NGOs in vetiver ventures (about $100,000), award prizes for good vetiver research and dissemination practices ($50,000), produce a new technical book on vetiver incorporating all we know ($50,000), produce new vetiver videos ($50,000), publish the newsletter, and continue the expansion of our home page on the World Wide Web. We are still short of some funds and look forward to receiving donations from vetiver users (especially those of you who are running profitable businesses using vetiver and the technical assistance that you have received though the network) and other donors who see the potential of vetiver technology in the mitigation of environmental problems. All donations should be sent to the Vetiver Network. More details under "ANNOUNCEMENTS page 10"

WHAT VETIVER USERS IN THE PHILIPPINES SAY

The following are testimonies by Vetiver (Vetiveria zizanoides) users given

during the Vetiver Users Workshop, May 24, 1996, Matalom, Leyte, Philippines. *Note in this part of the Philippines vetiver is known as "Mura" or "Mora".* Prepared by **Edwin Balbarino**, Program Field Coordinator, FARMI, ViSCA, Baybay, Leyte, Philippines. Email: v+visca@sat.vitanet.org

Leon Pen, *Barangay Chairman, Templanza, Matalom, Leyte.....*"I got my first Mura (Vetiver) planting materials from one of my barangay councilmen Jacinto Gerona. I planted Mura in my farm near my house. Mura is easy to plant with minimal maintenance. It grows very well and effectively controls the down flow of soil during the rainy season. At present, the contour plots of my farm have been leveled off. In addition, I am also using Mura to cure high blood pressure in my work as Tambalan (local medicine man). The only comment I have with Mura, is that my carabaos (water buffalo) do not like to eat it". *(If you cut your Mura regularly, say once a month, your carabaos will love it...Ed)*

Irene Pria, *Officer: Rural Women Association, San Salvador, Matalom, Leyte.....* "FARMI workers gave me the Vetiver planting materials in 1991. At the start (about the first 2 years of establishment) I did not practice trimming the Mura hedgerows. Then I found out that it is very strong and effective in controlling soil erosion. Now my Mura hedgerows are well maintained by trimming before flowering. Trimming the plant (during not before) is laborious because the stem is already hard. I placed the herbage along the upper portion of the hedgerows. This will help in trapping the soil during the rainy season. Other herbage is used as mulch for my sweet potato crop. I could also say that the wonderful contribution of Mura has ever given me is that it cured my thinning hair.

Note: Workshop participants and friends testified that Irene really suffer balding/serious thinning of hair before. She has the formula/technique of doing it which she will share to those who are interested. *("baldies" had better get in touch with Irene....Ed).*

Gertrudes Inderio, *67 years old woman-farmer, Altavista, Matalom, Leyte.....* "I was the first one to adopt the planting of Mura in my barangay (village). I noticed that my contour plots have leveled 3 years after I planted Mura. I really believe its effectiveness in controlling erosion. It is easy to plant and maintain. To maintain it, I just burn the hedgerows at the end of summer and in less than 5 days re growth is already visible. I have proven it myself that Mura grow in any type of soil. I have planted 6 lines of Mura in Anapogon (calcareous soil) and it is growing very well".

Note: Nang Itring's farm has a 25-40 degrees slope.

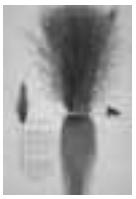
Photo 1**. Philippines. Lady framers sharing their Vetiver experience.* ***Photo Credit: Edwin Balabarino

Nemesia Purgatorio, *President, Women Association, Elevado, Matalom, Leyte.....* "My farm may not be as hilly as the farms of other farmers but still I notice how effective Mura is in controlling soil erosion. Once established, it is not easily killed by cogon grass (Imperata cylindrica) unlike other contour hedgerow species. Mura is easy to maintain. It does not grow anywhere except in the contour line where it is planted. I trim my Mura before planting corn or sweet potato or during land preparation. I am also using Mura as roofing materials for my Payag (animal shed)."

Rubelio Mazo, *Punta, Baybay, Leyte.....* "In my experience Mura is not effective unless we use the A-Frame in locating the contour line. Trimming is also very important. Mura should be trimmed before planting corn or camote to avoid "awong" (sunlight competition). If left untrimmed, there could be danger of accidental burning of the matured hedgerows when crops are still on the alleys. The herbage scattered along the hedgerow base also help in preventing the passage of soil during rainy days. Try to visit my farm, I am sure you will notice the difference between farms with Mura and farms without Mura hedgerows."

Santiago Llones, *Punta, Baybay, Leyte.....* "I like Mura because it is easy to establish and maintain. I do not practice trimming but instead burn my hedgerows because I observed that Mura grows more vigorously after burning. I do not believe that soil fertility is affected when Mura hedgerows is burnt. The effect of Mura could be seen in the healthy corn along the upper portion of the hedgerows. Mura does not compete with corn in sunlight and soil nutrients".

Norberto Inderio, *MAFUD President, San Salvador, Matalom, Leyte.....* "My contour farm is near (above) my small rainfed rice field. I have no doubt of Mura's effectiveness in controlling soil erosion. There was a big gully in my farm before but after 4 years of planting few lines of Mura that gully is no longer visible. The only thing that makes Mura unattractive to farmers is that it seems unpalatable to animals except during long dry season when grasses are scarce. During that 7 dry months in 1992 burned Mura was not able to recover. Mura



serves as a wind break of my rice and also serve as a nest for my hens. Mura should be trimmed to keep away the Maya birds from nesting on it."

Note: Maya is that small red-brown bird which is considered important pest by rice farmers.

Ronie Maso, Punta, Baybay, Leyte..... "I observed that farmers in the barangay who do not use Mura as a contour hedgerow frequently shifted farms. For me I have not shifted farms for already five years. The reason why they won't plant Mura is that they don't own the land they tilled. One observation I have with Mura is that it is easily dominated or overgrown by Kudzu especially if not well-managed." *(Development planners, please note the importance of land tenure, or lack of it, with regard to the uptake of longer term conservation technologies; also as we have mentioned before, vetiver hedgerows combined with other practices may be the answer to "slash and burn" problems. Ed.)*

Margarito Maso, *Punta, Baybay, Leyte.....* "I firmly believe that planting Mura grass is the most effective way to control soil erosion. I made a simple experiment on my farm by leaving a portion not contoured with Mura. In just few cropping seasons the difference in terms of soil erosion was already evident. I measured about 2 feet thickness of soil trapped at the upper base of the Mura hedges. Gullies are observed in the uncontoured portion."

Felipe Itallo, *Punta, Baybay, Leyte*..... "My experience with Mura is on paddy rice fields and not on upland farms. We have already been using Mura to stabilize rice field dikes several decades. It is really strong and lasts forever. It regrows even if covered with mud. Farmers just burn the Mura after harvesting to drive away rats and birds.

Bonifacia Gura, *Matalom, Leyte.....* "In the beginning we used rock walls as soil erosion control system in our farm. Along the rock walls we also planted Ipil-ipil (Leucaena leucocephala). After several years we eradicated the ipil-ipil because their roots are making land preparation difficult. During that time FARMI introduced Mura as contour hedgerows to control erosion. So I tried the grass as replacement of Ipil-ipil. We like Mura because it stays where it is planted. It is easy to establish and survives long droughts. One major characteristics of Mura that makes it an ideal control hedgerows is that it regrows or produces roots at the nodes making it effective as contour bands and riser stabilizer". *(This latter observation is execellent, and is exactly why Mura is such an effective stabilizer...Ed.).*

Concepcion Pada, *San Salvador, Matalom, Leyte*..... "I have not maintained (trimmed) my Mura hedgerows since planting because I fallowed my farm for 5 years. However, I noticed that the grass still exists after 5 years since it was planted. Now, my Mura hedgerows is already thick. I am planning to open my farm again and trim the Mura".

Nesias Galia, *Hitoog, Matalom, Leyte.....* "My farm is located below the barangay (village) road so that during heavy rains water is drained to my farm creating big gullies. As remedy, I formed contour bands and planted Mura and Napier along the bands. I observed that corn planted near the Mura produced bigger ears than those near the Napier. Napier roots runs through the alleys. The Mura hedgerows could be maintained by just cutting it at the base or stem regularly. It should be cut and cleaned regularly so that weeds such as Bokot-bokot (Micania cordata) can not dominate that would eventually kill it."

ORGANIZING VETIVER'S NEXT STEPS TO GLOBAL ACCEPTANCE

Presented at the First International Vetiver Conference, Thailand, February 1996 by Noel Vietmeyer, U.S. National Research Council, and Board Member of The Vetiver Network, Email: noelvi@aol.com

Introduction

For all its great merits vetiver has a major problem: it just isn't going to make many millionaires. Were it capable of creating lots of money for individuals, we vetiver specialists could retire to our laboratories, offices and test plots strong in the conviction that others would eagerly turn all our results and visions into practical benefits.

But the reality is that people of extraordinary conviction and vision, such as His Majesty the King, are the only ones going to dedicate their energies to moving vetiver upward and outward to its global destiny. As a result, we cannot go back to our research and expect that this immensely useful plant will advance into widespread acceptance by some sort of global osmosis. We vetiver champions must now shoulder the burden of selling the vetiver idea to people of influence worldwide.

And this brings up a second problem: vetiver is so good at doing so many things that our immediate challenge is an organizational one. Even we vetiver specialists become overwhelmed by the sheer breadth of the vision we see. And if we are confused, think about how baffling our story must be to those newcomers whom we must bring on board to achieve a successful global outcome.

To help bring some measure of order to our collective vision, as well as to boost the crop's advancement, I'd like to suggest that we move vetiver for-

ward by means of the following initiatives.

Soil Erosion Initiative, Extreme Soil Initiative, Water Management Initiative, Pollution Control Initiative, Farmer Support Initiative, Disaster Prevention Initiative, Basic Science Initiative.

These initiatives are more than just ways of thinking about the plant and its promise, they are compartments of practical progress, each distinct and selfcontained within itself. Of course there are overlapping borders indeed, a complicated chart could be drawn showing all the interrelations but for all that, each of these action oriented topics plays on different strengths of the grass and reaches out to different audiences. In addition, each requires a different approach from us as we shoulder our burden of locating partners for mutual support and for faster progress worldwide.

Let me see if I can explain this better by taking each initiative in turn.

The Soil Erosion Initiative

Of all vetiver's applications, controlling soil erosion is by far the best understood and furthest advanced. Probably 90 percent of all the work to date has been devoted to this initiative, and the fact that the plant stops soil loss is now abundantly clear. The effect is due largely to the strength of the stems in hedges placed along the contours of hill slopes.

I need not dwell on the details here, but I do want to note that this initiative must not be slackened. Soil erosion is arguably the worst global environmental problem, and for much of the world it was the least tractable until vetiver came along. All in all, this grass offers the first practical intervention with worldwide possibilities.

The Soil Erosion Initiative's next major challenge is to project existing knowledge to new locations and new people. In a sense, we must bring other nations up to the level of commitment and action achieved here in Thailand. If we can make perhaps 100 more nations as committed as this one, the global scourge of soil erosion would mostly be thwarted within our lifetimes. Of course, some nations are too frozen during winter to consider vetiver, but the United States is developing a complementary, vetiver inspired, grass hedge technology using cold climate species.

Bringing about the tantalizing vision of global success against erosion should be the Soil Erosion Initiative's aim. The existing vetiver publications are, by and large, adequate to the task. Farmers and foresters are of course the main audience, but we must reach out more to engineers and get them to take up vetiver routinely along roadsides, around construction sites, next to bridge abutments and along pipelines. Also we need to reach city officials so that vetiver gets put to use stopping erosion in the squatter settlements, storm water drains and other urban sites.

In addition, environmental scientists and conservation watchdog groups need to be made aware that vetiver is now a promising answer to the soil that washes into their natural preserves. They could, for example, push for the regional employment of vetiver hedges to reduce the waterborne silt that devastates coral reefs, fishspawning grounds and various other irreplaceable habitats. Three examples worth vigorous action are:

The Everglades. The delicate balance of this irreplaceable habitat in Florida is being upset by phosphate and other nutrients washing out of nearby sugarcane fields. To me, the solution lies in surrounding the canefields with vetiver hedges. Those hedges would trap the silt (along with the phosphate clinging to it) and absorb soluble nutrients before the water ever passes into the Everglades.

Lake Victoria. This large lake in the heart of Africa is suffering explosive blooms of water hyacinth. I'm informed that the problem has been linked to nutrient laden silt washing off the land and fertilizing the weed. A regional vetiver planting campaign in the watersheds serving the problem locations, might immeasurably benefit the lake, not to mention the watersheds themselves.

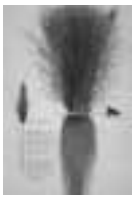
East Africa Coast. The grass might also prove useful in watersheds in eastern Kenya, where silt washing off the land is killing a priceless coral reef.

The Extreme Soil Initiative.

The primary challenge in this initiative is not erosion control; it is instead to make extreme soils productive, or at least more productive than at present. This is also an important challenge. Vast areas of the earth typically classified as "marginal lands," "wastelands," or "abandoned lands" are inadequately used because they are just too hard to harness for crop production.

A truly amazing aspect of vetiver is its ability to survive on sites so hostile toward plant life that people now universally write them off as impossible to cultivate. The relevant feature in this case has to do with the plant's root chemistry. We know from experiments and observations that vetiver grows in acid soil, alkaline soil, laterite, vertisol, toxic mine spoil, moderately saline soil, wetland and dryland soil, and even soils so dense they are likened, not inaccurately, to "concrete".

That vetiver can survive in such sites may at first sight seem just incidental, but having an adaptable and well behaved plant that stays neatly in place is probably the missing key to mitigating the harshness of many now barren lands. Vetiver hedges in this case would be deployed as vegetative shock troops to seize a botanical bridgehead on the



hostile site and open the way for other species to follow.

It seems likely that the lines of solid plant cover will indeed help get the restoration process started. Already the effect can be seen in many places. In Louisiana, for example, barren washes quickly fill with native vegetation after vetiver hedges stabilize the area. In northern India, sodic wastes were turned into luxuriant forests once vetiver hedges were in place. And in southern India, forests have been seen to colonize hillsides after vetiver hedges provided some protection.

This particular use of vetiver is hardly well known, and it deserves its own dedicated initiative. Research, testing and a comparison of experiences are all needed in a wealth of difficult sites. Globally important extreme soils to include from the beginning are vertisols, laterites, saline and sodic types. Get people excited about any of those and you'll really make a difference to vetiver and the world. The "laterite" that dominates the lowland tropics is an especially potent challenge. That particular type of soil red in color, very acid and high in soluble aluminum, a deadly toxin to most plants has long been considered beyond the possibility of highyield farming, but the fact that vetiver survives (even thrives) in laterite could turn out to be one of the great breakthroughs for tropical agriculture and forestry.

Combinations of vetiver hedges with appropriate leguminous cover crops that renovate infertile land between the hedges need especial consideration, That one-two punch, based on a natural succession of the vetiver pioneer and the nitrogen fixing successor, should open the doors to routine development of many now unusable sites. The combination with laterite tolerant leguminous trees, such as Acacia mangium, could also be a powerful intervention.

Taken all round the Extreme Soil Initiative is a way to "sell" vetiver to a new set of clients for whom soil erosion is not a main concern. Examples are landuse planners, international donors, economists, policy makers, government administrators and others worried over population pressures and immediate food supplies. In principle, hundreds of millions of hectares of now unused lands could be rejuvenated to support more people and more crops. Turning wastelands into farmlands would, in addition, be a way to save more natural forests from "slash and burn" destruction.

The Water Management Initiative. The fact that vetiver hedges are dense enough to dam up water is yet another distinct feature. The effect is due to the plant's stems and myriad leaves, as well as to the soil and litter that collect behind a hedge. The effect is more sophisticated than people imagine; a vetiver hedge handles different depths of water in different ways. A modest, ground level runoff hitting one of those hedges gets ponded, but a rushing torrent passes through with increasing ease as it rises past the point where the leaves splay outward. An established hedge, seldom gets knocked down, and its variable filter feature damming up ground level flows but progressively passing more water the deeper it gets is an important one.

Professionals and policy makers involved in water issues are unaware that vetiver can help their efforts. This Water Management Initiative needs to reach out and show them what they have to gain. Things to highlight include the following.

Watershed Management. By holding silt and water on hill slopes, vetiver hedges should be able to protect entire watersheds the way the original forests did. This would not only reduce soil loss and river sedimentation, but by keeping water on the land, vetiver would recharge groundwater supplies. Work in Malaysia shows that by using plants raised in pots, the hedges can become functioning barriers within weeks of being planted out. This holds the possibility of creating "instant" working watersheds over vast areas at modest cost. It would also mean that people might be able to stay living on the watersheds without severely affecting the area's vital hydrologic importance.

Waterway Stabilization. Vetiver planted along streams, river banks, canals, drains and ditches can help keep out silt, maintain the flow and prevent the banks from being undermined. This means, among other things, that capital investments in water supplies will be protected and enhanced.

Reinforcing. This coarse grass with its roots like chicken mesh projecting several meters into the soil probably can strengthen earthen structures such as small dams and dikes. Following the disastrous Mississippi floods of 1993, it was reported that all levees protected by switch grass remained unbroken. Vetiver should do at least as well because it is endowed with a better root and stem architecture for the task.

Sediment Control. Waterside "walls" of vetiver hedge, grown on the banks of reservoirs, would provide ideal holding "pens" for dredge spoil. By allowing the water to filter back into the reservoir, these cheap, porous barriers would make it feasible to isolate the solids for economic handling by people or machine. Such self rising silt traps might help rescue reservoirs serving cities such as San Juan, Puerto Rico and Port au Prince, Haiti. Those reservoirs, along with many more in the tropics, are fast silting up and prematurely losing their capacity to hold water or generate electricity. Of course, the whole siltation process should be slowed with vetiver hedges on the watersheds.

Engineering Water Flow. Vetiver hedges can be employed not only to retard runoff but to direct water toward,

away from or through some given point. Hedges angled down slopes, for instance, would divert water away from sites such as unstable cliffs. For the cost of a few tillers and a planting effort, hydrologists and engineers could harness nature to achieve water shedding or water harvesting or other forms of water control.

Waste water Treatment. Probably there is no better species for stripping nutrients out of domestic (and perhaps industrial) wastewater. A native of a wetland environment, vetiver withstands long immersion. Hedges grown across or around manmade marshes would likely block the passage of solids, strip out dissolved nutrients and detoxify pathogenic microbes through aeration or detention. By providing simple, compact water treatment facilities that require no chemicals or pumps, vetiver could create a new and cheap form of tertiary wastewater treatment for the countries of the "Vetiver Zone." In return, these wastewater treatment facilities could become vetiver nurseries. Fertilized by the wastewater nutrients, the plants should throw off tillers in abundance. Employing human wastes to grow vetiver for planting where it can do good for people and the environment is a new and especially elegant notion of recycling.

In sum, this Water Management Initiative could elevate vetiver into a tool for providing more reliable water supplies, reinforcing earthen dams, protecting river banks, treating domestic wastewater and much more. In selling the idea to hydrologists, sanitary engineers, public health specialists and so forth, a few spectacular successes could make all the difference. The Panama Canal, for one, would be a great showcase. Today, ship wakes erode parts of the canal banks, but vetiver hedges would absorb the swells and allow ship traffic to speed up, thereby increasing the canal's throughput and economy. Moreover, contour hedges on the surrounding hills and mountains would retard rainfall runoff, recharge groundwater supplies and probably restore the Chagres River to high year round flow as in the days when those watersheds were fully clad in forest.

The Pollution Control Initiative. Although vetiver has many potential uses in pollution control, none is being vigorously developed or promoted. The initiative needed here, is to reach out to governments, environmental scientists, industry and organizations concerned over cleaning up messes people or their institutions have left behind. Also, vetiver might be employed to prevent future messes from occurring or at least from spreading. A few examples of what vetiver might help clean up are given below.

Underground Flows. Surrounding polluted sites with vetiver hedges may well be a way to keep toxic compounds from moving outward underground. The massive, curtainlike "hangings" of interwoven roots seem ideally structured to filter out underground contaminants. If the plant can keep deadly pollutants corralled and unable to move outward and contaminate new ground, vetiver will have earned a place in everyone's gratitude.

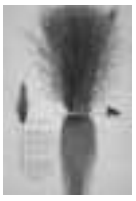
Soil. Paul Truong's magnificent work in Australia has shown that vetiver is tolerant of high levels of arsenic, cadmium, chromium, copper and nickel. The plant therefore seems highly suitable for rehabilitating and reclaiming lands contaminated by heavy metals, as well as perhaps by radio nuclcides and similar horrors resulting from mining, other industries, research facilities, landfills or other waste dumps.

Industrial Spills. No one has reported trying vetiver hedges against spills of industrial liquids, but it seems to me that a series of these very dense hedges would provide a cheap and probably effective backup protection against small spills at least. It would hardly matter if the hedge died, it could be easily replaced. Even crude oil might be held back. Indeed the oil soaked vegetation could be burned for furnace fuel.

Runoff. As mentioned above, vetiver hedges could block nutrient laden runoff. Such runoff from farms, industry, cities, landfills and even golf courses is a rising concern these days. Vetiver hedges could be especially useful as a "filtration barrier" around such sites, as well as around ponds and marshes built to contain or detain runoff. In the case of cities, contaminated stormwater is a particular concern.

Natural Waters. Hydroponics might be a way to use vetiver hedges to filter dangerous materials out of surface waters. This is a speculative and untested idea but, as noted, the plant is at home in watery conditions. In one form of hydroponics, the plants would be grown in an inert and highly pervious material through which the waters would pass. In another, vetiver might be grown with its massive roots dangling free in the water. This far out idea, which works for other plants, requires something (old tires perhaps) to keep the vetivers from sinking. Floating hedges might even be deployed across streams or canals to strip pollutants and dissolved nutrients out of the water passing by. This waterborne process might even prove a convenient way of growing vetiver roots for oil extraction (no digging needed, just clip off the root ends when they get too long).

Industrial Wastewater. I've already mentioned the possibility of treating human wastes in manmade vetiver filled wetlands. This nonchemical wastewater treatment also seem promising for cleaning waste products from aquaculture. It is already removing nutrients from trout farm effluent in trials at a U.S. Department of Agriculture research facility in West Virginia.



Taken all round, this Pollution Control Initiative opens up vetiver applications relating to some of the best fielded areas of research, with billions being spent in the United States alone. But the use of the grass is not currently a part of the experts' thinking. To correct that, vetiver needs to be tested widely in polluted sites, and fast. A success or two could launch vetiver into "big time" and well funded applications. In fact it would transform the world's appreciation of the plant overnight. In people's minds, a tool for removing deadly toxic hazards is something quite different from a tool to control soil erosion on foreign farms. A change of attitude like that would help everything.

The Farmer Support Initiative

Unless farmers deeply appreciate the plant and fully recognize that they are benefiting from it daily, we'll always have to struggle to get vetiver hedges on the land. So, while we're emphasizing grand global problem solving, such as those I've mentioned above, we've got to keep the farmers eagerly planting vetiver for themselves and for a surplus to sell. To assure this we need special efforts to get world wide appreciation for the benefits to growers. Many farmers won't plant anything new just for erosion control, but they will eagerly tend a crop that provides income or makes their lives easier or more secure. Here are some features of vetiver that provide salable products or a better life for farm families:

Handicrafts. Vetiver's bamboo like stems are ideal for making baskets and other small items.

Thatch. The leaves make one of the longest lasting and most beautiful roofs.

Supplementary Feed. Although not a great feedstuff, vetiver is better than many give it credit for.

Improved Crop Yields. Holding moisture back fosters better crop growth and helps keep wells filled.

Wildlife Controls. Pests such as rodents and Africa's graindevouring quelea bird might be kept out of crops. The birds, for example, like to roost in blocks of tall grass, and there can be trapped in the dark of night.

Mulch. The leaves create a long lived mulch that helps garden plants survive adversity.

Windbreaks. Standing up to 3 m tall, vetiver is ideally structured to resist the wind.

Boundary Markers. Several African nations recognize property lines demarked by vetiver because it stays in such a narrow band.

"Airconditioning". Mats woven of vetiver roots are placed over window openings and doused with water cool millions of India's houses. Breezes passing through are both chilled and perfumed. This could have wider potential than now imagined.

Ornamentals. In Miami, vetiver plants are being taken up for their beauty and good behavior in the landscape.

Screening. The tall, dense hedges are a way to provide a measure of privacy around houses, latrines, etc.

Animal Protection. Corrals and shelters for small creatures such as chickens seem a possibility.

Traffic Control. Vetiver can be employed to orient where people and animals walk and where vehicles drive. For instance, it can keep them off unstable banks.

Self Rising Utility Walls. Circles of vetiver might be used to enclose compost piles, trash heaps, farm gardens, fish ponds and more.

Weed Prevention. The hedges are said to prevent creeping weeds, such as Bahia grass, from invading gardens.

Making Steep Slopes Usable. Hedges across slopes make it possible to work where now even standing is difficult and everything washes away with the rains.

All of these farmer advantages need to be developed and exploited throughout vetiver country. They should be brought together in extension literature. In this case, the extension publications might mention erosion prevention, but their more immediate purpose is to stress benefits to the farmers' daily existence. In addition, commercial markets for vetiver tillers, handicrafts, thatch, "airconditioning" mats and other products need to be advanced. Rather than establish centralized nurseries, a commerce in farmer supplied planting materials should be encouraged.

The Disaster Prevention Initiative.

Given the deep roots, high tops and thick hedges, as well as the promise of practical largescale application, it seems obvious that this grass could play a role in mitigating (and perhaps preventing) various natural disasters.

This topic, speaking technically, overlaps water management and soilerosion control, but speaking in the political and humanitarian sense, the topic of disaster prevention takes vetiver into a different ministry and makes it of interest to different industries. Here the ultimate goal is not just to control water and retain soil, but to save lives and reduce property damage. The Disaster Prevention Initiative, then, is a way to reach out to governments, the worldwide insurance business, mortgage lenders and more. Here are some possibilities where vetiver might make the difference.

Mudslides. The stiff, strong tops of vetiver hedges stop mud and debris from passing by the massive underground walls of interlocking roots seem likely to stop slopes from slipping.

Floods. I've already mentioned how vetiver hedges may be planted in ways that rob floodwaters of the power to cause destruction, and that the hedges can hold rainfall on the watersheds.

Fires. In South Africa it has been found that burning off the hedges at the end of the wet season results in a flush of growth that stays succulent through the dry season. The forest insurance industry has accepted this band of green vegetation as an effective firebreak.

Droughts. By helping extend groundwater and surface water supplies (as mentioned above in watershed and reservoirs, for instance), vetiver should be able to benefit droughtprone areas.

Earthen Structures. Some (many?) earthen structures are in danger of collapse. A decade or two ago a dam in the hills above Los Angeles broke, releasing a deluge that caused immense property damage and some deaths. Vetiver appears to have potential to be an inexpensive reinforcing to strengthen such structures. Levees around New Orleans and along the lower Mississippi are likely candidates known to me. Were they to break, the devastation would be immense

We cannot be certain about vetiver's utility in any of these undertakings, but the authorities charged with disaster prevention should be given a chance to put vetiver to the test. Whatever is done to prevent disasters will have to be done over vast areas, and vetiver seems more suited than other possibilities, such as those employing concrete and steel.

This use of vetiver in emergency management would come clear to the appropriate authorities and businesses if it were employed on some high profile sites. An example might be Mt. Pinatubo in the Philippines where the massive landslides of volcanic debris are inundating towns and villages. In addition, disastrous mudslides have in the last few years caused deaths and/or destruction in Puerto Rico, Haiti, Leyte in the Philippines and Malibu in Southern California. All those locations seem ideal for vigorous vetiver growth.

In addition, the Mekong watershed might be tackled as an international vetiver planting test bed. The idea would be to keep silt out of the river and future floodwaters out of people's houses. Return the critical upland slopes to the hydrological state they enjoyed when fully forested, and perhaps Thailand's terrible floods can be a thing only of memory. A similar, but even bigger challenge, would be the protection of Bangladesh from Himalayan floodwaters. Such a mission might seem to be too vast to be possible, but vetiver would be a better place to start than anything else I can conceive of.

The Basic Science Initiative.

For all our experience, the truth is we still don't know much about how the plant ticks. Yet the workings of vetiver are what underpins everything. What makes it work so well at so many things? In this regard, how does it differ from other plants? These and many more question need answering.

In this Basic Science Initiative the audience is specialists such plant physiologists, microbiologists and (grass scientists). The topics here relate to pure science, rather than strictly to practical affairs.

Areas for basic science investigation include the following.

C02 Absorption. In this era of global warming scare, it is important to measure how much greenhouse gas vetiver stores in its massive roots.

C13 Absorption. Is vetiver, like corn, an accumulator of this uncommon isotope?

Taxonomy. What exactly is the relation between the sterile domesticated plants and the seedy wild ones?

Transaction of Oxygen. Rice survives in flooded paddies because it moves oxygen down into its roots. Vetiver also survives in paddies. Can it do the same oxygen transfer?

Heavy Metals. How well do pollutants move upward from the roots to the leaves? Is Vetiver a "superbioaccumulator"?

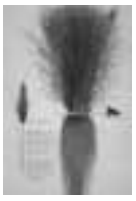
Disease Prevention. The plant is remarkably healthy, but let's get breeding and selection programs going so we don't got caught short if an outbreak occurs.

Mechanism of sterility. Why is the plant sterile? How reliable is that sterility?

Genetic Diversity. What are different types of vetiver? Are some better adapted for the various purposes than others?

Mycorrhiza. These fungi that colonize roots probably are one of the keys to the plant's survival in extreme sites. We need to know more.

Nitrogen Fixation. Does vetiver survive on barren sites because, like a few other grasses, it has a symbiosis with nitrogenfixing bacteria?



Cold Sensitivity. This is perhaps the biggest limitation for temper-

ate zone countries such as the United States. Can it be reduced or overcome?

General Tolerances. What are the theoretical limits to drought, water, and toxic conditions? What can be expected in practice?

Mechanism of Hedge Formation. Why do the plants in a hedge tend to interlock when most grasses stay in separate clumps?

Dwarfing. Can shorter hedges be obtained?

Root Growth. Just how strong are those reinforcings in the soil?

With topics such as these we need to reach out to scientists in the appropriate fields and show them how, through vetiver, their expertise can have a practical global importance. This is one area where vetiver specialists have the possibility of finding research partners likely to devote time and energy without much cajoling. This is because in the grass family vetiver falls between sugarcane, sorghum and corn, which means that it probably has much to contribute to the better understanding of those billion dollar natural resources. Researchers studying the basics of sorghum, corn, and sugarcane are natural allies of ours.

Conclusion

Breaking up the subject into these seven initiatives, can help generate funding, collaboration, innovation and new progress. More importantly, perhaps, it will inject backgrounds and special insights. No longer will vetiver be the exclusive of agriculturists; sharing our excitement will be environmentalists, chemists, engineers, hydrologists, and more. By this process of reaching out, vetiver champions can speak in seven voices, in seven forums, and stimulate outward momentum in seven directions. Also, it will give us feedback from seven different outlying visions that we now glimpse only vaguely, if at all. That will help us better use this immensely useful plant, and that will help the people of the world most of all.

VETIVER PROPOSED IN GHANA'S NEXT ACTION PLAN ON SOIL FERTILITY MANAGEMENT.

A major workshop on soil fertility management took place in Cape-Coast, Ghana from July 2. to 5. 1996 with more than 80 scientists, including agricultural and development economists, policy makers and selected farmers as participants. The main objective of this workshop was to come up with concrete proposals leading to the formulation of an Action Plan for Ghana towards the twenty-first century on the said subject matter.

The workshop was organized by the Ministry of Food and Agriculture jointly with their peers of Environment, Science and Technology; Land and Forestry. Assistance was provided by the International Fertilizer Development Centre, while Sasakawa Africa Association sponsored the workshop. CEDIA was invited by the sponsors in connection with the role vetiver can play as a component to such an Action Plan. In that perspective CEDIA made a befitting poster presentation on the use of vetiver under different conditions with various scenarios from many countries including Ghana, Malaysia, Thailand, India, Philippines and Fiji. The presentation, described as impressive, was possible thanks to the support of Dr.Tareke Berhe, Chief Agronomist from Sasakawa Global 2000, and Dick Grimshaw of The Vetiver Network.

According to the Minister for Food and Agriculture, this workshop was neccessary and timely because his ministry is currently reviewing the performance of the sector. The workshop's objective was to find ways of increasing food production in the country. Various presentations and reports of many working groups during the workshop acknowledged the importance and usefulness of vetiver grass, and proposed adoption of this hedgerow technology as a major component in land and water conservation and their management.

ANNOUNCEMENTS

CAMEROON WORKSHOP

A three day vetiver workshop, sponsored by Family Associationfor Rural Development (FARDP) will be held in north west Cameroon in the Mbingo-Belo-Kom area from February 6 - 8 1997. This workshop will be supported by The Vetiver Network, and the key resource person will be Mr. Alemu Mekonnen, Head of the Environmental Department, of the NGO Munchen f Munchen that operates out of Mettu in western Ethioipia. Interested persons should contact: Mr. Nwainmbi Simon Chia, Family Association for Rural Development (FARDP), PMB 42, Bamenda, Cameroon.

NEWLETTER #15 QUIZ WINNERS

Winners of the quizzes included in Newsletter #15 were: Mehari Abay, Ethiopia; Luttman de Vega, Brazil; and Bernard Byrnes, USA. Congratulations to you all and to all the others who submitted correct answers. The anwser to the quiz on page 15 is "a section of the vetiver woven grain store wall shown in photo 5 on page 10". The anwser to the quiz on page 30 is "a vetiver trial on the East-West Highway

in Malaysia". The anwser to the quiz on page 43 is "the distorted image of the vetiver water color on page 1".

THE VETIVER NETWORK SUPPORT PROJECT

The Vetiver Network has now raised sufficient funds, including a major donation from the Royal Danish Goverment, to enable it to proceed with the project through to the end of 1998. The project will:

- provide support to establish about five or six regional vetiver networks that would disseminate information on the vetiver technology reflecting local needs and languages (see details);
- provide support to key NGOs in developing countries to initiate or expand vetiver programs that would include training of other NGOs in the technology and the provision of vetiver plant material for propagation (see details);
- awards for innovative research and development;
- production of technical videos and handbooks;
- continued production of the Vetiver Newsletter;
- continued production of the Vetiver home page on the world wide web.

Support for the establishment of Regional or National Networks

The Vetiver Network (TVN) is prepared to assist in funding the establishment of regional and national networks. TVN could provide up to US$ 25,000 per network.

Networks would be expected to collect, produce and disseminate information relating to the vetiver technology in its use relating to soil and water conservation, land reclamation, embankment stabilization and for bio-remedial measures relating to waste management. The networks would disseminate information via newsletters, technical bulletins, videos, the world wide web etc. The networks would be totally independent non profit organizations, but would have informal linkages between other networks and TVN.

Eligibility Only existing or new (for the purpose of becoming a network) agencies that can demonstrate (through submitted evidence) a commitment to the technology and experience in use or promotion of the technology will be considered. The network must be prepared to share all available information with its network members and with other networks. At this time we are interested in establishing regional networks in China, the Pacific Rim and Oceana (PRO), South Asia, West Africa, Ethiopia (including other countries in the horn of Africa, South Africa and east and Central Africa. Networks already exist for Latin America and Europe. It would be important that networks have access to the Internet.

Funding TVN will fund the networks subject to the submission of: a "mission statement", detailed network proposals, both operational and financial to cover a period of two years. If additional funds are required over and above US $ 25,000 it will be important that the proposal sets out how such funds will be acquired. TVN will disburse the funds in two tranches. The first after the network has submitted evidence of its legal status as a non profit organization, and second 12 months later following the receipt of an annual report and statement of expenditure.

Vetiver Network Support to NGOs

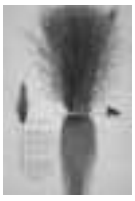
The Vetiver Network is prepared to support eligible NGOs with funding up to $10,000 to initiate or expand vetiver technology for soil and water conservation, land reclamation, and embankment stabilization. Funds would be available for propagation of planting material, training materials, technical publications (in local languages), and for farmer support in field establishment.

Eligibility. NGOs officially registered as non profit organizations would be eligible for assistance from The Vetiver Network (TVN). NGOs would need to submit a "mission statement", evidence (photographs, work descriptions etc.) of previous involvement with vetiver (if any) and soil and water conservation, and a current statement of income and expenditure. NGOs that have previously worked with vetiver grass would generally have priority. Apart from carrying out their planned vetiver program, participating NGOs would be expected to run simple workshops to train other NGOs and interested agencies in the technology.

Each NGO would have to submit a simple "project plan", including plan activities and expenditures over two years (1997 and 1998), acceptable to TVN. TVN would expect the NGO to be able to provide some of its own inputs into the project including "inkind" elements.

Funding TVN would disburse its fund in two tranches. 50% at the signing of agreement with the NGO, and 50% 12 months later.

At the time of submission of its proposal the NGO would have to provide name of bank account, account number, and name and address of bank.



Reporting The NGO would have to submit at six monthly intervals a written statement of project progress, including photographs, copies of technical bulletins, evaluations etc. At the end of 12 months and 24 months a statement of expenditure would be submitted. The second tranche of TVN funds would not be released if progress reports and expenditure statements are not submitted.

Interested NGOs or agencies should contact: The Vetiver Network, 15 Wirt St. NW, Leesburg, Virginia 20176, USA. Fax: 703 771 1942 Tel: 703 771 1942. E.mail: vetiver@vetiver.org

Vetiver Network Awards for Innovative Research and Technology Development

The Vetiver Network is pleased to announce its second series of awards for advances in the understanding and use of vetiver technology. The intention is to reward activities by individuals or "project" teams that have increased the value of knowledge we already have, that have added to our current understanding, or that have promoted the use of vetiver technology. The deadline for nominations is June 30, 1998.(Information on the first series of awards can be found in Vetiver Newsletters 9 and 10.)

Award Themes

Awards will be given for initiatives in seven areas:

1. soil erosion
2. improvement of extreme soils
3. water management
4. pollution control
5. farmer-support and secondary uses
6. disaster prevention
7. basic science.

Vetiver Global Initiatives

The seven Vetiver Global Initiatives were proposed by Noel Vietmeyer of the U.S. National Academy of Sciences at the First International Conference on Vetiver in Thailand in February of 1996. Dr. Vietmeyer explained the purpose of these initiatives at the end of the conference in a speech entitled, "Organizing Vetiver's Next Steps to Global Acceptance":

These initiatives are more than just ways of thinking about the plant and its promise, they are compartments of practical progress, each distinct and self-contained within itself. Of course there are overlapping borders; indeed, a complicated chart could be drawn showing all the interrelations but, for all that, each of these action-oriented topics plays on different strengths of the grass and reaches out to different audiences. In addition, each requires a different approach from us as we shoulder our burden of locating partners for mutual support and for faster progress worldwide. ....

Breaking up the subject into these seven initiatives can help generate funding, collaboration, innovation and new progress. More importantly, perhaps, it will inject backgrounds and special insights. No longer will vetiver be the exclusive domain of agriculturists; sharing our excitement will be environmentalists, chemists, engineers, hydrologists, and more. By this process of reaching out, vetiver champions can speak in seven voices, in seven forums, and stimulate outward momentum in seven directions. Also, it will give us feedback from seven different outlying visions that we now glimpse only vaguely, if at all. That will help us better use this immensely useful plant, and that will help the people of the world most of all.

Eligibility

Awards may be given to anyone (scientist, technician, farmer, NGO, innovator) who has shown initiative in advancing the usefulness of vetiver technology. The awards themselves will be granted for efforts that have yielded new, innovative, and demonstrable results; that is, projects that do not duplicate earlier work, that take a novel approach, and that can be repeated in other places.

Amount of Awards

Twnty one Awards totalling $50,000 will be made at the end of 1998. There will be three awards granted in each of the seven categories: for categories 1-6, awards of $4,000, $2,000, and $500 will be given in order of merit; for category 7 (basic science) the awards will be $6,000, $3000, and $2,000. The total value of the awards will not be decreased; however, if additional funding for awards is found the award value may be extended and the number of awards may be expanded.

Documentation

There is no award application form. You can nominate yourself or others. Applications must stand on their own merit. Documentation can consist of any type of information (personal accounts, reports, photographs, articles, scientific papers, testimonials, etc.), but be as brief and clear as possible. Please provide the Vetiver Network with the following by June 30th 1998:

1. Your name and address (phone, fax, and email if possible).
2. Award nominee name and address (phone, fax, and email if possible).
3. Project information:
   - Location of project.
   - Description of project.
   - Accomplishments of project.
   - Importance of project.
4. Supporting documentation (optional but helpful).
5. Name of someone other than yourself or the nominee who is familiar with this project

Award Selection

Projects will be judged on the basis of their merit, relevance, innovation, and

application. Merit refers to the quality of thought and methods used to accomplish the project's goals. Relevance will be evaluated on the project's potential to protect the environment, lower costs, improve the quality of life, or other noteworthy benefit. Innovation can be originality in any sense, including using old ideas in new ways. Application refers to the demonstrated usefulness of the results.

Submissions will be evaluated by ad hoc award committees, who will make their recommendations to the Vetiver Network. Final selections will be approved by Directors of the Vetiver Network, whose decisions will be final. Winners will be announced in December 1998.

Topics

Any individual/project may be nominated in any topic area. The following are examples drawn from Noel Vietmeyer's Global Vetiver Initiatives:

1. Soil Erosion Projects: Probably 90 percent of all vetiver technology work to date has been devoted to some aspect of soil erosion, and the fact that the plant stops soil loss is now abundantly clear; a major goal is now to project existing knowledge to new locations and new people.

2. Extreme Soil Projects: The challenge is to make extreme soils productive, or at least more productive than at present - this topic embraces the area of land reclamation as a whole, including establishment of native vegetation.

3. Water Management Projects: The potential of vetiver on a landscape scale is little-explored; this topic area covers a broad range of watershed management, waterway stabilization, reinforcing earthen structures, sedimentation control, engineering water flow, ground water recharge, water flow management in irrigation systems, and wastewater treatment.

4. Pollution Control Projects: The goals are to demonstrate vetiver as a tool for removing toxic hazards in underground flows, soils, industrial spills, runoff, natural waters, and industrial wastewaters.

5. Farmer Support Projects: This area recognizes the need for special efforts to increase appreciation of the benefits that vetiver provides to growers by increasing income, or by making their lives easier or more secure through providing mulch, thatch, fuel, supplementary feed, improved crop yields, handicrafts, wildlife controls, boundary markers, ornamentals, screening, animal protection, traffic control, "air-conditioning" (both living and harvested plants), utility walls, weed prevention, making steep slopes usable, and similar "secondary uses".

6. Disaster Prevention Projects: Demonstration of the role vetiver can play in mitigating various natural disasters such as mudslides, floods, fires, droughts, and structural failure.

7. Basic Science Projects: The workings of Vetiveria zizanioides underpins everything else, but much remains to be learned about topics such as environmental tolerances and responses, pest and plague resistance, heavy metals accumulation, C02 absorption, C13 absorption, taxonomy, genetic diversity, mechanisms of sterility, root growth, translocation of oxygen, mycorrhiza association, nitrogen fixation, mechanisms of hedge formation, potential for dwarfing, and myriad other issues.

Please send nominations to:
The Vetiver Network
15 Wirt Street
Leesburg, Virginia 20176-2808

Nominations will not be acknowledged unless a self-addressed card is included.

VETIVER HOMEPAGE www.vetiver.org

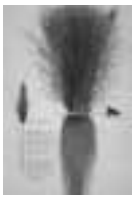
With the help of Mark Dafforn and some winter time to spare we hope to reorganize the homepage. One addition is in the inclusion of a search engine which should make it easier for you to find specific items of interest. We welcome any suggestions as to how the homepage can be improved, as well as new items that you might like to be included. If you have an E.mail address that you would like to share. Please E.mail it to: "MarkDaffor"<VetNet@aol.com>. **Please note that The Vetiver Network's new electronic addresses are: E.mail: vetiver @vetiver.org and www.vetiver.org**

LIST OF VETIVER GRASS SUPPLIERS

We want to create a list of vetiver growers who have planting material available for sale. This list will be published in our homepage (www.vetiver.org) and also in the newsletters. Those of you who are interested please write to "The Vetiver Network" or E.mail to: vetiver@vetiver.org

INFORMATION ON VETIVER DEVELOPMENT. RECEIVE A FREE VIDEO

We need more information on what you are all doing with vetiver grass and its application. Particularly we need information on farmer feedback, engineering use (if applicable), area under protection, estimated total hedge planted (km), technical pointers and issues, and economic benefits. Those of you who respond to all the forgoing questions will receive a free copy of the video — Vetiver Grass A Hedge Against Erosion - in either Spanish or English, PAL or NTSC systems



(Please specify). Send your response to The Vetiver Network. This information will help us raise additional funds which one way or another will benefit you all.

VETIVER PARTICIPANT DIRECTORY

We will no longer provide a hard copy of the directory. An up todate list is available by country on the homepage (www.vetiver.org) and diskettes are available on request. Please indicate whether you want Dos or Mac format in "Word" or "Word Perfect".

REGIONAL NETWORKS

The West African Regional Network (proposed)

The West African Vetiver Network is underway towards its establishment in Accra, Ghana. This regional set-up will be formally launched next January and will serve both English and French language users in the West African subregion including Cameroon. The network will be managed by CEDIA with collaboration from the Council for Scientific and Industrial Research in Ghana. Formalities in that respect are on course. On another hand the support and cooperation pledged by the President of The Vetiver Network have galvanized CEDIA to put the scheme on track earlier than projected. In line with the objectives of the said regional network, CEDIA with support from Sasakawa Global 2000 has successfully completed the translation into French the vetiver green booklet: "VETIVER GRASS: The Hedge Against Erosion". CEDIA takes this opportunity to APPEAL for funds and assistance to produce the French version of this useful manual in sufficient quantity to serve not only a region with dominating number of French speaking states but also the rest of French users in many other countries.

Enquiries should be directed to:
Linus Folly, The Programme Coordinator, C.E.D.I.A., P.O. Box C-753 Accra, Ghana.
Tel. 233-21-775311 ext. 688, Fax. 233-21-774880/775421, E.mail:**Balme @ug.gn.apc.org**

The Latin American Vetiver Network (LAVN)

This Network, which has now just published its second newsletter in Spanish, is managed by Jim Smyle and his wife, Joan Miller out of Costa Rica. The newsletters in Spanish are available from **"James Smyle and Joan Miller"<hamilton@sol.racsa.co.cr>** or "La Red de Vetiver Latinoamericana, Apdo. 173-2020, Centro Postal Zapote, San Jose 92332, Costa Rica". This network is growing fast. Please encourage others interested in land resource management to join it.

The LAVN newletter will also be published on the Vetiver homepage at www.vetiver.org

The European Vetiver Network

This Network is managed by Marco Troglia and manifests itself as a web page that mirrors www.vetiver.org (when up dated!!!) at **www.sia m.mi.cnr.it/Vetiver** . For more information contact: Marco Troglia at Email: "Tecnagrind s.l." <tecn agrind @iol.it>

The China Vetiver Network

We have agreed to establishment a new comprehensive network for China with the Agro Forestry Center, Institute of Soil Science, Academia Sinica, Nanjing, 210008, China. The network will start in November 1996. More will be posted about this network on our home page and in the next newsletter #17. The Network Coordinator is **Mr. Liyu Xu.** E.mail address: lyxu @ns.issas.ac.cn

The China Network will produce four newsletters a year and a series of vetiver fact sheets. It will also run workshops and set out practical demonstrations.

LETTERS TO THE EDITOR

From: **Ahmed Usman Ibrahim**, Bauchi State Agricultural Development Project, Nigeria.....

In Northern Nigeria we used to advise our farmers on mechanical soil conservation techniques to check soil erosion and conserve moisture; these mechanical techniques including terracing, check dams, gullies, gully concreting etc. We have now realized that these mechanical techniques are not only very expensive for the African farmer, but not easy to adopt.

In Bauchi State, Nigeria, since we got to know about vetiver grass hedgerow technology for soil and moisture conservation from the handbook "Vetiver Grass — A Hedge Against Erosion", the vetiver grass hedgerow planting for soil and moisture conservation started gaining popularity in northern Nigeria..

The Soil/Agroforestry Department of Bauchi State (a World Bank financed project) has pursued aggressively, since 1990, the dissemination of the following technical packages to the entire farming families in the State:

- vetiver hedge planting on farm boundaries;
- ridging on the contour across the slope;

- vetiver hedge planting around fish ponds;
- establishment of vetiver nurseries in areas where the grass (Vetiveria nigratana) does not grow naturally in the wild;
- other agroforestry plantings (windbreaks, orchards, alley cropping etc.)

These messages are being adopted by farmers in Bauchi State via the existing "Unified Agricultural Extension " through method demonstrations, adoption plots, posters, lectures, workshops, radio programs and village mobile cinema shows organized by the Bauchi State Agricultural Development Program (BSADP)

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From: **Ngwainmbi Simon Chia**, Medical Centers of West Africa, B.P.382, Maroua, Cameroon. Fax: 237-29-25-97, Tel: 237-29-25-79

The grass is very well known in Maroua, Cameroon. It has been here for many years, or can I say that it has been here since creation. The local name in Fulani is "saddordé".

It is used as land boundary marks in farms, home plots and whenever a new farm plot is sold or handed to a family member or visitor. It is also used for roofing homes. This is one of the best grasses to use in this area of Cameroon because insects (e.g. termites) cannot eat it up easily. It takes 3 - 5 years before the house roof is changed when roofed with Vetiver grass. The roots are used as medicines to treat bodily diseases locally. Also, it is used to produce caps known in the local Fulani language as "ndalaré".
This grass is very useful. However, my people did not know the importance, so, each year they cut and burn some of it. This is done in the dry season. As soon as the rains start, the grasses are back growing.
Anyway, the grass is now being grown in Bamenda, which is in the North West province of Cameroon, as introduced by me in 1990. It Is now used for soil erosion control and flood control for homes. In Maroua (Meskine village), many homes were flooded in 1994. I am now introducing the villagers to the uses of this "Miracle" grass to control floods.

Thanks to the Lord who is so kind and good to His people of Cameroon by providing this wonderful grass.

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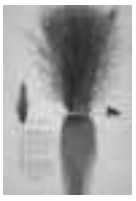
From: **Paul Wolfram Alderson**, Senior Horticulturist, LandLab, 3801 West Temple Avenue, Pomona, California 91768, (909) 869-4380 E.mail wolframald@earthlink.net (Paul Wolfram Alderson).

I am honored to be part of the Network! The vetiver I am currently growing, propagating, and distributing at just about all my project sites is derived from one mother plant that was in the Los Angeles County Arboretum Herb Garden (I have been the horticulturist for the Herb Garden there for the last 2+ years.) This plant was probably introduced there by Jean Cozart, a member of the Southern California Unit of the Herb Society of America. Jean is one of the founders of the Herb Society and a bonifide Vetiver "Nut". Jean, in fact, first introduced me to the myriad powers of Vetiver. She wrote a great in-depth article about Vetiver in the Herb Society Journal and she is one of the nation's great ancient herbalists! If she did not introduce it, then my next suspect would be Jim Bauml, Botanist for the Arboretum. He is wonderfully quirky fellow who is constantly feeding my herb garden with new and interesting specimens. The Vetiver I have has never produced seed that I know of. I have never seen other varieties of Vetiver, so I am looking forward to being more educated in this regard.

I am using Vetiver as a soil erosion control plant on severe very dry shale/clay slopes at LandLab. LandLab is a 340 acre environment that includes a 170 acre landfill that is going to close by the year 2,000. There is a lot of potential for Vetiver use at LandLab as well as on Campus—if I can only convince some of the old school in the Horticulture and Agriculture Departments *(I feel for you, story of my life...Ed.)*. (I'm sort of a "cowboy" here on campus when it comes to "revolutionary" stuff like vetiver—I did not come up through the academic ranks. *...nor did I or most of the other vetiver users around the world!! I guess we all know something that the academicians don't know...Ed.*). I am using Vetiver at range of other sites and situations as an herb and as an ornamental. I also manage a compost demonstration site and garden where I am using it to soak up leachate and flooding during the winter—the garden there is huge and long (sort of a glorified windrow) on the perimeter of a 400 acre agricultural field. I am also fooling around with Canna lilies and Sugar Cane to solve the same problems..... I am also introducing it to the Regenerative Studies Center (which is part of LandLab)—they seem very receptive. Today, I dug up some specimens from the Arboretum for propagation purposes. They were located in a non-irrigated section and planted in a full-sun, rocky, sandy soil that was also filled with decomposed cement. The specimens were happy and healthy and seemed none or the worse for all the abuse they were taking! After an initial irrigation period, it appears that vetiver does quite well off the water grid. I have planted Vetiver in some extreme situations here at LandLab at Cal Poly Pomona and I am quite impressed. Like many of the plants I planted here, it went chlorotic (*all bare rooted slips do the same whatever the conditions, Ed.*) whatever on me during the initial period, probably due to the "moon like" shale/clay soil on the cut slope face that I planted it on. The specimens at that particular location are now thriving. I don't know of anyone else in my horticul-



tural circles that is using or studying vetiver.....*(Horticulturists get in touch with Paul, I think you would be in for an interesting time, lets see some serious work stabilizing California's mud slides with vetiver grass.....Ed.)*

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From: **Dr. Julio Aleare Orihuela**, Head, Agroforestry Programe ICRAF Peru, Yurimaguas, Loreto, Peru. E.mail: "Alegre, Julio" <J.ALEGRE@CGNET.COM>. Fax: 094352675

I am a Senior Scientist with the International Centre for Research in Agroforestry (ICRAF) working during the last 20 years in the Amazon Region of Peru. I receive the vetiver newsletter and recently the World Bank Technical Paper No. 227 about Vetiver grass for soil and water conservation, land rehabilitation, and embankments stability

I enjoyed reading all the benefits of this grass; also I was a little surprised because I have not seen any references about the use of Vetiver in Peru.

Before I received the first news letter about Vetiver I knew nothing about the grass, and then I started to search for this grass in Peru, but I was not successful. Then last year I went to Nairobi, Kenya, and I saw a lot of vetiver planted on canals borders and for embankment stability. Some researchers from my Institution (ICRAF) have planted a nursery for vetiver propagation, and I got 10 slips (bare roots) of *Vetiveria zizanioides* which I took to Peru. I planted them on very acid soil, 85% Al saturation and low in all nutrients) and in 6 months I had 10 large plants with many tillers.

I started to propagate vetiver in other areas, and now I have material for around 5,000 slips. I sent material for propagation to other parts of the Amazon Region and I think in one year we will have enough material to start trials for soil conservation and inclusion in Agroforestry systems on slopy areas. My idea is also to support the community with the planting of vetiver in areas of waste disposal to the rivers where there are a lot of problems with weeds and erosion.

When I sent ths material to Iguitos (Capital of the State of Loreto) the local people recognized the grass which is known as **PACHULI** (*Vetiveria zizanioides* (L.) Nash) and has been used by the native people for a long time. The roots are used as a medicine for dermatitis and control of fungus. Also for hemorrhoids, fever, rheumatism and neuralgia. The fresh roots (25 gm) are boiled for 10 minutes in one liter of water and then applied in the skin. The dry roots are used inside the shelves to protect against insects.

Also the roots are mixed with sugar cane alcohol, and after a maceration is used as a lotion on the head for hair care *(see farmer responses from Philippines....ED.).* The roots are sold in the markets for around half dollar for a package of 250 gm. I got this information from the a Biologist Elsa Rengifo who is working with the Instituto de Investigacion de la Amazonia Peruana. She has planted Vetiveria mainly for medicinal purposes.

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From: **Chris Backhaus**, Dambulla Road, Kurunegala, Sri Lanka. Email: dzp@sri.lanka.net"

If somebody in Sri Lanka wants to contact people having experience with Vetiver planting in the Dry Zone of Sri Lanka, please contact the "NWP Dry Zone Participatory Development Project. We could also help out with (small) quantities of planting material! *(Chris, How about writing us a note about your experiences in the dry zone, we can then share it around the world. .... Ed.)*

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From: **Borys Justavino,** Sustainable Agriculture Program, Cerro Punta, Amisconde Project, Panama.

I'm very grateful that you maintain me in contact through the Vetiver Newsletter and the Collection of papers and Newsletters compiled by the Vetiver Network. I will tell you how vetiver grass begun to be a tool for me in soil conservation. I saw the plant as a barrier in Honduras when I was working in the Kellogg's Foundation Rural Development Project at the Zamorano Panamerican Agriculture School.

When I came back to Panama, after seven years in Honduras, I started to work with AMISCONDE bi-national project involving Costa Rica and Panama in the communities around the International Park La Amistad in Cerro Punta, Chirigui Province. One of the goals was to control soil erosion on very steep slopes cultivated with vegetables and legumes, where the erosion rates were around 240 tons/hectare/year.

We planned the annual activities and I asked for funds to go on a trip looking for Vetiver in Chiriqui, we found plants (*Vetiveria zizanioides*) in the courtyard of some houses, but only one big plant used for medicine. We asked the owners of those plants if they could give seeds of "Valeriana", as they called the grass. They wanted to give us all the plant, but we left some in the ground, and explained how we would use the rest.

With this first material we planted 150 square meters in March 1994. During this time we received the mini book from you, "Vetiver, la barrera contra la erosion", that gave us invaluable information about the plant. The first three months every one that saw the plant said to me that those plants were dead, because they looked dry even though

I was irrigating, but I knew thanks to the book that they weren't dead, and in the fourth month the first new leaves appeared, and continued growing until we took planting materials to the farms to be planted as barrier hedgerows

The farmers didn't wait to reproduce Vetiver in small scale nurseries, but motivated me to look for more material in Costa Rica near to the border with Panama. I was traveling along to the area of San Vito Coto Brus, walking half day to find on the Farm "Hacienda Rio Negro", 200 hectares under contour lines plus Vetiver well established barriers. I told the manager our intention about the soil conservation practices and the use of Vetiver grass. He said that we could take all the material that we need only taking care to prune the barrier and covering any hole where the water could erode.

I returned to Cerro Punta one week later with two trucks of planting material which we treated with some chemicals against pests. We planted this on ten farms, today, two years later, they have well established barriers, and some of this material is now being used for starting vetiver practices on other lands. I didn't stay only with this, because I read about Vetiver reproduction in vitro in the Newsletter, and a friend of mine produced in vitrio plantlets in a laboratory at a cost of 10 to 15 cents per plant depending of the quantity to order. Perhaps you could investigate for me what sustenance material they use for Vetiver reproduction in vitro.

We have made an agreement with a government agency for reproducing more Vetiver to introduce in others areas not covered by Amisconde.

I hope to meet you some day and receive a bit of the knowledge that you have about Vetiver. I heard that the World Bank will be establishing a Project about soil erosion control with Vetiver in 1998 in Cerro Punta. Amisconde, where I'm working right now, will finish at the end of 1997 and it will be great if I can continue promoting the use of Vetiver through this Project .....*(Borys was the first person to use vetiver for soil erosion control in Panama. Most officials did not think that vetiver even existed in the country. For more details see article in Newsletter #15. ...Ed.)*

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From: **Marcelino Pita Rivera**, Coordinator of Riobamba Zone, Farmer-Forestry Development (DFC), Ecuador:

The Farmer Forestry Development (DFC-INEFAN/FAO) project helps farmer organizations of the Andes of Ecuador. In the Riobamba Zone, the communities are conserving their soils through "Slow Forming Terraces" (SFT) using "milín" grass (Phalaris tuberosa); but there are soils which are erosive and of poor quality where the milín doesn't grow well. With the information I have about vetiver hedges, I believe that this plant can be a good alternative for these soils.

Thanks to Mr. Robert Kirmse of the World Bank who visited our area, I received the green vetiver book, which motivated us to import some vetiver plants from India this past year (1995) for the DFC Project. In Quito, the plants were multiplied and then distributed to the project areas.

In the Riobamba Zone, which is in the center of the country, on February 12, 1996, vetiver was planted at different altitudes in community forestry nurseries in order to assess and make comparisons regarding its adaptability. In the community of Chauzán San Alfonso at 3580 meters (*must be an altitude record for vetiver...Ed) ...* there is a survival rate of 30%, the leaves have a reddish color and have developed little. In the Association Cantera at 3420 meters there is a survival rate of 75% with a greenish color and the devlopment of the clumps is better although the growth is insignificant. Community Panza Quirola at 2850 meters the survival is 100%, the growth and development of clumps is better and the leaves of some plants were eaten by sheep.

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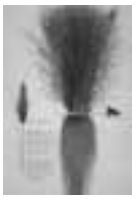
From : **Dr. Marco A. Martínez Sosa**, Center of Investigation and Technical Assistance and Design of the State of Jalisco, Guadalajara, México.

We started propagating vetiver planting material to obtain the essential oil. The original planting material was brought from the State of Chiapas, and we have developed an experimental plantation that is about 1 1/2 years old. This plantation is located in the State of Jalisco near the city of Tuxpan. For about 10 years there has existed an experimental plot in the State of Veracruz in the El Morro de La Mancho Experiment Station for vetiver oil production. Our plantations have not been developed with environmental conservation in mind; our center and research is dedicated to technology transfer in the area of pharmaceutical chemicals and perfume.

Here in the State of Jalisco vetiver has adapted well at a state government-run experimental plot. This plantation is very small, but it has adapted well in that the plants are now almost 10 months old and have not received any fertilization and are healthy.

From: **Ing. Pedro Córdova Alva**, Institute of Research of the Peruvian Amazon, Tarapoto, Perú.

Recently we have been working with vetiver, thanks to a gift of some tillers from Dr. Julio Alegre, who works with vetiver in the city of Yurimaguas, Peru. With these tillers we have established a small parcel (about 50 m2) in which we are evaluating its behav-



ior in this part of the Amazonian jungle of Peru (the high jungle is more or less at 350 a.s.l. meters, rainfall of 1150 mm/year, and an average annual temperature of 26˚C). The preliminary results show that vetiver has adapted well, it has already grown well in a relatively short time. We will let you know of the results of our evaluation. ...this is the first time that this species has been introduced into this part of the Amazon Region.

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From: **Mark Dafforn**. National Academy of Science, Washington DC. E.mail : VetiverNet@aol.com

John Greenfield always says vetiver forms hedges so well because it is clonal and there are not "distancing" effects between separate plants, such as you might get with sexually reproduced materials. I've wondered a lot about the reality of that: It's obvious other plants (clonal or not) can be grown as a hedge without gapping, but it does seem to take more effort with sexual material (e.g. Miscanthus) than with clonal (Liriope)? Anyway, I came across the below lead. It doesn't deal directly with hedging ability, but it's related...vetiver vigor? Any thoughts?

"Stephen J. Tonsor of Michigan State University and Mary F. Wilson ofthe Forestry Sciences Laboratory in Juneau, Alaska, found that some flowering plants, such as pokeweeds (Phytolacca americana) and English plantains (Plantago lanceolata), grow faster when potted with full or half siblings than when potted with nonrelatives. If these kinship effects are widespread, they could be used to advantage in planting crops."*Extracted from Scientific American article on kinship".*

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From: **Linus Folly**, The Programme Coordinator, C.E.D.I.A., P.O. Box C-753 Accra, Ghana.
Tel. 233-21-775311 ext. 688, Fax. 233-21-774880/775421, E.mail: "Linus Folly" <Balme @ug.gn.apc.org>

After almost two years since CEDIA organised "Wonder Grass '94", things seem finally set for a real take-off towards a full program on vetiver in terms of research and development as one component with multiplication and propagation as the other. This came as a result of CEDIA's participation with a focus on vetiver grass in the Soil Fertility Management workshop in July this year.

The main problem with government bodies and other institutions is the usual non availability of funds, although they strongly want to adopt the grass and its technology; even the minimum to start with. May I suggest if it would not be too much for the President to take on The World Bank to reconsider its withdrawal in funding and supporting the Vetiver Network enough to back regional networks with their respective programmes. A suggestion of 5-10 years under the Bank's funded and supported extensive program could be ideal as well as helping tremendously solve the security problem in developing countries.

(*Ed. ... Unfortuneately, in Africa, the Bank funded extension programs are not very interested in Vetiver. Local pressure on MOAs would probably work better*).

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From: **Oscar S. Rodriguez P.**, UCV-Facultad de Agronomia, Departamento de Agronomia, Apdo. 4759, Maracay-Edo.Aragua, VENEZUELA

I am still happy about our big and interesting meeting in Thailand. I think it was a great success and a great opportunity for all of us to learn more about vetiver and its multiple uses through many interesting and enthusiastic people. I have sent two samples to Mark Dafforn for the vetiver identification program. I am enclosing for your use a copy of the botanic vetiver samples in the herbarium of our faculty (University of Venezuela). It is interesting to know that the oldest one is from 1953. In other reference 1942, also enclosed, vetiver is referred as rope material, insect control to protect clothes and for its essential oil in the surroundings areas here in Niaracay. So, it has been with us for a long time; but for erosion control, the technique has been used only to a limited extent. I have learned about its use only within two of the experimental stations that belong to the University where I work.

We are trying to start a small project with farmers in different agro-ecological zones of the Central Region of Venezuela and have initiated the high potential for erosion control within all lands. The project will be conducted through an NGO (Sociedad Conservacista Aragua) which has been involved in forest fire control and environmental education since 1973. We have received an offer of about US$ 1000 to do the job from the Secretary of Environment of the Aragna State. I have checked your proposal for a project in Panama and the estimated costs are high especially for technicians salaries as compared to the costs in Venezuela. Other costs are not far from reality. As you can see we are starting from a very small project but maybe in the future it can growth. At the moment the main bottle neck is plant material and sufficient funds to support the project. The starting point is to develop a nursery. I will tell you if the project goes further. If you have any idea on how to get financial support, please let me know.

We have also the idea to publish an small technical bulletin on vetiver. Are there many constrains about copyright from the newsletter and from other technical material. Please let me know where there is freedom and where is

not. *(Anybody may copy information on vetiver so long as the source of the material is cited and acknowledged. Ed.....)*

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From: **Legesse Seyeum**, PO Box 865, Awassa, Ethiopia

I'm one of your regular receivers of the Vetiver Newsletter, thank you very much for your up to date information. Regarding information about vetiver grass in my organization. Estate coffee nurseries produce millions of coffee seedlings**.** In the course of the nursery phase (about 8-10 months) these seedlings have to be protected from strong sunshine, high rainfall and hail hazards; for this purpose 75 cm long posts are erected to support wooden frames that are covered with vetiver grass. Since the grass flourishes throughout the year it is found to be cost effective and highly helpful. Vetiver is used for mulching purpose especially on pre-germination beds of coffee. On slopey areas new coffee seedlings are planted on the contour between vetiver grass hedges for a couple of reasons: first for erosion control; and second for provision of mulch for the coffee.....

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Photo 2**. Ethiopia. Finchaa Sugar Project. Diversification scheme. Vegetables and fruit trees planted between vetiver hedgerows.* ***Photo Credit: Shimelis Kebede

From: **Shimelis Kebede**, P.O.Box 7016, Addis Abeba, Ethiopia

It has been some time since, I have written to you though, I have received your letter Sept 9 1995 after I returned back from Mauritius in Dec.1995. I was not in a position to participate Thailand Conference. I have recently received the compiled edition of the Vetiver Newsletter. Thank you very much. The establishment of the vetiver association of Ethiopia is not successful due to the bureaucracy and we have accepted your advice to avoid merging Vetiver with other associations. But, as to vetiver expansion some wise organizations (GOs NGOs) and individuals are using the best out of vetiver. My 3 ha demonstration field at Finchaa Sugar Project site has achieved great success and has been visited by various groups. I have successfully retained the soil insitu. And have 30 cm of soil behind the vetiver hedges in one season to form natural terraces.....

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From: **Mary Noah S.J. Manarang,** Officer In Charge, Bukidnon Forests Inc., NFDO Bldg., Department of Environment & Natural Resources, Visayas Ave., Quezon City, Philippines. Email: noah<joan @eiger.com.ph>

I've been to Thailand on a Vetiver grass study tour in December 1994. It created a big impact on me, as well as my companions, that I thought of making the seedling available to other Vetiver enthusiasts in the Philippines. As I discovered that it grows in my province (northern Philippines), I started a nursery based from what I learned from your technical papers and my exposure in Thailand. As of now, I have 30,000 two month old seedlings with 3-5 tillers. Maybe through you, other people interested in acquiring seedlings, should know about this nursery. I'm finishing the report regarding my own experiences in growing the grass in polybags and root trainers (which we are using for forest tree seedlings) and I will be sending one to you. I hope this would be of help to other Vetiver crusaders. As I still have to get my E-mail address this week, I could be reached through fax no. 00-632-7328462.Thanks so much.

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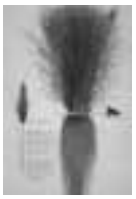
From: **Eduardo B. Principe,** Ph.D., (Forester, Ecologist & Environmentalist), Regional Technical Director for Environmental Management & Protected Areas Sector, DENR Region 13, CARAGA, Ambago, Butuan City, The Philippines. Email: "Principe Eduardo" <jfle@sun1.dost.gov.ph.>

Since the first time (in 1993) that I read the World Bank handbook entitled: Vetiver Grass: The Hedge Against Erosion, I have been an advocate of this grass in my personal, professional and official capacities. During that time, I held the designation from the Secretary of the Department of Environment and Natural Resources (DENR) as Project Director, National Forestation Development Office (NFDO) which oversees and coordinates the implementation of the National Forestation Program. This program was mainly funded through the ADB and OECF loans, amounting to about US$200 million. I found out that my three predecessors (the program started in 1989) had known about this versatile grass but were not able to evaluate nor test its potentials in this program. My first thoughts then (and until now) was that Vetiver is an ideal plant that may be able to solve many of the technological problems being met in typical reforestation projects such as in the Philippines. The first major problem then is how to obtain initial planting stocks, which was promptly solved through networking with col-



leagues and friends from other agencies such as the National Irrigation Administration (NIA). We were able to identify definite source of Vetiver from some Northern provinces of Luzon (Pangasinan, Zambales, and Ilocos Sur) where some farmers have been using Vetiver grass in their rice farm dikes and irrigation ditches since the Spanish colonial regime.

In the early part of 1994, NFDO had a remaining budget for about 1,200 hectares of watershed rehabilitation. I decided that this was a good chance to provide a pilot/demonstration in watershed rehabilitation through the main strategy of vegetative measures of Vetiver as an alternative way of reducing/eliminating the destructive effects of lahar in Central Luzon by massive hedgegrow plantings in the slopes and mountains around Mt. Pinatubo. This strategy could have lessened the cost of protecting the lahar-affected communities of Central Luzon and provide livelihood opportunities to these people. Through a community-based approach by awarding these rehabilitation areas for community contracts from planting of Vetiver followed by agroforestry development (by interplanting bamboos, fruit trees and agroforestry plants) once the mountain slopes had been properly stabilized and rehabilitated by the Vetiver technology.

Now, in my latest assignment as Regional Technical Director for Environmental Management and Protected Areas Sector (EMPAS) at the newest region, Region 13, CARAGA (Northern Mindanao) I am still promoting and prescribing the Vetiver grass technology to DENR clients engaged in mining and logging activities. My main concern is in the reduction of soil erosion in the uplands that are now extensively degraded because of the faster rate of deforestation. With the popularization of Vetiver, we may still have a good chance to recover from various impacts of soil erosion.

In the Philippines, there are no less that 10 million hectares of open and denuded grasslands that need immediate rehabilitation. These are all found in major watersheds of the country. The total area of the Philippines is 30 million hectares, where about half is classified as alienable or disposable, which means it is mostly in private ownership - under residential, commercial, industrial and farm cultivation uses. There are only about 5 million hectares remaining under forest areas (17%) mostly logged-over or the so-called secondary forest which are also in danger of disappearing because of tremendous population pressures. About 30% of the current total population of 70 million people are residing/squatting in the uplands. Now, given this setting, this country faces a massive problem and formidable challenges. We all know and realize that the government alone cannot solve this problem and I do believe, practically, that all sectors must pitch in and participate. But still, very few are aware and conviced that the Vetiver technology could provide the start of that technological solution in this problem. I am hoping that there might be a number people in this country who are already part of the Vetiver network willing to participate and share ideas in forming an action program that will be effective and widespread enough to create an impact against soil erosion, using mainly, the Vetiver technology.

Now allow me to start the ball rolling:

Step 1. Formation of National Volunteer Leadership Groups(s).

This group shall have the major role of promoting and creating awareness on the benefits of using Vetiver technology in erosion control and environmental rehabilitation, including recruitment and organizing of implementors and sponsor groups.

Step 2. Selection of project sites and training of communities or responsible implementor groups.

This will entail identification and delineation of proposed project sites in close coordination with DENR and Local Government Units (LGUís), and preparation of the specific management plan using community-based approach. Community participation of stakeholders should involve strongly in the planning, establishment, maintenance and protection and management up to sharing of project benefits.

Step 3. Installation of financial support services

A trust Fund shall be organized and instituted to provide the necessary financial and technical support services for every project site. Initially, it can be set up for the national level wherein financial sponsors are recruited to contribute in a pooled Fund, which, only the interest shall be used for operating initial/or priority projects. Financial sponsors shall be able to get back their capital contributions after a specific period of time, e.g., 5 years, for which they would be formally acknowledged for using Vetiver grass as its main anchor. Along with this, a shortened handbook/guidebook entitled: “Versatile Vetiver - for reforestation and watershed rehabilitation” was produced and distributed to all regions including the basic design of the pilot areas selected in the provinces of Pampanga, Tarlac, Benguet, Zambales, and Nueva Viscaya. The objective was to collect enough experiences and data on the performance of Vetiver in terms of its survival rates under various site conditions, including its effectivity in erosion control measures in the mountain slopes and in lahar-covered slopes affected by Mt. Pinatubo eruption.

However, in July 1994, I was given another responsibility as Deputy Director, National Watershed Development Program Office in response to the Water Crisis Act, which lessened my access to progress reports of the Vetiver Pilot areas. Nevertheless, I was able to visit once the Ambuklao Project site in

Benguet Province (about 1500 m asl) consisting of about 100 hectares which was contracted with local NGO. This was quite successful in terms of survival and growth rates and according to its latest report to NFDO, the Vetiver grass hedgegrows (4 m. apart between rows X 15 cm. within rows) have closed, vigorously growing, and firmly established despite some grass fires and drought experienced in this site. I have no doubts that the other sites will prove to demonstrate the versatility of this grass for erosion control in watersheds.

That is why I am also actively promoting the potential support that may be used for promotions or tax breaks of said sponsor institutions or persons.

Well, lets brainstorm on this further and please encourage everyone interested to participate so that we can evolve a workable conceptual framework which can effectively put more Vetiver plants on the ground to benefit people and their environment. For promotional purposes, I am also submitting a short article (Perennial Rice from Genetic Engineering!) dramatizing the possible use of genetic engineering on rice but actually focusing attention on the positive traits of Vetiver.

Please comment!

Thanks a lot for your patience on this long discourse and certainly will be glad to know if I can be considered part of the growing Vetiver networkers. Please reach out through e-mail: "Principe Eduardo" <jfle@sun1.dost.gov.ph.> *(Filippinos!! reach out to Eduado! He has a fertile and active mind, and his ideas are good. If you can put something solid together (networking, dissemination etc. perhaps the Vetiver Network can help you....Ed)*

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From: **Jim Smyle**, Costa Rica E.mail: "Jim Smyle and Joan Miller" <hamilton@sol.racsa.co.cr>

I found myself looking through somo photos and with time to play with my scanner. I am attaching 2 photos from our trip to Oaxaca. They were taken at La Soledad, Oaxaca where we planted the first demonstration hedge with SASO (Kevin O'Sullivan's group). Since it was a demo we wanted to be absolutely sure that we were putting in a good hedge. We thought it better to start with a no-risk spacing. We used "fists" as the spacing measure...say, about 10 cm between plants or 15cm centers...and used 3 tiller planting units. The pruned tops were then used to mulch the planting. Later, it was interesting talking to the 2 extensionists working with that community. They are two really good, experienced and dedicated guys who work during the week for an NGO and on weekends prefer to spend there free time with this community. They told me that they need to do this on weekends because it is the only part of their work which is personally satisfying. In working with government previously, and now with the NGO, they feel that they try to do too many things at once and so there is little impact. We talked about the World Neighbors philosophy of keeping things simple, identifying root problems and then concentrating on one or two messages at a time. Then keep pounding on those messages until everybody understands it and knows how to do it themselves. Then, see where you got to, re-prioritize and move on to the next message. They told me that they felt that this approach was missing from the way that technology transfer was normally done in their region and that this was how they should be working. They were going to keep vetiver as one of their messages...because in this community soil loss was identified by the community as their number one problem...and start talking with the people again to identify one more key message with them.

Photo 3. *Oaxaca, Mexico. It is very important to closely space vetiver slips at planting. Here is slips planted one "fist" apart as described by Jim Smyle in his letter.* ***Photo Credit: Jim Smyle***

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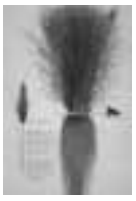
From: **Eduardo B. Principe**, Ph.D., (Forester, Ecologist & Environmentalist), Regional Technical Director for Environmental Management & Protected Areas Sector, DENR Region 13, CARAGA, Ambago, Butuan City, The Philippines. Email: "Principe Eduardo" <jfle@sun1.dost.gov.ph.>

PERENNIAL SUPER RICE FROM GENETIC ENGINEERING?.....As early as ten years ago, scientific breakthroughs were made in the field of genetic engineering, which are now producing entirely new sets of plant varieties, microorganisms, and even animals possessing genes coming from unrelated organisms. Therefore, to produce a persistent and perennial rice plant that needs NO INPUTS (i.e., fertilizer, irrigation water, and pesticides) is a clear and sure possibility. This



is peanuts, if one considers the fact that the earliest demonstration by genetic engineers/researchers have combined the genes from a firefly and a tobacco plant — producing a tobacco plant that glows in the dark!!! This is only to show that genes are the building blocks of living things and can be combined together from various unrelated organisms if it is so desired. It is already being put to practical use in many fields such as medicine, food processing, agriculture, and environmental protection. These are mainly involving the use of genetically engineered microorganisms such as those in the production processes using bacteria and fungi. But have you read about the super bull (cow), super mouse, and super trees in the science section of some newspapers or magazines? These articles point out that some outstanding or some selected traits (genes) have been incorporated, mostly from human genes, through the science of genetic engineering.

So what? You may say and shrug your shoulders. Well, based on the above existing premises, SUPER RICE is no sweat to produce in the laboratory. It only takes some will and a bit more creativity for our scientists, but surely, one has to gravely consider the political and economic impacts, which are negative and positive, that it may create. Nevertheless, lets look more closely at the positive side. Assuming that we really want to produce the SUPER RICE, which other plants(s) with desirable traits or genes can be combined with ordinary, expensive-to-produce rice? For those computer gurus/surfers, search in the INTERNET the words VETIVER GRASS!! Does it say or confirm the following?

- scientific name : Vetiveria zizanioides

- origin : From India, now pantropic, meaning, widely distributed in the tropics and sub-tropical climates. Further, it can be found in the Philippines!.
- local names : Khus-khus, Moras, Amoras, Anis (or Anias) de moras, Aniat.
- perennial grass with deep root system, up to 3 meters long.
- grows in any type of soil, even in toxic soils high with Aluminum, Sodium, or Iron.
- it tolerates both drought and waterlogged conditions.
- it grows even in high altitudes.
- it is fire resistant.
- it repels insects, rats, snakes, and other pests.
- it produces its own food by fixing Nitrogen and Phosphorous through its rhizobial and mycorrhyzal root associations.
- Uses : source of perfume called vetiver oil, leaves are for forage and roofing; erosion control, aquifer recharge, and site rehabilitation for watershed, agro-forestry, and reforestation projects; steep slope rehabilitation for road projects especially for ditches, waterways, embankments, and river banks; organic fertilizer; biological filtration system in settling ponds.

If and when SUPER RICE is finally produced, then our farmers will need less capital to produce our staple food. This means less irrigation water, with less or no fertilizer and pesticides, no more replanting every 3 months, and it can be planted almost anywhere including the lahar-covered Central Plains of Luzon and even in the slopes of Mt. Pinatubo!

Wishful thinking, a joke or pure hogwash? You may ask for confirmation from DOST if this is possible. Or better, lets dangle a couple of Billion pesos (save it from any white elephant projects) and challenge the PHILRICE .....to produce SUPER RICE in 5 years and then lets bet on it. If I lose, I'd go back to planting the poorest soils with Vetiver grass together with fruit trees, agro-forestry, and even ornamentals and still get back in return, a few million pesos. Now, dear readers, if you are an AQUARIAN like me, I might consider you a partner for this joint venture because its our turn to take over the world. Remember that now is the start of the Aquarian age! Thank you for joining me in this mind-surfing activity. Hope that it at least made your eyes open to the wonders of science and technology.

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From: **Mary Noah S.J. Manarang**, Officer In Charge, Bukidnon Forests Inc., NFDO Bldg., Department of Environment & Natural Resources, Visayas Ave., Quezon City, Philippines. Email: noah<joan@eiger.com.ph>

Hi, remember the big construction firm who was interested in using Vetiver in their project? Well,the First Philippine Holdings Company (FPHC) who is undertaking an 8 kilometer road construction in Subic has already started with their use of Vetiver. They wanted to hire Wik Wingramasinghe as a consultant but I think they were not able to fix his Visa requirements. Anyway, they asked me to visit their project 2 weeks ago together with a taxonomist from the University of the Philippines. The taxonomist was supposed to confirm if the planted grasses were indeed Vetiver and for me to look at their planting design. Well, the quality of the seedlings planted by their contractors were not up to standard as specified by P.K Yoon, and the planting design was if I may say, pathetic. It was scattered about like the style of planting rice. Even if I am not as knowledgable as Wik in terms of the engineering aspect, I did teach them the plantation guide as I know them from our reference (Vetiver Handbook) and as how I saw them in Thailand during my study tour. I was thinking it was better than what they are actually doing. I also gave them a quality control guide in checking the seedlings that are being planted by their contractors, again according to PK Yoon's specifications in his video and research results. Fortunately, they visited my small nursery, I think they liked

what they saw and FPHC required their contractors to get their seedlings from us, or at least follow the quality control specs. which I gave them. I think this is a test model for Vetiver in infrastructure project and I would really like to document it. By the way, I found some very interesting information about Vetiver in the Phils. Upon consultation with the herbarium of the University of the Philippines, I found a dried specimen of V.Zizanoides dated 1902! Dr. Lagunsad who is the taxonomist who went with me to the Subic project. is in charge of the herbarium and he believes that this is the earliest specimen of Vetiver in the Philippines.

I think there is a potential (active) network of Vetiver enthusiasts here in the Philippines, is there a network in Asia where we could individually link up (since there is no formal group in the Phils.)? And is there a way we could ask for some logistical support from these network if ever we document the ongoing Vetiver projects here in the Philippines (the Subic project for one)? With regards to my own report regarding my production of seedlings , I promised you this a long time ago but I want to include in my report the pictures of the plantable seedlings as delivered in Subic. I will send this to you as soon as I'm done (soon, I hope). Thanks so much for your support and I really wish to meet you in person.

(Mary Noah's point about "standards" is very important. There are a lot of contractors starting to use vetiver. It is essential that proper standards are used and that they are correctly applied. If they are not people will say that "the vetiver technology is no good - it doesn't work". The technology is fine, it is the users who time and time again fail to do things properly. ...Ed.)

Photo 4. *Oaxaca, Mexico. Hillside planting of vetiver in maize field.* ***Photo credit: Jim Smyle***

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From: **Jim Smyle**, Costa Rica. E.mail: "Jim Smyle and Joan Miller" <hamilton@sol.racsa.co.cr>

There is indeed progress on the ground in Central America but as always one only seems to get samples of it now and again. The EEC projects which are focusing on vetiver in Nicaragua, the NGO in El Salvador, the guy that wandered into my office last week because they want to do a big community vetiver program to protect their tourist trade on the Caribbean Coast (sediment building up from development activities and reef getting hit) and he had found the green book and one thing led to another. With these projects getting ready to kick off we will have the training courses to promote vetiver and project money to get it going...with LUPE having gotten Honduras going we will push it farther there with the project and get things moving in Nicaragua and Panama.

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From: **Tony Tantum**, PO Box 167, Howick, Natal 3290, South Africa. Fax 27 332 30 3000

Just a short note to fill you in on what is happening here in S. Africa. As you probably know Gueric Boucard (from Texas) came to SA to help with the first run of producing vetiver oil through the factory set up by Dickon Hall. The first oil was produced and appears to come up to the standards of the rest of the world. I believe Gueric enjoyed his trip and also learnt a few things about South Africa.

Based on the above findings Dickon Hall have committed them selves to putting up a factory which will handle 100 hectares of vetiver per annum. At present there is approximately 3 to 6 hectares bulked up for transplanting. By 1998 the factory should be in full production. This will now give us a lot of vetiver for the rest of the Country. The bio-mass from the crop will be crushed and protein added and sold as an animal feed. This will be pelletised. At last the whole plant will have been put to use. A first for South Africa.

Cedara Agricultural College has decided, because of all the inquiries they are now receiving with regards to vetiver and it's many uses, to test the grass in different uses. They will then be in a position to recommend vetiver provided it comes up to their standards. (I just hope they do not try to reinvent the wheel!! (*So do I....Ed!!*) I will be helping them as much as I can.

There is a student at Cedara who has done her thesis on the cost of re-establishment of land degregation using the vetiver system. At long last there is an Institution known to SA which is now prepared to go along with the use of vetiver. It has taken seven long years for this to happen and maybe now in the next few years it will be subsidised by Goverment for erosion control on farms etc. *(I hope not....Ed)*

Through Drs. Troung and Bristrow the Australian aid program is keen to do a vetiver project in SA. With a bit of luck I might be able to link Cedara and Paul Truong. He could oversee the project**.** Dr. Bristow and myself are trying to get Paul to SA to do a seminar for Australian aid to the various Goverment bodies. I have asked Sue Hart (NGO) to put forward a proposal for Australian aid to look at.

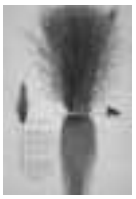

Photo 5. ***Portugal.*** *Antonio Vasco de Mello's lovely wife and his lovely vetiver!!! There is a huge potential for vetiver in southern Portugal, both on farms and for real estate stabilization.* ***Photo Credit: Antonio Vasco de Mello***

The Mocambique project (rehabilitation of wasted land at a gas drilling site) has a couple of weeks to run, and it will be finished. Once again vetiver has grown where other plant life has battled to suvive.....

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From **Joan Miller**, Costa Rica. E.mail: "Jim Smyle and Joan Miller" <hamilton@sol.racsa.co.cr>
... Finally, I heard from Jim, this morning, in Panama who said last week while in the Darien area of southern Panama at a little town he found a vetiver clump in someone's front yard. He got some good pictures and talking to the woman was told that everyone in town using the LEAVES for controllling their high blood pressure and everyone swears by it and that it's better than the medication they are given by doctors. They had never heard of using the roots for anything. Anyway thought you'd like the latest vetiver story.

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From **Antonio Vasco de Mello**, Rua 1.°De Maio. 124, 1300 Lisbao, Portugal.

Please find enclosed two pictures taken a few days (October 9th) ago of the Vetiver planted in April this year. As you may remember, the plantlets came from South Africa - supplied by Tony Tantum. The lady in the picture is my wife; she is not really a tall woman - just a very nice and pretty one - but you can see nevertheless how the plants have grown well. This fall I am thinking of making a first division - maybe an average of ten plantlets out of each main plant - and if that again grows well, next year I will try to install the first 2,000 meter long barrier. I would very much like to have you visit us whenever you come next to Europe, and meanwhile I look forward to see your comments on my plans.

(Antonio, you are doing great, and are obviously as proud of your vetiver grass as you are of your wife!! I always thought that Portugal would be a great country to grow vetiver, and I suspect that there are many instances where vetiver would have a very useful function. when you have your first 2,000 meters all like your first few plants I will come and visit you - that's a promise. ... Ed)

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From: **Nang Kham Noam.** E.mail: Nang Kham Noam <nangkham @esuvm.emporia.edu>

.... "In Burma, we call vetiver grass, Myat Myit Hmway, the meaning is "an aromatic root grass." .....

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FIELD REPORTS

AUSTRALIA

Monto Vetiver by Paul Truong

The followings are updates of the results of works on Monto Vetiver in the last 12 months.

1. *Palatability:* Monto Vetiver is readily grazed by cattle throughout Queensland, particularly *in* the low rainfall areas of Western Queensland. Due to its drought tolerance Monto Vetiver is often the only green plant to have survived the drought in Western Darling Downs in the last few years. Monto Vetiver has a very high digestibility *(52%),* high potassium (1.31%), medium in N (1.10%) and low in P (0.08%).

2. *Seed Sterility:* Flower heads from Monto Vetiver plants established in wetland habitats, three from Cloncurry and one from Innisfail were collected for seed sterility tests. These four samples plus one from Katherine, Northern Territory, were again found to produce no caryopses. This is in contrast with MOA recently collected native Vetiver, which had 14% caryopses and 8% seed viability.

This series of tests shows that for seven consecutive years, Monto Vetiver has not produced any seeds under a wide range of climatic conditions - Cairns and Cloncurry in the north, Darling Downs in the south and Katherine in the west - and under wetland, dryland and irrigated farm land habitats.

3. *Disease and Pest:* Under field conditions Monto Vetiver has not been attacked by any diseases or pests, but under glasshouse conditions it was attacked by army worms when young.

4. *Sensitivity to herbicide and shade:* Monto Vetiver sensitivity to

glyphorate (Roundup) herbicide has been clearly demonstrated under field conditions when drift from spray from nearby weeds often killed well established Vetiver plants. Shading by broad leaf weeds, particularly vines reduced Vetiver growth severely especially at establishment phase.

P N Truong. E.mail: truongp@dpi.qld.gov.au

CHINA

Vetiver's Application for the Prevention of Highway Slippage in South China

Last year we collaborated with Guangdong Provincial Highway Administrative Bureau to stabilize road cuts with vetiver hedgerows. The result indicated that it was successful to apply vetiver to protect road slopes (See Vetiver *Newsletter* No.15). Both the Bureau and us were satisfied with the results and are willing to continue cooperating each other. We continued conducting the new technology on the First - Ring Highway of Guangzhou under the auspices of the Bureau. Two steep and easily-erosive road cuts were selected, they are picture 1 and 2, respectively. Picture 1 is below the road, called "down-slope". It is a tetrapezoid slope with an area of (30+60) 25/2 m21 and with a slope of about 100%. The second slope is above the road, called "up-slope" (Picture 2). Its shape is a triangle with a base line of about 130 m long and a height of 65 m and with a slope of approximately 50-60 m or so. The soils are both sterile and spongy lateritic red earth developed from granite. It is clear from the first two pictures that the erosion was very severe, especially down-slope. Since a large amount of soil had been washed away from down-slope, erosion resulted in the formation of a 6 cm wide crevice in the cemented road surface, and furthermore half of road surface near to this slope began to sink (Picture 3). Collapse in this whole section of the road was expected at any moment. The circumstances of upslope was no better than that of the down-slope at all. From time to time, there were mud-rock flows from the slope washed down to the road surface, which resulted in traffic jams and affected the safety of vehicles and pedestrians. All of this made the Highway Department very anxious.

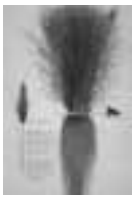
The vetiver project began on March 26th. Vetiver hedgerows were planted along the contours of 2.5 m apart. There were 5 rows in down-slope consolidated with sand bags (picture 4), the up-slope was not sandbagged. Between the hedgerows were planted ten species of rapidly growing trees, such as *Eucalyptus* spp., *Acacia* spp. The total number of trees were approximately 2000.

Photo 6 *China, Guangdong Province. Highway embankment stabilized with vetiver hedgerows.* ***Photo Credit: Xia Hanping***

We made the first observation on May 15, and found that the survival rate of vetiver was over 95%, and the trees some 80-90%. The second observation was made on July 2nd. By that time vetiver had averaged 1.6-1.8 m high, and the mean tillers numbered about 15. They had almost formed into hedge lines and taken effect on stabilizing the slopes and the subsidence of the road surface had ceased. Storms in the first half of this year (1996), which were more than those of the same period of former years, **destroyed the drainage ditch on the down slope**, but the entire slope had little damage under the conservation of vetiver hedges (picture 1 and 2). This indicates the effectiveness of vetiver on protecting road slopes. Obviously, the growth of trees was not bad either, for example, the trees *Acacia magium* averaged up to 86 cm (picture 5) on August 23rd, whereas their mean height was only 40 cm when planted in the end of March.

The severe clrcumstances of up-slope have also been nearly controlled after three months. Vetiver hedges have begun to take shape, and the trees are thriving. However, since it has a steeper slope, a far larger area, a poorer habitat, compared to down-slope it was much more difficult to deal with. In a word, the eftectiveness of vetiver on this slope is not perfect, and further work remains.

Compared with last year's program, this year's is more successful, the reason being the establishment of lots of trees. We think there are at least four advantages when trees are planted among vetiver hedgerows:



1) they assist vetiver hedges to stabilize slopes; 2) the canopies of broadleaf trees can very effectively alleviate raindrop erosion, especially storm conditions; 3) the effect of trees on afforesting and beautifying the highways is much better than that of vetiver; and 4) they are capable of producing greater economic benefits. Therefore it would be best to plant trees amongst vetiver hedgerows.

Xia Hanping Ao Huixiu Liu Shizhong and He Daoqian (South China Institute of Botany, Academia Sinica, Guangzhou, China 510650)

COSTA RICA

A Tour of Costa Rica

During January 1996 we (Jim Smyle and Joan Miller) toured southeastern Costa Rica in order to locate a source of vetiver planting material for a project for the Government of Panama (GOP). The GOP wants to include the use of live vetiver hedges in their technologies which they are offering to hillsides farmers. In the upcoming months MIDE (?) will start to propagate vetiver in intensivley managed nurseries. They want to produce enough planting material necessary to start working in the field in 1997. The first nursery will be started by MIDE in the northwest of Panama near the Costa Rican border. The trip gave us the opportunity to visit other interesting places where they are using vetiver in Costa Rica.

Initially we visited an area near San Isidro del General where AMISCONDE, a binational NGO (Costa Rica and Panama) is working in the buffer zones of La Amistad Park. They are managing projects in agroforestry, community development and educational projects. On both sides of the border AMISCONDE

Photo 7. *Costa Rica. Two year old vetiver plant on a Finca in south eastern Costa Rica.* ***Photo credit: Jim Smyle***

has worked for several years with groups and rural communities in the region in soil and water conservation using vetiver grass. In Costa Rica, they have established vetiver grass plantings with a group of rural communities in the region. We visited one demonstration plot that was established by a farmers' cooperative (COOPEAGRI) with the help of CIAT. It was established about 5 years ago with the planting of 30 meters of vetiver. They tell us that they now have an area of 5-6 hectares protected by live hedges (with 8-10 meters between each hedge); or rather, 4-6 km of hedges — all planted with material from that initial 30 m hedge. The plot serves as a training and demonstration plot to display the advantages associated with the uses of vetiver.

Speaking with some of the farmers working with AMISCONDE, we learned that an infusion of vetiver roots is used as an insecticide. They told us that they boil approximately 250 grams of vetiver roots in 1 gallon of water for 30 - 40 minutes. **The infusion is applied using a backpack sprayer on the soil below plants of coffee and sweet peppers. They say that this serves to control nematodes and "cochinilla". The Network had never encountered using vetiver as an insecticide**; as a repellent yes.. such as in closets for moths. It would be interesting to receive information from other users that have experience or knowledge of using vetiver as a biological control against insects or diseases. Perhaps someone could do some controlled experiments and send us the information to publish in the newsletter.

In San Rafael Jerónimo we visited a small coffee farm (finca) in the AMISCONDE project area. The owner of the farm had established vetiver hedges at the edges and within his finca. He was very enthusiastic about his vetiver hedges and could well explain to us how the technology worked in terms of slowing down runoff and trapping silt and organic material behind the hedges. He wants to continue establishing new hedges until his entire finca is protected by vetiver grass hedges. Recently he had started to plant some hedges not only in his coffee fields, but within his cornfield.

In the areas surrounding San Vito, close to the border with Panama, we found that the use of vetiver is common in coffee fincas. Driving along the roads we could see vetiver hedges planted in both small and large fincas. We were surprised and impressed to observe that a significant number of home owners had planted hedges at the top edges of their steep properties - apparently for conservation purposes.

We visited two of the larger coffee fincas in the area where vetiver had been established in hedgerows with very positive results. In the Finca Rio Negro, north of San Vito, vetiver has protected the roads for approximately 40 years! According to finca manager, Fernando Hernández, the coffee finca originally was owned and operated by a family from China or Taiwan. They planted vetiver along all of the major

Photo 8**. Costa Rica. Vetiver hedgerows used to protect coffee. Note the Arachis pintoii ground cover* ***Photo Credit.: Jim Smyle

roads running through the finca. Although they knew the value of planting vetiver along the roadside, they never transferred the technology to their coffee fields which were planted directly up and down the slope. Approximately 5 years ago the finca was purchased by an investment group from Switzerland and since then has been under local management. Luckily, the new manager (Mr. Hernández) identified the grass along the roadsides as vetiver. He had known about vetiver grass through the reading the World Bank's "green book" which he had received 6-8 years ago when he was working for the Costa Rican government. Subsequently in the rehabilitation of the coffee plantings during the past 5 years, vetiver grass hedges have been established and replanted in the coffee fields along the contours.

At first they used existing planting material from the roadsides of the finca to supply the planting material. The planting of the hedges used a "chicken foot" pattern; a triangular formation with 15-20 cm between plants. They say this allows the hedges to grow together more rapidly. The hedges were established along the upper edges of each drainage canal. Distances between hedges are 6 to 12 meters (depending on slope) and are pruned twice a year. Farm workers are paid 5-10 colones (US$ 0.02 to US$ 0.05) per meter of hedge established. This cost includes everything, with the workers obtaining planting material from existing hedges along the road and/or within the coffee fields This is equivalent to a cost between US$ 85/hectare (on the steepest slopes) and US$ 21/hectare (on lesser slopes) to establish the hedges.

Of the 200 hectares of coffee planted on the finca, approximately 60 hectares have been rehabilitated and protected by vetiver. The rest of the coffee fields will be protected during the upcoming years. Aside from the decreased losses of soil, they believe that there is an economic savings because there is little need to clear the drainage canals of sediment.

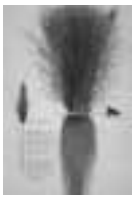
Photo 9 Costa Rica. Young vetiver hedge on steep land, prior to planting coffee. Photo Credit. Jim Smyle

One technical note from Mr. Hernández, administrator of Rio Negro...evidently when material is obtained from existing hedges, people want to remove entire clumps, rather than removing only tillers on the downslope side of the hedge. This practice of removing entire clumps is completely incorrect and damages the functionality of the hedge (See Technical Note: "How to Use Existing Hedges As a Source of Planting Material").

According to Waddy Villalobos, manager of Finca La China near the town of Sabalito (close to San Vito), they started experimenting with live hedges in May 1994. In an area where they were replanting coffee, they established vetiver hedges. In order to form the hedges rapidly they planted tillers every 10 cm. The follow year coffee was planted. We observed these hedges (18 months old) which were well formed, dense and apparently functioning very well. In the future they want to expand vetiver plantings where they will be replanting coffee. Also they have plans to mechanize the furrowing of the rows to reduce labor inputs for planting. Mr. Villalobos told us that for him, the ideal would be to always establish the hedges the year before you are going to replant coffee and during that year allow the weeds to grow. Thus, the soil is protected and you have the site pre-established for planting of coffee.

Also at Finca La China they have tried planting some areas with Arachis pintoii as a ground cover. They have 1 hectare of arachis planted between rows of coffee . They told us that after planting little time was needed for the arachis to cover the soil and decrease the need for weeding. They are planning to do an economic analysis of these systems (vetiver hedges with and without arachis); we hope that they will inform us of their results. At this time, they say that so far they are satisfied with the system although they are concerned that they could loose some coffee within the arachis during harvest time.

Joan Miller and Jim Smyle - Coordinators of the Latin American Vetiver Network. E.mail "Jim Smyle and Joan Miller" <hamilton@sol. racsa.co.cr>



ETHIOPIA

Report on Vetiver Workshop - May 1996 - Mettu, Illubabor, Ethiopia.

Debele Dinka, Deputy General Manager, Munchen f Munchen Mettu, Ethiopia

Introduction

Menschen fur Menschen (MfM) Foundation is very aware that soil degradation and erosion constitute a major regional and national problem, requiring effective management and long term conservation measures. MfM has also recognized the potential of vetiver grass as a practical and in expensive yet effective method for soil and water conservation.

With this in mind and to bring together experts, practitioners, government representatives from Illubabor, Western part of Ethiopia, MfM Foundation in collaboration with the Agricultural Development Department (ADD) organized a workshop on vetiver grass. The workshop was organized in honor of the Chairman of the Foundation, Mr. Karlheinz Bohm, who is the initiator, as well as strong supporter of the vetiver, for utilization for soil and water conservation in the region, under the theme "The strategy of MfM's soil and water conservation with particular emphasis of the role of vetiver grass (Vetiveria zizanioides) in Illubabor".

This workshop hosted by MfM Foundation was held at MfM Kerssa Training Centre, Metu, Illubabor , Ethiopia. From May 29 - 30, 1996. It was attended by about 58 persons, most of whom come from government organizations.

The discussions the following topics.

- Introduction to natural resources situation in Ethiopia in general, and in Illubabor region in particular.
- Vetiver morphology , physiology, and taxonomy
- Role of vetiver for soil and water conservation and its use for embankment and stabilization.
- Nursery development, field planting techniques and hedge management.
- Farmers' attitude towards vetiver uses for soil and water conservation in the region.
- Commercial uses and application of vetiver.
- The practitioners had also contributed their experience regarding hedge management.

A photograph and poster exhibition describing different MfM activities and vetiver multiplication and hedge management techniques and other uses of vetiver were displayed in a large hall.

Field tours

- Three sites were visited. These demonstrated:
- Techniques of propagation of vetiver grass.
- Techniques of planting out and loading of vetiver grass to the field.
- Uses of vetiver in degraded area.
- MfM strategy for promotion of vetiver grass for soil and water conservation and its efficiency (through discussion with the farmers).

After field tours open discussions, recommendations , quiz and quiz awards were made.

A closing speech was made by Mr. Adamu Legese, the Vice Administrator of Illubabor Administrative zone.

Excerpts from the statement made by Ato Debella Dinka. "This occasion is particularly historic as it marks the official launching of the vetiver network as a fully fledged inter institutional organization tasked to meet the region sustainable development need for up to date analysis of conservation measures technology trends."

Excerpts from the speech made by the Vice Administrator, participant of the workshop and member of the network. "From the lessons given to us, from what we had seen in the field and from the discussions we made with the farmers in the field, we can say that vetiver is really a miracle grass, which has got a multipurpose. Above all, it is the real soil and water conservation measures to alleviate the alarmingly taking place soil degradation without affecting farmers immediate needs. Therefore, we need to promote the use of vetiver in our region if we get technical and material support from the concerned agencies."

Recommendation and findings

- Since all the participants were enthusiastic to convince the farmers and to apply the technology in their respective areas, it was found indispensable to establish a Network. All the participants agreed to be member of the network. The members nominated a Network committee for immediate action.

- During the field tour, the participants found out that vetiver leaf

Photo 10. *Ethioipia. Farmers attending Mettu workshop visited field protected witrh vetiver hedherows. This area is typical of the eastern African highlands coffee zone.* ***Photo Credit: MfM***

Photo 11 *Ethiopia, Mettu. Vetiver is used often as a thatch in Ethiopia. It is long lasting.* ***Photo Credit: MfM***

is being used by the farmers for pest control in storage and for making rope.

- Since Oromiffa is the language spoken by the people of the region, the participants proposed to search a name for vetiver in Oromiffa.

- Finally the participants strongly insisted to search for a financial assistance to train technicians / developments agent on vetiver multiplication and hedge management techniques to promote the technology at an accelerating rate and have frequent and reliable feed back from the grass roots.

(Other groups wanting to run a vetiver workshop for the first time might be advised to follow the format of this workshop. I would add on other topic "farmer training methods and key points in a training program"...Ed)

GHANA

Vetiver Hedgerow Technology is catching up with Farmers.

Quietly but progressively on-farm vetiver hedgerow system is being adopted as a practical method of dealing with the century long problem of soil erosion on agricultural lands especially on slopes. A report from a recent survey carried out by CEDIA on a sampling basis within target groups has revealed this situation. Among the lots, two individual farmers have distinguished themselves and deserve commendation. They are Vincent Djarbeng of Kitase near Aburi in the eastern region and Bernard Kusiibuu of Tongo near Bolgatanga in the upper-east region; having used vetiver hedgerows in alley cropping; contour demarcation; and in agroforestry respectively.

Trials being conducted at an experimental site in Accra have shown so far Vetiveria zizanioides from Akola, India, and from Finchaa, Ethiopia are doing much better in producing more culms and within a shorter period of time. Vetiveria nemoralis ecotype Ratchaburi from Thailand comes next as far as number, size of culms and their production time are concerned. Observation on three different varieties of Vetiveria nigratana for the past three years has revealed that its root system is not as long, spongy, fibrous and dense as those of the V.zizanioides or V.nemoralis. Vetiveria nigratana is generally wilder and is not too disciplined in keeping in line on the rows which are mostly left with gaps; although the same planting interval (15cm) had been applied between the slips on each row for all cultivars regardless of species. Among the cultivars of Vetiveria nigratana in Ghana the overall performance classification goes in the following order: Zuarungu (Bolgatanga); Nyankpala (Tamale); Worawora (Kete-Krachi); Shai Hills (Dangme).

Linus Folly. E.mail: "Linus Folly" <Balme @ug.gn.apc.org>

(For Vetiver users in Africa it is important to move towards a program using 100% Vetiveria zizanioides. It is far superior to V.nigratana in many characteristics, not least it is not invasive. ... Ed)

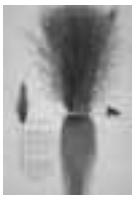
MEXICO

A Visit By The Latin American Vetiver Network To Oaxaca, Mexico.

Jim Smyle

In the beginning of May (1996) we visited the State of Oaxaca, México by invitation of Kevin O'Sullivan of the group Soils, Water, and Seeds of Oaxaca (SASO); SASO is part of a group of NGOs and a Technical Committee who are introducing the use and application of the vetiver technology to communities in Oaxaca. Jim Smyle's visit was paid for by the World Bank as a donation of technical assistance due to the good work accomplished in Oaxaca. In very little time they have accomplished much and shown others what can be done when people work together with good determination and organization. It also gave us an opportunity to observe a successful program, and to become familiar with the needs of technical assistance and type information that we can provide as coordinators of the Latin American Vetiver Network.

Many people in the region are aware that loss of soil is threatening their survival and their culture. Vetiver grass is not yet widely known in Oaxaca, but there is much interest regarding its potential. During our visit we had the opportunity to meet with some of the groups involved with vetiver in Oaxaca to learn about the program. SASO was started in 1995 with the initiation of the Program for the Control of Erosion and Restoration of the Soils of Oaxaca (PCERS), an initiative aimed at the necessity for communities to consider simple and low cost natural methods to improve their soils and reduce erosion. A Technical Committee was formed in April 1995 to coordinate,



supervise activities and facilitate the institutional involvment. The Technical Committee has 20 member organizations which includes member communities, NGOs, research and training institutions and government. The Committee delegated the initial implementation of the program to SASO and the administration to the Oaxacan Commission for the Defense of the Environment (CODE).

In July 1995, the mother nursery was established on the property of the Technological Institute of Oaxaca (ITAO), who have the responsibility to multiply the vetiver grass to provide planting material for the regional programs. The ITAO nursery produced more than 200,000 tillers for planting in 10 months from an original 6000 plants brought from a coffee farm in Chiapas, Mexico. In September of 1995 another mother nursery was established in the Isthmus and in addition, eight smaller nurseries have been established in different regions of Oaxaca.

As of mid-1996, there were already more than 15 demonstration plantings of vetiver hedges (some communities with more than 2) and numerous small community nurseries. The future plans for the vetiver program in Oaxaca include the establishment of more nurseries and demonstrations in farmer's fields and public areas; increased field research with research institutions, communities and the farmers; and the initiation of a network of participants to establish centers of experience to distribute information of vetiver at the community level as well as identify and promote other grasses, shrubs, native trees species in each zone that are appropriate for soil conservation and erosion control. There is also an effort to promote the participation of indigenous women's groups in the planting and care of vetiver in small nurseries for use in their activities related to raising vegetables, fruits and flowers.

One day during our stay we attended a workshop which focused on experiences with vetiver grass in Veracruz and Oaxaca. The workshop, held at the Secretary of Agriculture and Forestry Development (SEDAF) was attended by 25 people — representatives of Federal and state government institutions, coffee growers, NGOs and the consulate of Canada. Dr. Victor Hugo Díaz (INIFAP, El Palmar Field Station in Veracruz) described his work with vetiver during the last two years (1994-96) in propagation and research on the impacts of vetiver hedges in agricultural systems on hillsides in Veracruz. Mr. Gabriel Narváez and Efrain Paredes (Autonomous University of Chapingo, Oaxaca) related their experiences with vetiver propagation and planting trials in the northern Oaxacan Isthmus. Jim Smyle of the Latin American Vetiver Network, shared experiences regarding the use of vetiver in other parts of the world.

Several days were spent in the field visiting nurseries and communites to provide assistence on nursery management and to assess the existing demonstration plantings and help identify potential locations for future demonstrations. We observed that many of the plantings did not appear to be particularly successful. It turns out that much of the planting was carried out under less than optimal conditions. That is to say were planted at a time when there was still threat of frost at night (i.e. it was too cold); before the start of the rainy season so there was inadequate soil moisture; planted in partial shade; and planted too shallow. One recommendation made was that plantings should not be made until the rains have started which is to say one should consider planting vetiver at the same time of year that corn is planted. In spite of the poor state of vetiver plantings, the people were still enthusiastic and optimistic about using vetiver in their communities.

A high point of our trip was a visit to a community in the Central Valley which was actually planting a hedge that day. Two technicians who work as volunteers in the community told us that the people were very excited and interested in trying vetiver grass, especially the women who had an erosion problem due to the heavy rains that wash away the soils of their communal vegetable garden. It was along the lower edge of this parcel that they wanted to plant the first hedge. The entire community was out in force to help prepare the vetiver tillers and participate in the actual planting. Jim Smyle gave a lesson on the physiology of a vetiver tiller and then explained and demonstrated how it should be prepared and planted. As a good sign, when the planting was done the first drops of rain of the rainy season started to fall to assure that the hedge would be well established.

Since our visit to Oaxaca in May, we have heard from Viky Díaz of SASO who brought us up-to-date on the progess of some of the demonstrations and nurseries that we visited. In Soledad, the community that planted their hedges during our visit on May 11, she informed us that "...its leaves are already an average of 40 to 50 cm high with 2 to 3 leaves per plant... in June they planted another 5 hedges (200 meters) along drainage lines of a plot belonging to the students in the community where they have planted corn and guava and also a small nursery (800 plants) was established along river banks. All is doing well and have received the recent rains". In Santa Maria Tlahuitoltepec (another indiginous community we visited in the Mixe Alta region), a demonstration plot was established in which six lines of hedge (240 meters) were planted in a field cultivated half with corn and half with wheat. Also a small nursery was established at the community nursery. In early July in the community of Sola de Vega, three lines of hedge (210 meters) were established in a field "...cultivated in corn and beans, and in this same plot they want to establish an experimental planting of annual crops, fruits, and medicinal plants...

Also they established 2 small nurseries with 2,500 tillers each."

There is no doubt that the progress of the soil conservation program in Oaxaca is very impressive. Before the initiation of the vetiver program, its use was not known. After only 14 months there now exist central and community nurseries, technical and training materials for local promotion and extension purposes, articles published about vetiver in newsletters, newspapers, programs on radio and television have mentioned the vetiver technology to control erosion and as a result many people in Oaxaca are interested and ask for vegetative material to plant in their fields. The successful promotion of vetiver on the State level has resulted in interest from the State Government to promote the use of vetiver.

There does exist concern that vetiver will not be successful at the higher altitutes, semi-arid zones and in the extremely degraded soils of Oaxaca. Without doubt, vetiver will withstand the cold in Oaxaca (minimum temperatures below 5ºC in the cold season and a 5 month warm season with termperatures up to 35ºC and 4 to 5 months of rains averaging 600mm); but only while it is correctly established. There exist places in Oaxaca where vetiver probably will not have much success or use, such as in the zones of calcarious rock where there is no soil and in areas with high concentrations of sodium in the degraded soils (receiving no additional fertilization). Nonetheless, vetiver will be of great interest in Oaxaca for the rehabilitation of degraded lands and during the coming years it is recommended that there be small trials for the extremely degraded sites. For the near future, it seems best to concentrate the majority of the efforts with vetiver grass on lands that are already productive and have value thus needing protection. There is no doubt that the lands where the farmers already are planting crops could be used to establish vetiver to minimize the loss of soils, water, and fertility.

We hope that Viky and SASO keep us informed of the progress in these communities and the program in general. One can see the enthusiasm and seriousness of the groups in Oaxaca... in very little time they have accomplished much and continue to advance. They serve as a good example for all of us.

TANZANIA

Vetiver Grass In Soil And waWater Conservation Experience Of Hima Iringa Project, Tanzania.

Iringa District's HIMA project started by 1990. It is a Soil And Water Conservation project based at IRINGA district. The project attempts to increase and improve agricultural and forestry production per unit area through raising of soil fertility status and reducing soil erosion. The latter is one of the major problems facing the farmers in the district. Most farmers refer to soil fertility as their major problem but a close observation reveals that in most cases soil erosion is the main factor causing poor soil fertility due to dislocation of top soil.

As such, soil erosion control was anticipated by the project as an essential technology to prevent further decline of soil fertility and reduce land degradation in general. The project adopted "farmers active participation approach" of the recipients in identification of the problem, planning, implementation and evaluation.

On Farm Soil & Water Conservation Measures. Since the commencement of the project in 1989/90 season, several soil and water conservation measures were tried in the villages. These included;

1. Biological and agronomical soil conservation methods whereby contour grasslines are planted with vetiver grass (*Vetiveria zizanioides*) and Makarikari (*Makarikariencis*). Farmers are also encouraged to plant Guatemala and Napier grasses. Uncultivated grass strips and trash on contourlines were also practiced in the project's villages.

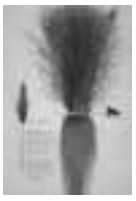
2. Physical soil conservation methods such as Fanya Juu terraces (excavated contour bunds), cut-off drains and ridge farming were also tested. Others are gully protection measures, like the establishment of stone and brushwood check dams across gullies.

3. Integrated soil and moisture conservation methods combining two or more measures at the same time in the same area such as:

- establishment of contour trashlines planted with Vetiver grass.
- fanya juu terraces planted with Vetiver on the same lines.

Photo 12. *Tanzania, Iringa. Vetiver hedgerows on steep crop land in Tanzania's southern Highlands. Photo* ***Credit: HIMA Project***

- grasslines with trashlines and spaced agroforestry trees.



- for gully protection, gabions and Vetivar or Napier grass planting.
- leaving the gullies untouched to give room for natural regeneration.

Farmers Training And Subcatchment Protection. Before indulging in any soil and moisture conservation work, farmers in their respective villages are trained and are made aware of the erosion processes, effects of erosion and how to solve the problem by using simple and sustainable technology utilizing available materials. Farmers are becoming competent to layout contourlines and they know how to stabilize them.

Farmers' Adoption Farmers' response to training sessions were good while adoption rate of the technology is moderate. Todate there are more than 1600 farmers who have tried one or more of the different soil and moisture conservation measures covering an area of 530 Ha. having about 190,000 running metres of contour bunds out of which 85% are stabilised by Vetiver grass.

Soil And Water Conservation Measures Preferred By Farmers.
Biological and Integrated Soil and Moisture Conservation measures establishment of vetiver contour lines, trashlines planted with Vetiver grass, Fanya Juu terrace stabilised by Vetiver, Napier or Guatemala grass.

A simple evaluation made to assess why farmers have adopted these measures, farmers stated that they prefer them most, especially Vetiver hedges because the measures are simple to make, not labour intensive, the grasses form permanent protective hedge/barrier that will remain effective for many years and effectively reduces soil erosion. They also encourage improved infiltration rate as the hedgerows reduce runoff speed. Farmers claim the increase in production per unit area in well conserved farms.

Farmers mentioned that vetiver grows upright and causes none or very little disturbance to the crops; terraces are easily formed, reaching 30 - 40 cm in just two to three seasons; Vetiver grows well in even drought exposed areas; rarely browsed by livestock, and is used for thatching houses and therefore some farmers earn income by selling it to their neighbours.

Requirement Of Grass Planting Materials Amongst several grass species used for contour stabilization vetiver grass is preferred most by many farmers. Others grass species such as Napier and Guatemala are preferred by livestock keepers to stall-feed their animals.

In 1990/91 season 3 central grass nurseries ($200m^2$ - $400m^2$) were established for Vetiver, Guatemala and Makarikari grasses. About 100,000 vetiver splits were produced and distributed. As farmers were interested in starting their own small nurseries the following season; in 1992/93 32 individual nurseries were established having the size of $10m^2$ - $50m^2$ producing from 800 to 8000 splits each.

As the supply of vetiver grass is less than the demand, HIMA project decided to collect some from Songea in Ruvuma region. About 55 tones of Vetiver clusters were collected and distributed to the villages in 1995/96 season. Despite of all these project efforts the farmers' demand was far to be reached.

The project expands from 27 villages in 1996 to 40 in 1997 the demand will also become extremely high, so individual grass nursery establishment is quite inevitable.

Prepared by **S.I.E. Mgalamo**, Land Use And Soil Conservation Officer, Iringa District, P.O.BOX 1187 Iringa, TANZANIA. **Arif Qaraeen**, HIMA Chief Technical Adviser, Iringa Region, P.O.Box 1187, Iringa, TANZANIA Telephone 2404

THAILAND

Vetiver strips or leucaena hedgerows?

While discussing with farmers involved in the on-farm research programme for soil conservation in Chiang Rai Province, several interesting points were noted by the 'follow-up team'. It was encouraging to learn that farmers were satisfied with the experiments and had expressed their willingness to continue participating in the on-farm research programme.

The past agricultural season had not been very good due to excessive rainfall, so farmers had not been able to determine the impact on yields of the soil-conservation practices they had used (leucaena hedgerows, vetiver strips, or a combination of both). However, purely visual observations had indicated reductions in erosion rates, since the runoff was clearer and there was evidence of terrace formation between strips or hedgerows. Four farmers out of the six originally participating in the programme thought it would be a good idea to increase the area under conservation. One of them, although satisfied with the experiment, was not interested in increasing the area because his wife has recently left to be a factory worker in Taiwan, which means he will be short of labour for the next couple of years.

Three out of the four farmers want to increase the area they are using for soil-conservation experiments, and to test a different practice than the one they used in the first year of the project. This was surprising since the choice of technique during Year 1 was the result of a logical decision making process. Farmers had been asked to identify soil-conservation techniques that

they wished to implement, whether local or 'introduced'. Three techniques had been identified, and all of them had already been promoted by other projects: hillside ditches, alley cropping, using a mixture of leucaena and pigeon peas, and vetiver strips.

Most farmers initially wanted to dig hillside ditches, but the idea was eventually discarded because farmers thought that it would be too labour-intensive, and would also be inappropriate for most of the fields because the slopes were too steep. The second choice was vetiver strips, but after working for a whole day in one of the farmers' fields (tiller-planting), all the remaining participating farmers chose the leucaena + pigeon pea option (seed broadcasting).

For Year 2, two farmers using leucaena in Year 1 want to shift to vetiver, and the only farmer using vetiver in Year 1 wants to shift to leucaena. The reasons for these shifts are linked to soil fertility and labour requirements. Most farmers agreed that, although vetiver takes much more time to plant, the overall workload over an entire year, which needs to take into account both cutting and pruning, is less than the leucaena + pigeon pea option.

The second main argument was that vetiver is perceived as being more efficient in controlling runoff and soil loss. Two farmers, who either use fertilizers or who farm relatively fertile fields, are more interested in erosion control per se, and therefore would like to shift to vetiver strips. On the other hand, the farmer who already uses vetiver is farming on an infertile field. She is more interested in fertility improvement, and would therefore prefer to benefit from the organic material provided by leucaena + pigeon pea hedgerows.

It is clear that more research needs to be carried out by farmer before they take any final decision towards the adoption or rejection of the tested soil-conservation practices. If it is decided to increase the area under soil conservation within the framework of the on farm research programme, the three farmers mentioned above will have the opportunity of testing different practices at the same time. This should allow them to decide which of the practices is most appropriate for his/her production system.

Fabrice Renaud, Associate Expert, IBSRAM Newletter March 1996

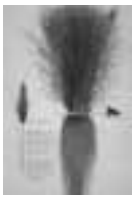
USA

Vetiver A Miracle Herb

Extracts from Jean Cozart article published in The Herbarist #61 1995 , Herb Society of America.

"I am sure that everyone has seen the destruction caused by flood, drought, earthquake, pests, disease and fire in Southern California on TV. We have had five years of drought, then fires burning out of control and erosion and floods sliding houses down canyons 113 tons of mud plus all of the topsoil that cannot be replaced, with sandbags stacked everywhere. Now I believe that the herb VETIVER is the ideal solution to most of these problems. I'd like to explain why I have come to this conclusion. Several years ago it was decided to remove a huge clump of Vetiver Grass in the Los Angeles Arboretum Herb Garden to make room for other plants in the fragrance bed. This plant was five feet wide and six feet tall. It was very dense and tough to remove. We finally ended up taking an axe to take it out. Lately I read some literature on Vetiver Grass that concerned erosion control all over the world. Suddenly I realized that this herb, Vetiveria zizanioides, could be the answer to our dilemmas here in Southern California.....". "...The hedges act as windbreaks against our severe Santa Ana winds and the leaves chopped, are an excellent mulch, around citrus trees and herbs. It is suspected to have nitrogen fixing mycorrihiza so it will remain green with adequate water and thus look well in any location. Vetiver hedges can take the place of block walls and will remain to protect the ground from the onslaught of the next rains.

Fortunately, my block walls withstood our January 17th earthquake of 1994, although hundreds of walls were down all over the Santa Anna Valley. In my garden I put my vetiver in a large pot, the size of a half-barrel so I can lift out the roots and cut off all the feeder roots because these are die scented ones that I use for potpourri as a fixative. I don't need sandbags or vetiver hedges yet, around my home, although I understand from a news broadcast that my sandy soil could slide from earthquakes! After all the damage to the Los Encinos Historical Adobe buildings, several herb gardeners have decided to replace their downed walls with vetiver hedges. In certain parts of India, vetiver hedges are legally accepted as property lines. Here in America, we are accustomed to thinking there will always be more—more good soil, good water, good weather but each year we lose 3 millions of acres to erosion and another 3 million to development. We have toxified the soils of thousands of acres of prime California production areas. We are always short of water. However our winter rains can cause devastation so vetiver hedges would be a way to keep soil on our steep hillsides where it is needed and around buildings during construction, because more and more people are building up on the slopes and tops of mountains. Everyone wants a view! Vetiver has a remarkable ability to hold rain runoff. It can block the loss of top soil. This deeply rooted perennial is capable of catching the soil to keep it behind the hedges. A major project to reestablish roads and steep slopes destroyed by the 1990 earthquake in the Philippines is relying on Vetiver. All homeowners should learn about this herb, and



be motivated to protect their gardens, that are subject to drought and fire in our dry season "Vetiver works!" quotes one admiring homeowner. We have to convince the average person because they believe things are good only when they are costly but it would be an inexpensive way to have a fence that can do much. It can block the spread of weeds including couch and Bermuda grass from invading your herb garden. Using the trimmed foliage for mulch saves money too, when it is spread on the garden because it does not seed or take root. The vetiver needs to be cut regularly to keep it uniform as a hedge and neat appearing. *(the best way to trim vetiver hedges is with a nylon strimmer or bushwacker - does a very neet job...Ed.).* Vetiver tops, used as a mulch have considerable amounts of nitrogen, phosphorous, potassium and magnesium and will conserve moisture. In order to form a hedge, the plants may need a little fertilizer and water to get established. However in other warm states, where there have been floods, hedges take water logging. Vetiver is well adapted to Memphis silt loam of Southwest Mississippi and will control sediment deposits. It acts as a trap especially holding back moisture long enough to accumulate an amazing amount of soil, building up behind it. This will stabilize the flood levees. It will also prevent devastating gullies such as we had behind our home in Oxford, Mississippi....." ..... ".....It is definitely limited by cold and can not reliably withstand freezing. Here in Southern California, we only have a few days of cold or frost so it never has been a problem for us.

Vetiver is not shade tolerant so don't plant tall herbs next to your hedge or put it near shade trees It likes full sun and adequate water to stay green. It will survive any stress that nature hands it except shade and freezing. Vetiver grows only where people plant it so be sure to keep it in full sun. If you plant vetiver in containers, it needs to have loose, light soil because the roots are thread like strands that form lacy networks so in order to harvest your feeder roots that you plan to use as a fixative for potpourri or other crafts, you must be able to pull the plant from its container to cut the outer smaller roots, then replace the plant back into the pot. Be sure to get the largest container you can handle. Vetiver needs to be pruned monthly to keep it trimmed but do not cut below 2 and 1/2 feet. This does no harm to the plant since you will fertilize and keep it moist until it roots form again. The leaves of vetiver have sharp edges so it is best to keep it topped and trimmed. Use the trimmings for mulch.

Hedges may take three years or more to be effective under low rainfall conditions. It depends on the site, the climate, number and sizes of plants put in. The roots will not interfere with herbs planted next to the hedge and does not rob them of moisture or soil nutrients. The hedges arc seldom wider than 3 feet and therefore will take up little space from your herb garden. They can act as borders to separate the herbs that have different uses or water requirements, and will last for years. The crown of the plant is generally a few centimeters below the surface of the ground. It has a tangled knot of reverse rhizomes plus the thin roots grow downwards rather than sideways forming a curtain hanging in the soil so their roots interlock when side by side. Once it is planted, it will stay in place. It reaches moisture far below the depth of most herbs. That is why it is a survivor and can recover quickly.

For a plant that grows well on levees, vetiver's natural habitat may seem swamps and bogs in India. According (many book on *'FLORA INDICA* written in 1820, one variety, native to Northern India, was called *Andropogon squarrous,* found in Ceylon, which flowers and sets seed, spread out and swimming in pools of water. Whereas the one we know as *Vetiveria zizanioides* in Hortus Third is always erect, awnless, muricate, sterile and grows to 8 feet. This description matches the Southern India plant *"Andropogon "muricatas"* that is very common in every part of the coast and also Bengal on the banks of water sources. *A. muricatus* grows erect whether in water or on dry land. It will thrive growing in the direct path of salt spray under very wet conditions. The root of this plant is delightfully aromatic particularly when moistened with water. I have very alkaline, sandy soil, in my herb garden. My vetiver is very erect. In Flora Indica, the grass is also called "*Aristida setacea"* and grows in dry barren, binding soil. It is a root perennial with culms very erect, straight and about as thick as a crow quill at the base. The Telinga paper makers construct their frames of the culms. It also serves to make brooms and toothpicks. It is used for making screens called "tatties". For this purpose, it is spread thin on bamboo frames and tied down. These are placed on the weather side of the house during the hot land winds and kept constantly watered during the heat of the day, rendering the temperature in the house very pleasant compared to what it is outside. This is a primitive form of air conditioning. The thermometer outside in India exposed to the wind but not to the sun, will then be at 115˚F or more but inside it can be kept down (85˚ F with two to three rows of thin tatties and all kept well watered. The difference of the thermometer in the sun, rises from l3˚F to 40˚F. These tatties are used in Bengal and make it more tolerable to those inside. The Indian common name for vetiver in Bengali is Khus Khus The roots when dry are used to make large fans commonly called Vissarees and also to make screens which are used before windows and doors and are kept moist so the air that passes through is both cool and moist. There is strong evidence to suggest that the vetiver from North India is different species from the vetiver in Southern India which

appears to bear infertile seed, and is the same as our *Vetiveria zizanioides.*

Propagation is mainly by division or slip. They can be ripped off the main clump and put immediately into the ground. It does need care during the period after planting. Vetiver will establish itself without roots as the amount of roots serve no purpose. The slips will only grow after they put out new roots. Once the roots start then they will continue to grow rapidly. ....You must use vegetative material to propagate. Absolutely DO NOT PLANT SEED. Otherwise it would become a pest. Most vetiver grown in the United States is the sterile variety. We insist avoid the use of seed. Seed when viable will only germinate under a narrow range of conditions and would create problems. Vetiver's tolerance to salt is high although it prefers slightly acid soil. The best soil is loamy sand although it is able to grow in any the type of soil regardless of fertility or alkalinity. It is also an acid tolerant herb. Phosphate and nitrogen together is very beneficial. I use bonemeal, bloodmeal, or fish fertilizer. I plant my slips in sand and newspaper pots set on black plastic in trays in full sun. I make the pots from strips of newspaper 2 and 1-2 inches wide, cut lengthwise and wind the strips into 2 and 1/2 inch pots then tape the ends. They are easy to make and the plastic keeps the sand from falling out the bottoms. The overhead mister does not deteriorate the pots as they are thicker from the layers of paper. You can make the pots any size or width you need, the same way.

Vetiver has been recorded as a medicinal plant in the Ayuveda era. It has a special use as a tea for curing hangovers and calming the nerves of people and horses in Honduras. In folk medicine, it is used to induce sweating and as a stimulating agent. Herbalists appreciate vetiver for its fragrant roots and as an insecticide or as oil for perfume. We weave the roots into baskets, mats, fans, sachets and ornaments. Oil from the roots is used perfumes because of its ability to take along time to evaporate from the skin, therefore perfumer combines it in soaps and scents to give them "persistence". That is why we use vetiver as a fixative in our potpourris. Vetiver can be made into hairbrushes to scent the hair, and basket weavers say that the stems hold paint and keeps its color better. It can be used to replace tree fuel. Vetiver can be harvested any time of the year. It is not a seasonal product. It has been used for ropes and for stuffing mattresses, it prevent bedbugs. Herb gardeners can plant vetiver in garden-size plots to use for herb craft and herb fairs. Some of the crafts include clothes hangers covered with vetiver roots and bound in ribbons They are thick and soft for hanging clothes on and look very special besides giving your closets a wonderful long lasting scent. One girl uses khuskhus grass with balsam for weaving distinctive baskets. Others make wall hangings, lampshades and hats. The vetiver can be relied upon to keep moths out of closets during hot summers. It is effective for two years. Vetiver oil is obtained by steam distilling the roots and is used in soaps, lotions, deodorants and other cosmetics. I have distilled rose petals at home and plan to do the same with vetiver. It keeps the more volatile oils in potpourri from evaporating too fast. It has a woodsy, earthy, musky scent and can dominate a perfume but it provides the base for potpourri. Vetiver was introduced to the perfume industry of Grass in the south of France. It still exists there and survives the Mediterranean winter. The oil will repel flies, cockroaches and other pests. The grass can be used as a pulp for making writing and printing papers or strawboards The roots are used as an important curry seasoning, in Malay. In Vietnamese and Thai food Khus-Khus is a flavoring for desserts, sherbets and canned asparagus. It is used with other extracts of Jasmine, Osmanthus, Pandan, and Lichee in Agar-agar and Sweet Rice.

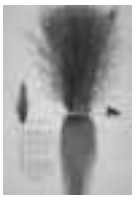
Vetiver plants are grown by the Boucard Brothers, American Vertivert Corporation in Leakey, Texas. The Texarome Inc. also of Leakey, Texas has a standing offer to purchase roots for *$350* a ton. A company in Sunshine, Louisiana will ship plants of Vetiver. Also here in California, vetiver plants are being grown in Woodland in a small backyard by James E. Eagan of Esparto, California. He has been amazed at the survival rate after experiencing very hot and adverse conditions with water, a serious problem with sparse irrigation due to the past drought conditions and then after a serious freeze. In 1990, he found all but a few plants showed signs of new growth. It is truly a miracle herb."

TECHNICAL NOTES

How to Use Existing Barriers as Sources of Planting Material

(By **Jim Smyle** - Director of the Latin American Vetiver Network. E.mail. "Jim Smyle and Joan Miller" <hamilton @sol.racsa.co.cr>

We found on our tour (in January in south-eastern Costa Rica) two interesting practices that people are using to obtain planting material for establishing new vetiver hedgerows. One of these was to remove an entire section of a hedge to obtain the planting material. Then the removed section is replanted. The other practice is to remove entire clumps (one every couple of plants) and either replant the gaps or wait for the plants on either side to grow together and fill the gaps. In the first practice, (the removal of entire sections) they told us that previously when they removed only tillers from the hedge the remaining parts were damaged and died, leaving gaps in the hedge. This is the first time we



had encountered this problem. The practice of removing tillers from the existing barriers is common. In many other places and projects one "removes half" of the hedge to obtain vetiver tillers. We have not previously received reports of this phenomenon where the clumps have died from removal of individual tillers. For example, the LUPE project (in Honduras) and in the Finca Rio Negro (in Costa Rica) they have obtained planting material from existing hedges for years without damaging the hedges.

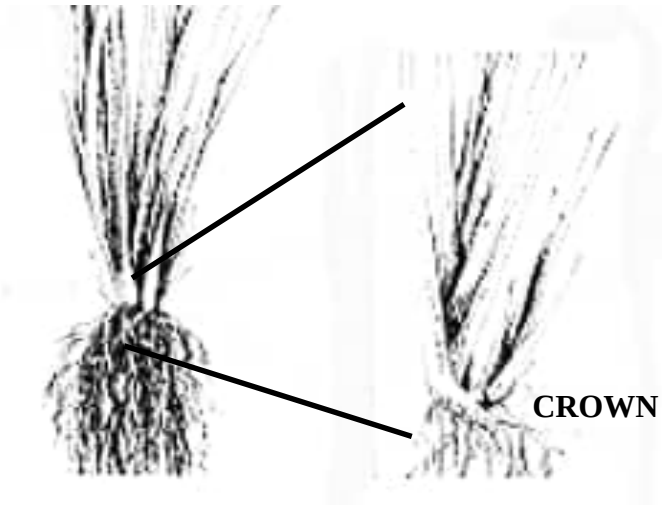
This practice of removing entire sections of the hedge and afterwards replanting or removing entire plants does not seem to be a recommendable practice (See Figure 1). Furthermore it damages the ability of an established hedges to function and can cause a significant increase in soil loss. We would like for those of you who have experience with the use of established hedges as sources of planting material to write us so we can report how you have done it and what are the results.

HOW TO PLANT VETIVER *by Jim Smyle*

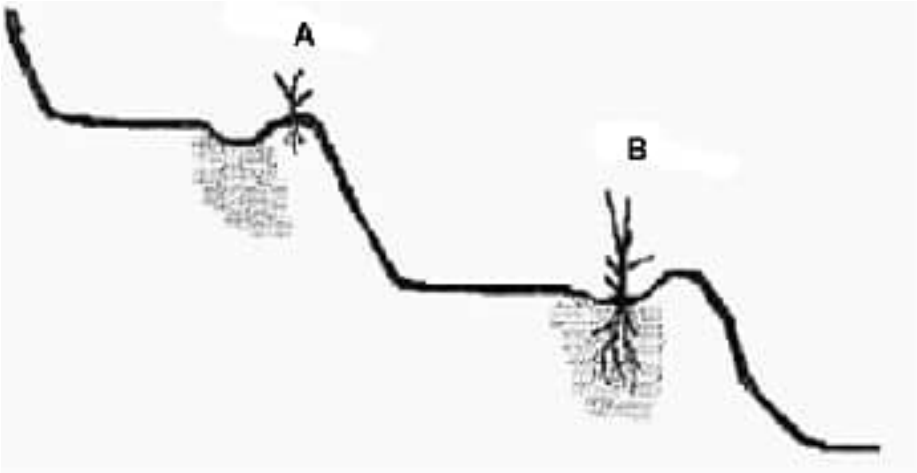
In the planting of vetiver one must take into account its physiology and the consider the effects resulting from one 's management of the plant:

First: When the plant is dug up, it must be kept in the shade with adequate moisture; treated in this manner the plant can be stored for a week or more between the digging up and planting. But, it is always recommended to minimize the time between excavation and planting. In order to minimize the mortality rate, plan on planting the same day the vetiver was dug out. If left in full sun, without shade or moisture the plants will wilt and dry out and lose any stored moisture; a significant loss can be expected in only a few hours if nc treated properly.

Second: The point c growth on vetive grass is in th "crown", which i found in the part im mediately above th roots - that is, th area between th leaves and the roots One can identify thi zone for its white/ye lowish color. Whe clumps of vetiver are dug out of the nursery, the existing roots have a tendency to die out, and usually die anyway from the digging out and the pruning of the leaves prior to planting. After planting new roots start to develop from the crown allowing the plants to establish and to start growing. Thus, **when planting you must assure that this area of growth (the crown) is planted completely below the surface of the soil.** It is recommended that each time someone demonstrates how to plant vetiver, they dig up a tiller and remove all the leaves so that they can show and explain to people that it is from this zone with its incipient leaves and "buds" where the roots and new leaves are produced. Finally, upon planting, the crown needs to be covered by well compacted soil around the plant in order to assure good contact with the soil and moisture. If the soil is not compacted, the plant dries out and cannot survive.



Third: A mistake often made by vetiver users is to plant vetiver on the edge of a terrace or in other micro-sites that are extremely dry and therefore are not acceptable. Another example is planting on the lower, downhill side of a furrow. For example in the drawing, tiller 'A' was planted on the lower edge of the terrace. In this micro-site evaporation is high, and, furthermore it is planted on an elevated spot so that water drains from the site instead of being captured. One must avoid planting in these micro-sites because they are extremely dry. On the other hand, tiller 'B' was planted on a micro-site



where it is most likely to capture the maximum amount water, therefore the establishment and development of the plant is better than 'A'. These are small differences, but small details determine success and failure. In dry and semi-arid zones, planting as in 'A' could be fatal to the survival of the plant.

Know Your Hedge Vetiver: Environmental Concerns About *Vetiveria zizanioides*

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Introduction

Thanks to the generous sponsorship of King Bhumibol, we here at the International Conference on Vetiver Grass have seen the scientific proof that vetiver is a "miracle grass". But in 1989, when we at the U.S. National Academy of Sciences first heard of it, vetiver sounded too good to be true. Erosion has been recognized since ancient times as the enduring enemy of human works, and the inevitable power of water against rock is a metaphor in every culture. Agriculture in particular, with soil laid bare to the rains, is a paradox: the very action that feeds us ruins us. We must clear the earth to plant, and the earth is swept away. Our tools against erosion - traditionally earth or stone - are almost all expensive, and almost always temporary.

In 1989, two World Bank veterans of tropical agriculture, John Greenfield and Richard Grimshaw, were claiming to have a simple, natural answer to soil loss and moisture control. They based their beliefs on what they had seen in traditional sugarcane agriculture. A contour hedge of grass, dense with stems at ground level, slows water enough that it drops sediments, layering behind itself a self-leveling bench terrace from which water flows gently and smoothly. Between the hedges can run fields, roads, canals, and other features of the "built" and natural environment. They declared that this biological system of erosion control, particularly using a ubiquitous tropical grass called vetiver (*Vetiveria zizanioides*), could be effective almost anywhere.

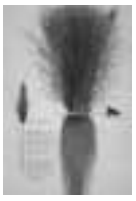
The Academy Vetiver Study

My colleague at the Academy, Noel Vietmeyer, with whom I've worked for ten years as a research associate, and I were skeptical to say the least. The purpose of the National Academy of Sciences, founded in 1863, is to "advise on matters of science and technology" through its National Research Council (NRC). Since 1970, our small NRC program has reported on technology innovations with the potential to help developing countries. During this time we have heard of hundreds of "breakthroughs" which might feed the world, or produce abundant fuel, or remedy any of a dozen of humanity's crises. Most solutions are impractical and would cause more problems than they solve. On the other hand, some ideas have true merit, and our program has produced over forty studies highlighting the potential of under exploited crops, fast-growing trees, and little-known animals. Almost all the innovations have been based on natural resources already important to some people at some time in some place: "lost" crops, "micro" livestock, "firewood" trees. Our job has been to draw on the best knowledge available to evaluate and explain whether these "new" resources truly had the potential to improve the quality of life and, if so, to make this information widely available with the endorsement of the National Academy of Sciences. In a sense, we put into practice the English saying, "The proof of the pudding is in the eating.": after all is said and done, does something work?

By 1989, John Greenfield and Richard Grimshaw had been very successful promoting vetiver hedges in World Bank projects in several countries. The U.S. Department of Agriculture (USDA) was exploring the idea of grass hedges for use in the United States, and had even sent an exploratory team to visit vetiver projects in India. The U.S. Agency for International Development (USAID) saw the potential of the vetiver system in many of its "sustainable agriculture" projects. But prudence dictated that before those agencies promoted the vetiver system, it should be investigated for both its strengths and weaknesses. Given other experiences caution was wise, for there seems to be a "law of unintended consequences" which states that the unexpected outcomes of our actions are often more costly than the anticipated benefits. So the World Bank, USDA, and USAID contracted for the National Academy of Sciences to "... assess the state of knowledge, the promise, and the possible limitations of vetiver use, as well as research that might be needed before vetiver can be deployed rationally and safely.".

As in all studies, we assembled a panel of supporters and skeptics. It was chaired by Norman Borlaug, whose high-yielding wheats had averted unprecedented starvation in the 1960s, for which he received the Nobel Peace Prize in 1970. The other panelists were Rattan Lal, author of several standard texts on erosion (including Soil erosion in the tropics: principles and management, and Soil erosion research methods); David Pimentel, a developer of integrated pest management and systems agriculture; and Hugh Popenoe, a senior authority on tropical agriculture and land-use systems.

It was David Pimentel who recast our task as "scientifically validating a traditional practice". This was made clear as we learned that vetiver hedges had long been used for erosion control. Vetiver was standard agricultural practice in places such as Fiji, Mauritius, and St. Lucia. We found that much of our background work had



been done by farmers and colonial agronomists: vetiver is not only well-known for the essential oil produced from its roots, but vetiver erosion-control hedges had often been recommended in the literature. Our task was not to create new or hypothetical knowledge, but largely to assemble and evaluate the wealth of existing experience and bring it to global awareness. We gathered agricultural and botanical information from around the world, eventually contacting in our quest for positives and negatives over 500 people (plus soliciting experiences from the then -1000 members of the World Bank's Vetiver Network). After four years, a mass of information was distilled into the peer-reviewed study Vetiver Grass: A Thin Green Line Against Erosion, in which the NRC panel unanimously reported that vetiver hedges were a cheap, safe, and effective technique to slow erosion and retain soil moisture. Vetiver could be used with confidence, but much remained to be learned. We should increase our knowledge of the system to the level known about engineered erosion structures, and of vetiver to the level known about other plants such as rice or wheat.

Doubts About Vetiver

This study was unique for Noel and me in that none of our other reports had touched upon the resolution to something as basic and widespread as erosion; it became clear that vetiver truly was an innovation of the first importance. The objections to vetiver were more unimaginative. Skeptics often seem to fall into three categories: traditionalists, innovators, and generalists. In this case, the traditionalists felt that proven technologies were the best immediate answer to the erosion problem: engineered structures were expensive to build and maintain, and it was difficult to get people to construct and maintain them, but they worked and what was needed was more investment and more education.

The innovators felt that there were many other ways to combat erosion, using contours and bunds and stone and vegetative debris and dammed ridges and trees and swathes of grass and scores of other techniques which largely depend on local conditions and local initiative and continual upkeep. The generalists themselves often acknowledged that vetiver worked wonderfully, but that the law of unintended consequences precluded its use: there was too little known and there had been too many blunders in the past. It was better where it could be afforded to stick with what was already proven, and elsewhere to suffer unchecked erosion rather than try the unfamiliar. Although vetiver was well-known to many in the tropics, status quo and risk aversion are strong inhibitors of innovation.

The first two types of objections, those from the traditionalists and the innovators, can be answered objectively. Quantifiable scientific data can show the relative costs and benefits of vetiver hedges. The amazing outburst of research and application catalyzed ten years ago by Grimshaw and Greenfield, and the great advances in knowledge documented by participants at this conference, have clearly demonstrated that vetiver hedges are a fundamental advance over both traditional and innovative erosion control methods. Vegetative grass barriers are an insight which is qualitatively different from most past approaches!... it is what Noel Vietmeyer calls "nudging nature". The vetiver system uses a natural process that grows stronger and more stable with time, rather than weaker and more vulnerable as do most other erosion-control techniques.

The now-obvious insight into the workings of a vetiver hedge has been in front of humans for centuries, in the soil built up along fence lines running across the contour, the silted debris-dams in contour rowcrops, even in dirt built up behind grass growing in the cracks of sidewalks. We have just been unaware about what was happening in front of our eyes. We lacked the insight. As John Greenfield is fond of saying, "we looked but did not see!". Today, the basic concept of the vetiver system is itself proven, and now the minutiae of soil, shade, rooting, and many other factors are being documented in ever-greater detail. Propagation, planting, and management techniques are nearly mature. Standards and specifications are evolving, combining engineering and agronomic principals. This blossoming of agroengineering is exciting. Such results as epitomized by this conference and now a part of the scientific literature were summarized by our panel: Vetiver hedges are cheap … and effective. There are circumstances in which other approaches are appropriate, but even then they are usually improved upon by incorporating a hedge as a key component of the system.

But during our study the generalists asked the more difficult question: Is vetiver safe? Unlike the misgivings of traditionalists and innovators, this fundamental question can not be completely answered objectively, for it is part value judgment and part null hypothesis. Just because we know no fatal flaw, we can not prove one does not exist. The question "When do we know enough" is one of the most vexing in science, and is often answered "never". Scientists are famous for always needing more research, more data, before they can give a final answer. But just as the emergency physician rarely has all the information needed to make an absolute diagnosis and so is forced to rely on past experience, scientists are forced to make recommendations based on incomplete knowledge. It is a balance between perceived risks and perceived benefits. For this reason, the techniques of risk-assessment have evolved to evaluate the unknown. The physician often makes quick decisions based on incomplete information because life is immediately at risk; the mathematician often develops elabo-

rate proofs over many years. The considered judgment of the NRC Vetiver Panel that vetiver was "cheap, safe, and effective" fell somewhere in between. The line of reasoning is that erosion is the number-one problem in agriculture and vetiver is a well-known plant occurring throughout the tropics whose wider use shows no cause for immediate alarm ... further research is prudent. Ethically logical but unprovable.

There is no final answer to the question "Is vetiver safe?". It will always be a value judgement based on past experience and new information. The "generalists" have three particular - and very valid - questions which will require vigilance as vetiver is planted on a massive scale:

1. Does vetiver harbor some pest or plague? is it a "vector"? which will ravage some crop or the environment?

2. Is vetiver itself vulnerable to some pest or plague which will make it unusable or, worse, cause a collapse of the vetiver system, leaving tracts of land unprotected by any erosion control mechanisms? This is especially worrisome if one vetiver clone is used as a monocrop across vast areas.

3. Is vetiver a weed, a plant which can invade and naturalize on its own?

I will briefly discuss the first two questions together, and deal with a framework for vetiver's weediness in greater detail. But let me point out some basic precepts to be kept in mind. First, ignoring concerns will not make them go away. Every country has plants which have run rampant or become a reservoir of disease or pest. Second, belittling the risks will only antagonize; that's human nature. Third, bombarding people with one-sided information will only confuse and, if just one fact is incorrect, the whole body of knowledge is made suspect. And fourth, steamrollering over people's objections will only strengthen their determination to oppose.

A passing word on "miracle" plants. The word is used among the smug as a snide or pejorative term, but I believe it was chosen for this conference, "Vetiver: A Miracle Grass", as a challenge. There are those so jaded or cynical that they forget we are surrounded by miracle plants!... those special plants that allow us to live as "domesticated" humans. Rice, wheat, maize, tell me these aren't "miracle grasses"! Bamboo. Beans. Pine. Potato. I'd say there are at least a hundred miracle plants for which we humans should be eternally grateful!... so vetiver would now make it one hundred and one. Vetiver seems destined to become a "global grass".

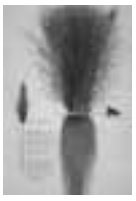
Pests and Plagues

The main pest-and-plague problems reported with vetiver have been few: fungal dieback from *Helminthosporium* and *Bipolaris,* bacterial leaf blight from *Xanthomonas*, sooty molds such as *Meliola*, stem borers and white grubs, maize cyst and root-knot nematodes, termites, and rats. The genus is susceptible to smuts from *Tilletiaceae* and from Ustilaginaceae. There is even an ascomycotina fungus called *Phyllachora vetiveriicola* indigenous to Gorakhpur, India, although I know nothing about it except that members of the genus cause leaf-spotting (black spot, tar spot) and they may be genus specific (there are species named *P. sorghi, P. sacchari, P. maydis, P. eucalypti, P. ficiuum,* etc.).

None of these pathogens have caused a failure of vetiver in the field, nor is there evidence of transfer to other crops. There are no reported cases of vetiver serving as a reservoir for pests or plagues, even when infected plants grow next to hosts. Vetiver has been cultivated on a large scale as an essential-oil plant for centuries, generally in association with our other economic plants. Its vulnerabilities and their treatments are well-covered in the literature. Each of the pests, even the stem borers, is harbored by many other species, so vetiver is not forming a unique refuge. Proper maintenance reduces or eliminates them as problems. Extension officers in Fiji, where there is the longest scientific field experience with vetiver hedges, have pointed out that under a proper maintenance program all known problems can be adequately overcome.

Vetiver seems unlikely to become a devastating vector nor itself catastrophically vulnerable to pests and plagues, no more than other crops planted on a vast scale. Sorghum, maize, and sugarcane are all close relatives which have survived intensive monocropping for centuries. It is of course a constant contest between agriculturists and nature, which thus far we have won with most crops in most places. During an early NRC strategy meeting, I believe Erik Arrhenius of the World Bank pointed out that, "Without doubt, sometime vetiver will be hit hard by something somewhere. It's only a matter of time".. This of course is true, as it is for all our crops.

Pandemic disease is a fact of life in modern agriculture. The same will be true for vetiver, and somebody had better be ready. Thankfully, agronomy is today a discipline in which both theory and practice excel. That is why vetiver should now be considered as a primary plant resource of humanity, receiving the same intensive research focus and development as our other major crops. I believe that if adequate scientific, economic, and political attention is given to vetiver, we have no more to fear than we do from the many other "miracle" plants which feed, house, and cloth us humans, we who after all are the most evident "monoculture" on the planet.



Weediness

So vetiver seems a miracle. Will some vetiver become a weed and tarnish that image? I think

most definitely not, if vetiver users continue to exercise the judgement and care in the selection of germplasm which they have shown in the past. The vetivers used in hedges do not have rapid reproduction, nor produce vast numbers of indeterminant seeds, nor have creeping rhizomes, nor possess most of the other technical characteristics ascribed to weeds. The two primary "weedy" characteristics shown by good vetivers are their ability to grow in a wide range of habitats and to be unusually persistent where planted. Yet vetiver proves easy to eradicate if desired.

By the way, many people seem to equate "weed" and "exotic", but the correlation is very weak and some of the worst weeds are "home-grown". Almost any weed scientist will tell you that 99% of introduced plants - especially domesticates - will never be weeds (look anywhere at fruits and vegetables, grains, legumes, trees, and ornamentals...most are exotics). Of the remaining 1%, 99% of them can be predicted as weeds; they have that combination of characteristics that cry out "Danger, Warning, Probable Pest". What concerns weed scientists, exotic plant committees, and other professionals is that obscure 1-in-10000 plant which seems well-behaved but which shows unexpected vigor and fecundity in some new environment. Regrettably, much of the clamor against "exotics" comes not from professionals but from armchair generalists. One of our duties is to provide them with field-proven evidence about our well-known vetiver, which has long been grown in every country and clime of the tropics. Nonetheless, it is important to point out our awareness that some members of the species and its congeners certainly do have the potential to be pestiferous, nor do I recall anyone ever denying this possibility.

The genus Vetiveria belongs to the Tribe of grasses called the Andropogoneae [Andropononeae]. One of the worst weeds in the world is an andropogon. *Imperata cylindrica*, widely known as cogon, lalang, and, in Thai, yaa kha, dominates several hundred million hectares of Asia, where it is native. It has little forage value, is persistent, and precludes land from useful purposes. About the only cost-effective way to recover the cogon lands is to battle it with one of those stubborn acacias, *Acacia mangium*, which has the ability to establish in the tangled mass of grass and eventually eliminate it through its dense shade. Mangium is nitrogen-fixing, fast-growing, and provides an excellent timber. It seems a real innovation in our struggle against cogon, and we hope some day to issue a report on this from the National Academy of Sciences. Incidentally, there is a diminutive form of imperata grown in the United States for its red leaves. Called "Japanese Blood Grass", it does not set seed around Washington but scientists in the South, in Mississippi, have shown it seeds abundantly there. Big cogon is already loose in the South, and I have fears about this pretty little ornamental further north.

Also closely related to vetiver is sugarcane. Another member of its genus is Saccharum spontaneum, infesting nearly every nook and crannie of perennial fields in its Asian home, not to mention roadsides, ditches, and waste areas. It is not as robust as sugarcane, but is much more feisty.

The closest generic relative of vetiver is sorghum (along with Chrysopogon, a widespread brush and lawn grass). Another member of the genus, *Sorghum halepense* (called Johnson grass in the United States after one of its early promoters), embodies the worst characteristics of a weed. Johnson grass was purposefully introduced in many areas because of its actual value for forage. It proves pioneering, invasive, and persistent; it produces both abundant seed and long, burrowing rhizomes, each of which can produce a new plant; it can be grazed, burned, dug, poisoned, and plowed, yet come back year-after-year to form impenetrable canebrakes; seasoned leaves develop prussic acid, which turns to deadly hydrocyanic acid in animals; and, worst, it has apparently borrowed some genes from its fellow sorghums which allow it to mimic them in seasonality, growth, habit, and reproduction. It continues to evolve, and there seems to be a genetic continuum between Johnson grass and sorghum, including even the shattercanes which slash yields in almost every field of sorghum in America. Thus, *Sorghum halepense* has become even more of a pest because of its association with agriculture than it ever was as an unaltered wild plant. Because of this history it is illegal to perform research, at least in parts of the United States, on transgenic sorghum. If one needs examples of undesirable plants, look no further than the andropogons.

If one needs examples of desirable plants, look no further than the andropogons. Most andropogons are perennials, which have a lesser need for seediness; the above examples are exceptions. The entire genus is noted by botanists and physiologists for its tendency towards sterility, surprising, given maize and sorghum. But none of the three most famous and useful andropogons, maize, sorghum, and sugarcane, can reproduce on their own in nature (this is common in domesticates; neither can wheat, rice, cassava, peppers, etc.). The seeds of maize, an unusual plant, are embedded in a cob and encased in a husk through which germinating seed can not penetrate; maize exists solely through human intervention. Grain sorghum has been bred to produce abundant seed, but because the plant throws its weight behind seed production rather than vegetative persistence, the plants themselves can not compete with other plants, especially other grasses. The ditches next to fields of sorghum in Africa, Asia, and America are not filled with sorghum for it can not survive with-

out the disturbance of cultivation. Sugarcane, which like vetiver is not grown for its seed, so rarely flowers that it was only at the end of the last century that seed-producing tricks were discovered that allowed selective breeding to begin. Sugarcane grows where humans plant it; feral plants are vanishingly rare or nonexistent.

Where does vetiver fall between these extremes? Different types seem to approach both ends of the spectrum. Wild forms of *Vetiveria zizanioides* from Pakistan to the South China Sea produce abundant fertile seed. They are a dominant grass in many areas of the Ganges Valley, and are usually called "North India" vetiver. Two points are important to remember about North India vetiver: 1) it is not very useful as an erosion control plant, for it is fairly lank and weak-stemmed, and 2) it is not reported as a weed in places where it has been introduced. Nonetheless, outside its native region, it should not be mentioned in the same breath as hedges.

On the other hand, there are forms of vetiver that for centuries have been selected and cultivated in South Asia and elsewhere for their essential oil. Most rarely flower and many have never been known to set fertile seed. These are usually called "South India" or "nonflowering" types (though they occasionally flower). Like sugarcane, they are extremely well-behaved. Some genotypes have full pollen sterility and/or full embryo abortion. It seems these are the types which were spread throughout the tropics in the last century, both for oil production and because they were used to protect the edges of sugarcane fields from erosion, as we discovered during the course of our study. The old essential-oil types are grown in every tropic soil and clime, and have never been reported to invade or naturalize. They are exceptionally persistent however, sometimes growing in the same row for a hundred years or more. This is why they are legal as boundary markers in parts of Africa and Asia. It is also this quality which helps make them premier hedge plants: they will stay where they are put, but they do not wander.

South India vetiver is also genetically distinct from North India vetiver. One study by Steve Kresovich of the U.S. Department of Agriculture has shown that three essential-oil genotypes from different countries are genetically almost identical, while all three are vastly different from wild North India vetiver. But elaborate tests are unnecessary to tell them apart in the field. They can be visually assigned by overall morphology to either the North India or South India "complex". In addition, leaf width and pigmentation, internode length, and several other measurable characteristics set them apart. Further, their oils vary chemically, they rotate polarized light in opposite directions, they smell differently, and are treated separately in commerce. Their taxonomy is tangled.

Incidentally, in the past few decades several countries - particularly India - have had breeding programs to improve the oil content of vetiver root. These efforts have naturally been based on fertile plants. These hybrids look like North India vetivers, but neither these nor the seedy North India types are widespread outside South Asia. It has almost always been the traditional essential-oil vetivers of the Indian Ocean region that show up in other countries. But these days, just because a plant is called an "essential-oil vetiver" does not mean it is a "non-flowering" vetiver.

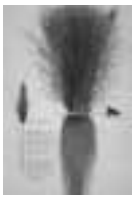
Germplasm

Past generations were admirably efficient at introducing high-quality vetiver to new environments, and today it is unlikely that one country has "better" vetiver than another. Good-quality vetiver is found nearly everywhere, so people do not have to introduce new germplasm. Indeed, it is fortunate vetiver hedges have come into pantropical use without facing the hurdles of phytosanitary quarantine that slows introductions of new plant resources.

So far as I am aware, members of the Vetiver Network have been as well-behaved as their vetivers; people haven't been sticking plants in their pockets and carrying them to other countries. Now is not the time to start smuggling germplasm! There is no practical need to exchange uncharacterized or uninspected planting material, the risks of introducing new pests or plagues are very high, and that is why unauthorized plant introductions are illegal in most if not all countries. For now, stick with the germplasm you or your neighbors have. Remember that vetiver's global reputation could still pay the consequence for one individual's negligence.

The few international exchanges that have occurred have been among official government programs, and strict quarantine and phytosanitary regulations have been followed. So far as I know, no introductions have entered into hedge use, for the local vetivers have always been as good if not better than the introduced material. If you are looking for vetiver, locate it in your own area or ask your national agricultural service. The Vetiver Network has identified suitable cultivars in almost every country and will be glad to help newcomers find starting material.

It is our duty as vetiver users to ensure we are using good-quality vetiver for hedges. Although seedy vetiver does not make good hedges and vetiver seed has rarely been used, to my knowledge, to establish them, seedy vetivers have been reported in a few countries outside South Asia, such as Colombia and Haiti. (Seed is always so much easier to introduce than vegetative material.) As I said, these are not reported pestiferous. The vetiver species endemic and widely used in Africa, *Vetiveria nigritana,*



is also fertile, as is *Vetiveria nemoralis* in Southeast Asia. Do not exchange seed outside areas of origin. We must stay on guard that our vetivers are not becoming problems, and we must ensure that new users, as well as skeptics, are aware of the risks and, more importantly, that we know and they know what kind of vetiver we are using.

Knowing Our Vetiver

How can we know our vetivers? There are two complementary paths. The first is to record as much as we can about the history and characteristics of the clones we are using for erosion control. How far back can this plant be traced? Was it used for oil production? Has it flowered? Set seed? Invaded or naturalized? The more we can describe our individual genotypes the better. Name your cultivars and characterize your germplasm, keep records of what you've planted, where, when, in what types of soils and with what kinds of associations, document and publish your experiences, and, especially, report unusual observations to the Vetiver Network.

The second path is to join with others in uniting our knowledge of vetiver. This task has been performed honestly and admirably by Richard Grimshaw and the Vetiver Network. Through this same Vetiver Network, I now hope to establish what Noel Vietmeyer calls a "Basic Science Initiative", in this case a "Vetiver Identification Program". Using classical and modern techniques of plant morphology and genetics, scientists should be able to unravel the taxonomic, systematic, ecological, molecular, and reproductive biology of vetiver. Because the profile of vetiver is rising in tropical agriculture, several researchers (with access to facilities and funding) have volunteered to assist in understanding the floristic, numerical, and cladistic taxonomy of vetiver, to test and document its ecology and physiology, and to perform DNA fingerprinting using RAPDs, RFLP, and FISH analyses. This is all for the good.

Here at the conference I am handing out accession, descriptor, and DNA forms to help accomplish these goals; these are also available on the internet at www.vetiver.com, by E.mail at vetivernet@aol.com, and by mail. We hope to soon be able to relate any unknown vetiver to all other vetivers, and to clarify genetic relationships among wild, cultivated, and hedge vetivers. The next steps will include physically linking genetic sequences with morphological characteristics such as rooting, tillering, flowering, and drought, cold, and chemical tolerances, and perhaps to unravel the many travels of vetiver. Perhaps most important, we may discover that some vetivers lack altogether the genetic ability to reproduce.

This is not as unlikely as it seems, and could be accounted for by one of two explanations. The first is that some vetivers may be naturally sterile. Low fertility and low seed-set are considered an evolutionarily advanced characteristic in andropogons, as shown by sugarcane and many of the grasses of my native Kansas prairie. However, if this is the case, there is always the possibility of genetic reversion to more primitive (fertile) states, or that introgression from fertile vetivers or other related grasses would create a reproductively active hybrid, as happens with Johnson grass.

The second explanation is that the essential-oil vetivers are domesticated plants, and having been selected for something other than seed (in this case oil in the roots) they have lost the ability to sexually reproduce, much like potatoes and sugarcane. In preparing this talk, I spoke with Jack Harlan, the USDA plant explorer (he collected vetiver in the 1950s) and geneticist who was elected a Member of the National Academy of Sciences for his contributions to understanding the origins and evolution of cultivated plants. He told me:

The wild vetiver is weedy; it's a seedy plant that has fertile pollen and normal meiosis, and it gets around on its own. I think the [traditional] oil-type vetiver is domesticated; it is not fit for survival in the wild. Because of pollen sterility and irregular meiosis in the South India type, I see no objection to calling it a domesticate. How does this sterile plant get by? Humans have made the sterility persistent by intervention. One could make the claim that it is a cultigen. (1/22/96)

If this is the case, and I believe it is, then it is possible that the best oil vetivers are also the most completely infertile: indeed, some essential gene necessary in the reproductive cycle may have been lost forever. A genetically certified sterile vetiver would be the best answer to the weediness question, and such clones may be found to be common through DNA analysis. On the other hand, if domestication is the cause of sterility it is likely that a gradient of fertile-to-sterile vetivers exists, and this too does seem to be true, so we must not forget the example of other domesticated root-crops. Radish and carrot come to mind. A few seedy plants among thousands of sterile plants have allowed persistent and pernicious "allied weeds" to become established and evolve wherever the cultigens are grown. Do not let this happen with vetiver! Remember the King's Rule to destroy any plants with seed (see below). Remember, our ancestors were cautious and only introduced the best. It seems likely - and we will soon know for sure - that Jack Harlan is right: most of us are working with domesticated germplasm.

Vetiver seems to have had two main paths of introduction to new areas. First, it formed part of the "economic botany kit" of the colonial powers; the finest germplasm was selected for introduction to possessions. Incidentally, much of the vetiver now used in hedges

came from botanic gardens. The second path was through indentured cane workers, particularly from southern India, who apparently carried vetiver with them to sugar tracts in Mauritius, southern Africa, the Caribbean, and elsewhere. A third, undocumented, route was perhaps via the Moors to Iberia and on to the New World. The biogeography of vetiver, reinforced by DNA analysis, will prove a fascinating story when someone takes up the challenge.

Hedge Vetiver

No matter the origin of the vetivers we use in erosion control, we must always adhere to King Bhumibol's Rules of Vetiver:

1. Use only high quality planting material, and destroy any plants with seed.
2. Plant vetiver as close together as possible.
3. Maintain your hedges.

Follow the King's Rules: the vetiver system will thrive and skeptics will continue to join us. How can we make it clear to others that we are adhering to the first rule? I recommend we adopt the term "hedge vetiver" for planting material in which we have documented confidence. This phrase would be reserved for plants we would be proud to publicly present to national leaders as examples of well-behaved vetiver. It is too early to establish firm practical standards for hedge vetivers, but here are some things to look for: the ideal is robust, dense and erect, with deep roots, wide adaptability, and nonseeding (though perhaps occasionally flowering).

It seems likely that most "hedge vetivers" will prove to be elite essential-oil types, but that is not clear as yet. Also unclear is whether we are talking about genotypes (vetivers sharing genetic characteristics) or phenotypes (sharing physical characteristics). We know that most vetivers out there are "good", but there are few records of the types of vetiver each of thousands of users are planting. By analyzing the characteristics of many different vetivers, we should be able to establish acceptable standards and unambiguous terminology to clearly and easily identify hedge vetivers. Comments and suggestions are welcome to help establish a grading system to ensure the phrase Hedge Vetiver is synonymous with top-quality planting material. If we promote the use of hedge vetivers, weediness will not be a concern. Establish the concept and practice the use of hedge vetiver.

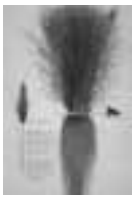
The Hedge Vetiver Challenge

As you can see, I believe the best way to handle skepticism of the vetiver system is to act responsibly and to understand and share the persistent and irresolvable concerns of the "generalists". We must work with them, for they have useful and important perspectives. We as individuals must be especially familiar and confident with the particular cultivar of vetiver we're using in our own work!... nothing can be more important both to success in the field and to success in the public's mind. Today, because of workers like you, the vetiver concept is infinitely more secure and robust in the thinking of scientists and bureaucrats than it was ten years ago, but we have only begun to awaken the awareness of the public. And for every inch of vetiver hedge now in existence I envision a mile (I'm sometimes not too metric). Imagine a grass hedge on every two-meter interval in every field in the tropics. This, colleagues, is a major ecological intervention. We must know our vetivers.

At about sunrise the day before the conference, I sat and talked about vetiver with my colleague and friend Jim Smyle of the World Bank's Vetiver Network. We did some quick calculations and conservatively estimated that more than a billion vetiver slips have been planted these past ten years!... it's probably closer to five billion. If vetiver becomes the standard conservation method throughout the tropics, being used in cotton and banana and maize and sorghum and cassava and the other crops, and to protect roads and waterways and civil engineering and watersheds, Jim and I speculated that within our lifetimes vetiver could become one of the most common plants on earth. Perhaps we were carried away by the intensity of this conference, but it demonstrates how serious is the challenge.

We must be prepared to meet that challenge. Although I believe we have the requisite skeleton of information, much remains to flesh out understanding. This exercise could be one of the great untapped adventures for vetiver champions: it gives each of you the golden opportunity to add new wisdom to the world body of scientific knowledge. Many of you are working with this plant every day, and many of you have specialized training to evaluate it. Take up this challenge. There are abundant opportunities for publications and theses on vetiver botany, physiology, pathology, entomology, agronomy, ecology, anthropology!... the list of -ologies goes on. If you tie your findings into these broader disciplines you'll contribute both to the advancement of vetiver and of science. It might even get you a promotion.

Vetiver is becoming a global resource. "Outside" scientists are increasingly willing to donate their time and resources to work with us and understand this new innovation. Vetiver's rising prominence in erosion control is not the only lure: its central but unresolved taxonomic position in the midst of the andropogons - among maize and sugarcane and next to sorghum - only reinforces the desire of scientists to unravel its nature. At the same time, more and more people are hearing of vetiver, and that means, always, more and more skeptics. The same objections will be raised again and again, the same poorly informed objections which occurred to Noel Vietmeyer and me



back when we first heard of the vetiver system in 1989. We must maintain our patience in honestly explaining the vetiver system, and we must maintain our commitment to improving our knowledge of it.

My commitment, as a scientist working only with paper in Washington, is to initiate the Vetiver Identification Program, and to coordinate accession and genetic records until a qualified team of scientists assumes long-term responsibility. I ask each of you who are using vetiver to document your clones, send copies of your records to the Vetiver Network, and to submit samples for DNA analysis. By participating in this effort you lose nothing while you help us all understand the environmental adaptations of vetiver genotypes, their vulnerability to pests and plagues, their origins, and much more. Hopefully, such results will allow us to quickly understand important agronomic and genetic information about clones, will shorten the time needed to evaluate new vetivers, and prevent much of the germplasm duplication which currently exists.

Using modern analytical DNA techniques, we will also be able to measure the "genetic vulnerability" which exists in hedge vetivers. In any given place most or all vetiver is genetically identical. If a pest or plague can harm one plant, it can harm them all, so it is useful to know how much genetic variety exists, and where. Steve Kresovich has already shown that three "different" hedge vetivers are genetically almost identical. This is one illustration of what a hundred analyses will uncover. It should be possible to group vetivers into a small number of types whose qualities are well-understood. Such an understanding is essential for efficient research, for confidence in planting hedge-grade materials, for insuring adequate genetic diversity in the future, and for answering questions from those unfamiliar with vetiver.

I pointed out earlier that we can never prove vetiver will never be a pest. All is not lost, however; other null hypotheses are that the sun will not rise tomorrow, that we will live forever, and that the government will eliminate taxes. All are possible, but don't count on any of them. Nor do I anticipate that vetiver, properly selected and installed, will ever create an environmental difficulty. I still stand four-square behind the conclusions of our National Academy of Sciences' panel: that vetiver is a cheap, safe, and effective way to slow erosion and increase soil moisture.

The Vetiver Network, lead by Richard Grimshaw, has performed admirably in bringing together and distributing this knowledge. What has been achieved in ten years is epic. The research presented at this conference, sponsored by the King of Thailand and bringing together 200 researchers from more than 40 countries, has provided hard evidence that vetiver hedges are indeed a robust innovation. So is the fact that just last week, after only six years of independent research, technical specifications for grass hedges were published by USDA researchers. It seems likely grass hedges will be approved in the "Farm Bill" currently before the U.S. Congress as the first legal alternative to engineered terraces for conservation compliance [Ed.-This has since been approved.]. You see, grass hedges are now considered by some authorities to be "accepted practice"; our goal is to make them "standard practice" around the world.

We here today have the good fortune to know vetiver and to know what it can accomplish for agriculture, civil engineering, and the environment. It is our responsibility to spread that knowledge conscientiously, honestly, and thoroughly. I believe we have an historic opportunity to show what a dedicated group can achieve when given the right tool, the right organization, and the right goals. We are building a knowledge base, and in time the concerns will fade. We will stay ahead of the "law of unintended consequences". In the meantime, with Hedge Vetiver, we will change the face of the tropics.

The original version of this paper was presented at the International Conference on Vetiver Grass held in Chiang Rai, Thailand, February 4 - 8,1996.

RESEARCH

Vetiver Workshop Australia

Research, Development and Application of Vetiver Grass for Erosion and Sediment Control in Queensland *Wednesday, 6th November 1996.*

Overview of Research, Development and Application of the Vetiver Grass System in Queensland and Overseas. *(Dr P Truong, Principal Soil Conservationist, RSC, Indooroopilly)*

The Hydraulics and Sediment Trapping of Vetiver Hedges on Steep *Slopes.(Professor Rod Smith, Head Agricultural Engineering, University of Southern Queensland).*

Use of Vetiver Grass for Engineering Purposes in Malaysia with Particular Reference to Slope Stabilisation and Erosion Control. *(Mr Diti Hen gchaovanich, CEO, EROCON, Kuala Lumpur, Malaysia).*

Application of Hydraulic Characteristics of Vetiver Hedges in Stripcropping on the Floodplains.(*Paul Dalton, Agricultural Engineer, University of Southern Queensland)*

Application of Vetiver Grass in Soil Erosion and Sediment Control in the Dar-

ling Downs. *(Clive Knowles-Jackson, Land Conservation Officer, Oakey).*

Strip Cropping with Vetiver Hedges - A Landholder View Point *(Mark Hensel, Prairie View, Jondaryan).*

Research, Development and Application of Vetiver Grass System in Thailand. *(Mr Sam Rajani, Director, Highland Development Office, Chiang Mai. Dr Vitoon Chinapan and Mr Chaicharn Chalothorn, Senior Research Officers, Department of Land Development).*

Vetiver Grass for Erosion Control in Forest Plantation. *(John Grimmett, Senior Research Scientist, Forestry Research Institute, Gympie).*

Vetiver Grass for Erosion and Sediment Control in Pineapple Farms. *(Cyril Ciesiolka, Senior Soil Conservationist, Toowoomba).*

Rehabilitation of Degraded Pasture - A Landholder View Point. *(Bevan MCleod ex Monto).*

Vetiver Grass for Erosion Control and Land Stabilisation in the Wet Tropics. *(Darryl Evans, Land Conservation Officer, South Johnstone*).

Vetiver Grass for Erosion and Sediment Control in Canelands in the Mackay Area. *(Frank Mason, Land Conservation Officer, Mackay).*

FIELD TRIP
Strip Cropping: Prairie View, Aubigny; Gully Stabilisation; Mechanical Planting Demonstration.

(If any person wishes to receive copies of the original papers please contact **Paul Truong**, Natural Resource Management, Queensland Department of Primaty Industries, Meiers Road, Indooroopilly, Queensland, Australia. E.mail: "Truong, Paul" <TruongP @prose.dpi.qld.gov.au>)

Vetiver Grass for Rehabilitation of Acid Sulphate Soils

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Introduction Vetiver grass (Vetiveria zizanioides L.) is being widely used overseas for soil erosion and sediment control (Truong, 1993). Research in Queensland showed vetiver is highly tolerant to drought and water logging, frost (-11˚C), heat (>45˚C), extreme soil pH (3.3 to 9.5), sodicity (ESP=33%), salinity (17.5 $mScm^{-1}$ for *50%* yield), Al toxicity (>68 Al/CEC%), Mn toxicity *(>578* ppm). (Truong *et al.,* 1996). Vetiver is also highly tolerant to a range of heavy metals such as As, Cd, Cu, Cr and Ni (Truong & Claridge, 1996).

Field trials in Queensland have shown that vetiver is highly effective in the stabilisation of steep slopes and rehabilitation of degraded and eroded lands. Vetiver is non invasive, only spreading by tillering. From the fertile vetiver cultivars in Australia, only a sterile line was selected and registered in Queensland as Monto vetiver.

Tolerance to low soil pH and high soil Al A strongly acidic soil with very high Al and Fe content was used in a glasshouse experiment to assess the performance of vetiver grass. Table 1 shows that when adequately supplied with essential nutrients, vetiver produces excellent growth under highly acid conditions (pH = 3.8) with extremely high level of soil Al (68% of CEC). Vetiver can not survive at an Al saturation of 90%. These trials did not assess the critical level of Al but observation during the trial indicated that vetiver growth occurred at level much higher than 68% Al saturation, as young leaves emerged and remained green for three weeks after planting in a soil with 87% Al saturation.

The critical Al level of vetiver is between 68% and 87% showing vetiver as extremely tolerant to high soil Al concentrations. These results were supported by overseas findings where vetiver has been satisfactorily established on soils with Al between *50%* and *85%* saturation (CIAT, 1992). Thus, vetiver is more tolerant to Al toxicity than some of the most tolerant crop and pasture species such as rice (>45%), corn (30%), wheat (30%), soybean (20%), lucerne *(15%)* and cotton (10%) (Fageria *et al.,* 1988).

Acid sulfate soils have severely affected sugar cane growth in north Queensland (Reghenzani & Hayson, 1986). Erosion of drainage channel banks of acid sulfate soils on an old cane farm near Babinda was persistent and severe. Several attempts in the past to stabilise these banks with various plant species have failed due to plant death and the land holder has resorted to using rocks to stabilise the most severe erosion on the banks. Vetiver grass was planted along the banks of these channels late in 1995 and after 8 months, although it is not fully mature, vetiver has successfully stabilised these banks during the last wet season. Table 2 indicates an actual acid sulfate soil exists and all samples analysed have high to very high potential to become acid sulfate soils. Vetiver was successfully established on these soils without any fertiliser and reached a height of 80cm after 8 months. Much more vigorous growth occurred when DAP (300kg/ha) was applied at planting. These results confirm earlier glasshouse findings that vetiver tolerates very high levels of soil Aluminium and acidity.

Conclusion The above results indicate that vetiver grass, with its very high tolerance to extremely acidic pH's and high Al level, is suitable for the

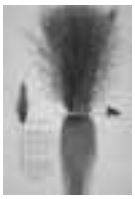


Table 1: **Soil pH, Al, Mn and yield of Vetiver of a Glasshouse Trial.**

Treatments	pH Modifying Agents	Planting pH	Al Sat%	Mn ppm	Harvesting pH	Al Sat%	Mn ppm	DM Yield gm/pot
Control	Nil	3.9	61	1.6	4.0	58	2.0	29.0
1*	S	2.3	87	22.0	2.2	90	22.0	0.0
2	Nil	3.8	66	2.1	3.8	68	2.0	47.5
3	CaCO3	4.3	38	1.4	4.4	36	1.0	47.4
4	CaCO3	4.9	10	1.3	4.8	11	1.0	49.4
5	CaCO3	5.4	2	1.0	5.5	2	1.0	46.5
6	CaCO3	7.4	T	T	7.6	T	T	46.9

* Treatments 1 - 6 received basal fertilisers (N = 184 Kg ia; P = 04 Kg/ha and K = 144 Kg/ha). T = Traces.

Table 2: Acidity and Aluminum Levels of the Acid Sulfate Soil at Babinda

Location	Depth cm	Initial pH	Oxidised pH	TAA mole H+/T	TPA mole H+/T	Al meqib0g	AVCEC %
Drain	0-5	4.0	3.5	36	272	2.4	21
	5-15	4.0	3.6	33	256		
Flat	0-10	4.0	3.5	33	312	2.9	20
+Fertilizer	0-10	3.7	3.0	51	410	3.0	21
	10-20	3.5	2.8	9.3	535	8.7	62
-Fertilizer	0-10	3.7	3.4	58	400	4.5	49
	10-20	3.7	3.3	85	426	7.8	71

TAA = Total Actual Acidity; TPA = Total Potential Acidity

stabilisation and rehabilitation of acid sulfate soils.

(References not included due to space constraint. Please contact authors for full paper..Ed)

An Assessment Of Strength Properties Of Vetiver Grass Roots In Relation To Slope Stabilization

Diti Hengchaovanich and Nimal S. Nilaweera Erocon *Sdn Bhd, Malaysia*

Abstract: The root properties of vetiver grass affect beneficially on the surficial and mass stability of soil slopes. In this process, the strength properties of vetiver perform a very important role by means of its very strong, prolusely grown, and deep penetrating fibrous root system. When compared to the root tensile strengths of many hardwood species, the vetiver roots are very strong with an average tensile strength of about 75 MPa. Experiments on vetiver root permeated soil shearing reveal that the abundance of fine, strong and vertically penetrating roots of vetiver grass increase the shear strength of soil considerably throughout the depth of root penetration. The root tensile strength of vetiver along with the root area occupied on a potential shear surface can be used to estimate the shear strength increase in soil due to the penetration of vetiver roots.

Introduction. Vetiver grass *(Vetiveria zizanioides)* has been utilized to reduce soil erosion in many countries throughout the world for a long time. It is well understood that the root properties of vetiver grass can help reduce soil erosion and strengthen slope stability when planted properly on soil slopes. Vetiver hedgerows cultivated across soil slopes can block the passage of soil particles and develop terraces in between the hedges enhancing the slope stability. Some previous studies on vetiver plant have elaborated the root morphological properties and their significance on erosion control and slope stabilization qualitatively (Grimshaw, 1994; Yoon, 1994). They emphasize about the early developed deep penetrating (sometimes up to 3.5 m) fibrous root system of vetiver and its capability of anchoring firmly into slope soil profiles. However, the

strength properties of vetiver roots, which also play an important role in terms of erosion control and slope stabilization by means of their influences on the shear strength of slope soil has not yet understood adequately. When a plant root penetrates across a potential shear surface in a soil profile, the distortion of the shear zone develops tension in the root; the component of this tension tangential to the shear zone directly resists shear, while the normal component increases the confining pressure on the shear plane. Therefore, it is essential to determine root tensile strength properties in the process of evaluating a plant species as a component of slope stabilization.

Recently, in Malaysia the vetiver hedgerow technique starts to gain popularity in erosion control and slope stabilization. It has been and will be used to stabilize several road embankments of the East-West Highway and some other road projects. Simultaneously, attempts have been made to analyze the effects of vetiver grass roots on slope stabilization and erosion control. This paper discusses about root tensile strength of vetiver grass and its contribution to soil strength through experiments on root tensile strength determinations and root permeated soil shearing, which are a part of an ongoing research work specially design to assess both root strength properties and root morphological parameters in relation to slope stability and erosion control.

Root Tensile Strength of Vetiver Grass

For the determination of root tensile strength, mature root specimens were sampled from 2-year-old vetiver plants grown on an embankment slope. The specimens were tested in fresh condition limiting the time elapsed between the sampling and the testing to two hours maximum. The unbranched and straight root samples about 15 - 20 cm long were connected vertically to a hanging spring balance via a wooden clamp at an end while the other end was fixed to a holder that was pulled down manually until the root failed. At failure, the maximum load was monitored. Subsequently, the mode of failure was examined for each sample and the results of end sheared samples and those with unusually altered rupture points were discarded. To calculate the root tensile strength, the root diameter without bark was used since the bark failed before the root due to its weaker strength properties, and eventually the total tensile stress transferred to the root core. About 30 vetiver root specimens of different diameter classes varying from 0.2 to 2.2 mm were tested and the results were interpreted as the ultimate tensile force and tensile strength in relation to root diameter without bark.

The ultimate root tensile force against the root diameter plot for the vetiver roots is presented in Fig. 1. The power regression analysis of the relationship between the ultimate root tensile force and the root diameter provides the best fit with equation

$$F_t = 46.93d^{14217}$$

where, *F1* - ultimate root tensile force; *d* - root diameter

This power regression relationship can be used to predict the ultimate tensile force of a vetiver root with known diameter. A comparison of tensile resistance of vetiver roots with those of some hardwood vegetation is illustrated in Fig. 2. The ultimate root tensile forces versus root diameter relationships for Japanese ceder, *Dipterocarpus alatus,* and Rocky Mountain Douglas-fir were obtained from early works of Abe and Iwamoto (1986), Nilaweera (1994), and Burroughs and Thomas (1977) respectively The comparison clearly indicates that the tensile resistance of vetiver roots as high as the hardwood vegetation, sometimes even higher, in contrary to being a grass species.

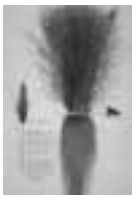
The tensile strength of root is defined as the ultimate root tensile force divided by the cross-sectional area of the unstressed root. If the root tensile strength is constant for vetiver roots, the ultimate tensile force, F_t should be proportional to d^2 . According to the relationship given by Equation (1), F_t is proportional to $d^{1.4217}$ implying that the root tensile strength decreases with the increase in root diameter. Figure 3 illustrates the actual relationship between root tensile strength and root diameter. The root tensile strength, T_5, decreases with the increasing root diameter, *d,* following the power regression relationship.

$$Ts = 59.80d^{-0578}$$

Similar relationships were reported from many previous works on hardwood roots. This phenomenon implies that stronger finer roots provide higher resistance than larger diameter roots with comparatively low tensile strength for a given root cross-sectional area of a species. According to Fig. 3, the tensile strength of vetiver roots varies from 180 to 40 MPa for the range of root diameter 0.2 - 2.2 mm. The mean tensile strength is about 75 MPa at 0.7 - 0.8 mm root diameter which is the most common diameter class for vetiver roots. Compared to many hardwood roots, the average tensile strength of vetiver grass is very high. Even though some hardwood roots provide higher tensile strength values than the average tensile strength of vetiver roots in the root diameter class of 0.7 - 0.8 mm, their average tensile strength values are lower since the average root diameter is much higher than that of vetiver roots.

Direct Shear Tests on Vetiver Root Permeated Soil

Roots of trees and other vegetation provide a reinforcing effect to soil through tensile resistance and frictional or adhesional properties. The reinforcing effect or the shear strength increase in soil due to roots can be quantified by conducting in situ direct shear tests



on root permeated and root free soils at the same location. The difference between shear strength values of root permeated soil and root free soil sheared under the same conditions gives the shear strength increase due to the roots. In order to determine the root reinforcement effect of vertiver grass, a large scale direct shear tests were performed in a slope soil profile of an embankment vegetated with vetiver. The test apparatus comprised a shear box, a hydraulic jacking system, a proving ring and dial gages. The shear box was made of 8 mm thick steel plates capable of holding firmly a soil block of 50 cm x 50 cm x 50 cm in dimensions. Hydraulic jacking system with capacity of 10 tons produced the shear load through the proving ring of 3 tons measuring capacity which controlled the shear force while four dial gages were measuring the shear displacement (Fig. 4).

The test plants were selected from a 50 cm length of a vetiver hedgerow that usually includes 3 plants planted with a spacing of 15 cm. The soil surrounding the plants was removed leaving a 50 cm x 50 cm x 25 cm root permeated soil block centering the hedgerow. Subsequently, the shear box was set so as to cover the soil block and the loading and displacement measuring systems were assembled. The soil block with 25 cm height then sheared horizontally towards the slope direction under the stress controlled condition. After shearing, the shear surface and the orientation of failed roots were examined carefully in order to estimate the shear distortion during failure. It was observed that the average shear distortion during failure was about 300. The total root cross-sectional area on the shear plane and the bulk weight of roots in the sheared soil block were measured in order to determine the root area ratio and the bio mass, respectively. This procedure was followed for each 25 cm depth under the vetiver hedgerow length 50 cm up to 1.5 m depth. For each depth level of shearing, a root free soil profile adjacent to the root permeated soil profile was also sheared under the same shearing conditions. Each soil block was sheared under the self weight as the normal load. The bulk density of test soil was determined before each test for the comparison of the normal load on root permeated soil block with that on the counterpart root free soil block. Each pair of test was made under equal normal stress condition.

The test results were processed in order to obtain the relationship between the shear stress and shear displacement for each test. Figure 5 presents the shear stress versus shear displacement curves, each plot representing the relationships for root permeated and root free soils for each 0.25 m depths up to 1.5 m of root penetration. The difference between the maximum shear stress of root permeated soil and that of root free soil at a particular depth is defined as the shear strength increase in soil due to the presence of vetiver roots (Δs). According to the test results, it is obvious that the penetration of vetiver roots in a soil profile increases the shear strength of soil significantly. For each test depth, the shear strength increase, the corresponding root cross-sectional area, and the bulk root weight per unit volume of soil were determined and tabulated in Table 1. The Δs value decreases with depth from 8.92 kN/m^2 at 0.25 m depth to 1.82 kN/m^2 at 1.50 m depth depending on the number of roots penetrating through the shear surface. A comparison of the variation of Δs and the root cross-sectional area on the shear surface is elaborated in Fig. 6 for the depth of root penetration. The vetiver root penetration of a 2-year-old hedgerow with 15 cm plant spacing can increase the shear strength of soil in adjacent 50 cm wide strip by 90 % at 0.25 m depth. At 0.50 m the shear strength increase is about 39% and gradually reduced up to 12.5% at 1.50 m depth. The shear strength increase due to 1 cm root area (As) is calculated for each test depth and presented in Table 1. The As value varies very slightly with an average of 5.1 kN/m^2 for the analyzed root penetration depth.

Table 1 Shear Strength Increase in Soil Profile Due to Root Penetration of 2-Year- Old Vetiver Plants with Spacing 15 cm in a Hedgerow of 50 cm length

Depth (m)	D_R (kg/m3)	A_R (mm^2)	A_R/A x 10^{-4}	Δs (kN/m^2)	%Δs	ΔS (kN/m^2)
0.25	1.522	331.0	3.31	8.92	90.2	5.39
0.50	0.701	176.2	1.76	4.17	39.3	4.73
0.75	0.521	137.8	1.38	3.46	34.6	5.02
1.00	0.378	106.8	1.07	2.61	26.3	4.89
1.25	0.181	71.2	0.71	1.94	19.0	5.45
1.50	0.135 `	51.6	0.52	1.28	12.5	4.96

D_R - bulk weight of root in unit soil volume, A_R - root area on shear surface, A - area of the shear surface, Δs - shear strength increase in soil due to roots, Δs - shear strength increase in soil due to roots 1 cm^2 root area.

Discussion Theoretically, the average tensile strength of roots can be used to compute the shear strength increase in soil due to the penetration of roots across a shear plane. The computation adapts the simple model of root reinforced soil subjected to direct shear (Wu, 1976). According to this model, the tensile force that develops in the roots when the soil is sheared can be resolved into a tangential component which directly resists shear and a normal component which increases the confining stress on the shear plane. The model simply assumed that the roots penetrate perpendicular to the shear surface and the tensile strength of the roots is fully mobilized during shearing. The mobilized tensile resistance in the roots translates into a shear strength increase in the soil as expressed by the following equation:

$$\Delta s = t_R\,[\cos Ø \tan ø) + \sin Ø]$$

where: $Ø$- angle of shear distortion
$ø$ - angle of internal friction
t_R - average tensile strength of roots per unit area of soil

The average tensile strength of roots per unit area of soil can be determined by multiplying the average tensile strength of the roots (T_R) by the fraction of the soil cross section occupied by roots or root area ratio (A_R/A).

Using T_R = 75 MPa, $ø$ = 300 and $Ø$ = 300, the shear strength increase in soil due to vetiver roots were calculated for each test depths and tabulated in Table 2 with experimental results.

The computed Δs values are about 3 times as high as the values obtained from the field experiments. The disparity between Δs values obtained from experiments and computation can be attributed to the assumptions made in the root reinforcement model and the nature of root specimens used in the tensile tests. During shearing of root permeated soil, the tensile strength of each and every root was not mobilized completely as assumed in the model.

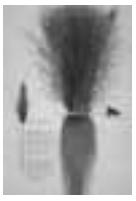
Table 2 The Experimental and Computed As Values with Depth.

Depth, m	Δs, kN/m^2 (Experimental)	Δs, kN/m^2 (Computed)
0.25	8.92	24.83
0.50	4.17	13.20
0.75	3.46	10.35
1.00	2.61	8.03
1.25	1.94	5.33
1.50	1.28	3.90

Some roots were pulled out completely or partly by a rupture at a finer point below the shear surface providing a lower resistance to shearing than expected. Even though the root penetration of vetiver is generally vertical as assumed in the model, some root orientations oblique to the shear surface can give rise to lower shear strength increase in soil. In actual conditions, the root crookedness, jointing and the presence of young roots yield lower Δs values than those are expected from straight, unbranched and mature roots which are more stronger than the former.

Though the adaptation of the root reinforcement model does not compute the shear strength increase directly, an estimation of shear strength increase can be made by dividing the computed values by factor of 3 for vetiver root permeated soil with the angle of internal friction 300. Furthermore, the correlations of Δs with the root area ratio and the bulk root weight per unit soil volume clearly indicate linear relationships which can be used to predict the shear strength increase in soil due to vetiver roots (Fig. 7). The value Δs increases linearly with the root area ratio in the order of 2.7×10^4 for vetiver grass. The relationship between the Δs and bulk root weight per unit volume of soil indicates some positive intercept of shear strength increase owing to the nature of roots and root penetration with depth. At shallower depths, the fractions of root weight given by obliquely oriented roots and by the roots terminated before the shear zone are higher than those at deeper levels. Therefore, at shallow depths the root weight is not directly proportional to the As value. As a consequence, a positive intercept in the relationship between the As value and the bulk root weight per unit area of soil appears though the intercept should be theoretically zero. For a known root area ratio or a known bulk weight of roots per unit volume of soil, these relationships can be used to predict the As value instead of doing rather difficult and expensive direct shear tests. Carefully extruded root systems of vetiver plants by water jetting can be used to determine the root area and the root weight at different depths of root penetration.

At present study, the shear strength increase in soil by the root penetration of a vetiver hedgerow at different depths up to 1.5 m was determined for a 0.5 m wide strip of soil across the slope. In general, for a 1 m wide hedgerow spacing these As values can be used directly at relevant depth intervals throughout the slope. However, for greater hedgerow spacings the As values should be corrected according to the pertaining areas of influence. It was unable to investigate the influence of vetiver roots on the shear strength of soil below 1.5 m depth due to the difficulties encountered during excavation and setting up testing equipment. Field evidences indicate that a gradual and slow decrease in root penetration



with depth after upper 0.5 m where a rapid decrease in root penetration occurs. According to the trend of the As decrease with depth it can be predicted a shear strength increase of about 1 kN/m^2 at 2 m depth below the vetiver hedgerow.

Conclusions

The root tensile strength properties of vetiver grass in association with its inherited root morphological characteristics improve the resistance of soil slopes to shallow mass stability and surficial erosion. The tensile strength of vetiver roots is as strong as, or even stronger than, that of many hardwood roots which have been proven positive for root reinforcement in soil slopes. The root tensile strength of vetiver decreases with the increase of root diameter as in the case of hardwood roots. Compared to hardwood vegetation, smaller average root diameter of vetiver furnishes very high mean tensile strength (75 MPa) indicating that the vetiver grass is more effective in the mechanism of root reinforcement in soil slopes. The penetration of fine and strong vetiver roots in a soil profile can increase the shear strength of soil significantly at shallow depths. The shear strength increase in soil due to the root penetration of a 2-year-old vetiver hedgerow with plant spacing 15 cm varies from 90% at 0.25 m depth to 12.5% at 1.50 m depth. The shear strength increase in soil due to vetiver roots can be approximated by using the average root tensile strength and the existing root area occupied by vetiver roots on a potential shear surface at a certain depth or by using the relationships of shear strength increase in soil versus the root area ratio or the bulk weight of root per unit volume of soil.

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(Figures not included, full, paper availble from authors.....Ed)

MALAYSIA

A seminar on vetiver grass technology was sponsored by the REAAA Malaysian Chapter, Institution of Engineers, IHT (Malaysian Branch) on August 17 1996. The seminar, under the Chairmanship of Dr. Ir. Wahid Omar, Director of Roads, JKR Malaysia, comprised a number of presentations and case studies of the Malaysian experience with vetiver grass technology. Readers interested in learning more about the seminar and its outcome should contact Dr. P.K. Yoon, 69 Jalan SS/3/39, University Garden, 47300, Petaling Jaya, West Malaysia. The presentations included:

Overview on the use of vetiver grass for erosion control and soil stabilization - P.K.Yoon.
The Malaysian Experience - Case Studies. Ir. Neoh Cheng Aik.
Slope stability design incorporating vetiver grass technology - Mohd. Asbi Othman.
Research and Development in Vetiver Grass Technology - Encik Mat Barhan Harun.
Prospects of advances in Vetiver production - Ismail Hamzah

THAILAND

Farmer Participatory Selection of Vetiver Grass as the Most Effective Way to Control Erosion in Cassava-based Cropping Systems In Vietnam and Thailand[1]

Reinhardt H. Howeler[2],Nguyen The Dang[3] and Wilawan Vongkasem[4]"
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Abstract

Research has identified various effective ways to reduce erosion in cassava-based cropping systems, including the use of vetiver grass contour hedgerows. However, few of these practices are presently used by farmers. To enhance the adoption of soil conservation practices by cassava farmers, a Farmer Participatory Research (FPR) methodology was used in two pilot sites each in Thailand, Vietnam, China and Indonesia to test and select the most effective practices. Farmers in Thailand and Vietnam selected vetiver grass contour barriers as one of 4-5 treatments they wanted to test on their own fields. After harvesting all trials and discussing the results, farmers in all three villages in Vietnam selected the vetiver grass treatment as the most effective in increasing income and reducing erosion. Although in one site in Thailand the vetiver grass treatment did not result in high cassava

yields or income, farmers in both sites selected the vetiver grass treatment as the most useful. In both countries, participating farmers, after seeing the benefits of vetiver grass barriers, requested additional planting material to plant on their fields.

Introduction Cassava *(Manihot esculenta* Crantz) is the third most important food crop grown in southeast Asia, both in terms of area planted and production of dry matter, following rice and either maize or sugarcane (FAO, 1993). In Thailand the crop is grown mainly for the production of dry cassava chips and pellets, as well as for that of cassava starch. The former are mainly exported while the latter is used for both domestic consumption and export. Cassava is generally among the three most important agricultural export products of Thailand. The crop is grown mainly in the northeastern and eastern part of the country in rather infertile lighttextured soils and under unpredictable rainfall conditions.

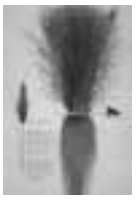
In Vietnam cassava is grown mainly for on-farm feeding of pigs, for direct human consumption, and for production of starch, maltose, noodles, cakes etc. Most of the starch is produced by small-scale family units, but in the past few years some large-scale search factories have been established in South Vietnam. Cassava is grown by small farmers throughout the country, but especially in the hilly and mountainous areas of North and Central Vietnam, on light textured and infertile soils which are very susceptible to erosion. Chemical fertilizers are seldom applied, but many farmers apply pig manure to maintain soil productivity.

Cassava is known to grow well on poor soils and under low rainfall conditions, but also has the reputation to exhaust the remaining soil nutrients and to cause serious erosion when grown on slopes. Research has shown that cassava extracts large amounts of soil nutrients only when yields are very high, but that per ton dry matter produced the crop extracts less N and P, and similar amounts of K as other crops (Howeler, 1991). Whether or not the crop causes more erosion than other crops depends largely on the soil and climatic conditions as well as on its management. Under the soil and climatic conditions of Thailand, Putthacharoen *et al.* **(**1992) found that the planting of cassava caused about twice as much erosion as that of mungbean, and three times as much as that of maize, sorghum or peanut grown only once a year. However, Wargiono *et al.* (1992) and Howeler (1995) reported that cassava grown in southern Sumatra of Indonesia produced similar amounts of soil loss as peanut and slightly more than maize or upland rice. Because of its wide spacing and slow initial growth, cassava plants leave considerable soil surface exposed to rainfall impact during the first three months after planting, and this can lead to serious erosion when the crop is grown on steep hillsides. However, the fact that cassava is often grown on eroded hillsides does not necessarily mean that the crop has been the cause of the erosion. It may also be that the growing of this crop is the result of erosion, since cassava can still be productive on degraded and eroded soils where other crops can not grow anymore, as shown by recent research in Colombia (CIAT, 1996). In any case, numerous erosion control trials, conducted both in Colombia and various parts of Asia, have shown that soil erosion in cassava can be reduced substantially by good management. Many management practices have been identified that can reduce soil erosion, such as minimum or zero tillage, mulching, fertilizer application, closer plant spacing, intercropping, as well as the growing of contour hedgerows of grasses, legumes or multipurpose tree species (Howeler, 1987 and 1994). The effectiveness of vetiver grass *(Vetiveria zizanioides)* contour hedgerows in reducing erosion losses in cassava fields in Colombia has already been reported by Laing (1992) from work done by Ruppenthal *(1995).* Similar trials conducted in Nanning, Guangxi province of China **(**Table 1**)** again showed that among various soil/crop management treatments, the planting of vetiver grass contour hedgerows produced the lowest amount of soil loss due to erosion as well as the highest cassava yields.

Many of the practices shown to reduce erosion, however, have certain advantages and disadvantages as they may require additional capital, labor or land, and thus may or may not increase the net income for farmers (Table 2). Since most cassava farmers are poor, and their main concern is to feed their families, they will not adopt soil conservation practices unless they themselves are convinced that these practices bring immediate benefits as well as protect their soil from long-term degradation (Fujisaka, 1991). Which management practices are most effective and beneficial is very site-specific and depends very much on the local soil and climate, the farmers' socio-economic conditions, as well as the traditional production practices. The testing and selection of the best management practices can thus best be done by the farmers themselves, in close collaboration with researchers and extension agents.

The Farmer Participatory Approach to Soil Conservation

The adoption of new technologies, such as new varieties or management practices, is often limited because the recommended practices were developed by researchers, who may not always know the farmers' specific needs and limitations. The recommended technologies may thus not fulfill the farmers' needs or may not be adapted to fit the local conditions. Farmer Participatory Research (FPR) methodologies have been developed by CIAT in Colombia (Ashby *et al.,* 1987) and Rwanda (Sperling, 1992), and were shown to increase substantially the adoption of new bean



(Phaseolus vulgaris) varieties. A similar approach is presently being used to improve the efficiency of cassava variety selection (Hernandez, 1991) as well as to enhance the adoption of better integrated pest management (IPM) practices for cassava in the northeast of Brazil, and that of better soil conservation practices in Colombia (CIAT, 1996) and southeast Asia (Howeler, 1996).

In 1993 the Sasakawa Foundation in Japan (now known as the Nippon Foundation) decided to fund a 5-year project, with the objective of enhancing the adoption by farmers of more sustainable management practices in cassava-based production systems in Asia, through the development and use of an FPR approach to soil conservation extension. The approach is based on the following basic principles of soil conservation:

1. Soil conservation is not an end in itself, but an integral part of good soil and crop management, including effective agronomic practices as well as the use of more productive germplasm.

2. Soil conservation must be done through a bottom-up program, planned and executed with the full knowledge, cooperation and participation of farmers.

3. Any proposed soil conservation practices must offer short-term benefits to farmers in order to be accepted, and must be suitable for the local soil and climatic conditions and fit the local cropping patterns.

The Sasakawa Foundation FPR Project The project started in 1994 with the organization of an informal consortium of collaborating research and extension institutions from the four participating countries, i.e. Thailand, Vietnam, China and Indonesia. In Thailand the project is conducted with participation of the Field Crops Research Institute of the Department of Agriculture, the Rice and Field Crops Promotion Division of the Dept. of Agricultural Extension, and the Thai Tapioca Development Institute (TTDI). In Vietnam the project is conducted in collaboration with the Agro-forestry College in Thai Nguyen, Bac Thai province, and the National Institute for Soils and Fertilizers in Hanoi. After the training in FPR methodologies of participating researchers and extensionists from the four countries, the project started with the conducting of Rapid Rural Appraisals (RRA) in potential pilot sites, so as to select the most appropriate sites and learn about the bio-physical and socio-economic conditions as well as the current production practices in each site; these data were used to identify farmers' needs and constraints. From the results of these RRAs, two pilot sites were selected in each country, based on the present and future importance of cassava in the region, the seriousness of soil erosion, and the interest of farmers to. participate in the project. Table 3 shows that the selected pilot sites differ markedly in terms of soil, climate, cropping systems and farm size.

Before the next planting season started, farmers from the selected pilot sites were invited to a farmers' field day to see demonstration plots that had been established by researchers on a uniform slope, usually at an experiment station, with a large number of soil and crop management practices. Soil losses due to erosion had been determined in each treatment by weighing at monthly intervals the sediments collected in plastic-covered channels at the bottom of each plot (Figure 1). Farmers could see with their own eyes the amount of soil that had eroded into these ditches as a result of each treatment. Farmers were asked to discuss the advantages and disadvantages of each treatment and to score the treatments in terms of general usefulness, based on yields of cassava and intercrops as well as effectiveness in reducing erosion.

Table 4 shows the ranking of the management practices considered most useful by the farmers of each pilot site. It is clear that farmer preferences vary greatly between countries, and even between sites within the same country, depending on the local conditions, farm size, and traditional cropping patterns (see Table 4). The use of vetiver grass hedgerows was the first choice among farmers from both pilot sites in Thailand, possibly because of their knowledge about the interest of His Majesty the King, King Bhumibhol Adulyadej of Thailand, in this "miracle grass" as an effective means to reduce erosion. Vetiver grass hedgerows was also among the first three preferences of farmers in the two pilot sites in Vietnam. It was not a preferred option in China and was not even used in the demonstration plots in Indonesia, as researchers considered that farmers would reject it as unsuitable for feeding their cattle, and would therefore prefer to plant elephant-grass barriers instead.

Upon return to their village, the farmers that were interested in conducting FPR trials met with researchers and extensionists to decide on the 4-5 most useful practices that they wanted to try in their own fields. In Vietnam, farmers in Pho Yen district of Bac Thai chose four common treatments (including one of intercropping cassava with peanuts and establishing permanent vetiver grass contour hedgerows) and one "farmer's" practice consisting of their individual current practice. In the other site, in Thanh Hoa district of Vinh Phu, seven farmers each planted two replications of one selected treatment in adjacent plots on 40% slope; one treatment involved cassava/peanut intercropping with vetiver grass contour hedgerows. In Thailand, farmers in both Soeng Saang district of Nakorn Ratchasima province and in Wang Nam Yen district in Sra Kaew province chose 2-3 common practices (among which vetiver grass hedgerows), the farmer's current practice as well as a farmer selected practice. The latter was

the farmer's individual choice of what he/she considered a most useful practice. This sometimes included cassava intercropping with sweet corn or pumpkin, the use of dry grass mulch, or contour barriers of mulberry bushes for feeding silkworms. Besides soil erosion control trials, those farmers having mostly flat land participated in the project by conducting trials on varieties, intercropping or fertilization practices **(**Table 5**)**. The FPR teams, consisting of researchers and extensionists, helped the participating farmers select the most suitable site for each type of trial, to set out contour lines, stake out the plots and construct the plastic-covered erosion channels at the bottom of each plot in the erosion control trials (Figure 1). Planting material of new cassava varieties and the selected hedgerow species, as well as fertilizers for the trials were usually provided by the project, but farmers were responsible for the planting, weeding and maintenance of their own trials. FPR team members visited the trials regularly to see the progress, discuss any problems and try to find solutions. They also helped the farmers collect and weigh the eroded soil sediments in each erosion channel, and to take samples of these sediments to be dried and weighed to determine the moisture content, in order to calculate soil losses on a dry weight basis.

Results of FPR Soil Erosion Control Trials

1. Thailand

In both pilot sites, erosion was particularly severe in 1995 due to unusually heavy rain. In Soeng Saang district, where cassava is planted as a monocrop on gentle (5-10%) but very long slopes, large amounts of rain water ran down the slope along natural drainage channels. This caused the formation of small gullies and washed out and exposed cassava roots. The diversion ditches and bunds constructed above each trial were often inadequate to stop this deluge, and sediments brought in from outside the plots often filled the erosion channels, making it impossible to accurately measure the effect of each treatment on erosion. In Wang Nam Yen district, slopes tend to be steeper but shorter and the clay-loam soil has much greater aggregate stability, which resulted in less serious erosion and less problems of sediments from outside the plots filling the erosion channels.

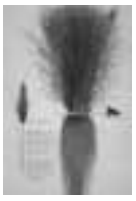
Cassava as well as the vetiver grass hedgerows grew well in both locations. Other hedgerows, like sugarcane (for chewing) or mulberry bushes did not establish so well and left wide spaces between plants, causing water to run unimpeded down the slope. When asked what practice they considered most effective in reducing erosion, almost all farmers in both pilot sites mentioned the vetiver grass barriers. Some, however, considered sugarcane or mulberry as attractive alternatives, since these crops can provide additional income. One farmer also mentioned that mulch of dry grass was more effective in reducing erosion than his vetiver grass barriers.

At the time of harvest, in each site a field day was organized to harvest together, farmers, researchers and extensionists, the various FPR trials, to determine in each treatment the average height of plants, and to pull out ten plants to weigh the fresh roots and determine starch content using a Reihman scale. The results were tabulated and written on large paper sheets to present to and discuss with the farmers.

Tables 6 and 7 show the average results of six FPR trials on erosion control harvested in Wang Nam Yen district and nine trials in Soeng Saang district, respectively. Since only *4-5* treatments had adequate replication, only those will be considered. In both locations cassava yields and starch contents were quite high (yields were about twice the national average), while soil loss due to erosion was low to medium. However, the latter are only rough estimates of erosion losses due to treatments, as some "additional" sediments that were believed to have come with runoff from outside the plot (as discussed above) were excluded.

In Wang Nam Yen district (Table 6) highest cassava yields and net income were obtained with the "farmers' practice" of up/down ridging; however, this practice also resulted in the highest soil losses due to erosion. Contour ridging produced slightly lower yields but significantly lower erosion losses. Vetiver grass hedgerows produced still lower cassava yields (partially due to space occupied by and competition from the hedgerows) and net income, while being only intermediately effective in reducing erosion. In spite of this, farmers overwhelmingly selected the vetiver grass as the best treatment, probably in the expectation that once the grass is better established,the hedgerows will become increasingly more effective in reducing erosion, while a better infiltration of runoff water will reduce fertilizer loss and result in better soil moisture during the dry season, while the mulching of vetiver leaves on the soil surface will help control weeds and erosion and also conserve soil moisture, which may lead to improved yields. Thus, farmers hope that the use of vetiver grass leaves as *in-situ* mulch, will give benefits similar to those obtained in the grass mulch treatment (T7), but without the hard work of carrying grass mulch onto the field from elsewhere.

In Soeng Saang district (Table 7) the "farmers' practice" of up/down ridging produced the lowest yield and the highest erosion losses. Although this practice is cheaper than any of the other practices tested, it still produced the lowest net income, clearly showing to farmers that this practice is counterproductive. The vetiver grass hedgerows produced the highest cassava yield and a high net



income, while being the most effective in reducing erosion. Contour ridging and planting sugarcane hedgerows were also quite effective in reducing erosion and increasing net income. Based on these results farmers from Noon Sombuun also overwhelmingly selected the vetiver grass as the best treatment, with contour ridges and sugarcane hedgerows as second and third best, respectively.

Most farmers were very interested in continuing the trials next year and requested additional vetiver planting material to plant in their cassava fields outside the FPR trials. That is probably the best sign of spontaneous adoption of the vetiver grass technology. However, it still needs to be seen how extensive actual adoption is, because farmers also mentioned that tractor drivers contracted to plow their cassava fields charge considerably more for plowing along the contour than for plowing up and down the slope, even on gentle slopes of less than 10%. This will be a deterrent for any farmer who wants to establish contour hedgerows to control erosion. Thus, the benefit of contour hedgerows, including that of vetiver grass, must also be conveyed to contract tractor drivers that often determine the method of land preparation for cassava farmers.

2. **Vietnam**

Field days were also organized in Vietnam to harvest and discuss the results with farmers in three pilot sites, i.e. in Kieu Tung village of Thanh Hoa district in Vinh Phu province, and in Dac Son and Tien Phong villages of Pho Yen district in Bac Thai province. During the field days, farmers looked at and discussed the amount of sediments in the erosion channels of each treatment (sediments had been collected from the channels only during the first two months, in order to let farmers see the erosion losses during the rest of the year), and pulled up at random ten plants in each plot and weighed the roots to estimate cassava yields.

Table 8 shows the results of total soil loss due to erosion, yields of cassava and peanut, and the gross and net income from each treatment in Kieu Tung village. Soil losses did not vary much among treatments, but were highest in those treatments with cassava monoculture, or where cassava was intercropped with peanut, but without fertilizer application. Soil loss was lowest in the treatment of vetiver grass barriers and cassava/peanut intercropping. This treatment also provided the highest cassava and peanut yield and thus the highest gross and net income. When asked, farmers overwhelmingly selected this as the best treatment and requested additional planting material of vetiver grass to plant in their own fields outside the trial plots. Similar results were obtained in Dac Son and Tien Phong villages of Pho Yen district in Bac Thai province **(**Table 9**)**. In both villages, the treatment of cassava/peanut intercropping with vetiver grass hedgerows produced the lowest amount of erosion and the highest or second highest net income. Based on these results, farmers from both villages in Pho Yen district voted overwhelmingly for the cassava/peanut intercrop with vetiver hedgerows as the most effective treatment to increase their incomes and protect the soil from erosion. They too requested additional planting material of vetiver grass for planting on their cassava fields next year.

During the course of the year, non-participating farmers from the village and those from neighboring villages often visited and talked about the FPR trials. Several asked to join the project in the coming year. It is hoped that when farmers themselves develop the soil conservation technology that is most suitable for their particular conditions, and they are able to see with their own eyes and through their own work what effect each practice has on. crop yields and erosion, that they are more likely to adopt those practices considered most effective. In the case of both Vietnam and Thailand this included the planting of vetiver grass contour barriers to slow down run-off, enhance water infiltration into the soil and thus reduce erosion.

Once farmers are convinced of the need to reduce erosion and committed to use soil conserving farming practices, they will show their neighbors and teach their fellow farmers about the best soil conservation practices for their region. We believe that through a bottom-up approach and farmer participation in the development of effective soil conservation practices for a particular region, farmers become more aware of the problem of erosion and the need for soil conservation practices. Farmers are the stewards of our soil resources - so essential for present and future food production - and thus should be the ones directly involved in the development of practices that maintain the soil's productivity for future generations.

(Tables, acknowledgements and references not included due to space constraint. Please contact authors for full paper..Ed)

INDIA

Fungal Endophytes of Vetiver.

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Many grass species all over the world have endophytic fungi without expressing any symptoms. Endophyte associations are known to confer certain advantages to the grass hosts such as - tolerance to drought and insect pests (Clay, 1994; Siepl & Bush, 1994). The endophytes, particularly *Acremonium* species, are also known to cause toxicosis in animals grazing infected grasses (Clay, 1994). We screened

vetiver for the presence of fungal endophytes, especially since it is remarkably free of diseases — National Research Council,1993).

Materials and Methods Leaf blade, leaf base and root bits of *0.5* cm length were cut froin South Indian Vetiver and were surface sterilized by immersing in 70% ethanol for 5 seconds, and then shaking in a solution of sodium hypochlorite (0.5% available chlorine) for 5 min. (Latch & Christensen, *1985).* Such tissues were plated on Potato Dextrose Agar medium containing antibiotics (100µ/ml penicillin and 100µ/ml streptomycin). The tissues were slightly pushed below the agar surfrce and incubated in darkness for 15 days at 30˚C (Latch & Christensen,1985).

Results and Discussion The tissues of vetiver did not have *Acremonium* as endophyte. However, other fungi were observed. Leaf and root had *Curvularia lunata,* the leaf base showed the presence of *Nigrospora oryzae* and *Ramularia sp.* A comparison of the fungal endophytes of some forage grasses such as *Panicum maximum, Cenchrus ciliaris, C. setigerus* and *Pennisetum purpureum* revealed that vetiver has a restricted numuber of fungi as endophytes.

This work forms part of the research project *Fungal endophytes of forage grasses & forest trees* funded by the Ministry of Science & Technology, Government of India.

(References not included due to space constraint. Please contact authors for full paper..Ed)

NIGERIA

The Effect of Nitrogen Fertilization on Growth and Root Yield of Vetiver Grass *(Vetiveria nigratana)* in Nigeria (Preliminary Study)

Vincent 0. Imoh *Bulletin of the Institute of Tropical Agriculture, Kyushu University, Vol 15, December 1992, pp.49-54*

Abstract

An evaluation of the effect of nitrogen fertilization (0 kg N/ha, 60 kg N/ha and 120 kg N/ha) on the growth and root yield of vetiver grass (Vetiveria nigratana) in a clay loam soil was carried not in polybags at Imo State University, Okigwe, using a completely randomized design.

Parameters measured were the number of tillers per plant, plant height, root yield (dry) and total dry matter production (TDMP). The data which were analyzed by analysis of variance showed that an increase in the level of nitrogen led to significant increases in the number of tillers per plant, plant height, root yield and total dry matter production. Application of 60 and 120 kg N/ha gave plant height values of 96.73 cm and 103.20 cm and tillers per plant of 10.13 and 12.73 respectively, compared with 80.20 cm (height) and 6.06 (tillers) for plants that received no nitrogen (0 kg N/ha) after three months growth. Similarly, values of root yield (dry) per plant of 13.67 g (379.72 kg/ha, calculated on the basis of 60cm x 60cm plant spacing) and 18.15 g (504.17 kg/ha) and total dry matter production per plant of 34.30 g (952.78 kg/ha) and 48.53 g (1348.06 kg/ha) for 60 and 120 kg N/ha, respectively, were significantly greater than the values of 9.96 g or 276.67 kg/ha (root yield) and 19.44 g (540.0 kg/ha TDMP) produced by 0 kg N/ha plants. The number of tillers per plant and total dry matter production in vetiver grass showed greater response to nitrogen treatment than plant height and root yield.

On the basis of the results of the trial, it is recommended that for optimum vetiver grass production in clay loam soil, a high level of nitrogen nutritients should form part of an agronomic package.

SPAIN

The Introduction, Early Results And Potential Uses Of Vetiver Grass Hedge Row (VGHR) In Mediterranean Regions[1] .

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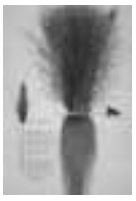
Introduction

In this project, an attempt was made to test the establishment, growth and potential uses of Vetiver grass hedgerows (VGHR) in the hostile aerial and edaphic environments of Murcia, Spain. Two sites were selected for testing , viz. El Chopillo (Latitude 38˚ 22' 08'' N Longitude 10 48' 06'' E) and Lorca (Latitude 37˚ 42' 36'' N Longitude 37˚ 37' 28'' E). The climatic conditions consist of a long dry summer with absolute maximum temperatures reaching of 42˚C in Lorca and 47˚C in El Chopillo, and a cold winter with absolute minimum temperatures of - 4˚C in Lorca and - 14˚C in El Chopillo Precipitation is low with averages of 27.51 cm per annum in Lorca and 40.45 cm per annum in El Chopillo, and with few rainy days. The relative humidity is consistently low with high evapotranspiration. Negative water balance occur over 6 months in El Chopillo and 10 months in Lorca. The soil type is quite calcareous, mostly clayey but sometimes alluvial with negligible nutrient. Hilly topography is common with serious yearly erosion rates of more 5,000 Tm / Km^2. The aim of the project is to use VGHR to minimise soil erosion and to enhance soil moisture. If successful, it will be tested as a means to improve crops, protect high-



way slopes and other embankments, as a source of biomass production and other applications.

Materials And Methods

Planting Materials used for Various Look - See Trials

i. Planting Materials for El Chopillo. A small consignment of 300 bare-root tillers was obtained from Malaysia and sent directly to El Chopillo in May 1994. They were raised in 12.5 cm x 17.5 cm polybags in a glasshouse for 11 weeks before being planted into the ground in El Chopillo on 29 July 1994.

ii. Planting Materials for Lorca
Large consignments of tillers were obtained from Malaysia in June 1994 and America in July 1994. They were planted in plastic planting trays of 37 x 30 cm; with 20 containers, of 22.5 cm deep and each container holding 800 cc of standard potting mixture (Composition 25% peat + 65% pine bark and other forest materials + 10% rice husk. Fertilization Osmocote 1.5 kg / m3, 16-8-12-2, 6-8 months). The plants were kept in a glasshouse near Barcelona with the controlled environment maintained at 18° C to 35° C and 60% - 80% R. H. Plants were irrigated for 5 to 10 minutes with a overhead mist for 1 - 3 times per day depending on the prevailing climatic conditions. They were also flooded with nutrient solution of "10-1 0-20-oligoelements" at a rate of 0.5 gm./1 once every 3 days. The bare-root tillers produced roots within 2 weeks. After 3 1/2 months, the roots had enmeshed the core of the potting mixture with the tops having 2 - 5 tillers newly produced in-site. The plants were cut to. 20 cm height before sending it to Lorca (Photo 1).

They were then reconditioned in an open air container nursery (Photo 2). These container plants were used in all the field trials in Lorca.

Irrigation and Fertilization System Used In The Look - See Trials.

In Phase I of the project, the main concern was to ensure establishment of the Vetiver plants in the hostile environments of Murcia. It was therefore decided from the onset to reduce the stresses from water deficit and low nutrients by adequate supplies. Irrigation and fertilizer were applied as follows

i. Ground Nursery in El Chopillo. The plants were drip-irrigated every 1, 2 or 3 days depending on the season. Water consumption was equivalent to 6,670 m3/ha from February to October 1995. Soluble fertilizer was distributed regularly through irrigation water; from February to October 1995; the total amount used was 170 kg/ha KNO_3 + 70 kg/ha H_3P0_4 75% + 500 kg/ha $KN0_3$ 59%.

ii. Container Nursery in Lorca**.** Irrigation was supplied by overhead sprinklers at a rates of 2 l/m^2 day to 9 l/m^2/day, adjusting it according to the climatic conditions. Fertilizer was applied at rates of 0.156 gm./m^2/day, KNO_3.

iii. Ground Nursery in Lorca. Irrigation was by flooding. The amount of water used was equivalent to 700 m^3/ha over 10 occasions from February to October 1995. Fertilizer was applied by adding the equivalent of 500 kg/ha N15P15K1, before planting; and 500 kg/ha KNO_3 distributed with the irrigation water over the 10 applications.

iv. Highway Slope. Irrigation was by drip-irrigation at rate 4 l/hr/m of VGHR. The total amount of water applied from February to October 1995 was 948 l/m of hedgerow. Fertilizer was through the irrigation pipes, using a total of 151 gm/m KNO_3 over the recorded period. This area was not linked to the farm's irrigation system. The pipe system was connected to a mobile tank of 6,000 litres placed at a higher level. Drip-irrigation was by gravity, at a rate of 4 l/hr/m of VGHR. The amount of water used was about 500 l/m from April to October 1995. Fertilizer, at a rate of 180 gm/m of KNO_3 was distributed in the irrigation water over the same period.

Design For Look - See Trials.

Our main concern at the beginning of the project was the establishment of the Vetiver plants; we were not even sure whether the plants would grow!! Thus only observational trials were set up.

i. Ground Nursery in El Chopillo
204 polybag plants were planted in a single block of 4 rows on 29 July 1994. The planting distance was 1 metre between rows and 0.33 metres between plants.

ii. *Ground Nursery in Lorca.* The total trial consisted of 2 blocks of 2,917 and 2,478 plants of Malaysia Accession, and 3 blocks of 2,587 ; 2,685; and 2,745 plants of American Accession. They were planted into the ground nursery on 5 - 19 December 1994. The block size was about 0.1 hectare and the planting distance was 0.33 metres with 1.00 metre between rows. Because the blocks were of irregular shape, the number of rows varied from 12 - 16 per plot and the number of plants per row varied from 150 - 200.

iii. Highway Slope. A trial was undertaken to test the effect of VGHR to prevent soil erosion on the Highway slope of 12 m vertical height and with 320 gradient. The slope construction used a rocky gyspic base covered with very irregular, unstable, not consolidated, clay soil. 3 blocks of 20 metres width were selected with the outer blocks planted with VGHR and the central block as control. Vetiver container plants were planted at 5 cm between plant distance and the VGHR were at 1.0 metre vertical intervals . 12 full length VGHR were planted in each block and the total plants used were 10,258. The VGHR were planted on 4 - 9 January 1995.

v. Almond Plots**.** Three VGHR of 90 metres length were planted between blocks of four almond rows on 7 April 1995. The between-plant distance was 5 cm and a total of 6006 container plants were used.

Observations Made.

i. Serial photos of the container nursery in Lorca were taken weekly, while for all the other ground trials, photos were taken at approximately monthly intervals. Qualitative assessment of plant performance were from examining these collections of photos.

ii. Quantitative count of tiller production and dry weight production were done by harvesting the tops as follows:-

a) Ground Nursery El Chopillo 4 groups of 6 - 8 plants each were cut at 20 cm from the ground. The fresh weight was measured and numbers of tillers of each top were taken. Subsamples were taken to obtain oven - dry weights.

b) Ground Nursery, Lorca To remove boundary effect, the boundary rows were topped by a mechanised grass cutter to facilitate sampling in the immediate adjacent rows. 3 groups are randomly selected and the plants were cut manually at heights of 20 cm. For the Malaysian Accession, 15 plants were sampled per group per row of each of the 2 blocks. For the American Accession, 10 plants were sampled per group per row of each of the 3 blocks. The fresh weight and tiller number of each top were noted in the field. Sub - sample's were taken to obtain oven - dry weights.

iii. Root Examination. Excavations to examine the root systems were carried out in September 1995. A backhoe was used to dig a large pit next to a group of plants ranging from 4 plants in El Chopillo to 7 plants in Lorca. To ensure the roots were not damaged, a gap of at least 20 cm were left between the hole and VGHR. A pressure pump, linked to a water tank, was used to wash away the soil and expose the roots.

iv. Meteorological Data were obtained from the official stations near the trials sites. For this paper, we concentrated on the maximum and minimum temperatures and rainfall as given in Appendices 1 and 2.

Results

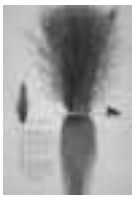
1. Establishment and Growth of Plants in Ground Nursery, El Chopillo. This was essentially our first observation block. The 11 week old polybag plants were transplanted into the ground in July 1995 in the warm weather of summer with very good transplanting success of 99.5%. Growth was good between August - September 1994 (Photo 3) with very vigorous growth from October to early December 1994. Subzero temperatures occurred between 23 - 28 December 1994 and the frost killed all the exposed tops. However, the buried crown-portion survived and by early February 1995 new tillers started to emerge. (Photo 4) From then to May 1995 there were rapid tiller productions. A census taken in June 1995 showed that 81.8% of the plants have fully recovered from the winter frost. Good growth was observed in June 1995 (Photo 5) followed by very vigorous growth rates from August to November 1995. (Photo 6)

Harvesting of the tops were carried out on two occasions. (Photo 7a) . The differences between the dry weights obtained in the 2 harvests suggested rapid biomass production in autumn 1995. This was confirmed by the very rapid regeneration of the cut tops. (Photo 7b + 7c).

Excavation showed the root system to have reached 2.6 metres deep, with very dense root mass on the first 0.5 metre depth. (Photo 8)

2. Establishment and growth of Container Plants in Lorca. The plants in planting trays, in the glasshouse in Barcelona, were cut back to 20 cm height and transplanted on 2 occasions viz.: 27 October 1994 and 10 November 1994, to a open air container nursery in Lorca (Photo 2). The plants transported well with no sign of transporting shock and practically no casualty. They stayed a healthy green colour but with little growth; the young tillers barely increased in height over the next few weeks. With the decreasing cold temperature in December 1994, the matured green leaves became bleached, turned yellowish and finally after sub-zero minimum temperature over 7 days in end December; they were killed and turned straw colour. Throughout this period, the young tillers continued to retain the green colour and turned dull green only after the sub-zero minimum temperature. On site examination showed that, whereas the matured leaves were killed, the young tillers and the crown region was alive. The dull green colour of the young tillers persisted through to March 1995, when, with the warmer weather, a healthy green colour was re-attained and growth resumed. Then, new tillers were also noted. Container plants were taken out for planting at various times, into the ground starting from 5 December 1995 and ending 7 April 1995. Towards the end, each container plant had a few actively growing tillers. The overall establishment success of field planting 32,498 container plants was 95.9 %.

3. Establishment and growth of plants in Ground Nursery, Lorca. At the time when the container plants were taken out, the cold weather had already turned the matured leaves to bleached yellow colour, but the young tillers were still green. After the transplanting and after the frost



in late December 1994, the matured leaves dried up into straw colour (Photo 9a); even the young tillers turned a purplish-green to straw colour. This condition persisted into the cold period of January - March 1995. With warmer weather in April 1995, the young tillers regained a healthy green colour and there were new tillers. By May 1995, there were good tiller production, followed by growth in June and July 1995. Very rapid growth was observed from August 1995 onwards (Photo 9b + 9c). Census taken on 4 July 1995 showed the overall establishment success to be 89.1 %. On two occasions, assessments of growth were carried out by topping the plants (Photo 10a)

The dry weights between the 2 harvests were substantially different indicating vigorous growth. Observations of rate of regeneration of cut tops confirmed this view (Photo 10b). Excavation of roots were carried out. The roots of the American Accession has reached a depth of 1.7 m while those of the Malaysian Accession was 2.1 m (Photo 11). However, the main and pronounced root mass was in the upper 0.4 metres, and there was no apparent difference between the 2 accessions.

4. VGHR to protect Highway slope. Planting was done on 13 - 17 January 1995, at which time the plants in the containers was suffering from the cold December weather; the mature tillers were dead and the young tillers were dull green in colour (Photo 12). However by late March, the young tillers had turned a healthy green colour and by April / May, new tillers were being formed. Very rapid tiller formation and good growth occurred between April and July followed by vigorous growth from August 1995 onwards (Photo 13). The overall establishment success was 98.8%. Observations in late September 1995 showed that the VGHR had effectively reduced soil erosion in the planted plots (Photo 13). Severe erosion had occurred in the control plots despite the low rainfall of 740 mm over 24 days since the establishment of the trial (Photo 14a + 14b).

5. VGHR to improve Almond Plots. At the time of planting in April 1995, the container plants had fully recovered from the frost injury; the young tillers were actively growing with healthy green colour and there were also new tillers being formed (Photo 15a). The plants established very fast with a good success of 99.3 %. From the beginning of transplanting new tillers were produced and by July, useful hedgerows had been formed. Growth from August 1995 was rapid (Photo 15b). In this trial, it is hoped that the VGHR will serve to slow down the surface rain wash thus improving infiltration and conserving moisture. There were also plans to cut the tops of the VGHR to mulch the almond plants. The effect of VGHR on almond production will be studied using the 2 adjoining plots as controls.

6. General Field Observations. In the field, some interesting observations were made

(i) Both the Malaysian and the American Accessions had not flowered though plants had many morphologically matured culms with distinct nodes.

(ii) The morphology of the Malaysian Accession in Spain seemed to be different from the same Accession in Malaysia. The culms of plants in Spain were clearly bigger and taller than the same Accession grown in Malaysia. However, the internodes were surprisingly shorter. In addition, there were very few culm-branches in the plants grown in Spain.

(iii) Plants in the boundary of blocks of Vetiver grass tended to be less vigorous and showed more stress symptoms of dying of the leaf tips, when compared with plants growing in the centre.

Discussion And Conclusion

There do not appear to be any documented record of Vetiver grass having been successfully grown in Mediterranean climate. Dr. Francoise Dinger reported his failed attempt to grow Vetiver in Draix (Haute-Provence Alps, France) in the Vetiver Newsletter #6. We are happy to have successfully established Vetiver grass and to be able to study the performance of VGHR in Murcia.

Field Establishment of VGHR Under Mediterranean Climate. Due to various logistic requirements, the large number of container plants were transplanted to the ground beginning 5 December 1994 and ending 7 April 1995. This, fortuitously, allowed the study of plant development stages on the transplanting success, establishment and growth under different weather conditions. It also permitted observing container plants over a longer period. Observations from the various trials in Lorca showed that new tillers were largely produced in May regardless of the time of the first transplanting into the field. The same time of new tiller production also occurred in the container plants. In addition, there was a distinct trend that plants taken out during the warmer weather have better establishment success. This ranged from 89.1% in the Ground Nursery (planted December 1994) through 98.8% in the Highway slopes (planted January 1995) to 99.3% in the Almond Plot Trial (planted April 1995). Therefore, it would appear that plants should not be taken out too early. In addition to better establishment success, the plants would be easier to irrigate and maintain in the container nursery. Based on this first set of results, it appears that the best time to take out container plants may be in the spring months of March / April. However, this gain in ease of management and less water

usage must be weighted against the advantage of winter planting with its least competition for labour; spring planting is normal for the main crops.

Growth and Biomass Production A most interesting field observation was that the plants in the boundary rows were smaller than those in the central rows and showed more stress symptoms. This occurred in all 5 ground nursery blocks and in the 2 Highway slope blocks. This is different from observations noted in the tropics where the central rows consistently performed poorer because of the shade sensitivity of Vetiver. This new observation may be due to the high solar intensity and the long sunlight hours during the growth period of May - September 1995 and the negative stress effect of low relative humidity. If so, moisture and water stress have become a stronger limiting factor when compared with light effect. Due to the growth pattern, biomass determination of the tops were not done until the plants have gone through some months of the active growth period. Active growth of plants in ground nurseries started in May 1995 in El Chopillo, but commenced in June / July in Lorca. This difference was most likely due to the different times of planting. Though the El Chopillo plants were damaged by winter frost, they already had an established root - system, and plant growth can take off faster. On the other hand, plants in the ground nursery in Lorca were only transplanted to the ground just before the winter 1994-5 and the plants will take time to establish first. Harvesting of plant tops in El Chopillo produced 1030 gm and 1388 gm per plant after 14 and 15 months respectively. For the same 2 periods, the number of tillers per plant were 55 and 67 respectively. In reality, as the tops of plants were killed during the frost of winter 1994-5, this biomass production was over a growth period of 5 and 6 months. These values were high and showed good growth of the Vetiver plants.

In the ground nursery in Lorca, the Malaysian Accession produced 45 and 47 tillers after 9 and 10 months growth respectively. Over the same periods the dry matter were 305 gm and 489 gm per plant respectively. The American Accession yielded 377 gm with 79 tillers and 560 gm with 65 tillers after 9 and 10 months respectively. After deducting for establishment time, the growth periods were only 4 and 5 months. It would appear that the American Accession was more vigorous than the Malaysian Accession but it must be noted that the trials were not designed for such comparisons; also the plants were rather variable as there were no stringent selection of container plants used for field planting.

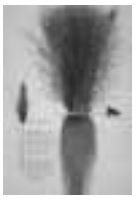
In both El Chopillo and Lorca, the cut tops regenerated rapidly confirming the good growth of Vetiver grass m autumn. Whether the impressive growth during the growing seasons is sufficient to compensate for negligible growth during the dormant and sustenance seasons to give good annual biomass production, will be the subject of future investigation.

The good growth of Vetiver grass and the rapid regeneration of cut tops point to potentially abundant in-site mulch to improve the main crops; this will be tested in the almond plots. Also the toppings may be considered for fuel, fodder, animal bedding, etc. The fast establishment of quality VGHR could be used to prevent surface soil erosion, as was clearly demonstrated in the observation trial on Highway Slopes.

Root System And The Need For Irrigation. Excavation to study the root systems showed that the roots of the plants in El Chopillo had reached a depth of 2.6 metres after 14 months in the field. In Lorca, the Malaysian Accession and the American Accession had produced roots reaching down to 2.1 metres and 1.7 metres respectively after only 9 months. However, m all 3 cases the massive root system was at the top 0.4 - 0.5 metres. The root Systems observed were not inferior to the condition experienced in Malaysia. In this project, there was an attempt to grow Vetiver grass in the Mediterranean climate of Murcia. Vetiver grass originated mainly from the humid tropics and it will therefore be most challenging to try to establish it in such an alien and hostile aerial conditions. For the first Phase of the project, Vetiver grass was irrigated to allow it to have a better chance of establishment so that its growth performance may be studied. However, irrigation is expensive and m certain locations, water may not be readily available. The ultimate economic success may ultimately be determined by its tolerance to water stress.

With the good root system produced, the plants may be able to tap into the sub-soil moisture during drought and that VGHR, once established, may be tolerant of dry weather conditions. This is a very important speculation as the need for continued irrigation may make VGHR not economically viable. Therefore, more experience is needed in order to confirm this key aspect of the project. Phase II Trials will be targeted to achieve this objective.

Plant Response to Climatic Conditions. Since there is no easy nor economical way to modify the temperature in the field, we decided, in Phase I of the project, to concentrate on studying its effect on the establishment and growth of Vetiver plants. The responses of the plant to the seasonal weather conditions showed very interesting results. With plants established in the ground in El Chopillo, frost killed the tops but the crown-portions were not injured. With the coming of the warmer weather, new tillers were formed. In the Container Trial in Lorca, the cold winter killed the matured tillers but not the newly emerged ones. This recovery from cold damage was not surprising as the Vetiver Newsletter had carried such



observations made in China, U.S.A., South Africa, Zimbabwe, etc. The plants in El Chopillo recovered from frost injury and cold weather much faster and produced tillers earlier than the plants in Lorca. The main reason may be, that the plants in El Chopillo were well established with a good root system while the plants in Lorca were being established in the field or were in containers exposed to the aerial environment. The depth of root in the warmer ground could be of importance in the plant's tolerance to cold as well as water stress. These observations, documented by serial photos, suggest that there seem to be distinct plant performance periods (at least under irrigation) viz.

- Frost injury and dormancy
- Awakening and tillering (regeneration or multiplication)
- Rapid growth and biomass production
- Slow growth or sustenance period.

The last period need to be verified during the coming 1995 - 6 late August to early winter months. If these observations were correct, the tropical to subtropical Vetiver Grass is behaving more like a temperate plant, adapting to the prevailing climatic conditions. This adds on to the documented great range of adaptabilites of Vetiver Grass, a very unusual plant indeed. It also points to the possibility of using VGHR in the Mediterranean regions as well as up in the cold highlands of the tropics and sub-tropics.

GHANA

Adaptive Research Collaborative Programs.

Linus Folly *- CEDIA, Ghana*

An adaptive research package is being worked out between CEDIA and the National Agricultural Research Project (N.A.R.P.) of the Council for Scientific and Industrial Research (C.S.I.R.) on vetiver grass in the area of Research and Development covering among others:

- collection of clones;comparative study and germplasm analysis;
- classification of ecotypes to march soil types and agroecological zones;
- selection of suitable genotypes for development, multiplication and propagation;
- research on pest, entomological and other related issues;
- setting-up of a data base ...

Another collaborative package on the drawing board is a Training, Application and On-Farm Trials program between CEDIA and the Department of Agricultural Extension Services (D.A.E.S.) of the Ministry of Food and Agriculture.

The Land and Water Management Unit of the Crops Services Department (C.S.D.) of the same ministry has also shown interest to include the use of vetiver grass in the syllabus for its training programs.

Other departments such as Irrigation Development Authority; Animal Production; and Fisheries Department are all targets of the package. Sectors like mining; roads and highways; land and forestry; environment, science and technology are becoming abreast with vetiver grass. Mining companies, such as Bogosu Billinton and Teberebie goldfields, are showing among others good examples of how to rehabilitate mine spoils, slime dumps and to restore vast areas of land with vetiver grass.

The last component of this package is the projected collaborative program between CEDIA and the Department of Parks and Gardens. This department had already given CEDIA a substantial quantity of polybags for the multiplication of vetiver slips on trial basis.

It is worthy to know that the binary section of Ghana Atomic Energy Commission (G.A.E.C.) has both the human and the technical capacity to produce the requisite quantity of vetiver slips by tissue culture production and multiplication techniques for CEDIA whenever a comprehensive agreement is reached between the two parties.

USA

Streamside Buffer Strips Improve Water Quality and Provide Wildlife Habitat

Richard Schultz *Iowa State University. USA*

Bountiful production of corn and soybeans can cause pollution of streams and groundwater. Along many miles of Iowa streams, row crops are grown down to the stream edge or cattle are grazed in narrow bands of land that include the stream and its flood plain. Before European settlement, Iowa had many more miles of streams that carried cleaner water than today. Floodplain forests, prairies, and wetlands along the streams regulated water flow and quality and provided wildlife habitat. As these plant communities were cleared and laid fallow for part of each year, and as many fields were tiled and stream channels were straightened, large amounts of soil and chemicals were carried to the streams. Streams carried more water after rains, which collapsed streambanks and caused them to erode deeper into the landscape.

Concerns about water quality and an interest in reestablishing forests, prairies, and wetlands in Iowa and the Midwest led the Iowa State Agroforestry Research Team (IStART) and the Agroecology Issue Team of the

Leopold Center for Sustainable Agriculture to develop a streamside management system. The multispecies system uses trees, shrubs, and prairie plants as a buffer strip along a stream. The basic model consists of four rows of trees planted along the stream edge, followed by two rows of shrubs and then a strip of prairie plants planted along the edge of the crop field. This plant community provides a frictional surface that "stops" surface erosion and causes most of the nitrate contained in the tile water. Microbes attached to sediments and decaying plant material use the nitrate molecule in place of oxygen to provide them air to "breathe" while releasing harmless nitrogen gas into the atmosphere.

The streamside management system, in concert with upland water and chemicals to soak into a "living filter" made up of soil, plant roots, microbes, and soil animals. Water moving through this filter is cleaned and slowly released to the stream channel. Many variations of this model, with widths from 50 to 100 feet, can be planted depending on the landscape features and landowner objectives. The rich soil along the stream edge can support many species of trees, shrubs, and prairie plants. The key is to get this plant community rapidly established. To accomplish this, fast-growing trees such as willow, poplar hybrids, and silver maple are usually planted in the two rows closest to the stream. The other rows may consist of fine hardwoods such as black walnut, oaks, and ash. Many species of shrubs can be planted to diversify the habitat for wildlife. This system has been shown to reduce chemicals and surface erosion by as much as 80%. Four times more bird species use this system than use the straightened streams where corn and beans are grown to the edge. If planted as a short-rotation woody crop or biomass energy system, all of the woody rows can be planted with tree species such as willow, poplar hybrids, or silver maple. The switchgrass strip provides an herbaceous energy crop. Another important component of this system is the use of willows and certain shrubs to stabilize the streambanks themselves. As much as 50-60% of the sediment carried in streams can come from the collapse of streambanks. Woody tree and shrub species that are able to produce roots from stem segments are pounded or pushed into the conservation practices such as minimum tillage, grass waterways, and terracing, can effectively reduce pollution produced by agriculture. At the same time it can provide diversified products for the landowner and a diverse habitat for improved wildlife and aesthetics. Native trees and shrubs together with prairie ....streambank, where they hold the soil in place once they have rooted and grown tops. The amount of work needed to assure success of this procedure depends on the height and shape of the streambank. Where streambanks are less than four feet high, it is possible to simply push or pound two rows of willow posts, large cuttings up to 4-5 feet long, along the bottom of the bank. Higher up the bank, smaller cuttings are pushed into the bank. If the banks are 4-10 feet in height, the toe of the bank must be specially stabilized with rock or red cedars to reduce the chance of undercutting and collapse of the streambank. Willow posts and cuttings are planted between the cedars or rock. Where vertical streambanks are 10 feet or more in height, equipment is used to produce a gentler slope (2:1). Grass may be seeded and a fiber mat staked down before the willow and shrubs are planted. In this case, stabilizing the toe of the bank with cedars or rock is even more important. These streambank bioengineering techniques can effectively stop erosion along critical streambanks and protect such structures as bridges, buildings, and fences that may be threatened by channel erosion.

The last component of the streamside management system is a small constructed wetland built within the buffer strip where a field tiledrains into the stream. A shallow depression, no deeper than 2 feet at the center, is excavated and planted with cattails, bulrushes, and other wetland plants. Such wetlands, when properly designed and maintained, can remove plants can help improve water quality and protect the long-term sustainability of Iowa and Midwestern farmland.

(in "warm winter" areas of the US vetiver coul;d be easily worked into such systems and would be very effective ... Ed).

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AQUACULTURE SLUDGE REMOVAL AND STABILIZATION WITHIN CREATED WETLANDS

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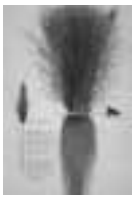
Introduction Removal of solids or nutrients from the effluents of fish farms is often required because of priority and regulations given to minimizing the effect of the discharge on the environment (Ewart et al., 1995). Aquaculture systems offen have two separate discharges, and solids and/or nutrients in both, if left untreated, can have a negative affect upon receiving waters. When systems have two separate discharges, the effluent of largest volume usually contains comparatively low levels of solids and



nutrients, particularly nitrogen and phosphorous. A second effluent, generated during clarifier backwash, is comparatively small but contalns high levels of concentrated organic solids. The settleable fraction of solids are often removed with settling basins to produce a siudge that is about *5%* solids. Many states in the US classify and regulate aquaculture sludge as an industrial or municipal waste, because the sludge is a residual product of wastewater treatment; however, other states consider the sludge to be an agricultural waste, because it is composed of manure and uneaten feed and is thus considered to be a non-toxic nutrient source (Ewart et al., 1995).

Aquaculture effluents such as these, however, do not have to be considered liabilities, because these effluents can be used as inputs for production of other products and used to improve overall facility sustainability. To better achieve sustalnability in aquaculture, *The Conservation Fund's Freshwater Institute* has been working with the *USDA/ARS Appalachian Fruit Research Station* on a project titled, "Aquaculture Linked to Plant Culture: Products and Processes." Research has been focused on developing technology to treat nutrients or biosolids in aquaculture effluents while producing other valuable products such as high-value fruits and vegetables (Adler et al.,1996 a; b; in press a), grass turf (Adler et al., in press b), and organic composts (Adler et al.,1996b). Although reuse of effluent streams is always worth considering, it is sometimes difficult to develop the technologies and markets required to support reuse as a form of effluent treatment.

The two most common methods used to recycle solid wastes from aquaculture facilities are land application and composting (Ewart et al., 1995). According to Ewart et al. (1995), land application of manure and other organic wastes (including wastewater) to fertilize agricultural crops is governed in most states by guidelines or regulations that limit the amount of pathogens, heavy metals, and other contaminants and the land application rates. In particular, application rates are based upon nutrient content, soil type, and plant nutrient uptake characteristics to prevent runoff or groundwater contamination (Chen et al., 1991; Ewart et al., 1995). Odor problems can also limit land application in populated areas. Sludge transport from the facility to another point of disposal or reuse is a major factor in the costs of sludge management, because the thickened sludge is greater than 90% water (Black and Veatch, 1995; Reed et al. 1995).

Depending on an aquaculture facility's location and the local regulations, an aquaculture facility may have only limited and costly options avallable for sludge disposal. If land application is not available adjacent to the facility, on site treatment of the concentrated solids discharge with an uncomplicated, low-maintenance plant-based system could reduce solids disposal costs (Outwater, 1994).

Created horizontal flow wetland (HFW; i.e., overland flow wetland) systems have been used with some success to treat high-strength aquacultural wastewaters (Pardue et al., 1994) and other agricultural, municipal, or industrial wastewaters (reviewed by Reed et al. [1995]). HFW systems are usually operated with a hydroperiod to produce cycles of inundation and dewatering. However, HFW systems typically are not loaded with thickened sludges.

On the other hand, constructed vertical-flow wetland (VFW) systems have been used, over the past 20 years to treat thickened sludge (1-7% solids) produced in the clarifier undefflow at wastewater treatment plants (Hofmann, 1990; Lienard et al., 1990; Nielson, 1990, 1993; Riggle, 1991; Outwater, 1994; Reed et al., 1995). VFW wetlands are generally referred to as "reed beds" because they are often planted with reeds. When used for municipal treatment, these wetlands are loaded with 7-10 cm of 2% solids approximately once every 7-21 days (about 30-60 kg/m2/yr). During operation, a series of vegetated beds receives sequential batch applications of sludge. The sequential batch applications are such that the more recently flooded VEW cells are dewatering, wffile beds with older sludge applications are drying. Intervals between sludge addition allow for dewatering and drying. Plants facilitate dewatering by conducting water along their stem and root paths through previous sludge layers and by removing water through evapotranspiration (Outwater, 1994; Reed et al., 1995). The plants also increase biological stabilization of the solids by transporting oxygen to their root zones. Reed bed treatment system have been reported to have a useful lifetime of up to 10 years (Outwater, 1994; Reed et al., 1995).

Aquaculture sludges are good candidates for use in both crop or created wetland. However, if transportation costs make sludge disposal on crop land uneconomical, disposing of the sludge on-site within created wetlands might be the next best alternative. The objectives of the work reported in this paper were to investigate disposal and treatment within created wetlands of an aquaculture sludge produced during clarifier-back-wash. This research focused on the variables controlling capture and stabilization of solids within created wetland systems. Solids removal and stabilization were investigated within two types of created wetlands where water flowed either: (1) vertically, down through a porous substrate; or (2) horizontally, over soil and through hedges. These two wetland types differed in both physical characteristics and in hydraulic distribution and collection.

Both created wetlands types were planted with vetiver grass *(Vetiveria zizanioides).* Vetiver grass was selected

because it is tolerant of a wide range of environmental conditions, and has been proven to control soil erosion throughout the world (Becker, 1992) when planted as narrow hedges, the dense vetiver shoots act as a filter, allowing water to pass through while holding soil back to settle by gravity, thereby preventing erosion.

Vetiver also has an extensive and deeply growing root system that would help malntains the bed's hydraulic conductivity and contribute to oxygen transport into the bed.

Methods Sludge used in these studies was collected from the recirculating trout-production system at the Freshwater Institute (Heinen et al., 1996). Sludge originated from the clarifier backwash and was collected and thickened to about 5% solids in a septic tank before it was pumped to the greenhouse where the wetland cells were located. However, the manner in which the sludge was collected and pumped from the septic tank to the equalization tank within the greenhouse diluted the sludge to about 0.75% dry solids by weight. Sludge pumped from the equalization tank was thoroughly mixed before it was applied to the wetland cells. Solids loading onto both horizontal and vertical wetland types was about 30 kg/m/yr. About 60 l of sludge was applied 6 times daily per wetland cell, approximately evety day from May 12, 1995, until February 18, 1996. No draln and dry period was provided for either type of wetland. However, on three occasions, flow to the HFW cells had to be discontinued for several days to prevent water levels from over-flowing the vessels. Flow rates to each wetland were checked three times per week. Occasionally, a plugged distribution pipe kept sludge from being applied to a given wetland cell.

Six 3.7 x 1.2 x 0.8 m (L x W x H) wetland cells were used to provide three replicates for both types of vetiver beds.

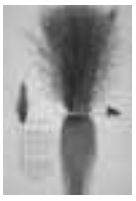
The VFW cells (Figure 1) are sand drying beds planted with vegetation. The VFW cells consisted of a 10-cm layer of sand and three layers of increasingly larger gravel to support the sand over a flow collection pipe (Figure 1), based on criteria provided by Cooper (1993). Sludge was distributed across the top of each VFW cell through a 2.5-cm inside diameter pipe (Figure 1). Solids were trapped on and within the sand as the flow passes vertically through the bed. A 7.5-cm inside diameter drainage pipe at the bottom of the bed collected and carried the flow from each VFW cell. Each VFW cell sloped 2% down to the point where the draln pipe exited the tank. Vetiver tillers were planted at about 15-cm intervals across the entire top of each VFW cell.

The HFW cells (Figure 2) were designed to have the flow travel overland, passing horizontally along the tank's long axis, from one narrow end of the cell to the other. The HFW cells were loaded to a depth of 51 cm with a local topsoil. Rooted vetiver shoots were planted close agalnst each other in three 35-cm wide rows; each row was oriented perpendicular to the long axis of the vessel, and each row was about 61 cm apart (Figure 2). About the same number of vetiver tillers were planted in a HFW cell as in a VFW cell. Sludge was distributed at the upper end of the tank onto a brick to disperse the energy of the flow. The flow passed through the vetiver hedges in the process of traveling from one end of the wetland to the other (Figure 2). The dense shoots of mature vetiver hedges were expected to enhance solids removal by straining and settling. After passing horizontally through the wetland cell, the flow was collected in a perforated draln pipe placed at the end of the cell's long axis and buried under sand and three supporting layers of gravel. Each HFW cell sloped 2% down to the point where the drain pipe exits the tank.

Data was collected on influent and effluent concentrations of total suspended solids (TSS), total volatile solids (TVS), total and dissolved chemical oxygen demand (COD), nitrate, dissolved phosphate, total nitrogen, and total phosphorus. Data was collected on 11 separate weeks from June through February. TSS and TVS were measured using standard methods (APHA, 1989). Total and dissolved COD were measured using a Hach spectrophotometer test kit (Loveland, Colorado). In water samples, nitrate and phosphate were quantified by ion chromatography (APHA, 1989) as described by Adler et al. (in press b). After chemical digestion, total kjeldahl nitrogen (TKN) and total phosphorus were determined by ion chromatography as described by Adier et al. (in press b).

Sludge depths and sludge samples were also taken from each wetland at the end of the 1-yr study and were analyzed for percent volatile solids.

Results And Discussion Results indicated that sludge removal and stabilization occurred within both wetland types (Tables 1 and 2). The VFW and HFW cells, respectively, removed 98 and 96% TSS, 91 and 72% total COD, and 81 and 30% dissolved COD (Table 2). Because little dissolved COD was expected to be removed by physical mechanisms, the increased removal of dissolved COD within the VFW cells was likely due to better anaerobic digestion occurring within the sand and gravel layers of the VFW cells. Both wetland types removed most, 82-93%, of the dissolved phosphate, total kjeldahl nitrogen, and total phosphorus (Tables 3 and 4). Nitrate was produced in both wetland types; however, there was much more nitrate in the effluent from the VFW cells than from the HFW cells (Table 3). Particulate phosphorus were the major form phosphorus in the treated effluent from both wetland types (Table 3). Nitrate was the major form of nitrogen leaving the VFW cells (Table 3).



Nitrate production (Tables 3 and 4) indicates that there was some aerobic bacterial activity (e.g., nitrification) in both types of wetland cells. Although the saturated regions of both VFW and HFW cells were mostly anaerobic, localized aerobic conditions may have been created within wetlands through either root transport of oxygen or by aeration of the flow as it trickied through the gravel-support layers within the vertical flow wetlands. The lower gravel layers were not saturated with water due to the large void spaces between large pieces of gravel. However, much more nitrate was produced in the VFW cells than in the HEW cells, probably because oxygen was transferred from the atmosphere as the flow trickled through the aerated gravel-support layers. Denitrification probably accounted for the removal of some nitrate from both wetland types, but the low level of nitrate in the effluent from the HFW cells may have been due to both insufficient oxygen transfer for nitrification, and to anaerobic conditions that

Table 1. Mean (±standard error) concentrations of TSS, TVS, percent volatile solids, total COD, and dissolved COD fed to and within the effluent of two wetland cell types.

Wetland type	TSS (mg/L)	TVS (mg/L)	Volatile solids (%)	Total COD (mg/L)	Dissolved COD (mg/L)
Influent	7,860±1849	6,204±362	82.8±1.6	6,855±125l2,	173±110
Effluent					
Vertical flow	156±29	93.3±14.4	572±2.3	539±134	419±68
Horizontal flow	229±30	147.51±17.9	65.l±1.5	1,761±289	1,486±136

Table 2. Mean (± standard error) percent TSS, TVS, percent volatile solids, total COD, and dissolved COD removed across two types of wetland cells.

Wetland type	TSS	TVS	Volatile solids	Total COD	Dissolved COD
Vertical flow	97.2±0.8	98.0±0.4	3041±3.6	91.3±1.9	81.0±3.0
Horizontal fiow	95.8±0.9	96.8±0.6	21.1±2.7	71.9±4.2	297±7.6

Table 3. Mean (± standard error) concentrations of nitrate, phosphate, phosphorus fed to and within the effluent of two wetland cell types,total kjeldahl nitrogen, and total kjeldahl phosphorous fed to and within the effluent of two wetland cell types.

Wetland type	Nitrate (mg/L as N)	Phosphate (mg/L as P)	Total kjeldahl nitrogen (mg/L as N)	Total phosphorus (mg/L as P)
Influent	0.057±0.009	1061±7	234±20	238±19
Vertical flow	4541±8.7	7.07±1.38	269±3.5	309±3.2
Horizontal flow	0.381±0.14	8.96± 1.72	32.5±28	422±3.4

*only a few data points were avallable.

Table 4. Percent increase of dissolved nitrate and percent removal of dissolved phosphate, total kjeldahl nitrogen, and total phosphorus across two types of wetland cells.

Wetland type	Net nitrate production	Phosphate removal	Total kjeldahl nitrogen removal	Total phosphorus removal
Verticalfiow	80,000	93	89	90
Horizontal flow	570	92	86	82

caused rapid denitrification of nitrate when it was produced.

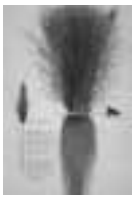
At the end of the study, depths of accumulated sludge in each wetland averaged 11 and 8.1 cm in the VFW and HFW cells, respectively. Although the density of the accumulated sludge was not measured directly, the sludge that accumulated within the VFW cells was less dense than the sludge that accumulated within the HFW cells due to the presence of large voids (air pockets) within the sludge from the VFW cells. Additionally, these sludges contained an average of 43 and 37% volatile solids, respectively. In comparison, the fraction of volatile solids in the sludge that was treated was about 83% volatile (Table 1), and it was 57 - 65% volatile in the treated wetland effluents (Table 2). Therefore, considerable mineralization occurred in the accumulated sludge.

Resistance to water flow through the wetland cells was greater within the HFW cells than in the VFW cells, as indicated by deeper water ponded above the HFW surface (on average 12-18 cm deep) than above the VFW surface (on average 5-12 cm deep). Additionally, we suspect that most of the water flowed horizontally above the soil and across the HFW cells and then filtered through the sand layer covering the collection pipe at the end of the cell. The distance the sludge had to flow horizontally and the thickness and number of hedges in the HFW cells were probably inadequate to physically remove most of the solids. These conclusions were supported by observations of the vetiver hedges and the sludge distribution across the top of the HFW cells at the end of the experiment, which indicated that the three hedges planted across each HFW cell did not develop stem and root masses thick enough to trap most of the solids. Performance may have been enhanced by allowing hedges to thicken more before application of sludge began. Therefore, we think that the similar and favorable particulate removal found in both the HFW and VFW cells were largely due to the sand layers that cover the effluent collection pipes within each wetland cell.

In this research, solids were loaded onto both horizontal- and vertical-flow wetland cells semi-continuously at a rate of 30 kg/m2/yr. Sludge was loaded on the wetland cells at about the same rate as others have recommended for wetland drying beds (Hofmann, 1990; Lienard et al., 1990; Nielson, 1990, 1993; Riggle, 1991; Outwater, 1994; Reed et al., 1995); however, sludge used in this experiment was relatively dilute (0.75% dry solids) when compared to the thickened sludges (1-7%) these same others reported. Additionally, the semi-continuous application of sludge in this experiment meant that only a small volume of sludge was distributed at any given application. Over a two-week period, the more dilute sludge concentrations applied (i.e., higher water content) resulted in a higher hydraulic loading rate than others generally applied to VFW cells (Outwater, 1994; Reed et al., 1995). After the first few weeks of operation, the hydraulic loading used in this experiment always maintalned a flooded condition. Maintaining surface flooded conditions was our original intent when we selected semi-continuous applications. We expected that, when flooded, the sand layer of the VFW and the soil within the HFW would make effective anaerobic filters, which proved true. This hydraulic loading strategy was contrary to conventional wisdom, as others have recommended altemating flooding and drying intervals to enhance plant growth and sludge stabilization by air- and photo-oxidation (Hofmann, 1990; Lienard et al., 1990; Nielson, 1990, 1993; Riggle, 1991; Outwater, 1994; Reed et al., 1995). It is generally held that an aerobic environment helps to minimize odors, breaks down organic matter more rapidly, and makes phosphorus less susceptible to leaching than would anaerobic conditions. However, it is also generally believed that an anaerobic environment stabilizes sludge to its minimum solids mass and requires less energy (e.g., trickling filter height, blower/aerator power) than an aerobic environment. Additionally, this study showed that the the anaerobic-sand filter proved effective at removing dissolved organic molecules.

At the conclusion of the experiment, root growth was observed when all material was removed from the wetland vessels. Root growth was thick below the vetiver all the way to the base of the 51 cm sand and gravel or soil media. Roots had even grown into the bottom drain pipes and had surrounded the bottom layers of large gravel suffiently to make manual gravel removal much more difficult.

Vegetation played an important role in dewatering the sludge, as evapotranspiration accounted for 12-20% of the water balance across both types of wetland cells during the summer months as others have also reported (Outwater, 1994; Reed et al., 1995). Plant growth was vigorous from spring until fall, when all but the base 20-25 cm of plant stem was cut and removed from all wetland cells. Much of the vegetation senesced through the winter, but shoot growth was occuring in portions of the wetlands by the end of February, 1996, when the experiment was terminated. It was apparant from the pattern of uneven shoot growth that occured in all three VFW cells, however, that some factor had limited plant revegetation within the lower third of each HFW cell. There was a total lack of vegetation in these regions. It is uncertain why revegetation did not occur in the lower regions of the VEW cells. However, because both the sand surface and the vessel base of each wetland cell had been sloped 2% down to the drain, an additional *5* cm of ponded sludge (when flooded) had accumulated at the lower end of each cell. It is possible that the additional sludge, along with the continuous



anaerobic digestion, ammonia production, and flooded conditions were critical factors that limited revegetation in the lower regions of the VFW cells. Therefore, in future studies we hope to investigate the impact of hydroperiod on revegetation and solids removal and stabilization within created wetlands.

(References not included due to space constraint. Please contact authors for full paper..Ed)

Vetiver Identification Program: General Information and Research Update

The Vetiver Identification Program is a plan to investigate the botany and genetics of vetiver. Research is carried out by independent scientists using their own funds; The Vetiver Network helps facilitate the flow of information. The Vetiver Identification Program is coordinated on a volunteer basis by Mark Dafforn, a professional staff member of the U.S. National Academy of Sciences who was research associate for their 1993 report, Vetiver Grass: A Thin Green Line Against Erosion.

Currently, scientists are investigating vetiver taxonomy, DNA, and oil chemistry in an attempt to make sense of what we see in the field. Other topics will be included as the opportunities arise. The knowledge to be gained from such research is a foundation for everything we do with the grass. Many questions remain about genetic relationships, biogeography, diversity, and similar topics. We cannot dependably document physiology, adaptability, pest or plague resistance, hedge formation, and similar characteristics without knowing what vetiver we are using. Initial observations from DNA research, described below, give a good example of the usefulness of this type of information.

Following the Summary is more detailed information on Vetiver Accession Forms, Taxonomic Research, DNA Research, and Oil Research. Each section is divided into Background and Importance, Status, Results, and What You Can Do to Help. As more results from the Vetiver Identification Program become available, they will be posted on the World Wide Web at www.vetiver.org and summarized in the next Vetiver Newsletter.

Summary

About 50 vetiver users have provided Vetiver Accession Forms. These are currently being compiled by the Vetiver Identification Program into a database from which it is already obvious that rooting depth varies enormously (is this genetic?) and that some vetivers die back after seed maturity. Other patterns are emerging but more Accession Forms are needed!

Taxonomic studies of the genus Vetiveria are underway at the Rijksherbarium in Leiden, The Netherlands. This involves examining a large number of plant specimens that are currently kept in herbaria scattered around the world, so it will be some time before results are published. It seems likely that there will be revisions in what is considered a member of the genus, but that *Vetiveria zizanioides* will remain a valid species.

Over a hundred vetiver users responded to the call for DNA samples. One group of specimens was tested in May and a second will be done in December, after which all results will be analyzed and published. Even without analysis it is clear that earlier distinctions between wild, seedy vetiver and essential-oil vetiver hold true. However, it was a surprise that almost all vetiver specimens from outside South Asia proved to be exactly the same clone. Accession records show that two of these have been on separate continents at least 60 years. Full analyses should be ready in time for the next Vetiver Newsletter; if you supplied a DNA sample but did not complete a Vetiver Accession Form, please use the blank one in this Newsletter!

It is hoped that oil chemistry can be used to separate different types of vetiver and perhaps to help unravel its history. These efforts are just getting underway, but researchers will be able to draw upon an enormous amount of previous industrial work on vetiver oil.

Vetiver Accession Forms

Background and Importance: Record keeping is as important with plants as it is with livestock and banking. It is important for vetiver users to maintain basic collection, ecological, and descriptive information about their genotypes. This is useful not only for their own records, but The Vetiver Identification Program can use these forms when analyzing taxonomic, genetic, and chemical tests. In fact, the key interpretive data for our program comes from the Vetiver Accession Form. In the future, we hope to be able to find obvious morphological characteristics that will allow users to easily identify the kind of vetiver they are using.

Status: We are still in the data-collection phase, and relay upon your cooperation. We do not yet have enough Forms or data to perform statistical analyses, but DNA results should show correlations with some physical characteristics.

Results: One unexpected variable has already shown up. Many users report that vetiver foliage dies back at seed maturity; many users report that it does not. This may be environmental or genetic or meaningless, but it could be an important agronomic factor. Rooting depth also varies widely (from .8 to 6 meters), as does leaf width, erectness, and several other characteristics.

What You Can Do to Help: If you are a vetiver user, begin record keeping today (a blank form is in this Vetiver Newsletter). Whenever you make a new observation about your vetiver,

update your form. If a category does not exist, create one. And please, share copies and updates of your form with The Vetiver Network.

Any information on the history of your material would be very helpful.

Please also pay close attention for foliage die-back at or after flowering or seed maturity. Does any nonfertile vetiver die back at or after flowering?

Do nonfertile clones drop their "seed" upon maturity?!

If any characteristic you think is important does not appear on the Vetiver Accession Form, please let us know.

Taxonomic Research

Background and Importance: *Vetiveria zizanioides* is now used throughout the tropics for erosion control. In South Asia, several native vetiver species are grown in hedges; in Africa, the indigenous *Vetiveria nigritana* is sometimes used. Even in these regions, however, *Vetiveria zizanioides* is the most commonly used species. Almost everywhere, these vetivers have been collected from gardens or the wild. It is crucial to be able to compare the physical and environmental characteristics of these plants with their botanical identity. Years have been spent accomplishing this with other grasses such as rice, wheat, and maize.

Most members of The Vetiver Network know there are two general types of *Vetiveria zizanioides:* a cultivated type (traditionally used for essential-oil production) that is vegetatively propagated, and a wild seedy type. The cultivated type is dense, erect, and has deep roots. It is the most desirable hedge grass of all; that's why there is a Vetiver Network! The wild seedy type is more open and lank, so it is less useful for erosion control. It also could colonize outside its native range. It is especially important to develop ways to distinguish these different types of vetiver.

The most recent taxonomic examination of the genus Vetiveria was by Eduard Hackel in 1889 (Hackel, E. 1889. Monographia andropogonearum, in A. de Candolle, Monogr. Pl. 6:1-716). Hackel was revising the Andropogoneae, the grass Tribe to which vetiver belongs. He agreed with many taxonomists before and since that the genus itself merited more detailed attention: its boundaries are unclear and delineation of its species is confused.

There are, however, far more species of plants in the world than there are botanists, so they have not been able to pursue every interesting scientific path. Since the source of vetiver roots and oil is usually elite cultivars of *Vetiveria zizanioides*, until now there has been no reason for botanists to spend their time scrutinizing the entire genus. But thanks to members of The Vetiver Network, the plant is now taking on far greater importance: understanding vetiver now has economic as well as scientific significance.

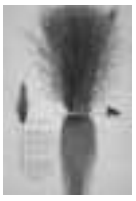
Status: J.F. Veldkamp, in collaboration with other botanists and institutions, is currently examining the genus Vetiveria using classical (morphological) taxonomic techniques. He is a botanist at the Rijksherbarium in Leiden, Holland and works with their Flora Malesiana, a long-term project begun by Cornelis Steenis in the 1940s. The Flora's goal is to document plants in Indonesia, Malaysia, the Philippines, Papua New Guinea, Singapore and Brunei Darussalam.

Plant biogeography and phylogenetic analysis are a focal point for Rijksherbarium research (taxonomy classifies plants and animals into groups; phylogeny attempts to ensure these groupings reflect evolutionary history). Dr. Veldkamp is the Flora Malesiana author for grasses, which are currently under revision for the project. Malesia is a region of diversity for the genus Vetiveria (it contains many of the currently recognized species), so part of Dr. Veldkamp's work involves documenting what has been studied before and what remains unknown about vetiver taxonomy.

Results: It will be some time before analyses are complete, but it is interesting to note that Dr. Veldkamp is examining some vetiver specimens that have not been looked at for nearly two hundred years, as well as some that have never been examined. He also believes that much valuable information is contained in older classifications (*Vetiveria zizanioides* itself has been listed under at least five different genera and a dozen different names [*Editor note: Dr. Veldkamp now reports 8 genera and 17 names!*]). Earlier authors felt some species of Vetiveria might belong in Chrysopogon, and that some other Vetiveria species should be recombined into different groupings.

Generically JeF Veldkamp believes he can clarify the close relationships between Vetiveria and its sister genus Chrysopogon; specifically he hopes to better delineate our familiar old domesticated essential-oil (hedge) vetiver, *Vetiveria zizanioides*. The Vetiver Identification Program will report results as they become available.

What You Can Do to Help: Please contact The Vetiver Network if you would like to collect voucher specimens for this study. Dr. Veldkamp would particularly like to examine variation in the Malesia region (see above), as well as Southeast Asia (Vietnam, Cambodia, Laos, Thailand, and Burma). Especially needed are botanical vouchers (and Vetiver Accession Forms) for naturally occurring nemoralis from the Southeast Asian mainland.



DNA Research

Background and Importance: DNA is a very simple molecule that performs a very complex op-

eration: its chemical code controls the functioning of life. That code is different in every living thing that reproduces sexually, and it is what confers the genetic nature of an organism ... in a plant these are things such as disease resistance, cold tolerance, and flower color. The code is carried by only four different chemicals, but the four appear in molecular strands that can contain millions of sequences of code. A fundamental belief in biology is that the more similar these sequences, the more closely related the organism. Humans and plants share less than 50% of their DNA; humans and chimpanzees share about 95%; you and I share more than 99%, you and an identical twin would share 100% of your DNA sequences.

The ability to compare the similarity of DNA samples is one of the most powerful tools to arise from biotechnology. Several different techniques have been developed to analysis DNA but, generally, they do one of four things: 1) they can tell whether a certain piece of DNA is in a sample, 2) what its code is, 3) physically where that piece is on the gene, or 4) what it does. In time, The Vetiver Network hopes that each type of analysis will be performed for many different characteristics on many different vetivers, but most of these techniques are still in the developmental stages. Many are quite expensive and scientists are only now learning how to read the results; such research has scarcely begun in rice and rats, much less vetiver.

One of these techniques has been used on vetiver. Called RAPD analysis, (pronounced “rapid”, for Randomly Amplified Polymorphic DNA), random chunks of specific DNA code a few hundred sequences long are chemically multiplied until there is enough of it to be measured. It is a yes/no test; either that specific sequence exists in a sample, or it doesn’t. By running RAPDs from different samples on several different sequences of DNA, scientists can run a number of statistical analyses to get a good measure of relatedness. RAPDs have been run on organisms from many different kingdoms — bacteria, fungi, plants, animals — so there is a general idea of how much variation exists in life.

Almost everyone using vetiver in hedges is using plants found locally. Unless we propagated the plants ourselves, we did not know if two plants growing side by side were identical or different. By using RAPD DNA analysis, we can measure the variation in our planting materials, ensure we maintain as many different types of vetiver as possible, and — most important — combine our knowledge for plants that prove to be genetically the same, even if they were collected in different places.

Status: Two series of RAPDs have been completed, and a third is underway. The first was by Steve Kresovich of the U.S. Department of Agriculture, whose results were reported in Vetiver Newsletter 14. He demonstrated that DNA from three essential-oil genotypes (collected in different countries) were essentially identical, while all three were quite different from wild, fertile North India vetiver. Then, at the First International Conference on Vetiver in Thailand this year, Pattana Srifah, Nitsri Sangduen, and Vinitchan Ruanjaichon of Kasetsart University presented results of RAPD classification and identification of vetiver collected from different areas. Their results showed that RAPDs are a “simple, quick, and reliable alternative to identify 9 Vetiveria grass ecotypes” in Thailand.

Robert Adams of Baylor University in Texas has volunteered to perform a third series of RAPDs for The Vetiver Network. Dr. Adams has long worked with essential-oil plants; his specialty is juniper but he has been familiar with vetiver in Haiti for years. We all owe our thanks to Dr. Adams for devoting laboratory time and resources to vetiver research! Thanks Bob!

Results: At the Vetiver Conference in February 1996, a hundred kits for collecting vetiver DNA samples were handed out to participants, and in April another 100 requests were mailed to Vetiver Network members. The Vetiver Identification Program received nearly one hundred vetiver samples before May 15, 1996. These included 70 samples listed on Accession Forms as *Vetiveria zizanioides*, as well as five other species: *V. nigritana* (but see below), *V. elongata*, *V. filipes*, *Chrysopogon fulvus* and *C. gryllus*. Specimens were received from 19 countries. About another 30-40 samples have been received since the deadline; many of these fill crucial gaps and thankfully will be tested in another round of RAPDs later this year.

From the first round of samples, Dr. Adams’ laboratory was able to extract DNA and perform RAPD analyses on about 60 specimens. Once all RAPDs are complete, data will be correlated using statistical tests to group the samples into clusters ... these will be compared with the physical descriptions on Vetiver Accession Forms and with botanical vouchers. In the near future Bob Adams will be performing RAPD analyses on some of the remaining material received after May 15. We need Southeast Asian samples! Once analyzes are complete, results will be available in tabular form by Vetiver Identification Number - with commentary. Results should be available in time for a full report in the next Vetiver Newsletter. In the meantime, some unanalyzed data are available.

Notice: The following discussion should be considered as speculation. Full analyses could dramatically change some of the following possible relationships!

These are raw results and NOT for Scientific Reference or Citation! They are provided as interim information for

the many members of The Vetiver Network who contributed time and samples to make this testing possible. If you do not find your Vetiver Identification Number below, your submission was either not analyzed in the first round of testing or the DNA had deteriorated beyond recovery.

Below is one way to look at the raw results of the DNA testing. This simple test compares the amount of variation of every sample against each sample in turn (obviously done by computer!); this is called "best-fit" or "nearest-neighbor". discussed below is the one scheme (of about 4000) that had the least overall variation. This result is not a scientific proof; it is a philosophical test stating that the simplest explanation is probably the best explanation. This test is called "Occam's Razor", and translated from the Latin states "A plurality should not be posited without necessity" (William of Occam, 1285-1347). Using this principal, the computer found that uncultivated specimen VET-K-Pnb-2 from Orissa, India was a representative sample against which all others could be compared most simply. The choice is not surprising, for this sexually reproducing clone is one of 12 closely related, carefully documented specimens collected in the heart of Vetiveria zizanioides distribution.

Using this simplest measure of variation, the samples fell into four general groups: 1) wild, seedy types of *Vetiveria zizanioides* from Northern India and Bangladesh; 2) cultivated, low fertility, oil types of *V. zizanioides* collected from cultivation; 3) other Vetiveria species; and 4) Chrysopogon, the "sibling" genus. In this respect, these initial results are a reflection of current botanical and agronomic knowledge. There are several puzzling samples using this scheme, however, and the following must be viewed as tentative.

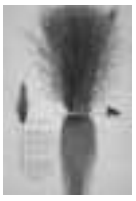
Group One: This group includes wild, seedy types of Vetiveria zizanioides from Northern India and Bangladesh. The representative specimen VET-K-Pnb-2 (from Orissa, India) is quite similar (0.90) to two other Orrisan samples (VET-K-Brk-8 and VET-U-Bdm-12), with this cluster in turn closely similar to VET-K-Dtp-1 (as well as VET-K-Dnk-3, VET-K-Blp-9, and VET-U-Gsg-11). (Note: The measures of similarity, such as 0.90, given in this discussion are not a measure of overall variation; the tests are designed to emphasis difference not similarity). These three samples (seven specimens) share about 0.85 similarity with VET-U-Nlg-10 from Orissa and VET-USDA-U1 from the Punjab (USDA PI 196257). Also in this group is a clone from Bangladesh (VET-BANG-B001, as well as the nearly identical B002, B003, and B004). Like the Orissan plants, these Bengali plants form a distinct, closely related subcluster such as could be found in locally collected sexual material that is vegetatively propagated. (This paragraph is full of examples of how DNA fingerprinting can help researchers eliminate duplicate germplasm.) Overall, these "Ganges" vetivers could be representative of the widespread, homogenous, sexually reproducing population of uncultivated "North India" *Vetiveria zizanioides* mentioned so often in the literature.

Group Two: This group includes cultivated, low fertility, oil types of *V. zizanioides* collected from cultivation, mostly outside South Asia. The members of this group are distinguished in the raw analysis not by their great genetic "distance" from Group One, but by their internal uniformity and behavior: these are apparently all oil vetivers and most are growing outside the native range of *Vetiveria zizanioides*. Variation from the wild, seedy baseline plant (VET-K-Pnb-2, above) used in this particular analysis ranged from about 3-15%; internally this group varied less than 2% (remember, subject to further mathematical analysis!). The group included one accession from Australia ('Grafton'; VET-PT-1C), one from Malawi (VET-ISV-AGA, see below), one from Nepal (VET-01-CWDS, which originated "in a tropical climate" outside the area), and twenty-five (25!) identical (>0.99) clones that came from around the world! Grafton is reported to have very low germination (<3%), the Malawi clone is free flowering with tillers dying back after flowering (seediness is not reported), the Nepal clone has not set seed.

Twenty-five identical DNA samples from around the world is a very surprising result. The DNA samples were sent from Australia, Costa Rica, Haiti, Hong Kong, Malawi, New Guinea, Panama, South Africa, United States, and Venezuela, as well as from Aneitym, Atui, Efate, and Mangaia in the South Pacific.

These clones are genetically identical; none have been reported to seed: VET-DEKN-1001, VET-DEKN-1002, VET-DEKN-1003, VET-DEKN-1004, "VET-GVB-001", VET-IMZ-AGA, VET-MRD-0001, VET-MRD-0002, VET-MRL-0001, VET-OSR-VV-7729, VET-PT-1A, VET-PT-1B, VET-PT-1D, VET-PT-1E, VET-RA-F1-7747, VET-RA-F2-7748, VET-RA-H1-7659, VET-RA-H2-7660, VET-RA-H3-7661, VET-RA-H4-7662, VET-RA-H5-7663, VET-RDH-0002, VET-RGG-CR-A, VET-RGG-PA-A, and "VET-MR-VAL1". These accessions include, among others, the cultivars 'Monto' (Australia), 'Sunshine' (United States), and 'Vallonia' (South Africa).

The history of a few cultivars is well-enough documented to know that they did not come from any one single plant within the last 60 years. In particular, 'Monto' has been in Australia since the 1930s; 'Vallonia' ("Charmoy") was brought to South Africa from Mauritius around 1920. From this, it seems likely that at some time prior to the Second World War, this single, very desirable clone of an essential-oil



vetiver was purposefully spread far and wide.

The unexpected result that one particular clone is so widespread has both good and bad aspects. The good news is that we now know much of the vetiver research in Australia, South Africa, the United States, and elsewhere has been performed using a single genotype. Therefore, research results from many different countries can now be combined and compared to form baseline data, at least in terms of germplasm response. What a bonus to be able to exclude this uncertainty from analyses of topics such as disease resistance and fertility! Further, given that in these tests more than 90% of the *Vetiveria zizanioides* from outside South Asia proved to be one single genotype, it seems likely this will be the clone found in use many other countries as well. This genotype is dense, erect, deep-rooted, and forms beautiful hedges. Now planted by the tens of millions, it is not reported to have seeded in any habitat. It is a superb hedge vetiver. This is all for the good.

The bad news is that we are now aware that there is a great deal of genetic uniformity in the vetiver we are using: the same clone is widely used and anything that harms one plant can harm them all. This is called "genetic vulnerability", and is a warning that we need to uncover further variability within the species, and to conserve it as a genetic reserve for the future.

Group Three: This group contains other Vetiveria species. Two specimens of *Vetiveria elongata*, a "narrow-leaf" type (VET-PT-2A) and a "broad-leaf" type (VET-PT-2B), that were recently botanically identified are clearly distinct from each other; both are equally distinct from *Vetiveria zizanioides* (.85 to the baseline VET-K-Pnb-2).

Two samples labeled *Vetiveria filipes* were also tested. One (VET-PT-2C) was recently collected and botanically verified. Like the *V. elongata* specimens, the degree of similarity to other vetivers (0.77 to VET-K-Pnb-2) is as would be expected taxonomically. The second sample (VET-FP-7734), however, is very different from VET-PT-2C as well as from all the other vetivers tested (0.67 to VET-K-Pnb-2). In fact, it differs more from *Vetiveria zizanioides* than does one sample of Chrysopogon, vetiver's sibling genus.

The plant from which came this seed sample (VET-FP-7734) was botanically identified in the 1950s. It was collected in Queensland, Australia by the Commonwealth Scientific and Industrial Research Organization (CSIRO) as Q269, and received by the USDA National Plant Germplasm Service on May 25, 1959, which gave it the Plant Introduction Number PI 257810. This unusual genetic result may be because of a true miss-identification; it also seems possible that it represents one of the recently named Vetiveria species described by B.K. Simon or a miss-identified species of Chrysopogon, or possibly (though unlikely) a new species. This sample would not make a good hedge plant and was included in the DNA fingerprinting for comparative (genetic) purposes. Nonetheless, hopefully someone in Australia will grow out samples of this seed and clarify the mystery identity.

The fourth sample in this group, from Panama (VET-RGG-PA-B), is another mystery. It varies from the baseline VET-K-Pnb-2 slightly more than the *Vetiveria elongata* and slightly less than the verified *Vetiveria filipes*. In form and habit, it can be confused with *Vetiveria zizanioides*. Coming from Latin America, it merits special attention (see below).

Group Four: This group includes *Chrysopogon fulvus* (VET-CFP-7769; USDA PI# 219579) from Pakistan and Chrysopogon gryllus (VET-CG-777; USDA PI# 383762) from Turkey. Results for both plants are what is to be expected from a separate genus: the latter sample shows the least similarity (.65) to the baseline *Vetiveria zizanioides* (VET-K-Pnb-2) of any plant tested. Interestingly, however, this distance is less than is "normal" for intraspecific variability, thus demonstrating how closely allied are the genera Vetiveria and Chrysopogon, and thus how genetically close are their constituent species. Further, in this "slice of the Razor", there is a smooth gradient of variation running from the baseline into Chrysopogon, rather than a gap between the genera as would be expected in two clearly differentiated taxa These relationships will be greatly clarified when other genera (such as Sorghum) are included in the next round of testing.

Falling between *Chrysopogon gryllus* and *Chrysopogon fulvus* in Group Four is the above-mentioned 1950's putative sample of *Vetiveria filipes* (VET-FP-7734).

Two samples from Bangladesh (VET-BANG-B005 and VET-BANG-B006) provided another surprise by having an intermediate variation between the chrysopogons and the vetivers (the two samples were distinct from one another, and showed equal variation compared to our baseline sample). These are probably two varieties of a different species. Our assumption prior to testing these samples was that these were from Vetiveria zizanioides. This was based on recent botanical surveys in Bangladesh that found V. zizanioides to be the only vetiver species in the country. This unexpected result could be explained in several ways. The submitters may have provided Chrysopogon or other samples; the specimens may have been miss-identified (though this seems very unlikely); it may be they are truly *V. zizanioides* and we have only begun to understand the genetic variation in the species; it may be that the current characteristics

used to classify *V. zizanioides* are invalid and that some second species is actually "masquerading" as V*. zizanioides*; it could merely be that in this simple text the Razor sliced the results incorrectly. However, to this author, it seems highly likely that the submitters of these samples (known for their sense of humor) have slipped in a test of the testing! Unfortunately, Vetiver Accession Forms are not available for these samples (hint).

What You Can Do to Help: Lack of diversity and genetic vulnerability is a true risk. Because we have discovered there seems to be limited genetic variation in nonfertile vetiver outside South Asia, it is important for everyone to maintain as many different kinds of vetiver as they can, and to describe them on Vetiver Accession Forms. This is especially important for clones that do not set seed. This means to maintain the clones you have; do not import new germplasm because the risk of disease to vetiver and other plants is simply too high!

We need one general name for the one genotype that is so widespread. John Greenfield — who first popularized the vetiver system — observed long-ago that most vetivers outside South Asia looked the same. He suggested calling them "Vetiveria ubique", Latin for the ubiquitous vetiver—the vetiver that is everywhere. Scientists won't accept such a Latin phrase unless it is used to describe a separate species, nor do the Botanical Rules of Nomenclature allow cultivar (cultivated variety) names to be Latin, so we can't just call it "ubique" — although UBK would probably be acceptable to the taxonomic community! We can name this vetiver type (it is technically a cultigen) almost any other way we choose, so please send us your suggestions! (By the way, Monto is a small town in Queensland, Sunshine a small town in Louisiana, and Vallonia a sugar estate in South Africa.)

We desperately need DNA samples from Southeast Asia (Vietnam, Cambodia, Burman, Laos, Thailand, Malaysia, and Indonesia). We learned from the first round of testing that no specimen preparation is necessary! Simply clip about 5 cm of green leaf, wipe it dry, and mail it with a Vetiver Accession Form to The Vetiver Network.

The Nepalese VET-01-CWDS should be closely evaluated and its history documented. Germplasm should be duplicated in other sites for safekeeping. It may represent important genetic diversity. It would be very helpful if a full botanical voucher could be provided to The Vetiver Network.

The Malawian VET-IMZ-AGA was submitted to the Vetiver Identification Program as "probably *Vetiveria nigritana*", although the accession form noted that it had many characteristics of *V. zizanioides*. It seems likely that it is the latter species; in any event it represents very interesting genetic variation. If it does not have viable seed, it could represent an important source of biodiversity. Although apparently abundant, material should be duplicated at other sites for safekeeping. It would be very helpful if a full botanical voucher could be provided to The Vetiver Network.

The Panamanian VET-RGG-PA-B should not be used as a hedge plant until it is collected, maintained, identified, and a detailed accession record begun. If it flowers, a qualified botanical identification should be made. Does it set fertile seed?! If it seeds after thousands of clones have been planted out, it could become a pest. On the other hand, if it is sterile it could be a very valuable addition to our arsenal of germplasm. In the meantime, until more is known about the plant, use the Panamanian VET-RGG-PA-A, which is the nonfertile hedge type of *Vetiveria zizanioides* (see above). It would be very helpful if a full botanical voucher could be provided to The Vetiver Network.

The Bengali mystery of samples VET-BANG-B005 and VET-BANG-B006 should be clarified. The Vetiver Network will gladly assist in authenticating. If they are botanically authenticated as *Vetiveria zizanioides*, there is something seriously wrong with this slice with Occam's Razor — or with the current taxonomic classification of the species.

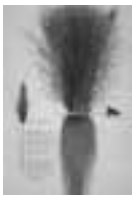
Oil Chemistry

Background and Importance: Vetiver has been important for centuries because of the fragrant oil in its roots. Perfumers distinguish two kinds of vetiver oil. Oil from the uncultivated, seedy "North Indian" type is technically called Khus Oil; oil from the cultivated "South Indian" type is called Oil of Vetiver (this is the vetiver oil of international commerce). The two types (perhaps mirrored in the above first-two groups) consistently yield oils that vary chemically, have opposite polar rotation, and smell differently. Much basic oil research has been performed in India and elsewhere.

One puzzle is the hypothesis that selection for maximum root mass gave us the dense, erect, heavily rooted, and sterile clones we have today. If this were true why would their oils be so dependably different? Does anyone know other species where two different genotypes consistently yield two different oils from the same tissue?

By answering questions about vetiver's oil chemistry, we may learn clues as to the origins of vetiver, could solidify DNA results (oil is a different "Razor"), and could possibly develop tests for distinguishing different types of vetiver in the field.

Results: This is an area in which several Member of The Vetiver Network have expressed interest but research is just getting started. Robert Adams has reported that a group



of scientists in Berlin is planning to do a complete analysis of Oil of Vetiver. They will surely be assembling world literature on vetiver oil; we will make every attempt to convince them to include Khus Oil in their analyses. Dr. Adams' own lab is also equipped for many types of analyses.

What You Can Do to Help: The ideal research would be based on oils that could be traced back to specific clones on which DNA fingerprinting had been performed and for which botanical vouchers and descriptions exist. Oil producers please help! This is an potential opportunity for you to receive no-cost, state-of-the-art analyses of your oils and germplasm while helping farmers and others throughout the tropics! None of this testing requires living tissue. Please let us know if you wish to contribute.

We would also appreciate oil or root samples from other vetivers, particularly those described as of interest above. Nepalese VET-01-CWDS, Malawian VET-IMZ-AGA, Panamanian VET-RGG-PA-B, and Bengali samples VET-BANG-B005 and VET-BANG-B006 merit particular attention At the moment Khus Oil is also needed for preliminary analyses. Please send well-packaged samples (and as much background information as possible) to The Vetiver Network. Please contact The Vetiver Network for further details.

The Future

The goal is to reach a point where this type of research will no longer be necessary! Our level of knowledge is rapidly increasingly, and many of the questions of 1990 are answered. Two sophisticated genetic techniques, coupled with new taxonomic clarity, may help us further along this path.

RFLP (Restriction Fragment Length Polymorphism) molecular analysis would allow study of the evolutionary and reproductive biology of vetiver. These tests could permit us to identify genes that influence morphological traits such as rooting, tillering, flowering, and seeding in vetiver. Once these are identified, new-found clones would not require lengthy field testing to determine their genetic characteristics. Plans are underway to initiate RFLP analysis of vetiver.

FISH (Fluorescence In Situ Hybridization) is an advanced cytometric technique for analyzing genetic location. Once RFLP has identified genetic sequences, FISH will allow us to locate its appearance[s] on vetiver chromosomes. Plans are underway to initiate a FISH analysis of vetiver.

Many thanks to all of you who have cooperated with the Vetiver Identification Program. We are open to suggestions for any other research ideas that may help answer questions about the identity of vetiver. Please contact The Vetiver Network with your ideas.

STUDY ON VETIVER GRASS IN BANGLADESH

Comprehensive Study. Bangladesh National Herbarium
by Matiur Rahman et al.

Summary
Vetiver is a versatile grass with unique characteristics. There is world wide evidence to support the use of Vetiver as an effective means of soil stabilization.

A project proposal was submitted to Danida by the Bangladesh National Herbarium to conduct a reconnaissance survey on Vetiver in Bangladesh in order to explore and identify the distribution and location of Vetiver, identify the different species and ecotypes of Vetiver, and its existing indigenous uses. The proposal was approved by Danida in April 1995.

The survey was conducted by a technical team which consisted of 5 persons (Annexure 2). The team leader, who is an agrostologist, and three taxonomists/botanists formed the core team while a sociologist was attached to the team for a shorter period.

The survey work was for a one year period starting from June 1995, with an extension of further three months. The study period was broken into two parts. The finding of the first part of the study was presented in a one-day workshop in February 1996 with 30 invitees. The workshop assessed the progress of the work and recommended future possible steps to be undertaken during the second part of the study.

The survey work was carried out in all the 64 districts of Bangladesh. The distribution and locations of Vetiver were explored and identified through numerous field trips by the members of the technical team. Each site was visited more than once and the technical team collected a total of 375 samples of Vetiver plants during the field trips. They made field notes and recorded information on individual collection supported by photographs of the habitat, the Vetiver colony, and the extent of the stands. The collected plant samples were processed, preserved and examined at the Bangladesh National Herbarium. Full botanical descriptions were prepared on the basis of the collected samples.

The investigations made in the survey revealed that there is a wide occurrence of Vetiver in Bangladesh including a number of large areas covered extensively by Vetiver. Some of these areas may be the largest populations of Vetiver ever seen in the world. It has been established that Vetiveria zizanioides (L.) Nash is the only species that occurs in Bangladesh. Three botanical 'forms' of Vetiver have been identified to occur though no ecotypic variation was found.

The study conducted by the sociologist revealed various past and present indigenous uses of Vetiver in Bangladesh including thatching, fencing, handicrafts, medicine, fodder, and in festivals and religious functions.

The present findings suggest that Vetiver grass has a great potential for use as a vegetative means for protection of river and coastal embankments in Bangladesh. Vetiver which is commonly found in Bangladesh will be most suited for this activity. Apart from its traditional use as a thatch grass, its use in handicrafts can also be expanded.

(The full report is available from the National Herbarium, Dakkar, Bangladesh).

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FOR SALE

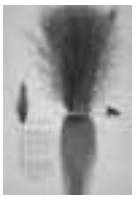
Video Films: Vetiver Grass - A Hedge Against Erosion. 28 minute video comprising 128 scenes of vetiver technology. Available in English or Spanish, and in PAL or NTSC formats. Price US $25, including shipping.

Slide set: (65 transparencies) of vetiver technology + write-up in English. Price US $65 including shipping and handling.

Available from The Vetiver Network.

MOST WANTED

We need to know whether *Vetiver nigratana* has oil in its roots. Also people with knowledge of *Chrsopogon spp*. please smell/bite the roots to see if they have oil any oilor other odor. Please pass information to Mark Dafforn.



VETIVER PHOTO GALLERY

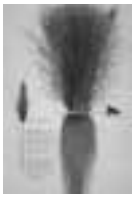
Australia, Queensland, from Paul Truong's collection.

Vetiver zizanioides (Vetiver Monto) grown in Queensland on acid sulphate soils to protect eroding field gully. **Paul Truong**

Same scene a year after planting with crops. **Paul Truong**

Vetiver grown on acid sulphate soils to protect a drainage channel. Note on the far side of the ditch the palm tree roots are unable to stop erosion and the bank has been temporarilly stabilized with sand bags, The vetiver has stabilized the near side very effectively, and for ever. **Paul Truong**

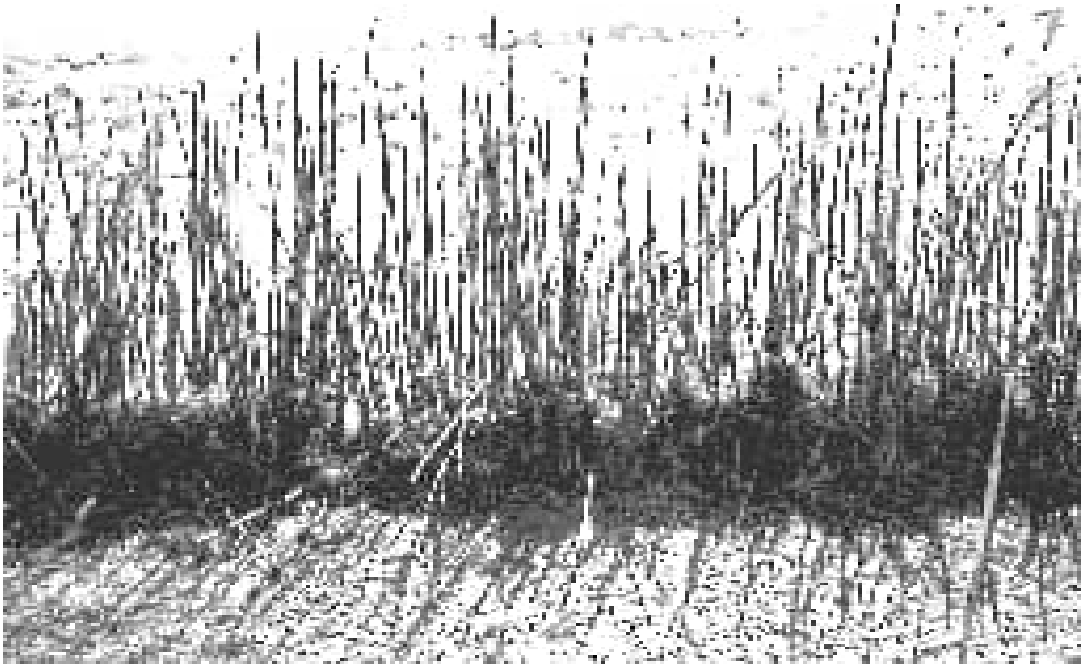
A deep flow of water of about 1.3 meter in a drainage depression flattened the native grasses, but not the vetiver. Note the stable, non eroded drain bottom. **Paul Truong**

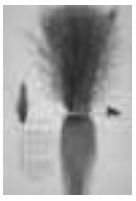


The same flow as the previous photograph. Note the debris collected on the head rod.
Paul Truong

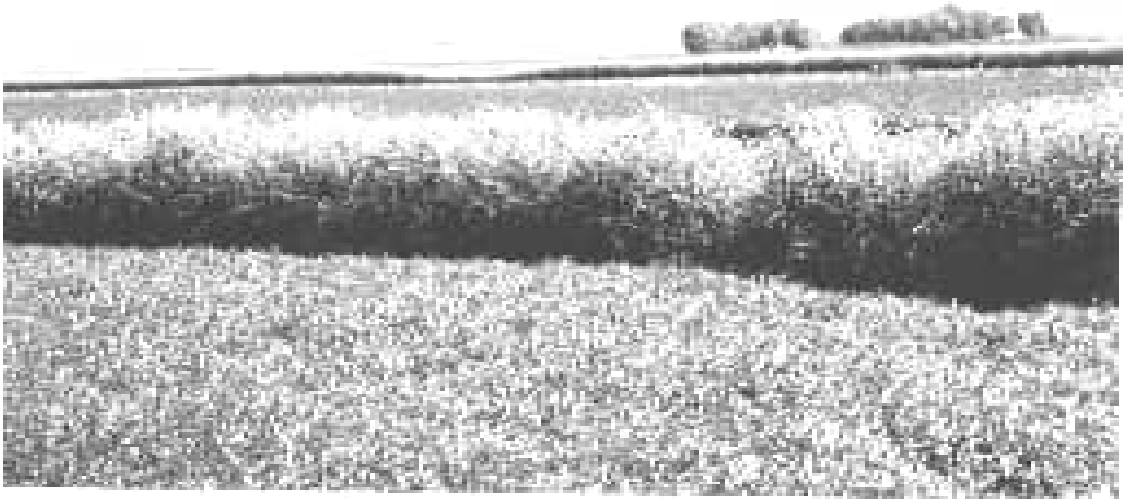
Vetiver does not burn well even under windy conditions. **Paul Truong**

Above: Vetiver was burnt to get rid of the mice which hide in the hedge during winter and attack the corn. Below: Vetiver after burning, It remains erect, and green shoots and leaves are still visible (in the color photograph). **Paul Truong**



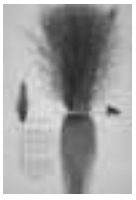


When protected with vetiver, the vetiver hdge farmer can plan the whole area, thus increasing productivity by at least 30%. Note the depression in the field above will be filled up over time and will become level. **Paul Truong**



Above: Typical strip farmer cropping layou on the Darling Downs. Normally at least 30%of the land is underbare stubble fallow. **Paul Truong**

Below: Vetiver used to stabilize a land fill area in Queensland. **Paul Truong**



China. From Xia Hanping's Collectiion

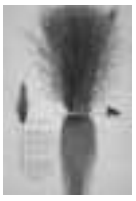
The following photographs relate to the article on page 25

Above: Cracking pavement on a new highway in Guangdong Province due to an unstable embankment. **Xia Hanping**

The cracking in the pavement was due to the unprotected embankment shown above. **Xia Hanping**

Above: The embankment now stable 6 months after the vetiver grass was planted.

Below: The cut slope protected by vetiver. About another three months was required to reach reasonable slope stability. Note the Acacia mangium **planted between the rows of vetiver. Xia Hanping**



Costa Rica. From Jim Smyles Collection

Vetiver plantedon a steep slope to protect coffee plantings. The leaves of the vetiver can be cut and used for mulching the coffee. **Jim Smyle**.

Vetiver used as a protective boundary hedge around house and garden.

Table of Contents

NEWSLINE 1
Editorial..... 1
Vetiver Network Funded for 1997 and 1998 2
What Vetiver User Say in The Philippines 2
Organizing Vetiver's Next Steps to Global Acceptance 4
Vetiver Proposed in Ghana's Next Action Plan on Soil Fertility Mnaagement..... 10
ANNOUNCEMENTS 10
Cameroon Workshop 10
Newsletter#15 Quiz Winners 10
The Vetiver Network Support Project..... 11
Support for the establishment of Regional or National Networks 11
Vetiver Network Support to NGOs 11
Vetiver Network Awards for Innovative Research and Technology Development 12
Vetiver Homepage www.vetiver.org 13
List of Vetiver Grass Suppliers 13
Information on Vetiver Development -- Receive a Fee Video 13
Vetiver Participant Directory 14
REGIONAL NETWORKS 14
The West African Regional Network (proposed) 14
The Latin American Vetiver Network (LAVN) 14
The European Network 14
The China Vetiver Network 14
LETTERS TO THE EDITOR 14
FIELD REPORTS 24
AUSTRALIA Monto Vetiver 24
CHINA Vetiver's Application for the Prevention of Highway Slippage in South China 25
COSTA RICA A Tour of Costa Rica 26
ETHIOPIA Report on Vetiver Workshop - May 1996 - Mettu, Illubabor, Ethiopia. 28
GHANA Vetiver Hedgerow Technology is catching up with Farmers. 29
MEXICO A Visit By The Latin American Vetiver Network To Oaxaca, Mexico. Jim Smyle 29
TANZANIA Vetiver Grass In Soil And Water Conservation Experience
Of Hima Iringa Project, Tanzania. 31
THAILAND Vetiver strips or leucaena hedgerows? 32
USA Vetiver A Miracle Herb 33
TECHNICAL NOTES 35
How to Use Existing Barriers as Sources of Planting Material 35
How to Plant Vetiver by Jim Smyle 36
Know Your Hedge Vetiver: Environmental Concerns About Vetiveria zizanioides 37
RESEARCH 44
Vetiver Workshop Australia, Queensland 44
Vetiver Grass for Rehabilitation of Acid Sulphate Soils 45
An Assessment Of Strength Properties Of Vetiver Grass Roots
In Relation To Slope Stabilization 46
Malaysia Vetiver Seminar 46
Farmer Participatory Selection of Vetiver Grass as the Most Effective Way to Control Erosion in
Cassava-based Cropping Systems In Vietnam and Thailand 50
Fungal Endophytes of Vetiver. 54
The Effect of Nitrogen Fertilization on Growth and Root Yield of
Vetiver Grass (Vetiveria nigratana) in Nigeria (Preliminary Study) 55

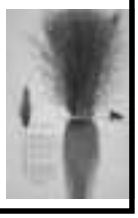


Table of Contents Continued

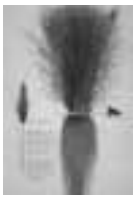
Spain- The Introduction, Early Results And Potential Uses Of Vetiver Grass Hedge Row (VGHR) In Mediterranean Regions 55
Ghana - Adaptive Research Collaborative Programs. 60
USA -Streamside Buffer Strips Improve Water Quality and Provide Wildlife Habitat 60
USA - Aquaculture Sludge Removal and Stabilization within Created Wetlands 61
Vetiver Identification Program: General Information and Update 66

VETIVER PHOTO GALLERY 74

VETIVER IDENTIFICATION PROGRAM FORMS 85

Vetiver hedgerows intercropped with banana in NE Thailand, Chiang Rai. ***Photo Credit: Dick Grimshaw***

Vetiver hedge rows intercropped with vegetables near Cebu, Central Visayas. Phillippines. Photo Credit: Edwin Ballabarino.



THE VETIVER NETWORK
Vetiver Identification Program

Vetiver Accession Form

(If you wish to help identifyb the vetivers that you work with, please fill in this form and either copy or cut along dotted line)

This form records basic collection, ecological, and descriptive information about a single vetiver clone. Make copies for multiple genotypes (we'll supply blank forms if you need them); use additional sheets if needed. Form should be kept updated. Distribute this form to others with different vetivers. Please send copies--or other accession records--to Vetiver Identification Program, 15 Wirt Street NW, Leesburg, Virginia 20176, USA; 703 771 1942; fax 771 8260; write, or check The Vetiver Network (www.vetiver.org) for new information.

Identification Number: #VET-_____-_____

Assign this number to one single plant (genotype)
(suggested format: VET-Your Initials-####).
Use this number on all information supplied to the Vetiver Information Program. We will use this number in correspondence with you and in presenting research results. As we trace the relationships of vetiver, identical clones will receive reference numbers and cultigen names; information will be made available through the Vetiver Network. Please indicate at the end of this form if you do not wish your name to be released without permission.
Date:

Your Name and Address:

Part I: Recording Your Vetiver
Everyone please complete Part I. This allows us to track distribution and to contact you with information about your plants. If someone else is maintaining records on the "foundation stock" of your vetiver clone (see Part II), this is all we need.

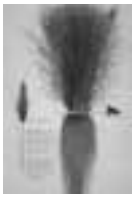
By what name do you call this clone?

Other type/cultivar/clone names:

Other accession numbers:

Genus/species, if known (botanically authenticated?):

From whom/where did you receive this clone? (Sample responses could be: "This is 'Sunshine' vetiver." or "Acquired from John Doe of the Elbonian Agricultural Service, [address].", or "My family brought this plant from Elbonia in 1935."):



Location of your clone (be as precise as possible, with latitude, longitude, and elevation if available):

How long have you had this clone?

How widely planted (thousands of plants, if known) is this clone (by you, and by others if available)?

Please reference others working with this clone:

Is this genotype duplicated in a national germplasm collection? ___ No ___ Yes; Where?

Have you prepared herbarium vouchers for this clone? ___ No ___ Yes; Where?

Have you submitted this clone for DNA RAPD testing? ___ No ___ Yes

Have you submitted this clone for DNA RFLP testing? ___ No ___ Yes

Are you a member of the Vetiver Network? ___ No ___ Yes

Part II: Documenting Your Vetiver

Complete Part II (and Part III) if you curate vetiver "foundation stock", that is, you maintain a particular vetiver genotype for use in hedges (especially if you have distributed the clone to others), or--if not a member of the Vetiver Network--you have a plant you'd like to know more about. If you keep accession records in another format it is not absolutely necessary to complete Parts II and III of the form, but please supply us with Part I and a copy of your records.

Original collection date and season, if known (when was this plant first collected as an accession):

Original collector name and contact information (if not you):

Original collection location of clone, if known (be as precise as possible, with latitude, longitude, and elevation if available):

Permanent location of clone, if different from above (be as precise as possible, with latitude, longitude, and elevation if available):

General description (erectness, density, flowering, abundance, etc.):

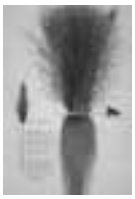
Ecological and habitat information (including soils, rainfall, moisture, and drainage regimes, temperature averages and extremes, seasonality, associated species, etc.):

Origin (any details you may know, including history either known or reputed):

Local or traditional uses:

Please explain any experience you have with this clone (please reference or attach copies of articles, letters, documents, or other papers discussing your work):

Special characteristics (including oil data):



Comments (use additional sheets and attachments if you wish):

Part III: Describing Your Vetiver

Part III lists simple physical characteristics visible to the naked eye. Some traits may seem obscure but, at some time, someone working with vetiver thought them important. Although the questions are designed to emphasis these points, they have not been tested: feel free to add anything you think is relevant. Provide as much information as is currently available; keep forms updated.

Plant Habit

Overall height (cm):

Crown density (tillers per unit area):

Crown diameter (cm):

Plant vigor compared to other accessions (1 = weakest, 9 = strongest):

Vegetative spread rate (one season; 1 = caespitose, 9 = 1 meter or more):

Dry weight = dry weight/wet weight:

Stems, Tillers, & Leaves

Erectness (1 = procumbent, 3 = sprawling; 5 = open; 7 = upright; 9 = erect):

Stem strength (1 = soft; 2 = average; 3 = stiff):

Stem adherence to crown (year-old culms) (1 = firmly attached; 2 = loosely attached; 3 = detached):

Last internode length (cm) (1-year plant):

Third internode length (cm) (1-year plant):

Number of tillers (1-year plant):

Number of leaves/main tiller (1-year plant):

Leaf color (1 = light green; 9 = dark green):

Pigmentation pattern (Regular/Intense to Irregular/Feeble):

Leaf length (cm):

Leaf width (cm):

Forage quality (if possible, give in vitro dry matter digestibility calculated by NIRS):

Forage yield (forage yield/ha at first harvest):

Flowering Characteristics
When (if) this clone flowers, please preserve specimens for botanical identification.

Number of panicles (1-year plant):

Flower length (cm):

Flowering habit (botanical type; 1 = determinate; 9 = indeterminate):

Female-infertile spikelets:

Awned glumes (length, if present):

Seed abundance:

Percent seed set (fertility):

Germination:

Aggressiveness:

100 seed weight (gm):

Seed retention (relative degree of seed shattering; 1 = shattering; 9 = retention):

Leaf senescence at seed maturity (1 = dead leaves; 9 = all green):

Chromosome number (somatic chromosome number):

Physiology

Acidity tolerance (1 = little tolerance; 9 = very tolerant; or pH):

Alkalinity tolerance (1 = little tolerance; 9 = very tolerant; or pH):

Salt tolerance (1 = little tolerance; 9 = very tolerant; or dS/m or mho):

Drought tolerance (1 = little tolerance; 9 = very tolerant; or min.):

Moisture tolerance (1 = little tolerance; 9 = very tolerant; or max.):

Poor drainage tolerance (1 = little tolerance; 9 = very tolerant; specify):

Cold Tolerance (1 = little tolerance; 9 = very tolerant; min):

Heavy metal tolerance (1 = little tolerance; 9 = very tolerant; specify):

Other tolerances:

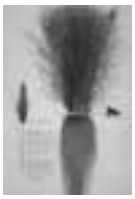
Roots

Depth of roots (deepest):

Root yield (gm/plant) (1-year plant):

Diameter of roots (cm/largest) (1-year plant):

Root color:



Has this plant been used for oil production? ___ No ___ Yes

Other root/oil observations:

Please provide any information on adaptability, pests, plagues, or other characteristics which may be important to understanding your vetiver genotype.

Part III is based largely on the “Descriptor List for Grass” used by USDA’s Germplasm Resources Information Network (GRIN), with other characteristics of special interest to vetiver researchers. Many were drawn from Ramanujam and Kumar’s 1964 paper, “Metroglyph analysis of geographic complexes in Indian vetiver” (Indian Journal of Genetics & Plant Breeding 24:144-150), as well as from various keys separating Vetiveria species. Other sources included the Smithsonian’s “Collection Reference System Data Standards” and the USDA’s “Preparing Herbarium Specimens of Vascular Plants”. Thanks to Rusty Russell, Je.F. Veldkamp, and John Wiersema.

For those with a deeper interest in recording their vetiver, additional information is available on the World Wide Web at www.vetiver.org and from the Vetiver Identification Program

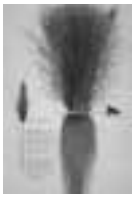
Updates: __/___/__; __/___/__; __/___/__; __/___/__; __/___/__; __/___/__.
(Please circle new information on updated copies sent to the Vetiver Network)

Nondisclosure request: If you do not want us to link your name with this clone, sign here:

X_____

If you are looking for vetiver, we’ve identified suitable cultivars in almost every country and will be glad to help you find starting material; please contact the Vetiver Network.

Ver 2.0t Oct/96



VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER NETWORK
NUMBER 17 JUNE 1997

ATTENTION !!

THIS NOTICE EFFECTS YOU.

DISTRIBUTION OF THE VETIVER NEWSLETTER AS OF JANUARY 1 1998

The Vetiver Network has now produced 17 newsletters and other documents since 1989. All these have been provided at no cost to the recipient. During this time we have never culled dormant receivers of the newsletter. Currently national and regional vetiver networks have been or about to be established. These networks will produce their own newsletters for vetiver network participants in their area of influence. Recipients in the USA and Europe have easy access to the Vetiver Homepage on the Internet, and are not restricted from making payments to the Vetiver Network. In most other countries recipients of the Vetiver Newsletter are either too poor or do not have access to foreign exchange, and are therefore very dependent on a hard copy newsletter for information. As a result of the foregoing the Network will institute the following policies.

(a) All current recipients of the Vetiver Newsletter are requested to complete the form at the end of this newsletter and return it to The Vetiver Network. If the form is not returned by November 1997 we will assume that the recipient is either no longer operating at the current address, or is no longer interested in receiving future issues of the Vetiver Network. So please fill in the form and return it promptly.

(b) Current recipients of the Vetiver Newsletter who fall under the newly established networks (China, Southern Africa, West Africa, Philippines, Pacific Rim and Latin America) will receive local newsletters from their networks at no cost. Those readers in these areas who want to continue to receive this newsletter - The Vetiver Newsletter published by The Vetiver Network - will in future be required to pay an annual subscription of US $20 per year, payable in US $ to The Vetiver Network, or the local currency equivalent to their local network. This policy will go into effect on January 1st 1998

SEE PAGE 47 FOR TABLE OF CONTENTS

King of Thailand Vetiver Award

'Vetiver for Sustainable Development'

It has been announced by the Royal Development Projects Board, Thailand, that His Majesty The King of Thailand has agreed to award two US$ 5,000 from His Majesty's Chaipattana Foundation funds under the general theme "Vetiver for Sustainable Development". These prizes will be awarded in early 1999 and will be linked with The Vetiver Network awards forInnovative Research and Technology Development. One prize will be for thebest judged vetiver research, and the other for the best program for thedissemination of vetiver technology.

(c) Current recipients in Austria, Belgium, Denmark, Finland, France, Germany, Italy, Japan, Norway, Portugal, Spain, Sweden, Switzerland, The Netherlands, UK, and USA, are requested to pay an annual subscription fee of $20 per annum if they wish to continue to receive The Vetiver Newsletters published by The Vetiver Network. This policy will go into effect on January 1st 1998.

(d) All other current recipients will continue to receive the Vetiver Newsletter at no cost until such time that a regional or national network is established for the recipients' area. As and when this occurs, then policy (b) will apply.

(e) Bonefide NGOs and government agencies using vetiver grass, wherever located, will continue to receive the newsletter at no charge.

(f) The Vetiver Network homepage on the Internet at ht.//www.vetiver.org will continue to operate and is accessible at no cost to the general public. The homepage fully reflects hard copy newsletters published by The Vetiver Network.

(g) All recipients who wish to continue to receive the newsletter, whatever category, are requested to send a short report no more than 500 -1,000 words) on how they use vetiver and the type of programs that it is applied to.

It should be noted that the above are combined in the form at the end of this newsletter. IT IS ESSENTIAL THAT THE FORM IS COMPLETED IF YOU WISH TO CONTINUE TO RECEIVE NEWSLETTERS. **SEE PAGE 51**

Moneys received from the annual subscription will be recycled for newsletter production and financial support to regional and national networks

From the Editor's Desk

This newsletter is published at a time ofchange for the Vetiver Network. Change in that The Network has a viable and fully funded support program to provide assis-

tance to regional and national networks and non profit organizations working with vetiver world wide, as well as the funding for awards for vetiver research and development. This newsletter starts with the overview from the 1996 annual report that provides a summary of where we stand at this time.

1996 Annual Overview

The use of vetiver grass for soil and water conservation and embankment stabilization continues to accelerate on a world wide basis, and the demand for planting material appears to exceed supply. There is generally a much greater awareness of the potential of the vetiver grass technology, and the scope of its application has extended considerably. During 1996 special interest in vetiver technology was, amongst others apparent in China, The Philippines, Malaysia, Australia, Brazil, Central America, southern Africa, Ethiopia and Nigeria.

Our knowledge about the vetiver technology has once again expanded during the year with research by Truong (Australia) on vetiver's tolerance to a wide range of heavy metals that have important implications in pollution mitigation and mining; and by Diti Hengchaovanich (Malaysia) on the tensile and shear strength of vetiver with important implication for the engineering sector. Other ongoing research by Bob Adams (Texas) has provided important information on the genetic relationship of various vetiver species and cultivars in countries around the world. It is reassuring to learn that most vetiver users are using a cultivar of Vetiveria zizanioides that can only be propagated through plant division and not from seed. Mark Dafforn is to be congratulated on his efforts to establish a world wide coordinated effort of vetiver identification (more details are available in Newsletter # 16). These and other research results have been reported in newsletters #15 and 16, and on the Network's homepage

The Vetiver Network's Home page (http://www.vetiver.org) on the Internet has continued to expand and has been "hit" approximately 3,600 times (3,000 hits in the last six months) since its inception in late 1995. Assuming that 50% of the hits are serious, and that information on the homepage is being used, the homepage has saved the Network much administrative time and mailing and printing costs. It is interesting to know that many young people are using our information for school papers and university thesis.

During 1996 The Vetiver Network published two newsletters, numbers 15 and 16. The Network wishes to acknowledge the in kind support of the World Bank in the printing and mailing of newsletters #15 and 16. The Latin American Vetiver Network issued two newsletters in Spanish, and The China Vetiver Network issued one newsletter in Chinese.

Vetiver Network participation remains around 4,000 (receiving hard copy newsletters) individuals and agencies, with tens of thousands secondary beneficiaries.

Five new regional and national networks have been established. One for Latin America, under the coordination and management of Jim Smyle and his wife Joan Miller, operating from Costa Rica. This network conducts its business in Spanish. A network has been established in Europe by Marco Troglia, Milan, Italy. This network provides a mirror service of our US Home Page. The China Vetiver Network, coordinated by Liyu Xu was established in November 1996 in Nanjing (southern China). It is expected to be very active in the promotion and development of the technology. The Vetiver Network, Philippines was established in December 1996 and is coordinated by Edwin Balbarino located in the Central Visayas. The latter is oriented to small farmers. In March 1997 a Regional Network for Southern Africa (SADC - Southern Africa Development Countries) was established under the Institute of Natural Resources, located near Pietermaritzberg, South Africa. The Pacific Rim Vetiver Network has been established in Bangkok, Thailand under the administration of the Royal Projects Development Board and under the patronage of His Majesty the King of Thailand. Another network is under establishment for West Africa The West African Regional Vetiver Network. All these networks are being supported financially and intellectually by The Vetiver Network. In the short term we see a need for new networks for Nigeria (national), India/south Asia (regional), Ethiopia (national), and Eastern Africa (regional).

The Vetiver Network has supported with small grants a number of NGOs (non profit organizations) who are working with vetiver. These include NGO's in Philippines, Nepal, Tanzania, South Africa, Ecuador, Mexico and Cameroon. The Vetiver Network supported The Royal Development Projects Board of Thailand to organize the "International Conference, Vetiver - A Miracle Grass" held in Chiang Rai. Thailand from February 4 - 8 1996. This conference attended by some 300 persons was very successful. Details can be found in newsletters #15 and 16 as well as on the Internet. It was agreed that the second International Vetiver Conference be held in South Africa in the year 2,000. The Institute of Natural Resources, affiliated to The University of Natal, will host this conference.

In October 1996 the Network was awarded the prestigious US$ 100,000 "John Franz Sustainability Award" by the Monsanto Company. The Network's submission was judged best out of over 70 entries by an international panel of 12 judges. The proceeds are being applied to the operation of Vetiver Network's Support Services Project.

In April 1996 the Network decided to look for donors to fund a US$ 500,000 Vetiver Network's Support Services Project. This project would provide the basic funding for administrating the Network as well as provide for the establishment of regional and national networks, support to non profit organizations to initiate or expand vetiver programs, support for research and for the production of books and imaging. The project which runs over 1997 and 1988 has been very nearly fully funded. We are grateful to the Royal Danish Government for a grant of US$ 300,000, to the World Bank for US $30,000 and to the Amberstone Trust for US $15,000. This together with the US$ 100,000 award from Monsanto, and inkind input from the Vetiver Network's coordinator has enabled the Network to go ahead with the project. At the time of issuance of this report, most of the recipients have been identified and funds have been committed. The demand for establishment of networks and support to non profits exceeds the funds available under the project. The Network will later in 1997 go out to seek additional funds to support a phase 2 project.

The Future

Short Term Clearly the demand for the technology is accelerating at a much greater rate than indicated by the number of newsletter recipients. For example in

Malawi it is now government policy that vetiver will be the key technology for soil and water conservation, hundreds of thousands of farmers will eventually become users. This story repeats itself in other countries. The Network's strategy is to help develop and establish regional and national networks that can in the future lead the drive in the dissemination of the technology quickly and efficiently to potential users in their area of influence. In the short time that the new networks have been established it is apparent that our hopes are being realized faster and better than originally envisaged. The new networks are being managed by innovative and dynamic individuals who are actively working to use our support to the optimum. It will be the Network's strategy to withdraw from those areas when the new Networks prove comparative advantage. In particular The Vetiver Network will transfer hard copy production and delivery of newsletters to up and running national and regional networks. However we will continue to collaborate with, and search for future funding sources for these networks.

The Network should expand its support to non profit organizations to initiate or improve vetiver technology programs. Although the Network provides only US$ 5,000 a year per non profit, these moneys are often enough to get things started and most times leads to multiplier efforts by other agencies and users. The Network is also able to help some non profits who are so small that they would normally never receive help from the donor community. The Vetiver Network has helped mainly those who have taken an earlier initiative to use the technology. In the future the Network hopes to rely on the national and regional networks to identify suitable non profit agency recipients. We hope that international donors will recognize what we are doing and will provide their support.

Medium and Long Term By the beginning of the next century The Network should provide coordination and advice to regional and national networks, facilitate exchange of information via the Internet and other means, and seek and provide funds for networking, research, and vetiver program initiation. At this time we are on track and moving towards these objectives.

1996 Accounts

The audited accounts and independent auditors report have been submitted to the Board of Directors. The Network completed 1996 with a cash balance $197,778 and assets of $357,667 (including $150,000 commitment from the Royal Danish Government for 1998). The Network pays no salaries, and administration costs amounted to only US$ 4,318, and represents about 5% of total expenses.

1997 and 1998 Budget

The Network's budget is dependent entirely on the level of donor support. We have assured funding for 1997 and 1998, and expenditures are set out in the budget. If additional funds become available they are most likely to be expended against increased grant support to new networks and non profit organization vetiver initiation programs. During 1997 the Network will continue to operate its homepage, produce two newsletters (July and December), support the establishment of new regional networks for southern Africa, West Africa, and the Pacific Rim (commitments have already been made for these networks), and support to a small number of non profit agencies. The Network plans to end 1997 with a cash balance of approximately $62,000, which together with the 1998 commitment of The Royal Danish Government, will meet all current and expected 1997 and 1998 commitments.

Conclusions

The main conclusions and objectives of the 1995 Annual Report were:

- The Vetiver Network has an important role to play in natural resources conservation.

- The need to establish country and or regional networks is clear, and the Vetiver Network will accelerate that process where funding is available.

The Vetiver Network has gone a long way to achieve these goals. It is expected that during 1997 the technology will continue to expand in use, and will excite all those involved with it.

It should be emphasized that vetiver grass is a unique grass, one that stands alone in its ability to adapt to a wide range of ecosites, and one that has a vast range of application. It is this very uniqueness that is exciting, and it provides a challenge for users, scientists and planners to make use of this extraordinary simple and low cost technology.

New Networks

During 1996 and 1997 (todate) the following networks were established:

China Vetiver Network(CVN)

This Network. located in Nanjing, China, carries out its work and produces newsletters in Chinese.

Contact: Mr. Liyu Xu, The Network Coordinator, The China Vetiver Network, The Institute of Soil Science, Academia Senica, PO Box 821, Nanjing 210008, China

Fax: 86-25-3353590, Tel: 86-25-3358720

Email: Liyu Xu <lyxu@ns.issas.ac.cn>

European Vetiver Network (EVN)

This Network, located in Italy manages a "mirror" homepage for easy access for Europeans: http://www.siam.mi.cnr.it/Vetiver

Contact: Marco Troglia at Email: "Tecnagrind s.l." <tecnagrind@iol.it>

Latin America VetiverNetwork - LAVN

(Central, South America and Spanish speaking Caribbean countries).

LAVN began operating in approximately November 1995 when Dick Grimshaw asked if Jim Smyle and I would be willing to operate a regional vetiver network for the Latin American countries since we were currently living in Costa Rica. There was a great need to serve the Spanish-speaking countries since the only material available in Spanish was the World Bank's vetiver publication ("Vetiver - The Hedge Against

Erosion"), also known as the "green book". Since I was not employed at the time I gladly volunteered as the Coordinator of the LAVN (La Red Latinoamericana del Vetiver) which means that I'm responsible for the newsletter and answering correspondence and anything else that I might think up along the way. Jim is here for consulting, acting as a sounding board and editor of my Spanish as well.

The first order of business was publishing our first newsletter in Spanish ("*El Boletín Vetiver*") which was finished in April 1996. It consisted mostly of information previously published in Vetiver Newsletters which had specific references to vetiver use and existence in Latin American countries. In addition, we also included an article about a "vetiver fact-finding" trip we had taken to southern Costa Rica in January 1995. Our first newsletter was sent out to those members of the Vetiver Network in Latin American countries who were already receiving the Vetiver Newsletter in English and numbered slightly over 400.

Our second (October 1996) and third (March 1997) issues of *Boletín Vetiver*, have reflected increased interest by our growing network. *Boletín #2* was six pages longer than the first and sent to over 450 members, while #3 ran 28 pages and sent to over 500 individuals. Articles published have included: several articles about Oaxaca, Mexico which has implemented an impressive soil conservation program; several articles relating to the February 1996 Vetiver Conference in Thailand; a recurring section in the *Boletín* includes translations of abstracts chosen from the Thai conference; technical issues that we perceive of interest and need to our readers such as "How to Use Existing Vetiver Hedges as Sources of Planting Material", "How to Plant Vetiver", and "Propagation of Vetiver in Nurseries". We have relied on the Vetiver Newsletter that Dick Grimshaw publishes as a source of material as well. And finally there is a continually growing section of letters from our readers and users.

We are very fortunate to have an enthusiastic membership in our region. In our first newsletter we requested that interested members contact us to help either editing our "spanglish" into proper Spanish or to volunteer to actually translate documents and articles from English into Spanish. The response has been encouraging and we have a pool of about 8 translators and editors on whom we rely heavily. This has been my biggest barrier in the publication of the newsletter. I've been in Costa Rica for almost 3 years now, but my Spanish is far from perfect and I need lots of help with the information I write or translate into Spanish. My goal is to get more people to actually write articles for us initially in Spanish so they can go right into the *Boletín* without editing or translating.

Aside from work on the *Boletín*, my time is spent on correspondence. We regularly receive requests from individuals via e-mail, fax and regular mail requesting general information about vetiver grass, where they might find it in their country, who else has experience in their country, how they might set up a nursery, etc. To new members we send out a general vetiver package which includes a copy of each newsletter, a green booklet (Vetiver, la barrera contra la erosión), a Spanish translation of a paper written by Richard Grimshaw which was presented at the International Congress on Soils in Acapulco, México (July 1994), and if they are English-speaking as well, they receive the green book in English and the blue vetiver book by the National Academy of Sciences. In addition, the Spanish version of the Vetiver video is sent to those who request it and we then request that they make 2 copies of the video to give to others. We now have translations in Portuguese of 2 chapters of the blue vetiver book by the National Academy of Sciences that we send out to new members in Brazil.

Knowledge and use of the Vetiver Grass Technology is certainly growing in Latin America. For example we have received quite a bit of correspondence from Bolivia although there is little vetiver currently in use there due to lack of planting material and projects - but there is interest. Others from Chile and Argentina are interested in starting up some soil erosion projects which include vetiver grass, but again lack of planting material is a real barrier. Hopefully we can help find some good people in these countries and help them get started on producing planting material.

In terms of adoption, one of the biggest success stories is in Oaxaca, Mexico. As of 2 years ago there was no vetiver known to be growing there. Thanks to the group SASO (Soils, Water, and Seeds of Oaxaca) there are a growing number of local and regional nurseries, demonstration plots and interested farmers throughout the entire state of Oaxaca (they hope to have 50 nurseries going by the end of 1997!) - all this stemming from the importation of 6000 plants from the State of Chiapas. There is also quite a bit of interest in other parts of Mexico which we refer to our contacts in Oaxaca for material and information.

We regularly receive information on previously unknown projects or programs using vetiver such as: a project in Costa Rica mentioned by a Peace Corps Volunteer; World Vision in Nicaragua (in the Río San Juan, and Nueva Guinea); GTZ project in state of Espiritu Santo, Brazil in coffee plantations; NOBS ANTI-EROSION in El Salvador which has planted vetiver along 300 km of roadsides and slopes; Fundación Golondrinas an NGO in Ecuador which is using vetiver to help stabilize and rehabilitate farm lands in the Mira Valley.

Our general goals for the LAVN in addition to our current activities include continuing increase in membership, increase the correspondence from users especially those willing to write articles about their vetiver programs in Spanish , and increase our pool of translators and editors. A data base of sources of vetiver in Latin America has been established which will be maintained by us and updated in each *Boletín*. We also would like to Set up alliances with 4 - 6 groups to: i) develop central nurseries and vetiver outreach and/or; ii) get vetiver road stabilization demonstrations with transport Ministries. — Jim Smyle and Joan Miller

This Network carries out its work and produces newsletters in Spanish.

Coordinators: Jim Smyle and his wife, Joan Miller out of San Juan Costa Rica. The newsletters in Spanish are available from "James Smyle and Joan Miller"<hamilton@sol.racsa.co.cr> or "La Red de Vetiver Latinoamericana, Apdo. 173-2020, Centro Postal Zapote, San Jose 92332, Costa Rica".

The Vetiver Network Philippines (VENETPHIL)

This Network carries out its work and produces newsletters in English.

Contact: Mr. Edwin Balbarino of The Farm

Resource Management Institute (FARMI), ViSCA, Baybay, Leyte, The Philippines. Email address: "Edwin A. Balbarino/ VENETPHIL" <vnp-ed@syntacs.mozcom.com>

VENETPHIL ACTIVITIES

- Known users and enthusiasts throughout the Philippines have been informed about the new network and its activities.
- Area coordinators have been appointed: Ms. Noah, Manarang for Luzon area; Mr. Andres Obusa for the Visayas, and Mr. Talpis for Mindanao.
- The three coordinators are now making an inventory of vetiver users/ project, sites, etc.
- Email communications being installed between coordinators.
- First issue of the newsletter VETIVERIA has been published and issued to 300 existing network members.
- NGOs and upland programs have been contacted and links are being established.
- An announcement has been made of the First National Vetiver Conference-Workshop to be scheduled from August 4 - 6 at FARMI ViSCA.
- Vetiver technoguide has been translated into two major dialects, and two more are under translation.
- Planting materials and technoguides have been distributed to Region 8 (Eastern Visayas) and Region 6 (Western Visayas)

Vetiver Field Program In Region 8

- Established a large nursery at Matalom producing bare root and bagged plant material.
- Initiated four on farm vetiver studies.
- Provided palnting material to 3 national irrigation projects, and 2 upland programs.
- Conducted 2 trainers training programs for vetiver promotion in Matalom and Baybay vetiver farmers.
- Run a vetiver radio program at DYAC and ViSCA with Mrs. Fati Balina.
- Conducted 2 vetiver farmer meetings.
- Started the establishment of 5 vetiver centers (multiplication sites) in five towns, and implememnted farmer-led multiplication programs

The Southern Africa Vetiver Network (SAVN)

(SADC countries - Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe).

In March the Southern African Vetiver Network circulated its first newsletter (see "What's New" on the vetiver website) to about 250 individuals and organizations - small beginnings but great promises for the future.

Vetiver is not new to southern Africa. First introduced from Mauritius about 50 years ago it has been used successfully for soil stabilization in a variety of habitats ranging from montane grasslands to coastal sugar cane plantations. Despite this success vetiver application has not enjoyed the public profile it deserves - until now, that is. Recently there has been a considerable increase in interest - mining companies are beginning to use it extensively to stabilize mine dumps and slime dams; civil engineers are specifying it for bank stabilization in road/rail construction and other large physical development projects; NGOs are promoting its use for erosion control and rehabilitation in degraded rural areas; and a pilot-scale essential oil production system has been established by Dickon Hall in Mpumalanga (eastern Transvaal).The recent increase in interest is also due, in no small measure, to the visit to southern Africa by Dick Grimshaw of TVN and Paul Truong from Australia. Their road show, organized by the 'father' of commercial applications in South Africa, Tony Tantum, exposed a broad audience to the opportunities offered by vetiver technology.

The spin-offs of their visit have been most positive:

i. The Institute of Natural Resources has been tasked with coordinating the establishment of a regional network and is being funded by TVN to accomplish this. The network aims to promote vetiver application through facilitating the free-flow of information between interested individuals and organizations within southern Africa, and between southern Africa and the world. It will include a regular newsletter, a website on the Internet, and periodic road shows. We will also distribute the TVN Newsletter on request.

ii. Project proposals are being generated which focus for the most part on the establishment of vetiver-based enterprises amongst previously disadvantaged individuals and communities.

iii. We have agreed, in principle, to host the next World Vetiver conference in the year 2000 and are currently formulating motivational proposals to generate the necessary funding.

Over the past month I have met with numerous individuals from a broad range of backgrounds and their enthusiasm for vetiver applications has been infectious. I am confident that through networking and the combined commitment of all these individuals we can make a difference in the quest for a sustainable southern Africa.

To end with a word of caution. I am a novice in the vetiver game but it seems obvious to me that in the stabilization of extreme slopes vetiver needs to compliment rather than be a substitute for conventional engineering solutions. I recently saw an example of vetiver application that to my inexperienced eye could quite easily fail. This would create the perception that vetiver has failed. The reality is that vetiver cannot fail. What can fail is our ability to apply the technology correctly. We need to curb our enthusiasm, follow conservatively design specifications, and leave the testing of the extremes of vetiver technology firmly in the research domain and not in the domain of application.—Duncan Hay

This Network carries out its work and produces newsletters in English.

Contact: Network Coordinator: Duncan Hay, Southern Africa Vetiver Network, Institute of Natural Resources, University of Natal, Private Bag X01, Scottsville 3209,

Republic of South Africa.

Email: “Hay, Duncan”<hay@inr.unp.ac.za>

Tel: 0331 46 0796. Fax: 0331 46 0895

The Pacific Rim Vetiver Network (PRVN)

Serves the countries of eastern Asia and the Pacific. These include: Australia, Brunei, Cambodia, Cook Islands, China, Fiji, Indonesia, Japan, Korea, Laos, Malaysia, New Zealand, Papua New Guinea, Philippines, Singapore, Solomon Islands, Taiwan, Thailand, Tonga, Vanuatu, Western Samoa, Vietnam and other countries that may fall within the region.

PRVN with the full support of The government of Thailand is managed by and The Royal Development Projects Board (RDPB) of Bangkok, Thailand and will serve those countries located in east Asia and the Pacific. The Network will produce newsletters in Thai and English.

Current participants from the Pacific Rim countries under The Vetiver Network are automatically PRVN participants (at present approx. 800 participants) . Others who want to join the network can apply directly at the address specified below. No application form is necessary, just identify oneself with name, current position, place of work, mailing address, Email address, and other information as preferred.

PRVN’s official homepage and the first newsletter will be launched by July 1997.

Correspondence with PRVN

Mailing Address : *Secretary - General,* Office of the Royal Development Projects Board, 78 Rajdamnern Nok Avenue, Dusit,

Bangkok 10300, Thailand.

Telephone Number: (66-2)-2806193-200

Fax Number : 2806206, 629-8915

Email Address : pasiri@mozart.inet.co.th

The West Africa Vetiver Network (WAVN)

Serves: Benin, Burkina, Central African Republic, Cameroon, Chad, Ghana, Guinea, Guinea Bissau, Ivory Coast, Liberia, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, The Gambia, Zaire, Togo.

It has recently been under established and will be managed by Linus Folly Coordinator, The West Africa Vetiver Network, Centre for Economic & Developmental Integration in Africa, PO Box C-753, Accra, Ghana.`**The West African Vetiver Network** (T.W.A.V.N.) will launch its newsletter “THE IDEAL FARMER” with the first issue coming out June ending. It will have English and French sections and will cover topics relating to land, water, farm management, techniques using vetiver grass and applying its technology on peasant and small scale farms.

The regional network has listed so far about 620 participants.Targeted 60 corporate bodies, identified 200 science and agricultural schools or institutions in the sub-region. It is expected that with French and major local languages being used the number of participants could reach 3000-3500 in the next two to three years

Cedia Training Program A training program in the form of workshops has been put in place by CEDIA for researchers, extensionists, local NGOs, Community groups, farmers etc.. The participants will be trained on propagation techniques, integration of vetiver grass into farm practices, other uses for both on and off farm purposes. The peculiarity of the entire scheme will be the use of teaching aids and training materials in local languages as well as the medium of communication. The program will be sanctioned by distribution of planting material to main zone groups across the country for field establishment.

Collaborative Research Program - CEDIA/CSIR C.S.I.R has responded favourable in participating in the above mentioned program. According to a letter from the C.S.I.R. executive the program would fit well into N.A.R.P. Agroforestry Program. The research team could be constituted together with CEDIA from their institutions to undertake the task, they are : Savanna Agricultural Research Institute; Soil Research Institute; Forestry Research Institute; Plant Genetic Resources Centre. NB: CEDIA IS STILL SOLICITING FUNDS TO SPONSOR 2 OF ITS RESOURCE PERSONS (BOTANY; SOIL SCIENCE) FOR THIS PROGRAM. ANY ASSISTANCE WILL BE APPRECIATED.

T.W.A.V.N. is calling on persons to contribute papers, articles etc. to its Newsletters to send them to the Network Coordination, Linus K. Folly, P. O. Box C-753, Cantonments, Accra, Ghana, West Africa. Email: “Linus Folly”<Balme@ug.gn.apc.org>.

OtherNetworks

Other Networks are being established at local levels within countries. Only those affiliated with The Vetiver Network are mentioned in this newsletter

Support for Regional Networks

China Vetiver Network—US$ 30,000

Status of Vetiver Grants

Latin America Vetiver Network—US$ 2,000
Southern Africa Vetiver Network—US$ 30,000
The Vetiver Network Philippines—US$ 30,000
The West Africa Vetiver Network—US $ 30,000
The Pacific Rim Vetiver Network — Memorandum of Understanding

Support for NGOs and Non Profit Organizations

FARMI - ViSCI, Philippines—US$ 10,000
Kaengesa Environmental Conservation Society (KAESO), Tanzania—US$ 10,000
Fundacion Golondrinas, Ecuador—US$ 10,000
Inter Aide France, Ethiopia—US$ 6,000
Community and Welfare Development Society, Nepal—US$ 14,000
Suelos Agua y Semillas de Oaxaca, Mexico—US$ 10,000
ECO LINK, South Africa—US$ 10,000Family Association Rural Development Project, Cameroon—US$ 6,000
Queensland Department of Primary Industries, Australia—US$ 3,000
Institute of Agricultural Botany, China—US$

5,000
Munchen f Munchen - Ethiopia—US$ 10,00

My name is Bood Hickson and I would like to subscribe to your network if I may. I have been trialling Vetiver at Melinda in

Letters to the Editor

Australia's very hot semi arid savannas for four years. trials undertaken with the Queensland Department of Primary Industries now Natural Resources) and the Cloncurry

Landcare Group had four objectives: 1. Ensure that the cultivar being used ("Monto") was in fact seedless so that we aren't introducing another weed. 2. Explore the diversity of vetiver applications on a 14,000 hectares cattle station, including rehabilitation of gully erosion and scalds (bare crusted soil) and protection for dam walls and by-washes from wave and running water induced erosion. 3 Gauge the amount of effort needed to establish vetiver (as labor is an expensive commodity). 4 To demonstrate vetiver's potential to resource managers throughout tropical and sub-tropical Australia and beyond.

So how did we get on?

Thumbs up for vetiver's potential. Monto proved to be seedless and the Environment Dept. is now supportive. Vetiver can be established in most of our largely alkaline soils with varying levels of nurturing i.e. water, protection from livestock and persistence in building a consistent hedge. It has lots of potential for all of our land managers, the primary obstacle in Australia will be time and wages. Those who have seen vetiver are invariable impressed, but that is too few at this moment. We have to get larger applications up in both our public and private sectors. Mining and Government are the most likely candidates at this stage because of funding constraints. Suggestions or comments always appreciated.

Bood Hickson "Huntly" Rolleston 4702 AUSTRALIA . Bood@peg.apc.org (Email) 61-(0)79-84-4518 (phone).

My particular interest in Vetiver relates to coffee, which is my trade. First there is the issue of soil conservation on roads, waterways and between rows of coffee. Secondly there is the issue of producing mulch during the early years when the leaf area index is small, even with the dense plant populations adopted in Malawi. Thirdly there is the prospect of trapping more of the available rainfall in the soil for use by the coffee. Fourthly, the aspect that most interests me most, is the prospect of planting Vetiver between the coffee plants within the row due to its deep, and supposedly non competitive rooting system might this practice assist in opening, and keeping the soil open in the rooting zone of the coffee?

As an under storey tree in the natural state, coffee is not a vigorous root producer. By and large it grows roots in the hole which you provide at planting. Not so surprising therefore that it suffers from lodging, biennial bearing and drought intolerance? Of course there is also the possibility that the roots of the Vetiver would allow water to penetrate along their courses, taking it to, and beneath the rooting zone of the coffee.

I was interested to see if skimming through one Newsletter that someone complained that Vetiver is killed under intense shade Hooray!, I suspect this would mean that as the coffee grew and the leaf area index increased that the by now unnecessary vetiver would be killed, leaving its root system to enhance the soil structure?

I have not yet had the opportunity to put any of this theorizing to practical test. We have planting material available and hopefully will soon have rain to make it grow will then let you now, in a year or so, what effects it had..... James Biscoe, Malawi

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From Joachim Boehnert, Caixa Postal 77, Nova Venécia - ES, CEP 29.830-000, Brazil:

... I have been working in Brazil for 8 months as a member of the German Development Service (GTZ) in cooperation with three Rural Development and Agricultural Extension Centers in the Sate of Espirito Santo. I am getting involved again with vetiver and some weeks ago we introduced the first vetiver plants from the neighboring state of Bahia into our areas. At present we have three small nurseries in each center. Our aim is to introduce vetiver as a soil conservation method in the coffee plantations. Soil erosion in the coffee plantations as a monoculture here in Espirito Santo is a very severe problem. ...Because of my work with vetiver in soil conservation in the Dominican Republic and Africa (Zambia and Kenya) I am convinced about this method. For my Brazilian colleges in this state in Brazil, vetiver and its uses are new and will take some time and practical experience to convince them. ...My Brazilian girlfriend who was studying with me in England has helped me with the translation of two chapters from the book "Vetiver - a thin green line against erosion" (ed. note - the publication by the National Academy of Sciences). ...We would be grateful if you can send us your "Boletín Vetiver" which I can share with my Brazilian colleagues since Portuguese is more or less similar to Spanish.

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From Dr. Reneé Zalles G., lawyer from Santa Cruz de la Sierra - Bolivia:

8 October, 1996: For two years I have been cultivating vetiver on my farm located near the city of Santa Cruz and have had good results with their development. The plants have reached a height of almost two meters and are flowering magnificently.

I have not had luck in the multiplication of my plants. When the plants are separated and planted they all die. I assume that the failure in replanting is due to my ignorance in the appropriate technology. (ed. note: We sent Dr. Seals our vetiver package and some general information regarding selection and treatment of the plant for transplanting and also mentioned that it is better to use young tillers instead of older ones which have flowered.)

29 November, 1996: Thank you for the letter that responded to my problems that I had with transplanting my vetiver. ...My new experiences with vetiver have produced good results. I owe my previous failures to poor management in that my tillers were of material which was too mature. I started a new planting three weeks ago and this time all of the tillers survived and are growing.

I propose to increase my areas planted with vetiver so that I can offer it for erosion control along the Piray River in this city and for

some roads in mountainous regions with high slopes where maintenance is difficult and often produce mud slides...

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From Heladio Reyes Cruz, ECOSTA, Tututepec - Oaxaca, Mexico:

...my organization (ECOSTA) started using vetiver 5 months ago as part of a program involving different organizations here in Oaxaca. We have a nursery with approximately 2600 plants which were planted in August of 1996 and have adapted well. We are at 50 meters above sea level and with average temperatures of 27º C. The vetiver will be used as a live hedge in three communities that work together with the Union of Indigenous Producers that is an organization of local farmers. ...on November 14, 1996 we met with all of the organizations in Oaxaca that had planted vetiver in order to exchange experiences and to try to define a regional strategy for soil conservation.

Australia

DEVELOPMENTS FROM THE FIELD

Australian Update - Paul Truong Resource Sciences Centre, Brisbane, Queensland

1. Vetiver Workshop

A workshop on the Research and Application of the Vetiver Grass System (VGS) was held in Toowoomba, Queensland in November 1996. It was intended for researchers and extension officers in Queensland to report their findings and assessment and Vetiver users (farmers) to evaluate the application of VGS in Queensland in the last five years. However with so much interest the workshop turned out to be first a national, then an international event with participants from southern states and overseas participants and speakers from Malaysia and Thailand and the US.

The 80 participants came from a wide range of backgrounds: farmers, University students and staff, soil conservationists, agronomists, foresters, engineers from Queensland Rail, Main Roads and Shire Councils, and horticulturists who, in addition to the soil conservation aspect of the VGS, were also interested in Vetiver oil production. With such an audience the discussion was diverse, ranging from environmental issues to toxic waste disposal. But to me the highlight and most significant issues were the works and quantitative data from the engineering researchers. I believe these original works on hedge hydraulics and root structural strength under field conditions, for the first time, provided much needed data for engineering designs and applications. This is a very important contribution to the knowledge of Vetiver technology.

As expected, the impact of these papers were immediate, engineers responsible for the infrastructure works in the region told me later that these were the data they needed for design specifications.

Perhaps of equal importance was the response received from the farming community. These words "*I am very pleased to know that we now have on hand a very simple soil conservation method that works*" from a farmer, demonstrated very clearly the positive outcome of the workshop.

The following is the workshop summary and conclusion.

Researches and applications in Queensland over the last eight years have confirmed most of the overseas findings and at the same time researches have extended Vetiver applications into the new fields of floodplain management and rehabilitation of contaminated lands.

On the agricultural applications, Vetiver has proved to be very effective in controlling soil erosion as well as protecting crop during floods on the Darling Downs. In addition Vetiver is also very effective in gully stabilization, sediment trapping and channel banks stabilization. However the most significant outcome is the application of the VGS which also bring direct financial benefit to the land owner. Mark Hensel mentioned that VGS cost him 5% in productivity (due to the occupied land, and light and water competition to the crop) which translates to $25.00 per hectare, but he gained $50.00 per hectare in overall production as a result of water conservation in dry time and crop protection during flood time.

If the costs of soil erosion can be calculated and taken into account, then the benefit would be much higher. This is very encouraging, as this is the result of the first three years of experimental application of the VGS, the benefit would certainly be improved with time. In addition, in the long term, with a drought proof and permanent soil conservation measure provided by the VGS, strip cropping farmers will have a greater flexibility with opportunity cropping which productivity can be improved up to 30% in some years.

On the environmental applications, due to its extraordinary tolerance to various environmental, soil and physiological conditions VGS has also shown to be very effective in the rehabilitation of industrial wastes and contaminated lands by stabilization, sediment trapping and leachate reduction.

On the engineering applications, researches both in Queensland and Malaysia have shown that VGS can be quantified and applied to some models for design specifications. The hedge hydraulic model developed at the University of Southern Queensland has been successfully used for erosion control in the floodplain and engineering tests conducted in Malaysia have also been applied very effectively for steep slope stabilization in that country.

On the negative side, the application of VGS in Queensland will remain slow unless establishment costs are reduced, particularly the planting costs. Mechanical planting can solve part of this problem.

Looking into the future, on the agricultural scene, research is needed on land where contour banks are traditionally used to control erosion, particularly on shallow soils and under dryland and broad acreage conditions.

On environmental applications, Vetiver applications in bio-remedial works, particularly in trapping and reducing farm chemical and nutrients runoff from contaminated and farms required further investigations.

2. Application in Queensland

There are four major impacts in the application of VGS in Queensland resulting from this workshop.

With the quantitative data presented by Rod Smith and Paul Dalton of the University of Southern Queensland and Diti Hengchaovanich from Malaysia, Queensland Main Roads and Railways (in Southern Region) are now adopting VGS in the design of their infrastructure stabilization, erosion and sediment control and water diversion programs.

Farmers from the floodplain in New South Wales have organized a field trip to have a closer look at our flood mitigation project at Jondaryan. They were very impressed with the results and are planning to adopt the system.

A number of mining companies have expressed interest in using Vetiver in their rehabilitation of mine tailings and also in the stabilization of deep dam wall slopes.

Shire councils are very interested in the concept of using effluent to irrigate Vetiver which in turn will supply plant top for mulch, planting material for soil conservation purposes and roots for oil production.

3. Planting Machine.

As mentioned in the summary of the workshop, the main obstacle to wider and large scale adoption of the VGS on the floodplain at the moment is the planting costs. To overcome this a local farmer has successfully modified a vegetable planter which can plant more than 1,000m per hour at the spacing of approximately 0.12m apart.

In addition a tree planter (olive) has also been successfully modified to plant Vetiver on 3:1 slope (approximately 33% or 15°).

With the availability of these planters, it is expected that adoption rate will be greatly increased in the next few years.

4. South African Visit.

On the invitation of Tony Tantum of the Specialised Soil Stabilization of Howick, Kwazulu- Natal, I spent two weeks late in January 1997 visiting several sites in south Africa with Tony and presented a series of seminars on the results of my research and application in Australia to various interest groups including Research Institutes, Agricultural College, Soil Conservation Services, Consultant Engineers, Vetiver oil producers and the South African Chamber of Mines in Johannesburg.

Thanks to Mark DaffornÕs great detective work on DNA typing, I was able to tell the audience that my research results based on Monto Vetiver in Australia can be confidently applied in South Africa as the Vetiver variety that Tony has been using, is the same as Monto Vetiver.

However, the greater impact of my visit to South Africa was probably not on the effectiveness of the VGS but in convincing environmentalists that V. zizanioides will not become a weed. Although V. zizanioides has been grown in various locations in South Africa since the mid 1800's, its weed potential is still a major concern to the community. As it took me seven years. to overcome these concerns to get Monto Vetiver registered and released in Australia. I was in a good position to allay these concerns, This is one aspect of the Vetiver work that I can absolutely sympathize with Tony's frustration.

It was a highly successful trip and an excellent opportunity to share our experiences as well as our frustrations on the application of the VGS. I believe that with the enthusiasm indicated and cooperation with the Institute of Natural Resources at Pietermaritzburg in future projects, Vetiver adoption in South Africa will greatly increase with plenty of demonstration sites for the Second International Vetiver Conference in the year 2000.

The hospitality extended to me and my wife Julie by Tony and family, Andrew Hall of Dickon Hall and family and Sue Hart of Ecolink made the trip most memorable. We wish to thank them all.

Vetiver Research at Australian Universities

Paul Truong Resource Sciences Centre, Brisbane, Queensland

Over the past seven years, research conducted on Vetiver physiology, adaptation and hedge hydraulics at several Australian universities have contributed greatly to the knowledge base of the VGS. In addition these projects also promote the awareness of the VGS among university staff and students and eventually its adoption.

Most of these projects were supported by the University Research Grant as parts of the student study program. Some received small grants from external sources notably the Australian National Landcare Program which contributed more than $120,000 to the flood erosion control project.

The followings are highlights of research results of projects that I have been associated with.

1. John Griffiths (1991). An investigation of Australian native plant species which may be useful in soil erosion control. Bachelor of Applied Science Report submitted to the University of New England (New South Wales).

An investigation of Australian native plant species reviewed two native species, *Vetiveria filipes* and *Lomandra longifolia*, and an exotic species, *Vetiveria zizanioides* for their soil conservation potential and ability to form a vegetative hedge.

A glasshouse trial compared the establishment and early growth of these two species with that of *V. zizanioides*. *V. zizanioides* exhibited rapid early growth, producing numerous tillers, and roots capable of achieving a depth of 40 cm within 21 days. *V. filipes* exhibited comparable root growth in establishment to that of *V. zizanioides*, but exhibited a slow rate of top growth. This species prefers creek and river flat habitats but can occur in a wide variety of soils. It appears to be both drought and flood tolerant. *L. longifolia* occurred in a wide range of habitats, including shaded sites, skeletal soils and coastal dunes. It appears to be a slow growing species and its application as a soil conservation plant may be limited to special situations. Further trials are justified to determine if the two native species can form an effective and manageable hedge, and also to determine the weed potential of *V. zizanioides*.

2. Greg Cook (1992). The soil salinity tolerance of exotic Vetiver grass species compared with that of two alternative native grass species. Bachelor of Applied Science Report submitted to the University of New England (New South Wales).

An investigation comparing the salt tolerance of two exotic grass species, *Vetiveria zizanioides* (Monto) and *Vetiveria zizanioides* (Grafton) with two Australian native grasses, *Vetiveria filipes* and *Lomandra longifolia*. These four plant types exhibit potential qualities that would enable them to be used as vegetative contour hedgerows.

A pot trial was set up and two methods were used to evaluate the increase in biomass at different saline soil concentrations. *V. zizanioides* (Monto) showed the greatest potential with the widest range of potential application. *V. filipes* exhibited comparable root establishment to that of *V. zizanioides* (Monto), but exhibited a less vigorous growth rate and the lowest tolerance to salt. *L. longifolia* had the highest tolerance to saline soil but due to its form would not make as an effective hedgerow. *L. longifolia* however does have site specific applications in highly saline soils. *V. zizanioides (Grafton)* suffered the most from osmotic and repotting stress. It seems to be as tolerant to salt as *V. zizanioides* (Monto). *V. zizanioides* (Grafton) seed is virile, this gives it potential in applications where vast areas of land need to be vegetated. Further trials are justified to determine the weed potential of the exotic species before the promotion of these species takes place in Australia.

Greg Cook was awarded a Research Award by the World Bank in 1993 for this work.

3. Jonathan Stone (1993). The response of *Vetiveria zizanioides*, *V. filipes* and *Lomandra longifolia* to Nitrogen and Phosphorus. Bachelor of Applied Science Report submitted to the University of New England (New South Wales).

The response to N and P application was compared between the native Vetiver (*V. filipes*) Lomandra and Monto Vetiver. Their requirements should be known to ensure better establishment and growth.

The addition of increasing levels of nitrogen resulted in a disproportionate increase in shoot growth compared to the roots of *Lomandra longifolia.* A positive response to phosphorus is experienced in shoot and root growth of *L. longifolia*. If *L. longifolia* is to be fertilised only low rates of phosphorus would be necessary to promote growth. *Vetiveria filipes* has a strong dependence on phosphorus to utilize nitrogen, with nitrogen being toxic at high rates when phosphorus is not present. Where *V. filipes* is to be fertilized, t he application of nitrogen would need to be accompanied by the supply of phosphorus. *Vetiveria zizanioides* responded positively to all applications of nitrogen and phosphorus, although at 100 ppm of both nitrogen and phosphorus the shoot response was proportionately greater than the roots which may lead to lesser drought tolerance. From the results of the experiment it is recommended that for *Vetiveria zizanioides* and *Vetiveria filipes* applying 50 ppm phosphorus with 50 ppm nitrogen will increase shoot and root growth and tillering significantly. Fifty parts per million is equivalent to 112 kg per hectare of the nutrient. *Lomandra longifolia* is best left or supplied with a low level of phosphorus alone.

4. Kit Jolley (1994). Vetiver, the answer for soil conservation in the Northern Territory. A Graduate Diploma Report submitted to the University of Ballarat (Victoria).

Soil erosion is one of the most severe land degradation problems facing the world today. Engineering solutions to the problem are not necessarily the most appropriate solution. Vetiver grass (*Vetiveria zizanioides* (Linn) Nash) planted as a single row hedge has been proposed as a viable alternative to engineered structures.

Success with Vetiver grass has been reported from around the world. It was not known if Vetiver grass would survive and form effective hedges in the semi-arid tropics of the Northern Territory. This project looks at survival rates and rates of hedge formation of Vetiver grass planted in the Katherine Region of the Northern Territory. Survival rate and rate of hedge formation at different slip sizes were also investigated.

Single rows of Vetiver grass were planted on four different soil types and on three different erosion types. The Vetiver grass formed effective hedges within one year on all of the soil and erosion types. These hedges also caught large amounts of soil and debris. Survival of the Vetiver grass ranged from sixty-nine percent to ninety-five percent. The best survival was obtained within a roadside drainage line on a loamy Red Earth.

Rows of Vetiver grass were planted using slips comprised of 1, 2 and 4 shoots. The best survival rates and rates of hedge formation occurred with slips comprised of four shoots.

From the results obtained it is concluded that there is a place for Vetiver grass in soil conservation in the semi-arid tropics of the Northern Territory. It is further suggested that the use of vegetative hedges using plants other than Vetiver grass should be investigated throughout all parts of Australia.

5. Jeremy Claridge (1995). Vetiver grass: the uptake and toxicity's of heavy metals. A Bachelor of Science Report submitted to the University of Queensland (Queensland).

Environmentalists are increasingly concerned with problems caused by contaminated land to the environment. Land contaminated by heavy metals, as results of mining and industrial and urban wastes, require effective erosion and sediment control measures to stop its offsite pollution.

Vetiver grass which is known to have high tolerance levels to some extreme soil and climatic conditions, is tested for its tolerance to a number of heavy metals common in mining and industrial wastes in Queensland.

Results indicated that Monto Vetiver can tolerate very high levels of heavy metals in the soil: Arsenic (100-250 ppm), Cadmium (20 ppm), Chromium (200-600 ppm), Nickel (50-100 ppm) and Copper (50-100 ppm).

Chemical analyses of Vetiver tops indicate that Vetiver can also tolerate very high levels of these heavy metals.

6. Michael McDonald (1996). Increasing *V. zizanioides* root growth when established in drought and salt affected soil. Bachelor of Applied Science (Hons). Thesis submitted to the University of Central Queensland (Queensland).

Vetiver acts as an erosion prevention agent when planted in hedges. The costs of establishing Vetiver is high as it can only be propagated by vegetative means (i.e. slips), and the initial establishment losses, especially in stressful situations can be high. Thus practices that improve the establishment of Vetiver in the field must be devel-

oped. The present study investigated auxin and bentonite pre-treatment of slips, and drought hardening of parent materials, as techniques to increase root growth following planting.

The initial experiments using low auxin concentrations (0.1-200mM) and short dipping solutions (10 sec - 15 min) had no effect on root growth. Subsequent experiments involving combinations of high (1,000-4,000mM) or low (100-10^{-3}mM) IBA concentrations with short (10s) or long dipping durations (24h-96h) revealed no increase in root growth. The extended dipping duration in the latter experiment resulted in a significant increase in total root weight.

Hardening the parent plants prior to preparation of planting slips resulted in a subsequent increase in root growth of slips in control (field capacity) and drought stressed treatments, but a decrease in salt stressed treatments. Bentonite is used to protect the roots of the plant from desiccation during transport and storage. In these experiments bentonite was applied immediately prior to planting, thus, no beneficial effects of bentonite were demonstrated. Instead bentonite was found to be largely inhibitory to root and shoot growth.

Morphological responses of Vetiver to drought were typically the conservation of root growth whilst shoot growth decreased, leading to an increase in the root:shoot ratio. This response was affected by physical changes that occur in soil as it dries. Salt stress caused greater reduction in root growth than shoot growth, decreasing the root:shoot ratio compared to the control.

Michael McDonald was awarded First Class Honours for his research.

7. Paul Dalton (1997). Vetiver grass hedges for erosion control on a cropped floodplain. A master of Engineering (Agric) Thesis submitted to the University of Southern Queensland (Queensland).

Hedge Hydraulics: This research is an attempt to quantify the hydraulic characteristics of Vetiver grass hedges and to develop guidelines for hedge spacing on a cropped floodplain. It was established that:

First, the flow through the hedge can be described by a simple equation relating discharge to the depths upstream and downstream of the hedge, with upwards of 90% of the variation in discharge described by the equation.

Secondly, it appears hydraulically feasible to use Vetiver hedges to control flood flow and erosion on cropped floodplains. The hedge spacings required are comparable to and slightly greater than the strip spacings required for conventional strip cropping but are far less sensitive to the magnitude of the discharge. The validation of the strip cropping model in field conditions would suggest that the hedge spacings derived from a similar model are feasible to control erosion.

Finally, it also appears that Vetiver grass hedges may be feasible at land slopes between 0.5 and 2%. This range of land slopes is not successfully protected from soil erosion by strip cropping or contour banks. If a narrow design spacing between Vetiver hedges could be tolerated by farmers then Vetiver grass would successfully protect these land slopes.

Although the equation has only been applied to design spacings on a floodplain it might be assumed that the hydraulic equation could be applied to Vetiver hedge spacing design for soil conservation on various topographical situations provided the hedge remains unsubmerged in the flow. The design would also involve using an appropriate model of the flow between the hedges.

Field Evaluation : The Vetiver hedge spac - ing model developed from hydraulic flume tests above is purely one dimensional . The field experiment showed that where flows were one dimensional and perpendicular to the hedges little or no erosion occurred between the hedges and flow velocities were maintained below erosive levels. At non-uniform flow points, erosive flow veloci - ties and some scouring occurred , however most detached soil was trapped at the next Vetiver hedge downstream. It is concluded that the hedges were successful in reduc - ing flood velocity and limiting soil move - ment. The hedge spacings predicted by the hydraulic model were not excessive.

An Overview of Research, Development and Application of the Vetiver Grass System (VGS).

Paul Truong, Leader, Land Stabilization and Rehabilitation Resource Sciences Centre, Department of Natural Resources, Brisbane, Queensland, Australia.

The following is an extract from Paul Truong's paper that he presented during his visit to South Africa. Complete paper can be found on the Internet at www.vetiver.org

Applications of the Vetiver Grass System in Queensland and Australia

Queensland has very similar climate to Natal, its capital city Brisbane is on approximately the same southern latitude as Durban. The climate is subtropical in the south and tropical in the north, temperature is moderate on the coast but can be extreme inland, ranging from more than 45° C in summer to -15°C (ground) in winter. Rainfall varies between 1500 mm/year in the south to over 3,500 mm in the north along the coastal fringe and between 300-800 mm/year inland in the agricultural zone. But this rainfall is highly variable and prolonged drought is a common feature of Queensland and Australian climate. Soil types range from the highly fertile black earth (minority) to poorly structured and infertile solodics (majority), except for the well structured red earth, all Queensland soils are highly erodible. Therefore erosion and sediment control in both agricultural and urban lands is imperative, particularly with the recent concerns about environmental degradation caused by soil erosion.

I first started conducting R&D works on Vetiver in 1988, most basic researches were conducted under glasshouse conditions but field works were established in all regions of Queensland and in cooperation with others throughout mainland Australia. Some of these works have been mentioned above, the followings are some other works of interest.

Substitution of Contour Banks in Steep Canelands

In steep canelands the traditional method of soil conservation using contour banks can present some problem for machinery operation as the channels and banks can be dangerous for harvesters and haul out

machinery. Replacements of contour banks with rows of vegetation such as Vetiver grass could offer a solution to the problem. In addition space saved from the conventional banks can be used to plant another row of cane next to the Vetiver hedge.

Two rows of Vetiver totaling 800m were planted on contour line on a property on the wet tropical coast near Innisfail. Results to date are very encouraging, however the full results cannot be assessed until the next new planting when the old crop will be ploughed out and fallowed. Vetiver hedges are in place to protect the steepland from early season storms.

Steep Slope Stabilisation

Embankment of both cut and fill slopes can be effectively stabilized by establishing Vetiver on contour lines. The deep root system stabilizes the slope while the hedges reduce runoff, increase infiltration and trap sediment providing a very favorable environment for the colonization by local volunteer species. This is well illustrated in the following two examples.

A very steep (1:1) and highly erodible sodic soil on a railway embankment near Cairns collapsed and needed to be rebuilt after almost every wet season. Obviously, the solution to this problem is a very costly engineering structure. As a trial, six rows of Vetiver were established on mini benches (0.25m wide) on the slope at 1m VI (Vertical Interval). A total of approximately 250m embankment was stabilized with Vetiver in June 1992. The Vetiver established and grew well despite the dry season and by December 1992, the slope was reasonably stabilized by the young Vetiver plants and local species began to establish between the Vetiver rows. In March 1993, nine months later, the slope was completely covered with local vegetation between the Vetiver hedges. Fifteen months later the embankment was completely stabilized with a mixture of Vetiver and mature local grass species. This embankment has withstood up to the last three wet seasons.

On another site, an old quarry at Henley Hill in Cairns where the old rubble surface has remained bare of vegetation since the quarry operation stopped five years earlier. Four rows of Vetiver, established on an 80% slope at 1m VI. Despite the extremely poor and hostile conditions of the coarse gravely ground, Vetiver established well (with NPK fertilizer) and started trapping debris from upslope. The stiff stems of Vetiver provided a very effective barrier trapping debris and rocks up to 70 mm in diameter. Twelve months later the old gravely slope was 75% covered with local vegetation between the rows of Vetiver hedges which had grown to 1.2m tall. Eighteen months later the slope was completely stabilized and revegetated with Vetiver and other local species including a pasture legume (Stylosanthes).

Gully Stabilization

Vetiver hedges are very effective in stabilizing gully erosion. When planted on contour line above gully head, Vetiver hedges will spread and slow down runoff water and stop the advancement of gully heads. This is well illustrated at a number of gullies in both cropping and grazing lands. Following the control of active erosion at the gully heads, gully floors are normally revegetated naturally with native species.

On large and long gullies where active erosion occurs both on gully floors and walls, Vetiver hedges established on gully floor will reduce flow velocity, trap sediment and reduce further erosion on the floor. At Ashall Creek, a very large gully system in the black earth on the Darling Downs, more than 0.3m of sediment was trapped by a series of 17 hedges over an area more than 400m long and 50m wide during the 1994 summer.

Stabilization of Structures in Flooded River

A large water cascade was built by South Johnstone sugar mill near Innisfail on the bed of the flood prone South Johnstone River to cool off wastewater from the mill. One side of the cascade is a large bund of about 200m long and 4m high at the top end lowering down to river floor level at the bottom end with 2:1 slide slope. This bund was built mostly from the highly erodible sand and gravel material from the river bed. Vetiver was used to stabilize the steep side slope, protecting it from high velocity flow during the wet season. This bund was completely stabilized and Vetiver has successfully protected this bank from several flood flows during the last two wet seasons.

In addition, Vetiver was also planted across the cascade floor to reduce flow velocity. Parts of these rows were completely submerged in hot running water during week days. Although still very young (3-4 weeks old) these Vetiver plants survived under these conditions for a few months, with water temperature reaching 45° C most of the time, but they were eventually washed away.

As a result of this success Vetiver is now being used by the Johnstone River Improvement Trust for several similar projects in the Johnstone catchment area.

Wave Erosion Control

Being able to establish and thrive under waterlogged conditions, Vetiver has proved to be very effective in reducing erosion caused by wave action on big farm dam walls. The erosion caused by wave action on the inside wall of a very big farm dam near Cloncurry was effectively controlled by establishing a Vetiver hedge along the high water mark.

Applications in Forest Plantation

Vetiver has been used successfully to stabilize shoulders of driving tracks on very steep slopes as well as gullies in a forest plantation at Imbil. It is also very effective in stabilizing and trapping sediment in waterways on very poor sandy soil at the Toolara forest.

Applications in Pineapple Farms

Farm chemicals and nutrients from pineapple plots were effectively trapped by Vetiver rows planted across drainage lines which were also successfully stabilized by these rows.

Lowering Water Table in Saline Lands

With its salt tolerant ability and deep rooting characteristics, Vetiver has been successfully used to control soil erosion and at the same time lower the saline water level in a trial in temperate southern Australia. It is now being trialled on a large scale for the same purposes in Western Australia.

Providing Shade for Sheep.

(Extract from Toni Somes' article in Queensland Country Life, 10 November 1994).

"An Asian grass, already used extensively to control soil erosion, may soon prove instrumental in boosting lambing percentages in western Queensland. The Vetiver grass (Vetiveria zizanioides) is being grown as part of shade plot trials at Toorak, a QDPI research station, south of Julia Creek.

Research has already found artificial shade plots on Mitchell grass country can boost lambing percentages by 15 percent. According to Toorak Manager, Tony Barnes, the Vetiver grass has considerable advantages over native trees and its predecessors, particularly Prickly Acacia and Parkinsonia. "Introducing thorny trees and shrubs like Prickly Acacia and Parkinsonia, for animal welfare reasons, has seriously threatened the viability of Mitchell grass pastures", Mr. Barnes said. "But research shows Vetiver doesn't spread - it can only be propagated by root division or slips - and therefore will not compete with natural grasses like Mitchell and Flinders". "It also grows rapidly and is capable of providing adequate shade for adult sheep after at least 12 months".

Although the Toorak trial is in early stages, research officer, Greg Bortolussi said he was confident of finding favorable results. "We planted the grass in February last year and now it stands about 1.7m high and provides quite adequate shade for sheep". Mr. Bortolussi said: Heat stress is currently blamed for approximately 20 percent reduction in the birth weight of lambs and up to 30 percent increases in lamb mortality".

Where From Here?

At the recent International Conference in Thailand, I was asked to lead the discussion on future applications of Vetiver grass. From the results of our research in Queensland and outcomes of the discussion panel, I concluded that we now have enough evidence that Vetiver is ready to move out of the farm gate, beyond the soil and water conservation applications in agricultural lands to the protection of the environment in general, with particular emphases on engineering applications, rehabilitation of contaminated lands, mining wastes and bio-remedial applications including wetlands and aquaculture.

Conclusion

From the above it can be concluded that:

With its wide ranging tolerance of adverse climatic and edaphic conditions the Vetiver Grass System offers a simple and low cost alternative to constructed soil erosion and sediment control measures.

On disturbed lands, where conventional methods of stabilization and reclamation are limited and costly, the Vetiver system offers a unique means of rehabilitation of these highly erodible lands.

More specifically with its high level of tolerance to extreme soil pH, soil salinity, Al and Mn toxicities, Monto Vetiver has great potential for reclamation work in mining and other industrial waste and contaminated lands.

Future application in bio-remedial works.

On engineering applications, although results to date have been very impressive, application of the VGS in engineering designs is till somewhat limited due to the lack of knowledge and design parameters which now start to emerge from recent researches. More researches are needed in this area so that bolder and more innovative applications, utilising its full potential, can be adopted with confidence.

Vetiver Grass For Erosion & Sediment Control In The Mackay Area

Frank Mason, Mackay, 1996

Introduction

The Mackay Central coast of Queensland has a rural industry based on sugar cane 135209 ha (CANEGROWERS 1994) with cattle grazing as the second major industry in economic terms. The district extends from the Shire of Proserpine in the north to Broadsound in the south. The climate is tropical with a summer dominated rainfall averaging 1714 mm. Approximately 70 percent of the median annual rainfall occurs in the four months from December-March. The one in 10 rainfall intensity is 8 mm per hour, (Institution of Engineers Australia 1987).

This high intensity combined with a large area of sodic soils results in a high potential for soil erosion. Research has shown cultivation is the major determinant of erosion. Losses of 200 tonnes per hectare from a single storm event have been recorded in a cultivated cane paddock (Sallaway 1979). The Department of Natural Resources has estimated there is in excess of 40000 hectares where soil erosion is excessive under conventional cultivation in sugar cane. Soil conservation measures have been implemented on only 24 percent of the vulnerable cane area. Green cane harvesting in the 1996 season is currently above 60 percent of the area which will result in reduced soil losses due to the lack of cultivation practiced in the trash blanket.

The fate of soil erosion including impact on water quality, infrastructure and the marine environment in coastal areas is becoming increasingly scrutinised. Legislation including the Environmental Protection Act, Environmental Management Plans and industry codes of practice will impact on the discharge of runoff from agricultural lands where sediment, nutrients and chemicals are present.

Tail water dams which aim to collect initial runoff are being investigated for their effectiveness however these structures do not suit many situations. Alternative solutions to filter the runoff and stabilize degraded areas within the Mackay District are currently under trial with Vetiver grass (*Vetiveria zizanioides)* discussed in this paper.

Applications Of Vetiver Grass In The Mackay Area

Vetiver grass was first trialed in Mackay district in 1993 in waterway stabilization. Since then it has been used for batter, river bank and gully stabilization. The grass grows well in the tropical climate of Mackay with a planting population of 6 plants per metre (2 to 3 slips per plant) forming a hedge in 6 months capable of trapping silt. Batters up to 2 : 1 have been stabilized in alluvial sands adjacent to the Pioneer river bank west of Mackay. The area was previously an active gully that had been eroding since the turn of this century when it was constructed as a drain. Earthworks including removing the rubbish and battering the gully head were performed in August 1995. The vetiver grass hedges were then planted in critical

areas. Grass was seeded between the rows of vetiver to assist in erosion control. The vetiver hedges have established successfully. Three applications of DAP were used due to the inherit lack of fertility and alluvial sandy subsoil. A further two rows have been planted in the gully to control erosion in the middle of the gully floor. This was due to the distance between the rows being planted too far apart (100 metres approximately). There are many similar gullies along the major river systems in the district that are in need similar stabilization techniques due to active erosion in flood and high intensity rainfall events.

Farm Waterways

The majority of vetiver grass plantings in the Mackay district have occurred in on-farm waterways to assist in erosion control in highly erodible sodic soil and in newly constructed waterways. The landholders are satisfied with the hedges and there is evidence of silt being trapped after flows in the waterways. The length of time for the hedge to establish, approximately 6 months, has been a problem when high flows occur during this period. Fertilizing, watering and planting at a higher density reduces the establishment period.

Road Batters

Road batters (2 : 1 grade) in granidiorite soils have been planted with three potential hedge forming grasses to assess their effectiveness in trapping silt and stabilizing the batters. The trial was planted at Teemburra darn which is under construction west of Mackay. A cut and fill batter were used to demonstrate the effectiveness of hedges. The grasses used were two natives, *Lomandra longifolia* and *Vetiveria filipes* which grow in moist areas associated with watercourse beds and the introduced Vetiver (*Vetiveria zizanioides)*. No significant rainfall events have occurred but dry conditions and cattle grazing has virtually eliminated the Lomandra. The native vetiver has survived however tends to grow prostrate while the introduced vetiver has grown erect and is envisaged will trap silt and stabilize the bank in event of a significant rainfall event.

Filter Strips

A research trial is currently being established on two sites to determine the ability of vetiver to trap silt, fertilizer (N P K) and pre-emergent herbicide (Atrazine). Natural rainfall events will be monitored together with a range of land management/cultivation techniques that are used in the Mackay district. The trial will be replicated and will use recommended rates of fertilizer and chemicals. The land management conditions include, bare cultivated, bare zero till, green cane harvested zero till (apply fertilizer on top and buried as two treatments). Runoff will be collected and silt traps installed above and below the vetiver grass hedge to enable analysis of the runoff from each treatment.

From the Mackay experience the advantages of vetiver grass are as follows:

- Adapted to a wide range of soil types including sodic and acid soils.
- Ability to survive fire, traffic and drought once the hedge is established.
- Limited palatability to cattle once the hedge is established.
- Stabilization ability due to the extensive rooting system with only vertical roots to reduce impact on adjacent crops and other grasses.
- Vetiver continues to perform sediment trapping in unstable areas as hedge continues to grow above silt layers.
- No major pests or diseases evident to date.
- Lack of weed potential due to absence of viable seed and extensive root system.

The potential disadvantages of Vetiver grass are :

- Establishment time for vetiver hedge to become effective (approx. 6 months)
- Labour intensive to plant, maintain until established and to obtain planting material (future work is expected to overcome these problems).
- Not tolerant of shade (may use native Vetiver, Vetiveria filipes which grows in many creeks in the district however this species is not as erect hence silt trapping ability not as effective. May use in combination with Vetiveria zizanioides).

From experience in planting Vetiver grass in Mackay the following issues are critical to achieve a dense effective vetiver hedge:

- Use well rooted and vigorous planting material (fertilized). Each plant should have two to three slips.
- Plant at least 6 plants per metre with closer spacing or double row in critical areas that require a quick hedge.
- Plant into moist soil and water until plants are established.
- Trim vegetative material to maximum 15 cm prior to planting to reduce evaporative loss. Do not trim roots as this will reduce survival rate.
- Provide weed control, during establishment phase (note vetiver very susceptible to glyphosate).
- Fertilize with phosphorus based fertilizer until established (e.g. DAP at 50 grams per metre)
- Trim hedge at least annually after flowering and hedge may be burnt once a year provided soil moisture present, to maintain hedge vigour.
- Clean silt trapped by hedge to reduce terracing effect in active eroding areas.
- Plant other stoloniferous grasses between hedge rows to reduce erosion.
- Avoid herbicide drift especially glyphosate.

Recommendations

Vetiver grass hedges from experience to-date is seen as a useful stabilization system an potential filter system from agricultural land. The grass offers an alternative to engineering solutions and from the successes achieved in the Mackay district, will gain wide spread adoption.

Future work will revolve around developing planting techniques for vetiver hedges that will reduce the cost and labour require-

ment. It is not envisaged vetiver grass will be used to replace contour banks in the coastal areas, rather in specific stabilization problems and as a filter for agricultural runoff.

Use of vetiver hedges in the extensive cropping areas west of Mackay will also be trialed in lieu of contour banks as a water spreading technique. Contour banks have been less than satisfactory due to cyclonic rainfall influences in the extensive cropping areas of Nebo and eastern Broadsound shires. Farming efficiency problems with non - parallel banks is also a impediment to conventional contour bank systems.

Vetiver Grass for Erosion Control in Forest Plantations

John Grimmett, Forest Development Group, Gympie

DPI Forestry currently manages 175,000 hectares of Hoop Pine (*Araucaria cunninghamii*) and Exotic pine (Pinus sp.) plantations situated principally in S.E. Queensland and within 200 km of the coast.

Hoop Pine plantings comprise about 45,000 hectares and are generally situated on the fertile ex-scrub soils of the coastal ranges. Although soils are relatively stable, logging and certain re-forestation activities on some of the steeper slopes (up to 35 °can lead to unacceptable erosion during early summer storms and before the site has been properly stabilized. Our major plantings of exotic pines comprising about 130,000 hectares, are situated on the depauperate 'Wallum' soils of the coastal strip. These soils are generally poorly structured and can be highly erosive despite the relatively gentle topography on which they occur.

Forestry Trials

Following a field day conducted by Paul Truong at Beerwah in October 1993 we decided to trial Vetiver grass (*Vetiveria zizanioides*) as a erosion control agent in two of our major plantation types in S.E. Queensland.

Three sacks of Vetiver vegetative material were obtained from the Ayr Research Station in October 1993. The large clumps were broken up into two to three leafed slips and planted into Vic Pots for growing-on prior to planting-approximately 500 plants resulted.

Material that was considered unsuitable for growing-on was placed in a bag and thrown in a corner of the nursery.

Much of this material, when inspected several weeks later was found to have initiated root and shoot growth, so we had obviously underestimated the extremely robust nature of Vetiver.

The Exotic Pine Trial

In November 1993, half the plants were deployed in an unstable waterway within a recently mounded second rotation exotic pine site at Toolara, east of Gympie. The waterway had been constructed with excessive fall and was draining too much area.

Active erosion was present, and previous attempts at stabilization using cereal crops and couch grass had proved ineffective.

Approximately nine single and/or double rows, each five metres wide, were spaced fifteen metres apart along a section of the waterway. Plants in each row were planted at 20 cm centers into virtual clay subsoil forming the bottom of the waterway. Because the wet season was already in progress, there was little time available for the plants to establish themselves on the site before their presence was required. Consequently, several breakthroughs and washaways occurred due to excessive water velocity and volume. However, where the barriers did hold, a substantial volume of sand was trapped and built up against them.

Obviously, with more extensive and better design and deployment of planted barriers, stabilization could have been achieved in that first year - at 20 cm spacing and growing in the clay, it took a full season for the plants to develop sufficiently to form an effective barrier.

The Hoop Pine Trial

Also in November 1993 the remaining Vetiver plants were established in an eroding unprotected gully in Hoop Pine plantation at Imbil, south west of Gympie. The site was steep (>200) and had recently been broadcast burnt, strip sown with kikuyu and millet, and replanted following harvest.

Again plants were spaced about 20 cm apart. Rows of Vetiver were planted for each metre of fall, which equated to approximately a row every three to four metros of gully length. A total of 18 rows were established from the point source of the erosion down to the intersecting gully at the bottom of the slope.

Growth was rapid. However, as before, because of the spacing between plants, there was a time lag between planting and the beginning of effective control of soil movement by the hedges. This time , because of the more fertile site, the period was about six months or half that at Toiler.

Weed and sown cereal growth was prolific at the time of Vetiver establishment, to the extent that all vegetation was contributing to erosion control, and competition appeared to be leading to a degree of suppression of vetiver development. Nevertheless, once the Vetiver grass gained control of the site, rapid and permanent stability of the gully was achieved.

Because most erosion occurs within the first three months following site preparation, when full site stability may not have yet occurred, a closer plant spacing would be more effective in achieving an early influence on the site. (e.g. <10 cm instead of 20 cm.). A subsequent small planting of Vetiver grass at Toiler utilized a virtual shoulder-to-shoulder placement of slips, and this resulted in a more immediate effect.

General Observations

- Vetiver grass does not seem to tolerate long periods of soil saturation as can frequently occur in coastal Wallum sites.
- Vetiver grass appears to be sensitive to shading competition so could be expected to die out in the plantation situation after canopy closure has occurred and before the next rotation.
- For early erosion control, plants need to be spaced more closely than in the above trials.
- Future plantings will need to dispense

with the intermediate nursery potting step so that slips are established directly into the field.

- Fertilizer application at the time of planting in order to achieve earlier establishment would appear to be beneficial.

The Future

We feel that Vetiver grass has a positive role to play in stabilizing point sources of erosion such as gully heads road turnout drains and unstable spots aggravated by harvesting and establishment machinery in both our hoop and exotic pine plantations.

Planning is in hand to establish our own resource of Vetiver grass at the exotic pine nursery complex at Toiler so that a prompt and comprehensive response to any future erosion problem can be activated.

Vetiver Grass As A Component In A Steepland Farming System Growing Pineapples, Gympie District, South-East Queensland

by Cyril A. A. Ciesiolka

Vetiver grass has been used as part of a farming system recommended for reducing erosion on steeplands growing pineapples. Slopes of 20-40% are regularly used to grow pineapples in South-east Queensland because of the problems of frosting and root rot on flatter lands. Excessive sedimentation in the valley floors from previous erosion has left lobes of sediment with slopes of up to 3%. Sediment input into the valleys still exceeds output at the downstream end of first order channels which drain catchments of 2 to 5 ha.

Characteristics of the recommended farming system for hillslopes

The recommended farming system uses hillslope ditches across the hillside with a bed slope not to exceed 4%, but depends on width of the blocks of pineapples. Length between the ditches depends on the conservation measures used. Examples of conservation measures are 1) rolling of furrows, 2) planting pineapple tops into the furrows to form a triangular shaped barrier, 3) tied ridges, 4) growing plants on some of the tied ridges, 5) spreading residues from pineapple plants in the furrows, 6) combinations of the above ,7) concave shaped roadway instead of convex shapes, 8) growing stoloniferous grasses on the roads and lining the centre of the roadway with green artificial turf or concrete.

Annual measured soil erosion from hillsides with some of the above practices is shown below.

(Table in original here)

Treatments

The following practices were laid out on slopes of 28-38%:-

1. 8.5m length, compacted furrows
2. 14.6m length, compacted furrows
3. 36.5m length, compacted furrows, 8m of mulch
4. 43m length, plants 8m apart, 8m of mulch
5. 47.5m length, plants 12m apart, 8m of mulch
6. 52m length, tied ridges, mulch on ridges
7. 55m length, tied ridges, mulch on ridges, compacted furrows and ridges 3. 58m length, continuous mulch in furrows, compacted
8. 62m length, continuous mulch in furrows

Other specialised plot treatments on 26% slope were:

1. 24m length
2. 24m length, 8 and 12m spacings between plants in furrows
3. 24m length, tied ridges to pond 15 mm of runoff
4. 24m length, tied ridges with plants on every ridge and every third ridge
5. 24m length, continuous mulch

Roadway treatments

The shape of roads was changed from convex to concave and all runoff from the adjacent blocks was channeled down the centre of the roadway. In the middle of the roadway the channel was lined either with cement or green artificial turf. The side slopes of the road were planted with creeping Indian blue grass for its high value seed.

Hillside conservation displaces the erosion problem into the valleys

During the l970s, studies from Europe and North America reported that when hillsides were put under conservation measures, erosion increased in the valleys. Gullies in previously well pastured valley bottoms soon developed and channel lines underwent accelerated erosion. Theory now enables us to understand this process. At the Imbil Landcare site, erosion exposed an old concrete channel in the valley floor and created overfalls and plungepools further downstream.

As this occurred at a Landcare demonstration site, it was somewhat embarrassing at first. However, the situation proved to be an advantage because the farmers saw that there were visible signs to the management of their properties in a very short period of time. The importance of catchment management was clearly evident because it was necessary for the landholder to be able to turn his machinery around in the valley floor. He could not afford to have a large gully develop.

Measurement of erosion processes in the valley

The investigation aimed to find out if 1) vetiver grass would stop reincision of the cleaner flows of water 2) vetiver grass would stop headward retreat of a gully incision, 3) vetiver grass would trap more of the fine suspended sediment load than the stoloniferous African Star grass, thereby reducing nutrients leaving the catchment and 4) vetiver grass could handle the fluxes of aqueously applied weedicides.

Vetiver grass was then planted at spacings of approximately 20 metros or upstream and downstream of the newly incised pools. The plants were placed into the African Star grass; by no means a highly suitable environment, but have grown well because of

the fertilizer washed off the pineapple plants. Equipment for measuring runoff and collecting water samples were set up in the valley.

Results

- Answers to the first two questions will not be available for at least another year.
- Vetiver and African Star grass have filtered out both bed and suspended load. Sediment concentrations at the top of the valley were twice those at the bottom of the valley (3.94g/l versus 2.33g/l) and similarly, electrical conductivity was less than half at the bottom end of the valley (263u5m/cm versus l28uSm/cm)
- The grass has survived for 12 months without any adverse effects of weedicides.
- Vetiver grass has proved to be "a carrot" for getting farmers interested in land conservation. At field days, grass was distributed to farmers who came along on the condition that they used some of the material to create a nursery that would be shared with another pineapple farmer.
- A gantry tractor was developed during the research part of this project for planting pineapple tops. It is expected to be able to plant vetiver (up to 50,000 plants per day) through this machine as it has been used to plant lettuce and the brassicas.

Future Plans

Vetiver is not seen as a stand alone solution for conservation in steeplands but as a component in a more complex system. As more of the pineapple industry moves from the very steeplands to areas where slopes are within the 3 to 12% range, more farmers are looking to manage their conservation layouts on the contour. It is envisaged that vetiver grass will be grown in conjunction with leguminous shrubs and stoloniferous grasses and legumes. along the road ways. Roadways will then become permanent and act as productive waterways.

Rehabilitation of Degraded Pasture

by Bevan McLeod and Lionel Cavanagh, Monto

Aim

To revegetate an overgrazed and eroded hill with Vetiver hedges.

Problem

A very steep slope (75-80%) on a dairy farm was overgrazed, bare of vegetation and highly erodible. As a result, natural revegetation has been very slow and rainfall can not infiltrate the ground.

Normal cultivation to improve water infiltration is not practical as the slope is too steep for safe machinery operation.

The Trial

Five rows of Vetiver planted on contour line at the vertical drop between 2m and 3m. The aim was to slow down runoff water to increase water infiltration and to improve the regeneration of native pasture.

Results

Despite very dry weather in the next 18 months, Vetiver established well in this very hostile environment and hedges were formed. Although there are many gaps in the hedges, regeneration of native grasses was very impressive as compared with the site where no Vetiver was planted. After 2 years there was enough regrowth that animals were allowed to graze during the summer. This practice was continued for the next 2 years and the hill is now completely grassed and both Vetiver and native grasses provided good feed for dry cows.

Results after 4 Years

Vetiver plants are about 1 m tall with basal stool about 10 - 20 mm in size. Where plant population is solid a good barrier has developed with evidence of soil and debris build up on the top side.

There has been little lateral spread of the Vetiver plants. Small amount of erosion occurred where water ran through the gaps in the hedges. If the hedges were properly maintained to reduce the number of gaps, the Vetiver grass system would be more effective in revegetating steep degraded pasture.

Vetiver Grass for Erosion Control and Land Stabilization in the Wet Tropics

Introduction

Vetiver Grass (*Vetiveria zizanioides*) was first introduced to the Wet Tropics of far north Queensland in 1988 when it was grown on the South Johnstone Research Station to build up stocks for use in other parts of Queensland. When enough material became available small plantings were established throughout the district in various locations to observe the growth habits and performance as an erosion control measure.

These locations were chosen so that the growth and erosion control potential could be observed on a variety of soil types with a range of physical, nutritional and drainage characteristics. Some of the locations included a railway cutting in alluvial soil, an old quarry site in gravel and some gully heads in Krasnozem soil.

During these first few years a large number of seed heads were picked and germination tests conducted to see if any fertile seed was produced. As no fertile seed was found the risk that vetiver would be a potential weed if it was used in the sugar industry was greatly reduced.

Use in the Sugar Industry

Contour Bank Replacement

In the wet tropics where sugar cane is grown on some fairly steep slopes the use of conventional soil conservation measures such as contour banks presents some safety hazards for machinery operators. The possibility of being able to replace an earthen contour bank with a vegetative one was very attractive.

In March 1992 the first planting was arranged on a cane farm to assess the compatibility of vetiver with sugar cane. A short contour bank was leveled with a back blade and the vetiver slips planted. Even though the cane was more than 2 metros high good

growth was achieved in the vetiver plants.

National Landcare Program funding was applied for in 1993 and in October of that year two long rows of vetiver were planted in a plant cane crop as a replacement for contour banks. The land slope of the paddock ranged from about 10% to about 18%. These rows had a gradient along them as would the normal contour banks in sugar cane, but no waterway was constructed in the depression as would normally be done with a conventional soil conservation layout. Conditions were very dry and the vetiver had to be watered once a week for about a month before sufficient rainfall was received to ensure continued growth. The erosion suffered in the plant cane in this paddock during the first wet season was quite acceptable to the landholder but was more than optimal. The contribution made by the vetiver hedges was minimal because although the vetiver was reasonably well established when the wet season commenced the hedges were not thick enough to provide a proper barrier to runoff water. The timing of the vetiver planting operation is one of the problems yet to be resolved in sugar cane in the wet tropics. The length of time required for hedge development probably means that it can't be used in ploughout and replant situations.

Waterway Stabilization

In the broken basalt country around Innisfail farmers have in the past used rock walls across depressions to trap silt. These are a problem for mechanical harvesting as well as being a rat and weed harbourage. The implementation of a conventional soil conservation layout would require the construction of grassed waterways in many of these depressions resulting in the loss of productive land. Most farmers are landlocked in this area and are not keen to lose any land as this means lost production. Stabilization of waterways is also a problem and grass establishment is often poor.

In other situations the use of vetiver has encouraged the establishment of other stabilizing vegetation. To see if stabilization could be improved in waterways short rows of vetiver were planted across two waterways at about 1 metre vertical interval. In these waterways the vetiver acted as a silt trap but in some places the strips were outflanked. The hedges were also not thick enough to be as effective as they should have been.

As an alternative to the construction of waterways several short rows of vetiver were planted across a hollow in the plant cane crop. In an adjacent hollow the cane was planted through the hollow as is normal practice on many farms. This was designed to see if vetiver strips were more effective than sugar cane in controlling erosion in these depressions.

The results were inconclusive in the plant cane because again the hedges were not as dense as they could have been. In some places the flow was strong enough to almost flatten the vetiver hedge while in other sections the vetiver was outflanked.

Drain Batter Stabilization

Two rows of vetiver were planted along the top of a section of a major drain where the batter was eroding from the runoff from the adjacent cane paddock. This planting took place in January 1993 and the soil was so hard that a crow bar had to be used to dig holes for the vetiver slips. Parts of the soil in the drain had the appearance of laterite. Fertility was low and growing conditions in general were very difficult. Even though a good strike was achieved and fertilizer applied the vetiver struggled for about the first year before achieving acceptable growth. It was noted on this drain that there was much better establishment of other vegetation on the side where the vetiver was planted.

Cooling Cascades

To try to achieve a reduction in the temperature of their waste water the South Johnstone Mill constructed a cooling cascade beside the South Johnstone River. This consisted of a plastic and bidum lined channel approximately 200 metros long and about 10 metros wide with a series of rock filled drops to provide agitation and cooling to the waste water. The main structure was constructed out of local river bank and bed material and consisted of a silty loam containing a large percentage of river gravel and stone. The structure was constructed in a flood prone area which would be at least partially flooded on an annual basis.

Vetiver hedges were used as part of the stabilizing vegetation. The vetiver was planted in October and November of 1994. The area was very dry at the time of planting and supplementary irrigation was used for a time until the cascade became operative and provided enough seepage water to satisfy the needs of the vetiver. The hedges were located along the edge of the containing bank of the cascade and at the foot of the batter and then about 1 metre vertically below the batter. Some vertical rows were established to provide resistance to flow along the batter. A mixture of millet and couch grass was used to provide cover between the rows of vetiver. Vetiver growth was quite good although there was severe competition from Guinea grass in some areas. Some weed and grass control was undertaken by the mill. The first flood occurred at the end of February 1995 and there was no erosion on the site. In March 1996 there was a much bigger flood and again no erosion has resulted. The vetiver has trapped some silt on the area suggesting that there is a significant retarding effect on the velocity of the flood flows.

Other Areas of Interest

Recently there have been inquiries regarding the use of vetiver in river stabilization by the local river improvement trust and local farmers. Vetiver is going to be used to provide some additional protection to a rock chute designed to prevent the South Johhstone River from cutting through the neck of a large loop.

There have also been quite a number of inquires for various types of stabilization ranging from gully heads to drain batters and creek and river banks. Often when told that there is no seed and that the vetiver will have to be planted by hand and is not going to provide an instant cover there is a loss of interest.

General Observations

There are many areas of potential use for vetiver but there are some major drawbacks to the ready adoption of its use.

When vetiver is planted at the same time as sugar cane the growth tends to keep pace with the cane for quite a while and this results in fairly spindly growth because I suspect that the shade inhibits stooling. This means that when the cane is cut the vetiver should also be trimmed to encourage stooling. In one trial the cane harvester was run along the vetiver row and the

vetiver successfully trimmed. This method probably has some potential in the sugar areas as the vetiver is given maximum time for growth before the shading effect from the ratoon cane becomes too great.

It would be important to ensure that the base cutter height was adjusted when cutting the vetiver as the level used to harvest the cane would probably kill the vetiver. Finding a planting time to fit in with the cultural practices presently used in sugar cane is a bit of a problem because the vetiver needs to be the most effective in the plant cane and this is the time when it is least effective using the present system. There has not yet been a crop of plant cane established in an area with a fully established vetiver hedge. Hopefully this will occur next planting season as the paddock with the best hedge in it should be ploughed out for replanting. The crop is either eighth or ninth ratoon this year.

Vetiver does not withstand strong weed competition. In the north there have been several plantings that have been well established and then overtaken and killed out by such grasses as Guinea grass (*Panicum maximum*) and Para grass (*Brachiaria mutica).* In the nursery at South Johnstone there is a problem with Signal grass (*Brachiaria decumbens*) taking over plantings if the management is not good.

Conclusions

It has not yet been proven that a vetiver hedge system is a suitable replacement for conventional contour banks in the steep sugar areas of the wet tropical coast of north Queensland. The planting method needs to be looked at with the aim of finding a system that will allow the establishment of a solid hedge in the least possible time. In the wet tropics this means a system which produces a solid hedge in time for the first wet season. Many of the potential uses involve works that need to be done fairly quickly because the planning and funding arrangements do not seem to allow sufficient lead time for good establishment. At present the cost of the planting material is fairly high and the planting method is very labour intensive and thus expensive also. Costs must be reduced significantly if the general farming community is going to be interested in using vetiver to its full potential.

Application Of Vetiver Grass In Soil Erosion And Sediment Control On The Darling Downs

by C. Knowles-Jackson

Early Experience

Flooding is a regular occurrence on the floodplains of the Darling Downs. Under the natural conditions of tree and grass cover, flood waters were spread out over the floodplains and caused little damage. When these areas opened up for cropping, most of the natural vegetation was removed, roads and fences were constructed and crops were grown in square or rectangular paddocks. These changes resulted in the diversion and concentration of floodwater into fast moving flows that caused crop damage and Soil erosion, and seriously affected the productivity of this valuable area.

To reduce the damage caused by floods, management practices have been developed to keep the water spread out and slow moving as occurred naturally.

Strip Cropping

Hector Tod a landholder in the Linthorpe creek area of the Darling Downs pioneered the use of strip cropping in Australia.

Strip Cropping is a soil conservation technique employed by dryland, floodplain farmers of the Darling Downs and north - western slopes of New South Wales. The floodplain refers to low gradient land (maximum slope 1%) which is subject to periodic, major overland flows. Strip cropping involves farming the land in strips of equal width, where the strips are positioned perpendicular to the water flow.

The management of the strips is governed by the farmer's crop rotation policy. A three-strip rotation implies that three years are required for the complete cycle. The rotation would be repeated throughout the length of the strip cropping sequence. Therefore if a farm was partitioned into sixty (60) strips, the three-strip combination would be repeated twenty (20) times.

The success of strip cropping significantly depends upon the crop rotation system (Marshall. 1988). The crop rotation provides agronomic advantages such as reduction in disease and insect problems, better use of soil moisture and improved soil nitrogen through the inclusion of legumes. In terms of soil erosion, the sequence of crops and crop stubbles is essential for strip cropping to be an effective soil conservation technique.

The principle aim of strip cropping is to protect the fallow land which must occur in a dry land crop rotation. The strip cropping arrangement forces the flood waters laterally thereby reducing the depth and velocity of flow (Smith et al, 1991). The flow is further resisted by the crops and fallow conditions, which act to prevent erosive velocities occurring in the bare or unprotected strips. Each strip would retard the flow in a different manner: the overall effect being a reduced velocity of flow over the unprotected strips. (Dryland farmers often refer to strip cropping as a "free irrigation" - prior to strip cropping flood flows were concentrated and tended to rapidly runoff the land, whereas flows throughout strip cropping are spread and slower, thus allowing more infiltration opportunity time).

Shortcoming's of Strip cropping

One of the main shortcomings of strip cropping is that during drought crops cannot be grown to protect the floodplains from overland flooding. During prolonged periods of drought as experienced in extensive areas of Eastern Australia in the 1990's large areas of the floodplains had no residual cover from previous crops, or any growing crops, hence extensive areas were exposed to potential serious erosion.

Use of Vetiver Grass on the Floodplains

The drought and the increasing occurrence of dryland cotton in the farming system has exposed the floodplains to increased erosion.

Vetiver Grass is now being grown on the floodplains of the Darling Downs in an effort to provide protection in erosion sensitive areas.

Vetiver grass is being grown in associations with existing strip cropping layouts so that the beneficial characteristics of the two systems can compliment each other.

Vetiver grass with its deep rooting and fast

growing properties will quickly form an effective vegetative barrier that will impede the rate of flow of the floodwaters. Unlike the annual crops, Vetiver with its deep rooting characteristics will be able to withstand the effects of drought more effectively.

The use of Vetiver grass in the concentrated flow areas is also proving to be a valuable tool in aiding the siltation and stabilization of those areas. Mechanical structures have not proved to be successful on the black soil plains of the Darling Downs. Where mechanical structures have been built on these heavy black clay soils they have generally failed. These structures have been costly to build, to maintain and the resultant damage has been extensive when they have failed. Vetiver grass is proving to be cheep and effective.

It is hoped that Vetiver grass will prove to be one more tool available in the fight against soil erosion.

Strip Cropping With Vetiver Grass, A Landholder Perspective

by Mark Hensel, Prairie View, Jondaryan.

Introduction

Aim of a land holder is to leave the land in better condition than when we started

- protection of soil essential
- management of water prudent
- slow water - reduces soil movement
- spread the water - greater area for moisture infiltration
- 15-20% increase in yield can double profit - 50% of profit from overland flow 'irrigation

Points

- Farm history
- purchased in '30's
- originally grassland, dairy farm
- cultivation commenced with growing oats and wheat in large square paddocks
- farm suffered sheet and gully erosion in major floods
- flood water following heavy rain in uplands once took a week to reach Prairie View
- currently flood peak arrives in about 8 hours

Need for Vetiver grass

- need to control erosion at all times, even in drought conditions when no
- crops can be grown. more run off in drought time due to depleted ground cover
- good strong hedge will slow and spread water and give better water infiltration
- small benefit from wind protection

Management

- water newly planted grass
- burn, slash after risk of severe frost has past, excess height unnecessary.
- if left to grow unchecked the centre of row will die due to lack of sun light
- apply fertilizer
- replant gaps in row

Disadvantages

- loss of yield up to 2m from hedge in adjacent crops
- harbor for mice
- sensitivity to roundup - minimum tillage - spraying of crops and fallow
- wash outs in weak spots
- weeds in potting mix
- labor intensive to establish

Advantages Of Monto Vetiver Grass

- Low risk of becoming a weed
- no viable seed
- no stolons
- no rhysomes
- can be killed with glyphosphate
- Drought tolerant when established
- Regenerates after frost (-12° C)
- Regenerates after fire

Future Management

- need to develop direct planter to save on labour, speed up planting operation
- widen strips
- keeping hedges clashed may reduce erosion problems where water breaks through
- keep hedges to a height of less than 500 mm may reduce yield loss caused by shading
- need to produce something from the hedge - essential oil - sale of planting material

Conclusion

There is no universal solution to the management of flood water and soil erosion. Vetiver grass is a useful management tool.

China

The China Vetiver Network. Vetiver Investigation in Fujian Province, China

Jointly organized by China Vetiver Network and Fujian Provincial Water and Soil Conservation Station, a vetiver field investigation was held from 23-31 December 1996. The investigation team consisted of 16 persons from The Institute of Soil Science, Nanping City Water and Soil Conservation Office, Jianyang County Water and Soil Conservation Station, Jianyang Agricultural

Foreign Investment Office, Fuzhou City Water and Soil Conservation Office, Pingtan County Water and Soil Conservation Station, and Pingtan County Agricultural Bureau etc. The purpose of the investigation was to: (1)evaluate the former experiences; (2) discuss new applications and extension measures; (3) consult new project proposals; (4) prepare some details on the proposed vetiver workshop to be held in Fujian later in 1997.

General Condition

Fujian Province is located on the southeast area of the country, E 115˚ - 120˚, N 23˚ - 28˚, with an area of 120,000 sq. km and a population of 30,000,000 (1990). About 85% of the area are mountainous or hilly. Under southern subtropical climate, a deep weathered red crust was formed with a thickness for several to dozens of meters. Due to increasing population and policy related problems the original forests were most destroyed, leading to heavily eroded lands. In many places, the land was covered by white semi-weathered granite rocks. There is also a long coast line in Fujian Province, about 3,300 km, and there are more than 1,000 islands in Fujian Province. Most of these areas were covered by white sands which contain high level of salts and was subject to wind erosion. Therefore, the plants can not survive or grow well. As early as in 1970's, vetiver grass was introduced into Fujian Province from Hainan Island for the purpose of extracting perfume. A perfume plant was established in Jianyang County. However, it was closed before long caused by low profit.

In late 1980's the Red Soil Project supported by the World Bank started in southern China and Mr. Richard Grimshaw came to China. Under his guidance and with his enthusiasm the vetiver trials and applications were carried out in much Red Soil Project area. At the same time, some scientists and technicians from non-project provinces went to this area to asking for plant materials and technology. Since 1988, vetiver has been extended to a large area in order to protect tea plantations with an area of 500,000 mu (33,000 ha) which were degraded owing to lacking of suitable protection measures. The planting area involves many counties such as Jianyang, Shaowu, Guangze, Shunchang, Anxi, Changle, Pingtan, Songxi, Pucheng, etc. About 200,000 kg plant materials was produced of which some was exported to neighbor provinces such as Jiangxi, Hunan, Sichuan, Shandong, Anhui, and Shanxi provinces. In addition to the National Vetiver Conference held in Shaowu in 1989, a workshop was held in Songxi organized by Nanping Prefecture. Vetiver planting was mainly organized by local Agricultural Foreign Investment Offices involving Red Soil Project and also water and soil conservation stations. The former mainly put emphases on extension, while the latter put emphases on field experiments.

Vetiver for the of Recover of Degraded Barren Lands

Experience shows that vetiver can grow on extreme soils such as the semi-weathered granite materials where the soil was almost completely eroded. The vetiver was contour-line planted in this area where other plants can not survive. The trial showed in Anxi County that after 3-5 years the barren land accumulated some litters, and other grass, shrubs, and trees grow gradually. At last, the barren and gully land was completely covered by multiple layer plants, shrubs and trees in particular, while it is difficult to find vetiver. So, farmers call vetiver a "pioneer grass". Besides, farmers told us that vetiver is a fire-proof grass, and can still grow when being buried by earth. Some persons said that after burning the grass can even grow better. In Fujian Province, vetiver can be multiplied 2-3 times per year. It survives easily. The trial conducted by Fuzhou Water and Soil Conservation Office showed that propagation can also be made through layering cut stem divisions. This method is very simple and very useful for filling the gaps of vetiver lines. When doing this, dig a hole in the gap with a spade and then bend the stems of vetiver at neighbor place into the hole and then put earth on it.

Vetiver for Orchard Protection

Vetiver was used by Jianyiang Water and Soil Protection Station and Agricultural Foreign Investment Office to protect orchards. They made hill-side ditches (narrow based terrace), circling surrounding hills with a width to which walking tractor can be operated. Along the ditch sides vetiver was double-line planted at a space of 20 x 30 cm without fertilizer application. The next year the grass grew up to 3 m, while the roots 1.5 m deep. The grass was cut 2-3 times a year, which promoted the grass to grow better and produce more tillers. The cuttings were used for ground mulch or pulp. About 1-2 years after planting the runoff decreased considerably. Three years after planting, the earth particles were efficiently detained by the vetiver "fence". As the out-sides of the ditches were a little higher than the inside, the ditches can retain water. Besides, they planted creeper grass to cover the ditch surface, such as Cassia rotundifolia, which promoted the protection function. The distance between two neighboring ditches is 20-25 m where fruit trees were cultivated, such as orange, red bayberry, or plum. The soil erosion in vetiver protected orchard planted in 1990 was completely controlled. Runoff became quite clear. The vetiver "fence" played an important role in erosion control, much better than building terrace which not only costs more money and labor, but also disturbs soil horizons, therefore influence the growth of fruit trees in the first few years.

Because rainfall occurs from April to June in Fujian Province, heavy rain caused serious soil erosion. Sometimes it rains "cats and dogs" and can wash 12 cm surface soil away. The vetiver protected orchards were never effected by the rain. Trials were conducted by Agricultural Foreign Investment Office of Jianyang County. They applied different fertilizers to vetiver, including rape seed cake, pig manure, lime, and calcium magnesium phosphate. The result showed that the pig manure was the best one for vetiver. However, it is unnecessary to use fertilizers for vetiver except for vetiver nursery.

Vetiver for Protecting Nuts Cultivation

Chinese chestnut has a wide planting area in northern Fujian Province. However, because of soil erosion the soil fertility has declined once the original plantation had been cleared and young chestnut trees have been planted. To solve this problem, the Hushan Orchard Plantation in Jianyiang County established vetiver fence in slope land with a slope of 12 degree. They cleared the degraded Masson pine and planted chestnuts with a space of 3 x 3 m. Instead of establishing terrace, they planted vetiver grass as a "fence" along contours every 2-3 meters in December 1990. The results showed that vetiver "fence" can control soil erosion very efficiently and saved the costs of building terrace. Now the chest-

nut trees have started to produce nuts. Their work also showed that the vetiver should be cut periodically. Otherwise, the grass may not grow well and produced fewer slips, which influenced its function of erosion control.

Vetiver for Stabilizing Coast Sands

In Fujian Province, there is a long coast line and there are numerous islands where the critical problem is wind erosion. The soil consists of coarse white sands which contain very little organic matter and much salts which cause difficulties for most plants to survive. The cultivated lands were frequently buried by sands and rivers and ditches were always being blocked by sands. As a result, farmers had to clear sediments away frequently. On the other hand some land and even villages were eroded out by sea water. To solve this problem wind break was established with Casuarina equisetifolia. However, the results indicated that the tree windbreak can not solve the erosion problem completely. Besides, farmers built rock walls along field blocks, ditches, or rivers. But walls were limited because they cost a lot. Since 1990's farmers there planted vetiver under the guidance of technicians. They planted vetiver along ditches, roads, and sea shore. Besides, they built windbreak nets with vetiver around plots to control wind and sands. In the plots they planted the profitable shrub jojoba to produce seeds for extracting lubricating oil. The vetiver was planted with double lines at a space of 20 x 20 cm and was cut two times each year. During the windy season, the vetiver windbreak was kept more than 2 m. They are proposing to build vetiver "fence" in a large area for vegetables and grain production in 1997.

Effects of Applying Fertilizer to Vetiver Grass for Erosion Control

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Introduction

South China's subtropical and tropical regions occupy an area of about 218 million ha, nine-tenths of which is located in mountainous or hilly areas. Statistics indicate that soil erosion in these regions covers 61.53 million ha, which constitutes 28 per cent of the total area.

Guizhou province is a representative area in respect of soil and water losses in south China. The province is located between 24°37' to 29°13' N, and 103°36' to 109°35' E, lying on the eastern slopes of the Yunnan-Guizhou Plateau. The average altitude is around 1000 m and the total land area is 17.6 million ha, of which 97 per cent comprise mountains and hilly land. As forest protection has been ignored and forest coverage has been decreasing, the area of erosion rapidly rose from only 25 000 km^2 in the 1950s, amounting to 11.5 per cent of the total land area of the province, to 767 000 km^2 in 1994, accounting for 35.2 per cent of the total. This resulted in a severe imbalance in ecology and impediment to the development of sustainable agriculture.

Of the agriculturally-used soils of Guizhou, the majority are on sloping lands, ploughed on slopes up to about 20° and tilled by hoe even on much steeper slopes. Because of serious erosion, the topsoil has disappeared in many areas and in some other areas, completely-stripped bare land has been steadily increasing. In an effort to protect soil resources, formerly the major erosion control measure was the construction of drystone walls, which, however, at about 180 yuan (US $22.50 approx.) per metre cost too much for farmers to afford. Biological control, i.e. planting grass or shrubs on sloping lands along the contours has been adopted in some areas and it possesses great potentialities. But in the first several years, as the grasses and shrubs grow slowly, the erosion is still very severe, especially on the infertile sloping lands.

In order to explore measures to promote the growth of Vetiver grass and to speed up the popularization of biological measures of erosion control, with the support of Hui Oi Chow Trust Fund, the Centre of Urban Planning and Environmental Management at The University of Hong Kong and the Phosphate and Potash Institute of Canada, a fertilizer trial of Vetiver grass for erosion control was conducted by Guizhou Academy of Agricultural Sciences.

Materials and Methods

Location and site characteristics

Located on sloping land of about 20° and at an elevation of around 600 m asl, the site is in Luodian county, Guizhou province. The average annual temperature in Luodian county is 19.6° and the annual precipitation is 1177 mm, 90 per cent of which is contributed from April to October (rainy season). The soils are derived from shale and are classified as Hapludults. The soil chemical properties are shown in Table 1.

Table 1. Soil chemical properties of site

Land type	depth (cm)	pH (H2O)	C (%)	Tot. N (%)	Av.N (mgkg-1)	Av.P (mgkg-1)	Av.K (mgkg-1)
	0-20	5.0	0.76	0.11	101.0	12.7	39.3
Farmland	20-40	4.0	0.28	0.09	66.4	1.0	26.6
	mean	4.9	0.56	0.10	83.7	6.9	33.0
	0-20	4.8	0.57	0.11	79.6	2.0	57.9
Bareland	20-40	4.8	0.21	0.08	51.0	0.8	29.9
	mean	4.8	0.39	0.10	65.3	1.4	43.9

Texture is angular pebbly sandy clay loam with rather more organic matter on farmland than on bareland, as reflected in the carbon content.

Experimental design

The trial is divided into two parts. The first part examines the effects of differing fertilizer regimes on the growth of Vetiver. This was conducted in 1995 and 1996. The second is the determination of the effects of applying fertilizer to Vetiver grass for erosion control using the optimal treatment established in 1995 and comparing this with no treatment. This was conducted in 1996 and will be continued.

For the first part, trial was arranged on two land types: farmland and eroded bareland. The experiment was carried out using a randomized complete-block design with five replications on each land type. The Vetiver grass was planted along the contour with single row, three tillers a hill, at hill intervals of 10 cm. Each block was 0.6 m long and at maturity 0.5 m wide i.e. 0.3 m^2 in area. The treatments validated were as follows:

T1 Control, no fertilizer
T2 NPK
T3 NP
T4 NK
T5 PK
T6 NPK with N in two split applications
T7 NPK with N in three split applications
T8 Organic manure only
T9 NPK and organic manure

N splits:(1) at planting (2) before tillering at 5 weeks (3) end of rainy season

The fertilizer types and applied quantities were the equivalent of:

N urea 12 g per lineal metre
P calcium magnesium phosphate 18 g per lineal metre
K muriate of potash 9 g per lineal metre

organic manure barnyard manure 450 g per lineal metre (nutrient content not measured)

The Vetiver grass was planted on 6 April 1995 and the fertilizers were applied to the root zone at planting out.

For the second part, the experiment plots were on the eroded bare land, and the area of plot was 15 m x 3 m for each treatment. The settling basins were installed at the bottom of experiment plots in May 1996. The treatments validated were as follows:

T1 Control, no fertilizer was applied
T2 NPK with N in two split applications

The Vetiver grasses were planted along the contour in May 1996, in three lines per plot and with the line intervals of 5 m horizontally.

Results and Discussion

<u>The growth and development after Vetiver grass was transplanted</u>

1. Stage of recovery from transplanting. After Vetiver grass was transplanted in early April 1995, this stage took about one month. During this stage, most tillers recovered from transplanting very well and their roots developed rapidly, and a part of tillers gradually died. The growth vigour of Vetiver grass seems mainly dependent on the quality of the seedlings, although the application of fertilizer also affected their growth. For farmland, the treatment "Control" (T1) possessed the highest tiller-rate, and excessive fertilization disturbed the recovery of Vetiver (Table 2 - not included). For bareland, the tiller rate of the treatment "Organic manure" (T8) was the highest. The tiller-rate at the end of this period was a little more than that during the transplanting period (Table 3 - not included).

2. Rapid-growth stage. From May to August 1995 after the recovery of Vetiver and with the coming of rainy season, the growth and development of Vetiver grass were very rapid. The growth vigour of Vetiver in this stage mainly depended on the soil fertility and the application of fertilizer, while the growth vigour of the first stage also affected the growth. The growth of treatment "Control" (T1) in the farmland was still better than that of most other treatments. In this period, a large numbers of tiller grew and the Vetiver grasses of most treatments reached the jointing stage in the early June. The stems of Vetiver spread out to from the hedgerows in August for most treatments.

3. The trimming and gathering stage. The normal heading period of Vetiver in Luodian County is in early or mid-September. In the first year (1995), the fresh grasses were trimmed and gathered three times, i.e. in the mid-August, late September and early December and in the second year they were trimmed five times, i.e. the early May, mid-June, mid-July, late August and mid-November. The average fresh-grass yields on the farmland and bareland were equivalent to 59.6 t ha^{-1} and 27.4 t ha^{-1} respectively in 1995, and 66.9 t ha^{-1} and 30.2 t ha^{-1} respectively in 1996.

<u>Effect of applying fertilizer to Vetiver in different land types</u>

1. Differences of soil fertility affecting the growth of Vetiver grass. There were two types of land in the trial plots: farmland and bareland. The soil layer of the farmland is comparatively thicker, and the content of soil organic matter, nitrogen and phosphorus in the farmland is also higher than that in the bareland. So the growth vigour of Vetiver for all treatments on the farmland was better than that of the same treatment on the bareland, especially in the rapid-growth stage. The number of tillers for the treatment "Control" in the farmland was about the double of that in the bareland. The grass-yield of the treatment Control on farmland (Table 4) was more than the double of that from bareland and the formation of hedgerows in the farmland was also earlier than that in the bareland.

2. The application of fertilizer to the farmland had no major effect on the growth of Vetiver grass. From Table 2 it can be seen that most fertilization treatments on the farmland adversely affected the growth of Vetiver in the earlier periods, especially in the first month after the Vetiver grass was planted. From the second month on, the growth under the treatment "Organic manure" (T8) was better than that of the treatment "Control". Then the growth under the treatment "NPK with three split applications" (T7) also became better than that of the treatment "Control" from the third month on, though the differences between these and "Control" - no fertilizer - are not large. Only "NK" (T4) had a consistently adverse effect. It is obvious that, if we transplant Vetiver grass on the farmland to control erosion, we need not to apply fertilizer; if we have to apply fertilizer to farmland in order to multiply seedlings of Vetiver, we had better use fertilizer as after manure, not in an initial application.

Effects of applying different fertilizers to Vetiver grass in the bareland

Table 4. The fresh-grass yield of Vetiver from different treatments (weight as harvested)

Treatment	Farmland 1995 g/m²	%	1996 g/m²	%	Bareland 1995 g/m²	%	1996 g/m²	%
1. Control	572	100.0	692	100.0	203	100.0	271	100.0
2. NPK	554	97.9	599	86.6	275	135.5	287	106.0
3. NP	554	96.9	512	74.0	256	125.9	288	106.3
4. PK	620	80.5	595	86.0	165	81.3	230	84.9
5. PK	620	108.4	719	103.9	274	134.8	324	119.7
6. 2x1/2NPK	527	92.1	712	102.9	385	189.6	333	122.9
7. 3x1/3NPK	604	105.5	703	101.6	298	146.5	340	125.6
8. O.M.	776	120.8	708	113.8	256	125.9	293	108.1
9. O.M. + NPK	691	120.8	704	101.7	352	173.2	341	128.8
Mean 1-9	596		660		274		301	
S.D.	93		73		68		37	
Mean 2-9	599		657		283		305	
S.D.	99		77		66		38	

Note: g/m² calculated from size of mature block, 0.3m².

1. The application of fertilizer to the bareland had a distinct effect upon Vetiver grass. Because of the steep slope and severe erosion, the soil layer of bareland is very coarse - textured, thin and its fertility is low. According to observations from the second month (June 1995) on the growth of Vetiver grass with most fertilization treatments to the bareland was obviously better than that of the treatment "Control" (Table 3, Table 4 **not included**), although by the end of the second year, three treatments on bareland were inferior to "Control" in terms of vigour as measured by number of tillers.

2. Organic manure is better than the chemical fertilizers. Probably because organic manure did not disturb the recovery of Vetiver grass and supplied nutrients to Vetiver grass continuously, the growth and yield of Vetiver grass under organic manure application was better than most treatments under chemical fertilizer application (Table 4). On bareland, organic applied together with some chemical fertilizer (T9) was the best among all treatments. It is also likely that organic manure also improved water retention though this was not measured.

Table 5. Influence of applying fertilizer to the tillers of Vetiver on bareland

	No fertilizer Plants m^{-1}	tillers m^{-1}	tillers plant^{-1}	Applying fertilizer plants m^{-1}	tillers m^{-1}	tillerper plant
22 Aug	20	51.0	2.55	19.7	84.9	4.31
22 Sept	20	69.6	3.48	19.7	101.7	5.16
14 Oct	20	77.0	3.85	19.7	121.0	6.15
15 Nov	20	84.3	4.22	19.7	132.3	6.72

Note: The Vetiver was planted in May 1996

Effect of applying different chemical fertilizers to Vetiver grass in general

Of all treatments, that lacking of phosphorus fertilizer (Treatment NK) seriously disturbed the growth of Vetiver in all periods. After transplanting, in the first three months the growth and development of Vetiver with the treatment NP was better than that of the treatment PK, and from the fourth month on the growth of Vetiver under treatment PK became better than that of treatment NP. So if we apply nitrogen and phosphorous fertilizer to promote the growth of Vetiver in the early stage, then we had better apply some potassium fertilizer as after manure at the jointing stage.

The split application of chemical fertilizers is better than the whole application at transplanting

The observation and determination result indicated that applying the fertilizer with split application (two or three times) was obviously better than that applying the whole quantity of fertilizer at transplanting.

Effect of applying fertilizer to Vetiver grass for erosion control

1. Applying fertilizer promoted the formation of Vetiver hedgerows on bareland. Based on the trial of 1995, the split application of chemical fertilizer was adopted in a new trial (1996) the Vetiver grass grew more vigorously. The survey results indicated that the tillers of Vetiver grass for treatment "Fertilizer application" was more that that of treatment "Control" (Table 5), and the clump diameter of treatment "Fertilizer application" was also larger that that of treatment "Control" (Table 6). This made the Vetiver grass with applied fertilizer form thick hedgerows earlier.

2. Applying fertilizer to Vetiver grass obviously decreased the soil erosion. The observation in the rainy season of 1996 indicated that (Table 7):

a) The precipitation in the rainy season (from June to August) of 1996 was 678.8 mm, and the maximum rainfall intensity for 5 minutes reached 120

Table 6. Influence of applying fertilizer to Vetiver on bareland (averages)

	(1996) Fresh weight		Height	Tillers	Clump diameter
	(kg/lineal m.)		(cm)	(tiller/plant)	(cm)
Applying fertilizer	2.63	163.1	6.72	7.29	
Control (no fertilizer)	2.08	155.3	4.22	6.55	

Table 7. Runoff and soil erosion under different treatments on bareland

	precipitation (mm)	(1996) soil erosion (t/ha)		runoff (m^3/ha)		coefficient of runoff (%)	
		T1	T2	T1	T2	T1	T2
June	162.5	16.39	6.91	465.4	492.9	28.6	24.7
July	351.9	15.02	7.69	1235.9	930.7	35.1	26.5
Aug	164.0	2.05	0.33	349.5	204.1	21.3	12.4
Total	678.8	33.46	15.16	2050.8	1537.7	30.2	22.7
compared (%)		100.0	45.31	100.0	74.98		

Note: T1 - no fertilizer T2 - applying fertilizer

Table 8. Runoff and soil erosion under different treatments

(1991 - 1996)

	Precipitation (mm)	Runoff (m^3 ha^{-1}) T1	T2	Soil loss (t ha^{-1}) T1	T2
1991	823.3	2080.40	2390.40	46.64	57.78
1992	897.3	407.27	689.84	14.95	84.04
1993	1147.0	589.05	1527.32	21.87	95.45
1994	669.7	18.75	39.26	0.00	0.41
1995	1066.7	264.63	437.78	0.02	0.34
1996	855.0	na.	na.	0.00	14.36

T1 - planting hedgerow

T2 - farmers' practice (no hedgerow)

mm hr-1, for 30 minutes reached 59 mm hr-1.

b) The runoff of the treatment over the period June to August "Fertilizer application" was only 75% of that of the treatment "Control".

c) The soil erosion of treatment "Fertilizer application" was 55% less than that of the treatment "Control".

From above, it can be seen that applying fertilizer to Vetiver grass had an obvious effect for erosion control.The data in Table 7 are, of course for a very short period and may be compared with data from plots nearby, also at Luodian, where observations began in 1991, as shown in Table 8. These show great variability in both runoff and soil loss from year to year, broadly reflecting the precipitation regime. On plots with hedgerows (of shrub legumes) soil loss is substantially less than from plots under "farmers' practice" but it is also striking that over time, soil loss under "farmers' practice" has declined without hedgerows. The explanation for this is, of course, that there has been a decrease in erodible material through time. The legume hedgerows are now rather broad' about 60 cm at the base which is also woody and appears to be much less effective than the Vetiver nearby in retaining finer materials moving downslope. The legume hedgerow crowns are also more broadly spreading than Vetiver (which is kept trimmed). Crops near the hedges show clear signs of depressed growth whereas no such depression is observed near the Vetiver hedges

Conclusion

Planting grasses or shrubs along the contours is extremely effective for erosion control on slopes. In order to explore measures for speeding up the growth of Vetiver grass and the formation of hedgerows for erosion control, fertilizer trials were conducted.

On farmland, the Vetiver grass in the Control plots survived very well and formed hedgerows rapidly and the treatments of applying fertilizer showed no obvious effect. As most fertilizer disturbed the recovery of Vetiver grass after planting out, if we must apply some fertilizer to farmland in order to multiply seedlings of Vetiver, we had better use fertilizer as after manure.

On sloping bareland, the organic manure is better than the chemical fertilizer, and the treatment NPK+O.M. had more obvious effect. The lack of phosphorus would seriously disturb the survival, growth and grass-yield of Vetiver. If we apply the NPK fertilizers, we had better apply them in split applications, which is better than applying the whole NPK at transplanting.

Applying fertilizer promoted the formation of Vetiver hedgerows on infertile bareland. The result of observations indicated that the treatment Fertilizer application decreased the runoff by 25% compared with treatment Control, and reduced the soil erosion by 55%. Applying fertilizer to Vetiver grass had obvious beneficial effects for erosion control on the bare sloping land.

Costa Rica

Soil Conservation and Vetiver Grass in Puriscal - Costa Rica

By Marco Rojas, Student at the University E.A.R.T.H. (Regional Agricultural College of the Humid Tropics), Guacima - Costa Rica

The district of Puriscal, Costa Rica, located 45 km southwest of the capital of San José, is a highly eroded region where the majority of the territory over the years was deforested in order to establish crops such as coffee and tobacco and to graze livestock. The region is predominantly of irregular topography characterized by slopes over 40% and soils with a thin or nonexistent A-horizon. Having removed the vegetative cover, the existing soils were easily eroded due to overgrazing by cattle and the lands abandoned because they were no longer productive.

In the 1980s soil conservation was included in some agricultural projects promoted by the EEC (European Economic Community). Lemon grass was promoted as a live hedge as it was supposed to have a potential to generate income based on medicinal uses of the grass. In addition to lemon grass, itabo *(Yuca elephantipes)* and Indian cane *(Dracaena fragans* var. *massageana)* were also introduced because of these income generating potentials as export crops. It didn't take long for plagues and diseases to develop in these crops (lemon grass hedges were ultimately lost due to fungus and insect attack) which required increased investment to control. Additionally, the product marketing was not easy so many farmers abandoned or eliminated these crops. Also the soil retention using these plant systems was not very good and large volumes of soil were still lost through erosion. Finally, the itabo and Indian cane were intended to be monocrops in many cases rather than intercrops. Lack of market incentives thus led to their rapid abandonment.

Other systems used were hedges of king grass *(Pennisetum hybridum)* and dwarf elephant grass *(Pennisetum purpureum)*, as well as *Arachis pintoii* as a vegetative cover. The grasses were not widely accepted because they spread, taking over cultivated areas.

Vetiver grass was introduced as a vegetative barrier as a soil conservation measure in these projects, by the EEC with Ministry of Agriculture and Livestock (MAG) and the Ministry of Natural Resources, Energy and Mines. Vetiver, known as "violeta grass" in Costa Rica, adapted well in the zone with satisfactory results. One problem encountered with the use of vetiver was that it was simply given away to the farmers who often left it to die. Nonetheless, amongst the farmers who use it, vetiver functions very well.

Regarding vetiver, Mr. Edén Delgado of San Antonio comments: "It develops very quickly and in little time forms a terrace illustrating its good function. I only prune it at the end of winter at soil level and in 22 days it returns."

Mr. Victor Madrigal of San Juan community says: "This vetiver is resistant to drought, holds the soil and the remains of the pruning can be used to make 'bocachi' because it decomposes rapidly." (Note: Bocachi is a fermented organic material made from the food wastes, tubers and other vegetable wastes with high compositions of carbohydrates, proteins, sugars, etc. Fermenting the wastes encourages growth of microorganisms that help in decomposition which stimulates plant growth when applied to crops. The increased populations of microorganisms is beneficial to improve soil quality. In Central America it is becoming widely promoted.)

With respect to other hedges, vetiver requires less labor. Comments Mr. Darío Sarmiento of San Juan: "There have been no diseases and I have never fertilized. The results have been so good that I have decided to extend my hedges in my coffee field and put them on both sides of the terraces."

Mr. Joel Leiva of Bajo de la Legua agrees that vetiver requires little labor input and also says: "This grass grows together very quickly and when I burn it back in the summer it grows back like nothing happened."

The majority of users in the area are small farmers and vetiver is used in various crops. Mr. Antonio Mora of Bajo de La Legua tells us: *"On my property I plant mostly tobacco which must always be free of weeds. I planted this violeta grass (vetiver) brought from another town in order to hold my soil. When the tobacco harvest has passed, at the start of winter I plant corn or beans to better take advantage of the land."*

Furthermore, Mr. Buenaventura Vargas of Charcón adds: "I worked for a long time with lemon grass, but it spreads easily and finally it was lost. I got violeta (vetiver) at a farm close to here and planted it; with just one plant one can advance quickly. These hedges are 8 years old and the my secret of maintaining them is I do nothing more than cut them every year. You can observe my good results here."

An observation by Enrique Martínez of the Fundación Ecotrópica indicated that some farmers fertilize their vetiver thus promoting growth requiring increased labor for pruning.

One disadvantage observed with vetiver is that the pruning of hedges is hard work. The sharp-edged leaves are a problem to laborers when they are working near the hedges. Other complaints include that the hedges provide a place where snakes and rodents can nest, take up space that could be used for crop production and obstruct paths within a farm.

An unfortunate situation occurred at the Agricultural School of Puriscal where for a long time there existed vetiver hedges. Recently the hedges were dug out and removed with the justification that the labor of pruning was very difficult and its sharp leaves were leaving cuts on their laborers' skin. The problem is that no other system

or plant was used to replace the vetiver for soil conservation purposes. It is necessary for a school to set a good example and become a pioneer in soil conservation education especially since they can influence generations of farmers who will control of the destiny of the country. Vetiver is known by the majority as are its properties as a good, soil conserving plant. However, whether or not it is used for establishing barriers depends on the willingness of the farmer to do something about his/her erosion problems.

Vetiver's use as a conservation hedge is spreading very slowly. This slow acceptance is due to the lack of farmers' knowledge and lack of available planting material. The decision on whether or not to use vetiver is not specific to either large or small farmers and the choice of utilization varies from person to person. Vetiver is used principally for protection of coffee, tobacco, corn and beans and it also can be found protecting roads, slopes and soccer fields. The farmers need to be educated to realize the long term benefits of soil conservation. They need to be aware that any type of conservation system will require a certain amount of space and maintenance. Most importantly the farmer must be offered an alternative that requires less labor and more benefits.

Versatile Grass Fights Erosion

By Ed Bernhardt — From Tico Times, January 17, 1997

I can still remember my first encounter with vetiver here in Costa Rica. Strangely enough, it was in the streets of San Jose' as I was becoming acquainted with an Indian woman who was selling herbs from a blanket stretched out on the sidewalk. She handed me a small roll of dried beige roots that had a wonderful fragrance of lavender. She called it zacate violeta, and said it was used to protect your clothes from bichos like cockroaches and moths. I bought a rollito and found it worked just as she said, as well as adding this wonderful lavender scent to my clothes.

LATER, I learned from a friend that this plant, which is actually a grass, is used extensively in the production of perfumes. Now, vetiver is being promoted for another reason. Agricultural researchers have discovered that vetiver is an excellent erosion-fighter. Vetiver is a native of the Old World tropics, and although there are 9 species, *Vetiveria Zizannoides* is considered the best one for domesticated use. Its tremendous root system anchors soik to prevent erosion, and when planted in a dense line along the contour of a hillside, it will actually collect soil particles that have been eroded from the area above the vetiver planting. Vetiver has another advantage. It doesn't spread! Once planted, each clump of vetiver will grow to a height of between .5 to 1.5 meters, but remains in the location it has been planted. The seeds, for some reason, do not germinate, and so, the plant is easily managed between annual and perennial crops.

EVERY year, this grass can be manicured to keep a low profile. The dried grass can be used as mulch, or as in many countries, thatching for roofs. Once you get some clumps of vetiver started, you can separate the young new plants on the outside of the clumps to be replanted in new areas. If you plan to plant vetiver as an erosion barrier, the distance between each plant should be about 15 cm. or 6 inches, to insure that the planting is dense enough to filter runoff from heavy tropical rains. Presently, vetiver is most often found in the Central Valley as an ornamental in gardens and landscaping designs. Even so, the Ministry of Agriculture and other leading institutions are now promoting the use of vetiver to control erosion, and provide vetiver plants for propagation.

THE World Bank has even entered the project to provide funds for the promotion of planting vetiver. Here in Costa Rica, you can receive more technical information on how to plant vetiver from the La Red Latinoamencana de Vetiver, A.P 1732020, San Jose' Costa Rica. Joan Miller, who is in charge of the project, writes a newsletter and provides a useful booklet in Spanish to those who are interested. So, if you have problems with erosion think vetiver! You'll find it a very useful plant for your home or farm. And, if you are interested in more information about gardening in the tropics, be sure to write us at The New Dawn Center; A. P 372-8000, San Jsidro del General, Costa Rica for our books, newsletter, classes and seeds for gardening. Until next time - Happy Gardening!

El Salvador

NOBS Anti-Erosion: A Company Against Soil Erosion

NOBS ANTI-EROSION (NOBS) is a company based in El Salvador working to promote the use of vetiver hedges for soil erosion control for use in agriculture, industry and construction purposes throughout the country. Aware of the country's serious problem with soil erosion, NOBS ANTI-EROSION was created in 1994 as a subsidiary of NOBS HIDRODIFUSION, Inc. which was established during the mid-1980s as a producer of essential oils for the perfume industry. They have worked with the cultivation of vetiver grass for 14 years making selections for better growth, survivability, as well as for oil production (quantity and quality). The vetiver selection that has resulted from their work has been named "JF91".

Cultivation

Since it was established, NOBS has worked on nearly 90 erosion control projects in cooperation with NGOs, the Minister of Agriculture, construction companies and industry. Their involvement in such projects has ranged from promotion of vetiver hedge technology, provision of technical assistance and training, and as providers of vegetative planting material.

NOBS currently has more than 150 ha planted with vetiver grass for oil production and production of material for erosion control. Most of this farmland is privately owned or leased on the coastal plains south of Volcan Chinchontepec in San Vincente and Volcan Chaparrastique in San Miguel. The vetiver planting material for erosion control are actually a by-product of the oil production business (the entire plant must be excavated in order to harvest the roots for oil extraction) and on a yearly basis NOBS has about 80 ha of vetiver grass available for sale as planting stock.

Interestingly the cultivar which NOBS is using is one which commonly flowers, but there has been no indication that viable seed is produced because in 14 years it has not spread anywhere outside of where it was planted. What is interesting is that the north Indian vetivers are those which usually flower and their oil is known as

"khus", whereas it is the south Indian vetivers which are normally used for large scale production of "vetiver" oil, and these vetivers are non-flowering. The south Indian, non-flowering types, have also generally been the preferred vetiver for use in hedges; though in north India the local vetiver is used in many erosion control programs.

The planting and harvesting of vetiver plants/roots has been semi-mechanized. A basic plow is employed to make the furrows for the planting of the new plants, which is done by hand. For the harvesting of roots one of two methods is employed depending on the site, either: (i) a subsoiler is used to dig out the plants and roots or (ii) something similar to a potato harvester is used, which digs out the plants and rotates them in a cylinder to loosen and remove soil remaining on the roots.

Practical Experience

The experience which NOBS has had with vetiver has produced some interesting results with respect to damage to the plant by insects or rodents. Leaf-cutter ants have been found to eat the leaves from newly planted vetiver, but only when planted directly on top of an existing nest. Vetiver which is planted in an area without leaf-cutter nests is not damaged or eaten. In areas of rich and fertile soils where burrowing moles are found, vetiver roots have been found to be damaged. Also in areas where cane borers are a problem in corn and sugar crops, in the very moist sites the borers have been found to lay their eggs in the vetiver, thus allowing the vetiver to become an alternate host for the cane borer. The vetiver plants themselves are not affected by the borer. (Note: this can be controlled by burning the hedges.)

For the establishment of hedges, NOBS uses 8-10 tillers planted at 8-10 cm apart . This ensures that a hedge is quickly and successfully established decreasing the chances of gaps forming in the hedge. At NOBS they stress that in order to establish successful vetiver hedges strict guidelines must be established and followed which includes: use of good quality planting material, proper handling for the excavation, transport and planting, and follow-up maintenance of the plants to include irrigation and gap-filling as needed. They have devised methods to irrigate roadside plantings with a power sprayer attached to a truck for periodical watering until the plants are well established. NOBS estimated the costs in US dollars per unit (8-10 tillers) of planting material at approximately US 0.06 - 0.07/plant in El Salvador.

Projects

Government and private construction companies have been NOBS' main clients to date. They have planted 300 km of vetiver hedges along the roadsides and slopes of El Salvador.

In 1996 operations were expanded to try to increase the use of vetiver hedges, particularly for use among the most popular crops (which are also the most erosive) such as corn, sorghum, and beans on slopes greater than 5%. Approximately 80% of El Salvador's cultivated land area is used for the cultivation of these crops.

In El Salvador, NOBS has worked to promote the vetiver technology with: the Minister of Agriculture, the president of the Hydroelectric Power Commission, the National Water Authority, the Minister of Public Works, the Private and National Banking Systems, the National Environmental Secretariat, and a large number of environmental NGOs.

Recently, the Government of El Salvador opened a soil conservation credit line through the banking system with 6% interest rates and 15-year paybacks. NOBS is promoting this as an opportunity to establish as many vetiver hedges as possible. The total amount of credit available is about $US 10,000,000.

After a presentation made by NOBS to the board of directors of Banco de Fomento Agropecuario (BFA) (government bank that basically works with the small farmers), they adopted reforms to their credit pre-requisites such as "...previous to any credit approval the farmer should show proof of some soil conservation application in his/her plot. This could be dead barriers, pineapple, izote, lemongrass, vetiver, or simply organic debris...". This bank services approximately 11,000 small farmers. Approximately 210 agronomists from BFA have been trained by NOBS in vetiver technology and they also have assigned 3 of their own technicians to work within the field offices.

In coordination with the National Environmental Secretariat, NOBS conducted three 1-day seminars for the six major universities, 30 NGOs, and all the secretariat technicians involved in the approval and financing of ecological projects under the Americas Initiative Program.

Promotion

Included in NOBS' efforts have been nationwide radio announcements on 15 radio stations which promote the use of vetiver on lands where basic grains are grown. The radio campaign is oriented towards the small farmer and designed to educate them in the use of vetiver technology. Additionally, they have published articles in the national press on the soil erosion problem in El Salvador and the use of vetiver to deal with it. Also a promotional booklet with drawings has been developed for small farmers to explain the problem of soil erosion and how vetiver hedges can be used to control the loss of soil and improve crop production. Vetiver roots are never mentioned to farmers as having any use or value because there is too great a risk that individuals will start excavating the plants for the roots thus defeating the purpose of using vetiver for erosion control.

To help convince potential users of the profound rooting depth of vetiver plants they have grown vetiver in a model which displays the rooting system. A length of PVC pipe several meters long, was cut open and the open side replaced with clear plastic, filled with soil and planted with a vetiver tiller; after several months the vetiver roots in the model were so long that they grew out of the bottom of the tubing. Also they have built a model similar to that at the USDA which shows water ponded behind a clump of vetiver.

In an attempt to increase the uses of vetiver NOBS has recommended using vetiver leaves for roofing thatch, mulch, and brooms. In addition, they have given leaves and roots (from which oil has already been extracted) to a European company which produces banana leaf papers to see whether they could also use vetiver "by-products" in their paper products.

Green Enterprises Find Friendly Funding

A resourceful company in El Salvador

called NOBS Hidrofusion recently received $50,000 to help develop an innovative product that's both environmentally friendly and economically promising. Environmental Enterprises of Central America (EACA), an investment company based in San Jose, Costa Rica, that finances private projects with environmental paybacks, provided the infusion of funds. EACA, a subsidiary of Environmental Enterprises Assistance Fund in Washington, D.C., finances projects in Central America through a $10 million dollar venture capital fund, the first for environmental projects in the region. EACA-backed enterprises can receive $50,000 to $750,000. EACA offers better rates than commercial banks and in some cases, grants a grace period before the debt must be paid back or exchanges debt for stock in the business. "We are open to hearing different business proposals, as we are very flexible," says EACA manager Leonardo Ramirez. EACA has provided funding for renewable-energy, wastewater-treatment, recycling, ecotourism and forest-management projects. To qualify for funding, projects must be developed by the private sector, be technically and financially feasible, have capable administrators, and represent a clear contribution to environmental protection. NOBS, the Salvadoran business, plants a type of grass called vetiver. General manager Aldo Miranda says that the company extracts the oils from the grass and sells them to the perfume industry in Europe and the United States. But vetiver also has a distinct environmental benefit: It checks erosion. NOBS promotes vetiver cultivation throughout El Salvador, where some 140 metric tons of the country's soil are lost each year to erosion, caused by deforestation for agriculture and development. Miranda explains that vetiver's roots are "abundant and strong and can grow some four meters deep, in a direct line, so they retain the soil." The grass doesn't compete with other crops since its propagated by rhizomes, not by seed. "In 1996, we planted 300 kilometers of vetiver," Miranda reports. "Farmers and urban developers buy it to avoid erosion. If it isn't cut, the grass can live more than 200 years." He adds: "EACA's financing gave us breathing room. No one believed in our project, since it was very innovative. Now we have working capital.

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Mexico

We announce with great sadness the death of Kevin O'Sullivan who initiated a vetiver program in Oaxaca, Mexico. I never met Kevin, but spoke to him many times on the phone. I am not sure where he first heard about the vetiver technology, but he was hooked on it. He found *Vetiveria zizanioides* in State of Chiapas and took it over to Oaxaca where he and his friend Nick Dolphin established an organization to tackle, through the local communities, the serious soil erosion problems of that part of Mexico. This organization, Suelos Agua y Semillas de Oaxaca (SASO), has been written up in a number of the issues of the Vetiver Newsletter, and has accomplished a lot in a short time. Its method of operation is a good example how many different agencies can be pulled together to deal with an important problem such as erosion. This year SASO will be setting up 25 new community vetiver nurseries, bringing the total to 50 in 18 months. A good effort, and a nice memorial for Kevin O'Sullivan.

Nepal

Vetiver Grass For Road Embankment Slope Stabilization In Nepal

by Ishwar Sunwar, Soil Conservation Officer, Eastern Region Road Maintenance Project, Dharan, Nepal

General

Eastern Region Road Maintenance (ERRM), funded by the UK Overseas Development Administration, and managed by Roughton International, has been responsible for some years for the maintenance and rehabilitation of a number of roads in the Eastern Region of Nepal. We have been using Vetiver grass as a road embankment slope stabilizer since 1992. Originally it was used on an experimental basis, but latterly it has been used extensively on the embankment slopes of roads on the Terai, the flat, low lying area to the south of the mountains.

The type of Vetiver used by ERRM is native, and is collected locally. It is thought to be Vetiveria zizanioides, but has not yet been positively identified. Originally this grass was collected in clumps from the wild and split into slips. The slips were then planted in rows in preformed furrows 100-150 mm deep and 700-1000 mm apart vertically down the slope.

Justification For Using Native Vetiver

There was a pressing need to revegetate embankment slopes of the roads that had been rehabilitated on the Terai. The target for one year was a 30 km length of road, to be planted during the pre and early monsoon season (June to August). This required approximately 1.8 million planting drills and therefore of the order of 6 million slips (assuming 100 mm drill spacing and 3-4 slips per drill). To produce this quantity of planting material, it was therefore necessary to establish large nurseries as well as an easy and productive propagation method.

ERRM therefore established two large nurseries where Vetiver is propagated mainly from seeds and later transplanted as slips in the nursery beds. It was appreciated that types which produce viable seeds should not be used due to the possibility of their spreading as a weed. However there was a demand for a large quantity of a quick colonizing planting material. Having decided to use the native Vetiver, the advantage of using seed was that it avoided the need to dig up large quantities of native grass, and thus destabilise soils.

As part of the ERRM project there is a road maintenance component, which should carry on indefinitely, after the project has wound down. This includes maintenance of the embankments, part of which is the trimming of the Vetiver and cutting off any seed heads that form before the seeds ripen. This procedure has removed the risk of the grass spreading by seed reproduction. An additional safeguard is that most embankments are beside paddy fields, whose characteristics limit the spread of

Vetiver.

Other Uses Of Vetiver

Vetiver grass is also known as "Sinki" on the Terai. Some tribes use the main stem (the long internode between the seed head and the top node) as a weaving material. They make baskets and other decorative materials. Some people, for example the Tharu, uproot the grass in the summer months, wash it in clean water, and hang it over the verandah The root gives off a pleasant scent. It is generally replaced each week.

Vetiver is not thought of as palatable, but sometimes Nepalese animals break the rules. When there is no greenery left in the area, it is in fact heavily grazed. When the new shoots sprout, they are soft and used as a poor fodder.

Limitations

From the literature it would appear that Vetiver should grow well under conditions found in the Himalayan foothills. Indeed we have found that it does grow at least up to 2000m above sea level. On our general trials along the road side slopes, it was found to be far more successful on fill slopes than on the cut slopes, which are steeper. A trial was conducted with two different grass types, Vetiver and Kans (*Saccharum spontaneum)*, on a steep south facing slope of 50˚. The annual rainfall at the site was 1000-1500 mm (almost all during the 5 month monsoon period). It was found that the Kans grass was far more successful than the Vetiver.

The Future

The roles of Vetiver and indeed any vegetation in road projects are slightly different from their roles in the agricultural and irrigation sectors. It is likely that Vetiver will be used in large quantities by the Department of Roads in Nepal in the near future. There are question marks about its use on road embankments, especially close to the shoulder, and it is important that its use is fully researched, in order that organizations such as the Department of Roads can be given guidelines. ERRM are currently carrying out research on the "use of Vetiver for road embankment slope stabilization purposes".

Malaysia

Use of Vetiver Grass for Engineering Purposes in Malaysia with Particular Reference to Slope Stabilization and Erosion Control.

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Introduction

Over the millennia, Nature has 'designed' vegetation as a means to blanket and stabilize the good earth. In the humid tropics in which Malaysia is located, this has evolved into rainforests comprising complex multi-strata canopy, from big trees, shrubs and leaf litters, covering the organic humus-rich topsoils, that offer excellent overall protection.

With development, be it agricultural, infrastructure or townships, vegetation has to make way for this inevitable encroachment. As a consequence, there arise, and on an increasing rate, problems relating to erosion and stability in view of scarcity of land on the plains as people move further hinterland into the hilly and mountainous terrain.

In the light of the current awareness and conscientiousness of environmental issues, the preferred option to address the above problems would be to go back and seek solutions that Nature has already provided in the first instance to human prior to his ravaging; that is, by way of revegetation. This may be, as it were, a way of 'atoning' the wrong doings to the ecology !

From ancient times, it has been on record that people have used vegetation as a means of erosion control and slope stabilization. For instance, it has been documented that the Great Wall of China, the ziggurat in Baghdad, used reed for soil reinforcement purpose. During the Ming Dynasty in China some 400 years ago history recorded that willow was used for embankment stabilization. In India, where the vetiver grass originated, the local farmers have for centuries used it as a soil binder; vetiver strengthens bunds and creates boundaries for paddy fields as well as fortifies river banks, canals, ponds etc. to keep the land from collapsing into water. The farmers know that it would work but cannot really explain how or why. When Indians moved overseas, presumably the grass was brought along by them and the usage continued in the new localities. Thus one sees Indian cultivars in far flung corner of the globe.

Near Kuala Lumpur, Malaysia, it was mentioned that vetiver was in 1908 planted for the purpose of holding up steep banks (Ref. 1).

After the World Bank Agricultural Advisers stumbled upon and 'discovered' the vetiver grass, promotion of its use has gained impressive momentum since the 1980's but mostly in the field of 'soil and water conservation' in the agricultural sector with success stories to boot. However, it has also been observed that sloping lands planted with vetiver grass are less susceptible to landslips apart from having less or controllable erosion problems.

Use of vetiver grass in the engineering circle has yet to catch up with its agricultural counterpart. To date there are pockets of its use here and there with some beneficial results based on precedent cases, rule of thumb or trial and error basis. Part of the reasons for its limited use could be due to lack or

dearth of 'quantitative parameters' to plug into elegant mathematical formulae to come up with computed figures of which the engineer is so fond before he finds it acceptable or comfortable with and eventually convinced, like other engineering materials. With current trends now favouring 'green approach' to environmental problems and more databases now become available, this attitude is gradually changing for the better.

It is the aim of this paper to disseminate the information that there is now some quantitative parameters available especially for vetiver grass vis-à-vis other vegetation (albeit in the preliminary stage) and to present those findings and cases of successful applications of vetiver grass, in the Malaysian context.

Peninsular Malaysia. Topoagrapgy and Climate

Malaysia lies near the Equator of the South-East Asian region. Peninsular Malaysia, where development and population are mostly concentrated, is formed from mountain ranges with low-lying coastal riverine plains. The Main Range with a series of roughly parallel, north-south ridges rising to over 2 000 m, traverses the peninsular spine-like. Deep weathering characterizes most of the country ground profile (Fig. 1).

Malaysia is subjected to both South-West as well as North-East monsoons. The former lasts from April to September and brings with it rains to fall on the West Coast and some part of the interior, while the latter, developing from high pressure trough originating in Siberia, always brings the moisture-laden clouds from the South China Sea to rain on the East Coast states and their vicinity from October to March. Mean annual precipitation ranges from 1 750 mm to 2 500 mm. In the highlands in the interior, mean annual rainfall rises to 3 000 mm, as it is vulnerable to both monsoons and can go up to 3 500 mm in some wet years. Daily totals with a 10-year return period vary from 125 to 150 mm over most of the country (Fig. 2).

With such heavy and intensive rainfall pattern and the grounds being composed of residual soils derived from the weathering of granite or other rocks which are mostly sandy/silty in texture, erosion and slope stability problems are acute and chronic problems in Malaysia (Fig. 3, Fig. 4 & Ref. 2).

In fact, during the monsoon, the news items often appearing in Malaysian newspapers are stories of either earth slips or landslides.

Vegatation for Slopes Stability and Erosion Control

As stated in the Introduction, use of vegetation for slope stabilization started many centuries earlier, revival of the ancient practice and current development started in the Germanic-speaking countries (Austria, Switzerland, Germany) in the 1930's and spread to the US and Canada in 1970/80's with more relevant research being undertaken.

That a blanket of dense grass or herbaceous plant is able to protect against rainfall-induced erosion is generally well accepted by commonsense. However, it may not always be true for Malaysia, because, as mentioned in the Introduction, of the high and intense rainfall prevalent in the country compounded by presence of erodible soils. Even a well-designed slope (plus good grass cover) having satisfactory factor of safety (say F.O.S. >1.3) for mass stability still suffers from shallow mass moment with 0.3 -1.5 m depth of slip surfaces from time to time.

Confronted with this problem, this Author has since 1983 conceived of the idea of further stabilizing the slopes using trees, in particular those fast-growing species, e.g. *Acacia* spp and *Eucalyptus* spp, and others mostly originated from Australia. This is to arrest the shallow mass movement. It worked well on all the slopes planted (total no of tree planted > 100,000) and the results are published in Ref.

No theoretical or quantitative figures, however, were provided to back up the favorable qualitative outcome of erosion control and stability enhancement of slopes.

In recent years, a number of researchers (Ref. 3 & Fig. 5) have investigated the factors contributing to the stability of slopes by vegetation and they concluded that these comprise hydrological and mechanical mechanisms. The hydrological factors are rainfall interception and evapotranspiration, hence pore pressure reduction (positive effect) together with increase in infiltration, permeability (negative effect). The mechanical factors are surcharge of vegetation weight on slope plus resistance to wind (negative effect) and root reinforcement (positive effect). Although data are not yet so extensive but sufficient enough for conclusions to be drawn that the net effects are

1) Vegetation can reduce pore pressure

2) Soil shear strength can be increased by the 'inclusion' or presence of roots which contributes to the apparent cohesion (c_r), in similar manner to the 'reinforced soil' concept

Ref. 4, and Fig 6. shows the increase in factors of safety by the presence of roots vis-à-vis no-root scenario.

Vetiver as a Unique Vegetation for Slope Stabilization and Erosion Control

Although vetiver (*Vetiveria zizanioides*) belongs to the grass family (*Graminae*), it is unlike other grasses, just as bamboo which is considered a special grass. Architecturally it looks like lemongrass and keeps its leaves up off the ground and is bottom heavy (no falling over). Its leaves are somewhat like sugarcane but smaller. The stems which act like the backbone of the erosion control barrier are strong, hard and lignified (as in bamboo), they act like a wooden palisade when planted on contour across the hill slopes (Ref. 5).

Among the many unique characteristics of vetiver grass (hence some term it Miracle Grass) are (Ref. 1)

i) It grows fairly fast and erect and acts as a stiff barrier or hedge after a few months

ii) It has a vigorous, strong, long, and massive fibrous root system (with fragrance for some cultivars)

iii) It is perennial requiring minimum maintenance

iv) Its seed does not germinate, nor does it spread by stolons or rhizomes to become a 'weed'

v) Its crown is below the surface, protecting it against fire and overgrazing

vi) It does not harbour rodents, snakes or other pests.

vii) Its leaves and roots are disease-resistant

viii) It grows under both xeric and hydric soil conditions and hence able to survive both drought and flood

ix) It tolerates a wide range of soil conditions (low fertility, acidity/alkalinity, salinity, high aluminium content)

x) It grows across a wide climatic range (0 - 45° C and mean annual rainfall of 300 to 6 000 mm)

xi) It is self adjusting, i.e. the crown of the hedgerow climbs with trapped soil, thus preventing it from dying off.

Of these characteristics, two properties stand out that make it ideal for erosion and slope stabilization work, namely,

1) It grows upright and with its stiff stems is able to form a dense hedge in 3 - 4 months and thus capable of slowing down rainfall run - off, distribute it uniformly, filter it and trap transported or eroded sediments at the hedge face. The hedge height is self adjusting in tandem with trapped silts.

2) It has a vigorous, strong, deep and massive root system that can penetrate up to 5 m underground (see Fig. 7), depending on soil condition.

The Author would hasten to add the third characteristics (pending more investigation to verify his preliminary experiments) that because of its massive and deep root networks and abundant, long leaves, vetiver would tend to help increase the slope stability through soil moisture depletion (i.e. soil suction phenomena) via the process of evapotranspiration (Fig. 9). This theory might contradict the conviction of the agriculturist that it helps introduce and conserve moisture into the ground by filtering and infiltration at the hedge! (Perhaps the steepness of slope land in agriculture which is seldom more than 20% compared with > 100% for engineering works could account for such difference).

As to the erosion control properties, there have seen studies carried out by several Malaysian workers (Dr. P.K. Koon and Dr. F.W. Lim, Ref. 6) which showed that compared with bare soil, vetiver was able to control run-off to reduce by 73% and the total eroded soil (soil loss) by 98%. Recent study (Ref. 7) at the Universiti Kebangsaan Malaysia (UKM) revealed that vetiver could trap 600 gm/m≤ of surface soil loss against 18 gm/m≤ by cow grass (*Axonopus compressus*).

With regard to contribution of the vetiver root to the stabilization of slopes, it was reported by this Author and his co-worker (Fig. 7 & Fig. 10 and Ref. 8) that the tensile strength of vetiver was in the order of 75 MPa (or approx. one third of that of mild steel). Comparing with other types of the

Moreover, because of its dense and massive root system underground it offers better shear strength increase per unit fibre concentration (i.e. 6-10 kPa per kg of root per m≥ of soil) compared to 3.2 ~ 3.7 kPa per kg of root/m≥ of soil for tree roots (Ref. 4 and Ref. 8).

Table 1 Tensile strength of roots

Botanical name	***Common name***	***Tensile strength MPa***
Salix	Willow	9-36*
Populus	Poplars	5-38*
Alnus	Alders	4-74*
Pseudotsuga	Douglas fir	19-61*
Acer sacharinum	Silver maple	15-30*
Tsuga heterophylia	Western hemlock	27*
Vaccinum	Huckleberry	16*
Hordeum vulgare	Barley	15-31*
	Grass, forbs	2-20*
	Moss	2-7 kPa*
Vetiveria zizanioides	**Vetiver grass**	**40-120 (Average 75**)**

* After WU (1995), Ref. 9
**** After HENGCHAOVANICH AND NILAWEERA (1996), Ref. 8**

The fact that vetiver can grow vertically on steep slopes (more than 150%), faster growing and imparts more reinforcement to the soil makes it a better candidate to consider for slope stabilization than other plants. Another less well known characteristic and sets it apart from other tree roots is its power of penetration. Its 'innate' strength and vigour enables it to penetrate through difficult soils, hard pan or rocky layers with weak spots; it even manages to punch through asphaltic concrete pavement (vide Fig. 8).

Indeed, one can say that vetiver roots basically behave like 'living' soil nails or dowels of 2-3 m depth commonly used in 'hard approach' slope stabilization work.

Application of Vetiver on Malaysian Highway

A small trial on the cut slope of the North-South Expressway was carried out by others in 1991, followed by major planting by us (30 km of running hedgerow length so far) since 1993, on slope remedial works projects on the East-West Highway funded by Public Works Dept. (PWD), Government of Malaysia. Vetiver grass have been used on the above projects to complement the engineering designs to enhance the erosion control and slope stability aspects in view of the adverse soil and climatic conditions on the East-West Highway cited in Ref. 2 to provide added assurance or 'bonus'.

On these projects, vetiver grass has been used to trap silt at culvert inlets and outlets, alongside cascading drains, interceptor drains, canal banks and on the slopes as hedgerows on contours at 1 or 2 metre vertical height interval (vide Fig. 11 to Fig. 14). Planting of vetiver was governed by strict specifications as to the quality of planting material and the planting technique itself. From observations, the vetiver grew well, with hedgerow gaps closing in 3-4 months. Silts were trapped thus keeping drains and culverts clean and surface sloughing or shallow mass movement was non-existent. To dispel the doubt as to its long rooting depth, a wash-excavation

was carried out for the client's benefit, which revealed an attainment of 3.6m penetration (Fig. 15).

Vetiver planting (4.5 km) was extended to another PWD-funded contract on Jalan Gunung Raya, Langkawi, on similar slope remedial works project involving substantial number of soil nails. The results have also been successful (vide Fig. 16).

On the Kuala Lumpur-Karak Highway Privatisation Project, vetiver was used for cut slope stabilization at locations where soil is known to be relatively weak. However, a majority of plantings are on spoil disposal areas (approx. 42 km). This is to check the loosely-dumped spoil from collapsing and to trap silts from washing downslope into nearby rivers, a Dept. of Environment directive. This has proven effective to date (vide Fig. 18 to Fig. 21)

A small-scale trial, was carried out to stabilize and to render erosion control for a very highly erodible embankment built of silty sands on Kuala Kangsar-Gerik Road Upgrading Project. This is shown in Fig. 17. The results have been impressive to the Government-appointed consultant supervising the works.

The projects cited above were undertaken by us and proven effective and satisfactory to the clients. It has been brought to attention that there were instances where vetiver hedgerows were not successful elsewhere in Malaysia. On inquiry, it was found that mostly those failures could be attributed to poor agricultural practices e.g. poor planting material, incorrect planting techniques, stunted growth due to competition for sunlight or space by other grasses, legumes or weeds due to no maintenance etc. It is not within the ambit of this paper to discuss failures but suffice it to say that like other engineering undertaking, quality control and supervision play a vital role for the achievement of success.

Summary and Conclusions

Over the last decade, people are adopting 'green approach' for erosion control and stability problems due to greater accent being placed on environmental issues. Vetiver, for a long time unknown and ignored, started to gain acceptance prominence due to heavy promotion by the World Bank, mostly in the agricultural sector with reported success stories. Application in engineering is still somewhat limited due to lack of knowledge and availability of design parameters which now start to emerge from recent researches. Compared to many countries, Malaysia has made good stride in the use of vetiver grass for erosion control and slope stabilization in highway engineering prompted by necessity due to the nature of its highly erodible residual soils and adverse rainy weather conditions. However, the design is still somewhat conservative, treating vetiver as 'a bonus' or added assurance. Once more data and track records come to light, especially on the evapotranspiration and hydraulic aspects, bolder and more innovative designs maximizing the full potential of vetiver grass should be adopted.

INDIA

Vetiver Grass Hedge Row Establishment - Plant Spacings. (Under Semi- Arid Conditions)

by S.C Mahnot, Project Director, and P.C.Chaplot, Assistant Research Officer, IWDP

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Udaipur a semi-arid region or Rajasthan, being situated at 24^0 N latitude and 75^0 E longitude at an elevation of 579 meters above mean sea level, has a typical sub-

Table 1. Tillers/plant and clump girth (cm) due to spacing density.

spacing/	Arable				Non-arable			
density	10	15	20	Mean	10	15	20	Mean
1	7.5 (9.8)	8.2 (10.5)	10.0 (13.5)	8.6 (11.6)	5.2 (7.2)	7.5 (9.5)	7.5 (10.0)	6.6 (9.1)
2	12.0 (13.3)	13.5 (15.3)	16.2 (19.0)	13.9 (15.8)	7.5 (10.2)	10.5 (13.3)	11.0 (13.1)	9.6 (12.5)
3	15.4 (17.7)	16.5 (23.0)	18.5 (22.0)	16.8 (21.2)	9.8 (13.5)	12.8 (15.8)	13.6 (17.1)	11,9 (15.4)
4	16.6 (17.2)	18.0 (25.1)	24.0 (25.5)	19.5 (22.6)	10.2 (13.0)	14.0 (17.2)	16.0 (19.2)	13.3 (16.5)
Mean	12.9 (15.5)	14.0 (17.9)	17.2 (20.0)	- -	8.2 (11.4)	10.8 (13.9)	12.0 (14.8)	- -

LSD (P=0.05)

	Arable			Non-arable		
	Spacing	Density	spacing X Density	spacing	Density	spacing X Density
Tillers/ plant	1.38	1.60	2.77	1.28	1.48	2.56
Clump/ girth	1.37	1.64	2.74	1.09	1.26	2.18

(Clump girth is in parenthesis)

tropical climate with an average maximum temperature or 31^0 C and a minimum of 16.5^0 C, is by mild summer and winter. The average annual rainfall is 630 mm, most or which is received during July to September. Average number of rainy days are 23.

The trial consisted of planting vetiver at densities of 1 to 4 slips per hill at an interval of 10, 15 and 20 cm (12 treatments) on different class of lands, i.e. on Class IV and Class VII; classified as arable and non-arable lands, respectively, Soil of arable and non arable lands is vertisols sandy loam in texture and slightly alkaline in reaction. It was poor in available N, medium in available P and rich in available K with low water holding capacities.

Non arable lands of Class VI are completely eroded and devoid of any kind of vegetation. The vetiver was planted in the field during monsoon season of 1991, regularly pruned at 40 cm height and kept in field for two years and growth observations were recorded. The results are illustrated in Table 1.

Percentage of survival was about 75 to 93 % when planting was done with 2 or more slips at all planting spacings on both arable and non arable lands. Reduction in survival was more when only one slip was planted. Tillers/plant and clump girth increased significantly with increased number of slips planted/hill at all plant spacings an both types of lands. Although planting of 4 slips at 20 cm spacing recorded maximum tillers/plant and clump girth but it was found to be statistically at par with 4 slips at 15 cm spacing (Table 1).

The average gap size recorded in the present study on bath arable and non arable land shows that planting of more slips per hill reduced the gap size irrespective of plant spacing. This may be due to emergence of more tillers per plant and increased clump girth which is clearly evident from Table 1.

Results of field trial has clearly indicated that planting of one or two slip per hill may not be desirable for establishing vetiver hedge rows in semi-arid regions of Rajasthan State; this is confirmed by viewing the data on survival, number of tillers per plant, clump girth and gap size. Under the existing environmental conditions of the region planting of 3 or 4 slips per hill at 15 or 20 cm spacing observed to be an appropriate system for establishment of effective hedge rows.

Philippines

Farmers decide to replace hedgerow with *Mora* (Vetiver)

Matalom (Leyte) farmers met last December 17 to discuss the destruction of their contour hedgerows by animals. About 300 farms have been contoured since 1991 mostly with napier *(Saccharum officinarum)* and other forage grass species as hedgerows. However, the majority of these farms are either abandoned or are cultivated with collapsed contour bunds.

The farmers noted that napier and other forage grasses are ineffective as hedgerows. After only a few cropping seasons, the napier encroaches into the contour alleys and becomes a weed problem. During the summer fallow, the grass easily dies especially if heavily grazed by farm animals.

The cut-and-carry system of feeding farm animals has not been accepted by the Matalom farmer. Local ordinances disallowing pasture in fallowed farms has not been effective. Thus, the farmers took a serious look at the original idea of having hedgeows both for soil erosion control and livestock feed. The decision reached was to change the forage species to *Mora* (Vetiver). This decision was backed by the farmers' realization of the need to control soil erosion as a top priority and their observation that *Mora* is the most effective and strongest grass species for erosion control.

Vetiveria Newsletter Vol 1 March 1997

Mora (Vetiver) Hedgerows in Punta, Baybay, Leyte

The upland farmers of Barangay Punta in Baybay, Leyte took a giant step towards sustainability with their adoption of the *Mora* (Vetiver grass) as foundation for contour hedgerows. Some 132 contour hedgerows with a combined length of more than 5 km have been established over 31 parcels of upland farms.

It all started with a consultative meeting between some FARMI staff and the barangay officials and upland farmers of Punta. The subsequent assessment conducted by a multi-disciplinary team using a modified participatory rapid appraisal (PRA) identified soil erosion as the major factor that caused the low productivity of the farms in the area. To address the problem, farmer-leaders nominated by the barangay captain were sent to Cebu to observe existing upland projects on Soil and Water Conservation (SWC). After the trip, the farmer-leaders shared with their co-farmers their observations on the farm piactices/technologies which they believed applicable to their own situation

Two farmers (one farmer-leader who joined the trip and his son) were initially taught how to locate contour lines using the "A"-Frame. Then, started to establish a few contour hedgerows of *Mora* grass. Later the other farmers tried the technology and the number of contour hedgerows steadilly increased.

The rapid adoption of the Mora technology was also facilitated by the introduction of the *alayon* system. This involves labor exchange wherein all members of a group jointly perform the activities in each other's farms in a rotation scheme. Thus, a Group with 5 members performs the activities of the first member on the first day, that of the second member on the second day, and so on until the cycle is completed.

Vetiveria Newsletter Vol 1 March 1997

Southern Africa

A Visit to Southern Africa

Reported by Dick Grimshaw. The Vetiver Network

When the historians of the future look back at soil and water conservation developments of our era, unassuming people with names such as Sue Hart, Francis Mbuka, Mathews Munda, Tony Tantum, Jano Labat, Stephen Carr, Malcom Blackie, and Glenn Allison will, amongst others, be remembered for introducing the modern vetiver grass hedge technology to southern Africa countries. These men and women, all with strong agricultural and environmental backgrounds and convictions, and deep understanding of Africa, knew the need for low cost conservation systems that require little

maintenance. They also were aware of the failure and high cost of more traditional systems. They are an ingenious and innovative lot, who were able to recognize the uniqueness of Vetiver grass its use. Most importantly, they and a growing number of southern Africans, were committed to share their successes with others. This is their story.

South Africa

There are two species of vetiver grass in South Africa, Vetiveria nigratana, an indigenous grass, found mainly in some river systems that are linked to the Okavambo swamps, and Vetiveria zizanioides, introduced from Mauritius to the Province of Kwa Zulu/Natal as early as 1860. It is this species that is now being used by Tantum and others for soil and water conservation and land stabilization. It is believed that in the 1940s a Frenchman initiated a long forgotten vetiver based conservation program in an area south of Durban, remnants of which exist some 50 years later, although current generations don't know why it was planted!! Importantly what we do know today (thanks to the Vetiver Identification Program) is that the Vetiveria zizanioides used all over South Africa today is genetically identical to Monto Vetiver of Queensland, Australia, Sunshine Vetiver of Louisiana, USA, and the oil producing vetivers of Mauritius and south India. It is also identical to vetivers from Guatemala and Fiji All these vetivers are sterile and non invasive, and can only be propagated by plant division. The Australian Government only recently approved the release of Monto Vetiver to the public after six years of intensive and controlled site investigations by Paul Truong.

Sue Hart, the founder of an environmental NGO, ECOLINK, operating in Mpumalanga Province, not far from the famed Kruger Game Park, has a small vetiver program that helps to stabilize household plots in a very densely populated area in the Nelspruit area. This program will be expanded with the help of Vetiver Network funds. Most of the targeted householders are controlled by women and it was interesting to see how vetiver was being used, primarily to stabilize the land immediately surrounding the house "Kraal". It also gave the families some privacy from their neighbors, was seen to keep rats and snakes away, and was a form of beautification. We also learned that if a bunch of roots were put in the roof of the house bats would quickly move elsewhere. Of course there were many other uses that these Swazi ladies had not been made aware of including vetivers use for: thatching, mulching, medicine, fodder, and handicrafts (mats, plates, etc.). The Vetiver Network will provide ECOLINK a grant to expand its vetiver initiatives. ECOLINK is keen to develop linkages with other vetiver networks and operators by Email. ECOLINK can be contacted at rural@cis.co.za.

At Nelspruit Andrew Hall of Dickon Hall (a large fruit processing company) has established a pilot oil extraction distillery, and the early results show that very high quality, Reunion grade, oil can be produced from the roots of vetiver grass. Dickon Hall will process vetiver roots from out grower farmers (large and small), including Sue Hart's Swazi ladies. Andrew Hall who is not only an astute business man, is also a conservationist, and firmly believes in the importance of developing firm links though outreach programs with his less fortunate neighbors.

In Kwa Zulu Natal there is a growing awareness of the use of vetiver grass. Maxime Robert's sugar farm is now completely protected by vetiver grass hedges, and government conservation staff are beginning to appreciate its use. There seems to be a general consensus from the field to the top conservation staff of the national Department of Agriculture in Pretoria that traditional engineering methods have generally failed and that vetiver hedges must be seriously used for conservation. We expect to see engineers and agriculturists from the Cedaro Agricultural College spearheading field efforts to expand the use of vetiver. Paul Klopper of Dundee has demonstrated vetiver's for stabilization and protection of dams and reservoirs. He claims that vetiver has survived 12 months of total submergence in water Vetiver grass can be used in most areas of South Africa, and has particular application in the heavily degrading small farm African areas of Transkei and Mpumalanga where some well known NGOs are operating.

Tony Tantum, in association with staff of some of the mining companies, has amply demonstrated the utility of vetiver in stabilizing "slimes dams" (mine tailings). Thanks to Paul Truong's work in Queensland we now know that vetiver is in most cases more tolerant than any other species to heavy metals such as chromium, arsenic, manganese etc. These metals, as well as others, are found in slimes dam materials.

Work by Mark Berry (de Beers) on diamond mine slimes dams at Premier (800 mm annual rainfall) and Koffiefonteine (300 mm) mines confirms that vetiver does the job very effectively. It is interesting to note that the surface temperature of the dam materials, that are black in color, reaches over 55˚ C. - - at this temperature most seeds are unable to germinate. Vetiver hedges at 2 m VI provides shade that cools the surface thus allowing germination of other grass seeds. Vetiver is truly a pioneer grass. Further, on slopes often exceeding 50%, vetiver hedges are able to withstand the pressure of slipping materials, and can hold that material in place behind the hedge rows. Berry can be contacted at markpsb@imed.co.za

Tantum has been personally involved in successful stabilization of slimes dams at the Anglo American platinum mines at Rastenburg, and the Velkom, President Brand Gold mine. It is important to note that at all the successful sites (as compared to reports of failure) strict technical standards have been set and applied. Tantum finds that chicken manure gives vetiver a great start (just as the Chinese in 1989 found with pig manure). Planting strikes must comprise of at least 3 slips and the strikes should be planted very close together, no more than a "fist" apart. For gold mines where the pyrites, when exposed to erosion, produce "sulphuric acid" with pH levels of less than 3 special methods have to be applied. These include the smoothing of the slope to remove all rills, the incorporation of up to 60 tons of lime per ha. and jet spray irrigation for the first two or three years. The key to success is to keep the pyrites from exposure and oxidization.

Another area of growing interest is the use of vetiver grass hedgerows for the stabilization of industrial construction site fill areas. Tantum has recently completed the stabilization of an enormous site at Mahogany park, Pinetown, Kwa Zulu Natal. The client now feels that he can sleep easily at night!!

Tantum estimates that he can provide and plant vetiver at Rand 6.0 (US$ 1.3) per lin-

ear meter. He and others sell vetiver plants, cut and ready for field planting, by the cubic meter. One cube (approximately 2,500, 3 slip, strikes) is sufficient for 250 to 300 linear meters of planted vetiver hedgerow. He contracts local farmers to produce planting material. Depending on site and client requirements he often hydroseeds the area between the vetiver hedgerows using local grasses including some Erogrostis sps. The last word from Tantum is "apply the technology correctly and the results will always be satisfactory". He is right, but you also need the experience that he has built up over the years that adds that a little extra to assure success. One of those little extras is supervision of field workers. If they are not properly supervised the chances are that the results will be less than optimal, and could even be a failure. Tantum can be contacted at: Specialised Soil Stabilization, PO Box 167, Howick 3290, Republic of South Africa. Fax/Phone: (27 332) 303000. He can supply vetiver grass planting material, contractual and advisory services, both locally and internationally.

It appears that the time is ripe to make a more intensive effort to disseminate information about vetiver grass technology in southern Africa. Very few people know about the technology, many more should!! The Vetiver Network has therefore agreed to collaborate with the Institute of Natural Resources (INR) in the establishing of a southern Africa regional Vetiver Network as of January 1997. INR is a non profit organization affiliated to the University of Natal located at Pietermaritzburg. This network will send out newsletters and fact sheets, and if funds can be generated by local businesses and mining companies it will run workshops and perhaps provide micro grants to NGOs and others to develop small vetiver programs. The new network will also establish its own homepage on the Internet, as well as mirroring The Vetiver Network's homepage (www.vetiver.org) on its server at University of Natal.

For the interim Duncan Hay is acting as vetiver network coordinator and can be contacted at Institute of Natural Resources, Private bag DX01, Scottsville, 3209, Republic of South Africa. Tel: (27- 331) 46-0796, Fax: (27- 331) 46-0895, Email: breen@inr.unp.ac.za. Those living in southern Africa and are interested in joining the network should contact Duncan Hay.

Zimbabwe

Like South Africa, there are two species of vetiver grass in Zimbabwe, Vetiveria nigratana, an indigenous grass, found mainly in some river systems that are linked to the Okavambo swamps, (also in the Zambezi Valley) and Vetiveria zizanioides, introduced from Mauritius to the sugar growing Low Veld in south east Zimbabwe. In fact it is known as Mauritius grass, and like the grass in South Africa, it is identical to that in Natal, Louisiana, Fiji, Guatemala and Australia, and is non invasive and sterile.

Like Tantum in South Africa, Zimbabwe has its vetiver champion too — Jano Labat of Chiredzi. Jano is a sugar farmer near to the enormous and famed sugar mega giants Hippo Valley Estates (Anglo American) and Triangle. In the early 1990s Jano started using vetiver grass for stabilizing his field drains, irrigation ditches, and farm roads. At the same time he championed vetiver grass across Zimbabwe. He has supplied planting material, advice and good will to hundreds of would be vetiver users in a country where soil erosion is estimated to cost billions of dollars annually. Like all new technologies it is rather slow to be accepted by the traditionally conservative farming community and technical support services. But it appears that adoption is now on the roll and Zimbabweans are turning to this unique plant to stop erosion.

Labat's farm is on flat land and is irrigated. The problems that he faced including deteriorating canefield roads, eroding drainage ditches, and collapsing irrigation channels. in addition he faced a growing and costly weed problem in the drainage ditches that were expensive to maintain. He turned to vetiver grass to solve these problems.

He established 3 ha of nursery to supply vetiver for his own need and for sale to other framers and users. His technique for stabilizing field drains and the immediately adjacent field road is unique and a lesson for all of us. He plants closely spaced vetiver strikes (3 - 5 slips per strike) along the edge of the drain (about 1 foot back). He then grades the field road to the hedge, thus water on the road drains to the vetiver hedge, where excess sediments and gravels are retained and the water is filtered through the hedge to the drain. On the other side of the drain more often or not is a square section concrete gravity irrigation channel, that is in danger of collapse when the support earth bank is eroded. Thus he plants a vetiver hedge along the bottom of the support bank which coincides with the top of the drain. In one stroke he has stabilized both channel and drain. The latter is "V" shaped (45˚),from 2 -3 m wide at its widest section, from 1.5 to 2 meters deep and about 0.5 meters wide at the bottom. Half way down the slope he plants another vetiver hedge on both sides. This hedge traps any sediment that may get through the first hedge, and any major slippage or erosion between hedges. Once a year the ditches are cleaned of a much reduced sediment load, and the cleanings are deposited behind and above the lower hedge. This has three advantages: (1) overtime it creates a level terrace half way down the ditch (2) the top hedge remains free of excess sediment from the ditch cleanings and thus road drainage is maintained; and (3) the bottom of the ditch settles at its final grade, and there is minimal drain disturbance. This is not all, perhaps the most important aspect of all is that the leaves of the two lower hedges completely shade the bottom of the ditch resulting in a completely weed free environment. Thus there is no impediment to drainage water flows, and drain maintenance is virtually reduced to zero. Where limited planting material is available Jano Labat recommends establishing the two lower vetiver lines first. This assures that weeds are quickly shaded out and assures guaranteed establishment because of higher humidity. He also suggests that in instances of limited planting materials the bottom lines can be split after a year or so to plant the top two rows. He recommends that where sufficient planting material is available planting strikes should be planted with zero gap thus assuring a 100% effective hedgerow. One last point that Jano is quick to point out is that the vetiver hedge along the side of the roads keeps tractors and trucks firmly on the surface of the road. The Vetiver Network will henceforth refer to this technique as "The Labat System".

Labat is also using a variety of "Lily of the Valley", *Ophiopogon intermedius*, brought in from Mauritius (originating in Nepal) where it is known as "Muget", for soil stabilization under heavy shade. It is both pretty and a good soil binder.

Jano Labat has demonstrated the effective-

ness of vetiver grass to stabilize the interface of concrete works and earth, reservoir embankment stabilization and its action to depower wave action on the inside of a reservoir. The cost of this is minimal compared to stone rip rap and lasts for ever. Believe it or not—vetiver has established well on 5 mm of soil overlying mass laterite, the roots growing into and through the laterite!! Vetiver cut off at ground level has even grown through a gunited surface on the side of a drain!!

Hippo Valley Estates (HVE) have also been using the Labat System with varying modifications and successes. It would be useful if full and detailed specifications are established so that all the estate sections follow the same standards.

Labat working with HVE stabilized an 80 m wide reservoir spillway. The method used was to plant rows of vetiver 1m apart across the spillway, starting at the base of the concrete sill at the head of the spillway. It could be further improved with vetiver hedges planted at right angles to the horizontal lines to create a sort of honey comb effect. During my visit I witnessed a flow of the order of 9000 l/sec passing over the spill way. It was an awesome sight. The vetiver depowered the water over 80% of the spill way area, with the main flow concentrations centered on two rock sections that were free of vetiver. The vetiver only two years old held well, either remaining upright, where the water was not too deep, or bending over to form a continuous mat where the water depth was greater than the vetiver. Jano will send The Vetiver Network new photos after the spillway flows cease.

Another interesting use of Vetiver by HVE was the lining of the banks of two rivers that conveyed water to the above mentioned dam. Both rivers were under continuous flows of between 4000 - 5000 l/sec and were acting as unlined canals. Vetiver provided an almost perfect protection to these river banks. HVE has planted 313 km of vetiver for canal bank, drainage, catchment area protection. Approximately 47 km remains to complete the program. At a workshop of some 50 participants it was recommended that HVE establish detailed technical standards to assure that variations in quality are reduced.

HVE has an outreach program that was previously reported on by the Network. This program has expanded considerably since that time and there is an accelerating interest by small farmers living in highly erosive areas in the hinterland of the commercial estates. Currently HVE supports 11 small projects that include schools and communities. In total 50 km of vetiver hedge has been planted. Under these projects vetiver is used for on farm soil and water conservation, grazing area rehabilitation, irrigation infrastructure stabilization, and for stabilization of gullies. Both are successful and are particularly appreciated by participating women. HVE and Labat are also working with Danish and IUCN (International Union of Nature Conservation) supported NGOs who have similar objectives of assisting the rural areas. Other NGOs including World Vision and Biomass Users Network are also expected to accelerate the use of vetiver in their programs. All agencies working with rural farmers and households report great interest by participating clients. The latter are particularly responsive when given adequate training and when made fully aware of all the benefits of vetiver grass including social benefits such as its use for thatch, livestock feed, and herbal medicines. Clearly the potential for expansion is considerable and the Vetiver technology should play an important role in Zimbabwe's conservation efforts.

Jano Labat can be contacted at: Vetiver Grass Stabilization (Pvt) Ltd. PO Box 14, Chiredzi, Zimbabwe. Tel: (263) 31 2245. Fax: (263) 31 3026. He can provide quality planting material, contracting and consulting services.

Malawi

Stephen Carr, who has a long career in African agriculture, lives on the slopes of Zomba Mountain in the southern part of Malawi. Stephen who started his career as an agricultural missionary in Africa and ended it with the World Bank, "retired" to work in Malawi because that country has one of the world's poorest populations of which 93% live off the land. He has done much to create change in Malawi's agriculture in the past few years. He works with communities, particularly Christian ones of any denomination. In Malawi large numbers of people, particularly women, attend church—often more than 100 times a year — a great contact point for disseminating information about low cost known technologies. Government extension workers are being encouraged to attend church meetings, and when invited they tell the congregations about new technologies that will in particular help improve soil fertility. A few years ago Stephen introduced the vetiver technology to Malawian smallholders in the Zomba area.

Vetiver grass hedge row technologies are part of a soil improvement package. After initial reluctance the technology is now virtually universally accepted by agricultural and conservation staff. The key to effective application has been the use of an "A" frame for establishing level contours. Dumpy levels and long waits for a conservation assistant to put in a contour line are now history!! The farmer, after training, can peg out contour lines him or more often herself.

In Malawi there are two vetivers, V. zizanioides and V. nigratana, the latter is a common grass in the Lower Shire Valley, and probably migrated from the Zambezi Valley. V. nigratana, is being used effectively as a hedge row, but it does seed (not a problem to the farmer) and it does appear to compete more with the adjacent crop than does V. zizanioides. Over the longer term V. zizanioides should be the first choice and all efforts should be made to multiply it in very large quantities. Under good conditions (irrigated and fertilized) 1 ha of nursery will produce about 20 linear km of hedge a year. This is sufficient to protect about 20 to 30 ha. of farm land (using a 10% average slope). To make any impact on Malawi's, or for that matter any other country's erosion problems, many thousands of hectares of nursery will be necessary.

In Malawi soil conservation is fundamental to soil fertility maintenance, and as such an integrated approach is being taken. Without subsidy it is hardly economic to grow maize using inorganic fertilizers, and yet maize is the staple diet for Malawians, and 70% of the total cropped land is under maize. There is intensive activity by the Malawi government and donor agencies to look for alternative methods to supply plant nutrients other than inorganics. Stephen Carr introduced Magoye soybeans from Zambia a few years ago, today thousands of hectares are grown by Malawi's small holders. This crop nodulates without inoculates and produces a positive net soil nitro-

gen gain (estimated at 60 kg N per ha.) Another new and promising approach is to interplant the legume *Tephrosia vogeli* as a green manure at the time of the second weeding of a standing maize crop. This legume produces over 100 kg N per ha and can be ploughed in as green manure or left on the surface as part of reduced tillage systems. This is a much more manageable approach than alley cropping, and follows the successes in central America where lablab, velvet and jack beans are being used as intercropped green manures as part of successful reduced tillage practices. Vetiver grass hedgerows fits well with this approach, and is seen as an integral part of the system. An interesting aspect of vetiver is that it may contribute to the recycling of phosphates that are deep down in the soil profile. Stephen Carr can be contacted at: Private Bag 5, Zomba, Malawi.

Glenn Allison lives in Lilongwe, the capital of Malawi, and manages a European Community project known as PAPPPA (Poverty Alleviation Program Pilot Project Agroforestry—a rural poverty oriented project). Glenn has been a keen advocate of vetiver grass hedgerows for ten years now and as manager of PAPPPA has been able to introduce the technology on a wide scale. Currently PAPPPA has helped the Ministry of Agriculture and some NGOs establish over 180 vetiver nurseries and another 180 are to be established next year. Farmers are very enthusiastic and the demand for plant material is far greater than supply. Vetiver technology is catching on fast and is now backed fully as part of Government's policy to reduce erosion. Glenn Allison's key partner is Mathews Munda of the Ministry of Agriculture, and together with support of Francis Mbuka of the local World Bank office are forging ahead with this exciting program that includes not only establishment of vetiver hedges but also the establishment of 200 trial plots throughout Malawi that are testing and demonstrating on farmers fields vetiver combined with low cost fertility building technologies. The master mind behind these trials is USAID's Trent Bunderson.

Establishing large quantities of vetiver planting material has top priority, some interesting approaches are being taken. Farmers are being paid about $400 per hectare of vetiver nursery, if specifications are met. Other nurseries are established with maize as an intercrop. This means that farmers can still harvest their vital maize crop, whilst vetiver is being established, the maize does not interfere with the growth of vetiver. This system should be extended, as thousands of hectares of nurseries could be established in this way.

Malcom Blackie who is in charge of The Rockefeller Foundation's Maize and Soil Fertility Program in southern Africa is also a vetiver enthusiast. Because vetiver is accepted so readily by farmers he sees vetiver hedgerows as providing an entry point for other low cost sustainable technologies that farmers may take longer to adopt The latter include the introduction of Magoye soybean (the latter needs no ryzhobia inoculate to form nitrogen fixing nodules); reduced tillage systems involving leguminous mulching using Tephrosia vogelii, the latter is not eaten by livestock, and will therefore remain intact during the dry season when livestock free range over farmers' fields; and the introduction of *Faidherbia albida* (Msangu tree) and a live cattle proof hedge *Acacia polyacantha*. These technologies are all under test and evaluation under farmer conditions.

VEZA (Village Enterprise Zones Association), an NGO, is working in broken and heavily eroded country side that forms part of the Lake Nyasa escarpment not far from Lilongwe. VEZA has introduced vetiver grass hedgerows as contour marker lines to 240 farmers. These farmers have also adopted some of the other practices noted above, particularly the growing of Magoye soybean. The objective is to use these farmers to demonstrate and disseminate these new technologies to their neighbors. The quality of work is generally quite good, and VEZA staff are well trained and active.

A general comment is that all farmers using vetiver should be informed of all the benefits of vetiver, including its use as thatch (very important in the context of Malawi), fodder, mulch, and handicrafts. It is believed that such information linked with poster, radio and other information campaigns would further accelerate the demand for the technology, and improve the understanding of the intended beneficiaries.

This year Malawi has received very heavy rainfall, the rivers are full of run off and silt. Much of this sediment comes from point source erosion locations such as collapsing river banks and newly constructed roads. As a result vital reservoirs such as those serving the capital city of Lilongwe are losing their capacities very rapidly, as is the headworks of the country's critical electrical power supply on the Shire River. The sources of this sedimentation should be clearly identified and fixed with vetiver grass.

Glenn Allison can be contacted at: PAPPPA, PO Box 1481, Lilongwe, Malawi. Fax: 742 393.

Thailand

The application of Vetiver Hedges in Soil and water Conservation Sytems: Integrated Conservation.

Boonyarak Suebsiri and M.R. Samjamjaras Rajani, The Royal Project Foundation, THAILAND.

Abstract:

The principle conservation on sloping land by maneuvering run-off velocity proves to be effective, though this strategy demands engineering skills and comparatively high investment cost. The more economic and simple strategy of applying vegetative measure using Vetiver hedge, entice widespread adoption to the tiller.

Hydraulic characteristic of Vetiver hedge examined in an experimental flume at University Southern Queensland, Australia reveals that run-off velocity is increasing after passing each hedge. In the field, the application of only Vetiver hedge alone does relevant downstream erosion by both run-off accumulation and increase velocity. The situation even gets worse after run-off passes more and more hedges especially at the foot of the slope.

The set of bunding with close parallel Vetiver hedge at the outside end of the intermittent small level bench terrace enhances the solution. Bunding fills the lower gap of the grass and the grass reinforces the bunding. The symbiotic bioengineer not only promotes integrated conservation but also accents water harvest system. On the other hand, after establishment a few rows of Vetiver hedge, either add diversion to divert run-off to moisture check dam or add

level terrace to convert surface run-off to sub-surface flow.

Slope Stabilization: Vetiver Application from a Bio-Engineering Aspect.

Karn Trisophon and M.R. Samjamjaras Rajani, Department of Land Development. THAILAND.

Abstract:

Tremendous earth work during the construction of Noppamaetaneedol and Noppapol Phumisiri Pagoda at Intanon summit has caused substantial change in the relief on the construction site. Falling earthwork had formed a steeper slope which was stable enough to sustain itself during the dry season. But in the rainy season infiltrated water which was contributed by sub-surface flow had gradually increased pore pressure and subsequently overcame shear stress of the soil. This caused slope failure. In order to reduce pore pressure strips of gravel pit were built so as to induce inflow from the excess moisture content of the soil. The excess water was then drained into concrete dikes next to each pit. Even though most of the excess water was drained out, what was left was enough to make the portion of slope adjacent to the dikes become unstable. To remove this problem a row of vetiver was planted on the outer bank of each dike. The vetiver outstanding root system had two roles. The first was to mesh up and mechanically add stability to the slope. The second role was to suck up the excess water and dissipate it via evapotranspiration process.

Tissue Culture of Vetiver Grass

Artit Sukkasem and Withoon Chinapan, Land Development Department. THAILAND.

Abstract:

The study on propagation of 3 ecotypes of vetiver grass by tissue culture was carried out from sterile vetiver with clorox 15% and 10% at 10 and 15 minutes respectively. After cutting the leaf sheet, dressing the bud, then feed them in the culture with 6-benzylamino purine (BAP) at 10 micro molllitre. It was found that one piece of vetiver can produced 3-5 tips and after feeding in the culture with the same BAP but reduce the concentration to 50 milligram'litre and mixed with 3-indolebutyric acid ('BA) 0.1 milligram/litre vetiver would increased 10-20 times with in 4-6 weeks. After moving them to feed in MS culture (without growth control enzyme), they produced 5-10 roots within 3-4 weeks. After transferring the young vetiver shoots into the plastic buckets and wetting them under the semi shading for another 4 months, they can then be divided and planted in the greenhouse. It was found that propagation by this method, gave the vetiver seedling strong, good tillering and the percentage of survival up to 90%.

A Study of the Ecotype Comparison of Vetiver Grass

Withoon Chinapan, Arthit Sukhasem and Lex Moncharoen. Department of Land Development, THAILAND.

Abstract: The vetiver grass of 28 different ecotypes were collected from the brackish water coastal areas in the southern to high mountains in northern parts of the country. These vetiver grass were identified as 17 ecotypes of *Vetiveria nemoralis* A. Camus (upland species) and 11 ecotypes of *Vetiveria zizanioides* Nash (a wetland species). 1 ecotype was introduced from Sri Lanka. These vetiver grasses were used as plant materials in the experiments at 12 different locations that were conducted to test the vetiver grass characteristics suitable for hedge development in sandy loamy-clay and lateritic soils. The growth of vetiver grass considered were: tillering clump diameter and height at the age of 90 days after planting which started from July 27 1992 to October 27 1992. The experiment results showed that high growth of vetiver grass were *nemoralis* and 4 ecotypes of *V. zizanioides*. *V. nemoralis* appcared to have on average more tillering than that of *V. zizanioides*, 30 tillers per clump and 18 tillers per clump respectively. Nevertheles the average of clump diameters were not different - 12 cm. The average height of *V. zizanioides* was higher than that of *V. nemoralis*. 104 cm and 99 cm respectively.

The eotypes suitable for hedge development in sandy soil were 4 ecotypes of *V. nemoralis*. Nakhon-Sawan (v7). Kampaengpet. 1 (v8). Roi-Et (v13). Rachburi (v20) and 2 ecotypes of *V. zizanioides*. Kampaengpet 2 (v9). Songkhla 3 (v28).

The ecotypes suitable for hedge development in loamy clay soils were 5 ecotypes *of V. nemoralis*. Loci (v6). Nakhon-Sawan (v7). Kampaengpet 1 (v8). Rachburi (v20). Prajuabkirikhan (v22) and 2 ecotypes of *V. zizanioides*. Suratani (v23). Songkhla 3 (v28).

The ecotypes suitable for hedge development in lateritic soils were 2 ecotypes *of V. nemoralis*. Loei (V6). Prajuabkirikhan (V22) and 4 ecotypes of *V. zizanloides*. Sri Lanka (V4). Kampaengpet 2 - 9). Suratani (V23). Songkhla 3 (V28).

Study of Optimum Rows and Different Plant Spacings of Vetiver Grass for Soil Erosion Control on Sloping Land.

Pitak Intaphan, Sawatdee Boonches and Sasriprapa Vathatum. Land Development Department. THAILAND.

Abstract:

The optimum rows and plant spacings of vetiver grass to control soil erosion on sloping land was studied at Chiang Dao District, Chiang Mai Province during 1993 - 1994. A randomized complete block design with 3 replications and 7 treatments were observed. The treatments were single and double rows of vetiver grass with hill spacing at 10, 15 and 20 cm., the distance between rows of double row treatments was 30 cm. compared with the farmers' practice treatment (without vetiver grass).

The results indicated that single row planting obtained better growth than planting at double rows. Wider hill spacing also provided a higher tiller number and bigger hill size than close spacing. There were not significant differences in crop's yield among the treatments. By planting vetiver grass in single or double rows gave significantly differences in reducing soil loss than without vetiver grass and there was no differences between the single and double rows. Moreover, those treatments tended to conserve soil moisture longer than that of farmers' practice treatment.

A Test of Planting Vetiver Grass at Different Vertical Intervals for Soil and Water Conservation on Sloping Lands

Pitak Intaphan, Sawatdee Boonches and Sasriprapa Vathatum. Land Development Department. THAILAND.

Abstract:

During 1993 -1994, a test of planting vetiver grass at different vertical intervals for soil and water conservation on sloping land was undertaken at Chiang Dao District, Chiang Mai Province. Seven treatment included: 1) bare plot, 2) ploughing and planting up and down slope, 3) ploughing and planting along contour lines, 4) alley cropping (+ pigeonpea) 5), 6) and 7) a single row of vetiver grass with 1, 2 and 3 meter vertical intervals respectively were studied.

The results showed that vetiver grass treatments were more effective in reducing soil loss and run off compared with no vetiver hedge-row. There were not significant difference in crop yields among the treatment tested.

Zambia

Vetiver grass for conservation in Gwembe South, Zambia

Methodist Relief and Development Fund: Africa Link - newsletter #15, April 1997

A nursery for vetiver grass, both the Indian variety, *Vetiveria zizanioides*, and the African variety, *Vetiveria nigritana*, was originally established at the Gwembe South Development Project (GSDP) compound in Kanchindu village in 1992/93, the aim being to multiply it for distribution to interested farmers so they could plant it in line on contour as hedgerows for the purpose of soil and water conservation. Pickson Chimomba, the first farmer in the Musiyo area to receive vetiver grass from the GSDP nursery in 1995, says he much appreciates it because it can even stay green in the dry season, and he also uses it for thatching his house and his store. Paterson Siamuche, another farmer in Musiyo, now has an excellent nursery of vetiver grass, from which other farmers in the area are being supplied.

Siamucaala village in Gwembe valley is extremely remote, very far from the nearest bush road, and it is a credit to the GSDP Sustainable Agriculture Programme field staff that they reached this area last year and surveyed the land. Visiting the farm of Alfred Namukamba, he proudly showed us the lines of vetiver grass he had planted across what had been a large gully, and also in lines across his field. This has already been effective in slowing and halting the movement of soil. In spite of being grazed right down by cattle, the vetiver clumps were still firmly in place and green, even though there had not been rain for the past 9 months. To be effective at all, vetiver grass must be planted closely, at no more than 4 inches (10 cm) apart, on the contour, in lines right across the field being protected. This is exactly what Alfred Namukamba had been doing, and this is the main reason for his success.

USA

USDA 1996 Workshop on Grass Hedges for Erosion Control

The USDA GrassHedges Research Group is a cooperative research effort being\conducted by staff and scientists of the USDA Natural Resources Conservation Service (NRCS) and the USDA AgriculturalResearch Service (ARS).

1996 meeting of the Work Group on Grass Hedges for Erosion Control October 22-24, 1996

Organized by Seth Dabney, USDA-ARS-Sedimentation Lab, Oxford, Mississippi and Joel Douglas USDA-NRCS Whitten Plant Materials Center, Coffeeville, Mississippi

Executive Summary

Flume and field studies show that stiff stemmed densely tillered grasses in mature hedges are able to stand up against concentrated water flow, pond the water, and commonly deposit most of the sediment upstream from the hedge.

Vegetative barriers of 10 species of perennials were planted across a slope of about 7% in a field at Coffeeville, MS. Sediment moving downhill in response to cultivation and runoff in an area extending ten meters up hill from these hedges has deposited in front of the barriers to depths of ten to fifteen centimeters in four years. This has reduced the average slope of the cultivated area to about 5%. Species ranging from switchgrass to blackberries to weeds (which displaced some original plantings) were about equally effective in stopping soil movement under these conditions where intense concentrated flow of water does not occur.

Tall grass hedges which overshadow soybeans, cotton and other short crops, reduced yields in the crop rows adjacent to the hedge unless the hedges were trimmed back early in the year. Combined with the Coffeeville results, these findings suggest that shorter varieties of grass can and often should be used in hedges where they are not crossing concentrated flow channels.

Candidates for grass hedges ranging from 50 to 200 cm in height have been identified from the literature and in plantings at several NRCS Plant Material Centers and lists thereof are included in the minutes of the workshop along with hardiness zones to which the grasses are adapted and sources from which they can be obtained. As grass hedges mature it is apparent that they trap most of the sediment coming off the field with the runoff, which reduces sediment damage to downstream channels, reservoirs, and ecosystems. As these switchgrass, miscanthus, and Eastern gamagrass hedges mature and their residues deposit on adjacent soil, runoff is being reduced by as much as 46%, which is similar to runoff reductions reported in India and other tropical countries by vetiver grass hedges. This has multiple benefits since there is less runoff to cause downhill erosion and since more water is made available to crop root zones and to recharge ground water and sustain base stream flows.

Accidental and intense spraying with paraquat appeared, a few days after spraying, to have killed the four year old switchgrass hedges at Southland farm in northern Mississippi. However, new shoots emerged from many nodes of the stems on which the original leaves died. Each of these new shoots bore 3 or 4 new leaves which kept the hedge alive. This ability of switchgrass stems to produce new shoots from nodes, and previous observations that

roots grow from nodes when they are covered by sediment, raises the possibility that new plants can be generated to fill gaps in hedges by bending over and partially burying nearby stems of grass in the gaps and getting them to produce new shoots and roots from the buried nodes.

In Hawaii stems of napier grass overlapped and tied together in long bundles have been partially buried and staked into shallow trenches across steep and extremely eroded hillsides. Shoots have emerged from the nodes above the soil and roots from those below to establish hedges, while the long bundles of stems provide significant initial erosion control. This "wattling technique" has controlled erosion where many other approaches have failed.

In the excavations in acid claypan soils, associated with the 1995 workshop, Eastern gamagrass (E.G.) roots were found penetrating through the claypan and extending to depths of about 200 cm. This was about 3 times the depth of rooting of soybeans on nearby soils. This increased depth of rooting explained continued growth of E.G. when other crops and grasses on these soils were desiccated and dying during prolonged drought periods. It also explains why there is little competition of E.G. hedges and adjacent crops for water where the E.G. can take most of its water from deep soil layers. Abilities of E.G. to root so deeply in this soil were explained by the aerenchyma and acid tolerance of its roots. Aerenchyma enable the roots to grow down through these seasonally saturated and often anaerobic soils by providing passage for oxygen within the roots. This ability to grow into saturated soil enables E.G. roots to push through these soils when the soils are wet and weak. Roots of most other species do not tolerate pH levels below 5.0 . Controlled studies show that E.G. roots grow into soils at pH levels from 5.0 down to 4.2 which are common in acid claypan soils.

E.G. roots are large and scheduled to die within two years of their initiation. In the claypans sampled they had engendered a three fold increase in large pores compared to claypans under other nearby crops. These large pores facilitate passage of water. The decaying roots and associated large pores encourage invasion by microorganisms, earthworms and roots of successive crops, which produce or redistribute organic matter and exert forces on the soil which help keep it pliable and granular rather than allowing it to become harder and monolithic. The permeability or infiltration rate, is a defining factor in soil quality and erosion because it determines the portions of the precipitation which will enter the soil, or run off. When there is no runoff there is no erosion. Erosion is generally about a squared function of the runoff. Fragipans generally contain less clay but tend to be harder and more restrictive to root extension than claypans. Fragipans are found in about 70 million acres of land ranging from Mississippi to New York. Soil cores 1.4 meters deep taken in patches of E.G. growing on fragipan type soils in Missouri showed that E.G. roots had grown down to at least 1.4 m and had grown into saturated soil. In an area with lower water tables at Coffeeville, MS, E.G. roots found in the sides of pits in fragipan soils were down to depths of about 120 cm, but did not appear to have gone deeper than roots of switchgrass.

The North Carolina Wildlife Management Division is recommending strips of tall warm season grasses in cropped fields to the NC State Natural Resources Conservation State Technical committee based on studies of song and game bird populations and reports of our work group on grass hedges for erosion control. The tall and stiff stemmed grasses impede entrance of foxes, coyotes, racoons, and other predators and help restore bird populations.

Evaluation of vegetation eating insects and insect predators in, near, and distant from relatively new grass hedges indicate that populations of both the insects and their predators are higher in and near the hedges. This was also true of earthworm counts. These higher earthworm and insect populations in and near the hedges may also be a factor in growing bird populations where tall grass strips are part of the conservation plan. Grass hedges and vegetative barriers in general have unique potentials for erosion control. They require time, some protection from weeds and some maintenance to reach those potentials. They are not an "immediate fix", but can be excellent long term investments. Their abilities to control erosion improve with time. They are highly interactive with adjacent crops, soils, and precipitation; competing for water, sunlight, and nutrients with adjacent crops. However, they also decrease wind speed and evaporation, increase infiltration and foster biofactors in the soil, most of which have long term beneficial effects on crop production and environment.

Zimbabwe

An initiative to save the Save

Story and photographs by Keith Harvey, chairman Environmental Committee

The remorseless ecological degradation of the Save Valley over the past 40 years has been a national disgrace.

In spite of numerous conferences, committees and the formulation of 'action plans' as far back as 1984, the deep hippo, pools have become sand traps and the river is biologically dead.

The Save is Zimbabwe's biggest internal river. It has a catchment area of 4.3 million hectares, which is more than 10 per cent of the nation's land surface. It is bounded by the Eastern Highlands and the central watershed from Mutare through Marondera to Chivhu, southwest to Gutu and Bikita. Its major tributaries are the Odzi, Rusape, Macheke, Ruzawi, Mwerihari, Nyazvidzi, Devure and Turgwe. They contribute a total mean annual runnoff of 3 million megalites or 18 per cent of our internal yield of surface water.

As little as 40 years ago these tributaries carried negligible amounts of silt compared to their present gross annual soil load, estimated to be in excess of 100 million tonnes.

It was further estimated that 96 per cent of this total originates from approximately three million hectares of land under communal tenure.

The traditional land-use patterns of the past are only sustainable in marginal woodland savannas of SubSaharan Africa at fairly critical population levels of both humans and their domestic animals. Once these levels are exceeded, an escalating process of degradation follows.

The tree vegetation is depleted at a much faster rate than its natural regeneration, the grazing areas are subjected to serious overutilisation, loss of vigour and unrelenting encroachment by crop land.

Due to the depleted vegetative cover, soil temperatures increase and the remorseless process of erosion and desertification inevitably follow.

The economic consequences are equally remorseless. In 1992 soil loss estimates for poorly managed crop lands varied between 25-80 tonnes per hectare, so that on average 50 tonnes were lost, for every tonne of maize produced, an unacceptable cost for any nation! Soil loss from over-grazed land is even more serious.

A further estimation indicates that with losses of this magnitude on typically sandy soil the potential for economic production will diminish after 10 years and terminate after 30.

Similar soil types under improved management techniques, including grass lay rotations, would have an economic life of over 450 years!

In these rather over-simplified terms we identify the problems, their causes and effects. The difficult task has always been to find solutions to a complicated and sensitive socio-economic situation.

What has long been needed to reverse these trends is a new initiative, an unsophisticated technique and some well-intentioned enthusiasm. All these are currently in abundance in rural Gazaland.

Silt Traps

The simple technique is the planting of Vetiver grass in lines across the slope to act as silt traps.

The initiative has been taken by a group of Chipinge commercial farmers to bulk up the grass on a large-scale for free distribution to communal farmers and was actively supported by members of the Lions Club.

The enthusiasm was so infectious that it won the support of Manicaland governor, Kenneth Manyonda, the Rural District chairman and all who were fortunate enough to join a recent whistle-stop tour of the Chipinge area.

Vetiver grass has been extensively and successfully used in other sub-tropical countries for many years. It was introduced into Zimbabwe from Mauritius but did not seem to attract much attention until recently, possibly because of commercial exploitation and also its less vigorous growth on poor sandy soil.

However, extremely impressive dense inter-row hedges were seen on a coffee farm, and even more so on a small-scale holding that had been cropped continuously for over 20 years. On a steep slope and on gravely soil very healthy maize plants were growing adjacent to the dense contour hedges of Vetiver.

A more convincing demonstration of its effectiveness as a conservation measure would be hard to imagine; it was really impressive.

At the conclusion of the day, Governor Manyonda committed himself fully to mobilising support for the development of the project and the Chipinge Natural Resources Committee members stated that ARDA's

Dr. Liberty Mhlanga had agreed to provide several hectares of irrigible land on *Chisumbanje Estate* for further building-up of planting material.

The committee members will also be invited to address the Provincial Council and possibly be co-opted to a PDC sub-committee concerned with catchment protection.

Finally, the Lions Club of Zimbabwe intend supporting and sponsoring similar vetiver projects on a national basis

The Good Things about Vetiver

Vetiver grass has some unique qualities. It has an unusually dense and vigorous root development, which penetrates straight down to well over one metre, making it extremely drought resistant.

When it is established it does not compete with, nor invade, close growing crops. It does not produce viable seeds, but is easily propagated from rooted shoots which, if closely spaced (10-16 cm) quickly form dense upright hedges. These must be aligned on the true contour so as to effectively check run-off down the slope and effect the deposition of silt.

Its major advantage, however, is that it is most unattractive to grazing animals.

Establishment and management techniques in a communal scenario have still to be worked out, but, in theory, one could visualize continuous level contour lines of hedges at suitably spaced intervals extending over both arable and grazing areas for every minor catchment in these areas draining into the Save River.

The Farmer, February 6, 1997

The following agencies have special grant schemes that the Vetiver technology may fit.

Sources of Funds for Vetiver Programs

KPF (Germany)

Small-Scale Project Fund for the application and dissemination of Appropriate Technology (AT)

The KPF is a project of the Division: Environmental Protection, Conservation of Natural Resources (URS) and Dissemination of Appropriate Technologies (GATE) of the GTZ

The AT Small-Scale Project Fund

The supra-regional project "Information Service for Appropriate Technologies" (ISAT) of the GATE section of GTZ, has existed since 1977. Originally conceived purely as an information service, the project was widened in scope to include the provision of consultancy and support services for the adaptation and dissemination of individual technologies, on a pilot basis. This development took place over a number of years, as it became apparent that executing agencies required not only information on specific technologies, but also in some cases lacked the means to adapt and test, as well as implement and disseminate, these technologies.

To overcome this problem, the AT Small-Scale Project Fund (KPF in its German abbreviation) was set-up in 1986, with the aim of promoting small-scale projects and activities implemented self-reliantly by institutions of developing countries in the field of appropriate technologies (AT).

The Fund is designed to help improve the living conditions of poor sections of the population in developing countries with the aid of appropriate technologies, and to strengthen the self-help potential of grass-roots groups.

At the same time, the documentation of the measures promoted by the Fund is designed to guarantee that, when performing its consultancy activities, SAT is able to draw on the experiences gained.

Since the Fund's inception in 1986, some 170 (as at July 1994) projects have been supported, among others in the fields of environmental protection, biogas, biotechnologies, photovoltaic systems, food processing, co-generating plants and appropriate land use.

The Fund promotes organisations from developing countries which are already operating successfully in the field of application and dissemination of appropriate technologies, which involve target groups in the planning and implementation process, and which themselves bear a considerable share of the costs and risks of the respective project.

Projects for which support is requested from the Fund should be self-contained measures with innovative potential.

Criteria for Promotion

1. Formal requirements for the application

1.1 A project application, drawn up by the project implementing institution itself, must be submitted in writing in English, Spanish, French, Portuguese or German.

1.2 The implementing institution must be a juristic person (organisation, association etc.) which has been operating in a developing country for some time. As a rule, individuals cannot be considered. The organisational form and grass-roots-orientation of the institution should be such as to demonstrate that it is capable of implementing a project in close cooperation with target groups, preparing an interpretable final report and dealing with the project accounts in an orderly fashion.

1.3 For each project a liaison person should be named who, if possible, should be working in a German development organisation. Individuals should be considered who have had dealings with the project institution for some time, and who could visit the project during its term.

The project institution shall also be responsible for ensuring that the monies are put to the stipulated use, that the contract is complied with, and that the final report and final invoice are submitted on time.

2. Project-related criteria

2.1 The project shall include a significant technological component, which is to be executed in an appropriate and innovative way.

2.2 The project must help improve quality, enhance performance and/or increase income in a given production or services sector.

2.3 The project shall aim to satisfy basic needs, pursuing an approach based on help toward self-help.

2.4 The project shall not entail any negative impacts on women, either directly or indirectly.

2.5 The project shall not entail any unwarranted negative environmental impacts, either directly or indirectly.

Criteria of exclusion

The following project measures cannot be financed:

- projects of universities or public institutions involving only research
- personnel costs (long-term)
- proposals from industrialised countries
- appraisals and trips of experts
- scholarships
- if over 30% of the total financial aid is required for imports from industrialised countries
- all expenditures which can be covered by a local contribution, in particular work intensive preparations, materials
- motor vehicles

Should you wish to submit an application, please note the following:

1) Experience has shown that applications take 4-8 months to process, from the date of receipt of your project application to the first payment.

2) For all measures, a project liaison person must be appointed. This should either be a staff member of a development organisation, or the confidence of such an organisation in the individual concerned should have been demonstrated.

3) The assistance will be disbursed in installments. Before the final installment is disbursed to the supported institution, the final report must have been received by the Fund. The final installment of the assistance must therefore be advanced.

4) An interim and/or final report shall be obligatory.

5) All projects must contain a contribution of the executing agency applying for funding.

Those wishing to submit proposals should send them to:

Mr. Reiner Woytek, Deutsche Gesellschaft fur Technische zusammenarbeit (GTZ) Gmbh, Postfach 5180, 65726 Eschborn, Germany.

Tel: (06196) 79 3186. Fax: (06196) 79 7352
Email: Postmaster@gtz.de

THE WORLD BANK

A Global Partnership for Development. The Small Grants Program

About the Program

The Small Grants Program was created in

1983 to provide a way for the World Bank to promote dialogue and dissemination of information about international development in forums outside its own operations. During fiscal year 1995, US$ 500,000 in grants were made to 40 different organizations around the world. Thirty-three of these grants were made to organizations based in developing countries.

Who Can Apply?

Any institution concerned about development can apply for a grant. However, the Small Grants Program prefers to support nonprofit, nongovernmental, nonacademic organizations. The Program is particularly interested in supporting developing-country institutions and/or activities taking place in developing countries.

What Sorts of Activities Are Supported?

Activities supported by the Small Grants Program promote dialogue and dissemination of information about international development. These activities are most often conferences and seminars, special publications, audio-visual materials, or other innovative networking efforts that small organizations generally find difficult to fund through their regular program budgets. The grant activities focus on socioeconomic development problems such as poverty reduction, environmental protection, human resource development, and private sector development. Examples of activities supported by the Program are attached.

What Size of Grants Are Awarded?

Most grants are in the range of $10,000 to $15,000. Smaller grants are possible, but larger grants are rare. The Small Grants Program does not fund 100 percent of any activity and usually funds much less than half of the proposed budget for an activity. The Program therefore prefers that its grants help to generate additional contributions from other sources. Applicant organizations are asked to describe how a grant from the World Bank might help them to raise funds from other donors.

How Are Grants Awarded?

Grants are awarded by a Small Grants Committee with representatives from a variety of World Bank departments. Applications are screened and reviewed by World Bank staff prior to submission to the Grants Committee.

How Are Applications Evaluated?

The Small Grants Committee reviews applications against the following criteria:

- Will the grant promote useful dialogue and/or dissemination of information about international development?
- Is the grant for a specific activity?
- Is that activity to be completed within one year?
- Will the grant be used to generate additional support from other donors?
- How well were previous grants to the organization used (if applicable)? Is the institution suitable for World Bank support?

Which Grant Activities Are Given Priority?

While all applications which are favorably evaluated against the above criteria could be eligible for grant support, the Small Grants Committee gives priority to:

Developing-country-based organizations and activities;

Activities which focus on more than one country;

Activities which promote active linkages with, and cooperation among, diverse groups of actors, such as local people, NGOs, governments, the private sector, international aid agencies, etc.;

Activities which focus not only on identifying a problem, but also on finding a solution to the problem;

Applications which are received six to twelve months in advance of the grant activity and which can show that early World Bank support will help generate additional support from other donors; and

Applications from organizations not supported by the Program in previous years (organizations are not eligible for two grants in one fiscal year).

Which Grant Activities Are Not Supported?

Grants are not available from the Small Grants Program for:

Research programs

Formal academic training programs

Operational projects

Ongoing institutional support

Scholarships, fellowships, or study programs

Individuals applying on their own behalf, including for travel or studies

How to Apply for a Grant

The Small Grants Committee meets as required throughout the year. Because it can take a number of months to process an application, applicant organizations should apply at least four to six months in advance of the date of the grant activity. Applicants should be advised that competition for grants is intense, and with a limited budget, the Small Grants Program cannot support all of the many worthwhile activities for which applications are received.

Applications should be sent by mail or fax to:

Mr. Peter G. Hemsch, Coordinator, Small Grants Program, External Affairs Department, The World Bank,1818 H Street, N.W, Washington, D.C. 20433 USA.

Telephone: (202) 473-3501; Fax: (202) 522-2654

Internet: phemsch@worldbank.org

Information Needed to Complete a Small Grants Program Application

The World Bank Small Grants Program does not have a formal application form. However, all grant requests should include information on the following:

PLEASE COMPLETE CHECKLIST

I. <u>Information on Grant Activity</u>

Detailed Description of Proposed Activity

Budget and Information on How Costs Will Be Met (including amount of funding requested from the Small Grants Program)

Other Possible Contributors/Donors (including amounts pledged, if possible)

Detailed Agenda or Action Plan (includinglikely dates)

Intended Audience(s)

Invited Persons, Participants, and/or Speakers (including lists of names, if possible)

Expected Outcome/Follow-up

II. Background on Applicant Institution

Background (date established, purpose/mission, etc.)

Organizational Structure (kind of organization, etc.)

Leadership (names of board members, officers, etc.) and Personnel (paid staff; volunteers, etc.)

Membership (who, how many, etc.)

Recent Programs/Projects/Activities

Publications

Annual Report

Annual Budget and Sources of Revenue (dues, grants, donations, fees for services, etc.)

III. Additional Support and Previous World Bank Support

Additional Support: Include a statement on how a grant from the World Bank might help generate additional support (either financial or in-kind) from other donors for the proposed activity.

Previous Small Grant Program Support: Attach a final report on the outcome of an earlier grant activity supported by the Small Grants Program, as well as a detailed financial statement on the use of the World Bank's grant funds (if applicable).

IV. Organizational Contacts

The World Bank: Provide information on previous contacts with the World Bank (if applicable), including names of Bank staff familiar with the applicant organization.

Applicant Institution: Include the name, address, and telephone and fax numbers of the person in your organization with whom the Small Grants Program should correspond. When sending correspondence by fax, please indicate the total number of pages sent.

Examples of Activities Supported by the Small Grants Program

Women-in-Development and Poverty-Reduction Workshop in India

Biomass Systems Workshop in Zimbabwe

Environmental Newsletter in South and East Asia

Microenterprise Workshop in the Philippines

Seminar on Disabled Children in Lithuania

Traditional Foodstuffs and Nutrition Security Workshop in Nigeria

NGO Caucuses and Consultations with Government in the Philippines

Health and Nutrition Conference in Senegal

The Vetiver Network, 15 Wirt Street NW, Leesburg, Virginia 20176, USA.

Tel: 703 771 1942; Fax: 703 771 8260

Email: vetiver@vetiver.org
Homepage: http://www.vetiver.org

The Vetiver Newsletter is published by The Vetiver Network. Editor and Vetiver Network Coordinator: Dick Grimshaw

Corporate Secretary: Mark Dafforn. Email: "Dafforn Mark"<VetiverNet @aol.com>

Vetiver Network Awards for Innovative Research and Technology Development

The Vetiver Network is pleased to announce its second series of awards for advances in the understanding and use of vetiver technology. The intention is to reward activities by individuals or "project" teams that have increased the value of knowledge we already have, that have added to our current understanding, or that have promoted the use of vetiver technology. The deadline for nominations is June 30, 1998.(Information on the first series of awards can be found in Vetiver Newsletters 9 and 10.)

Award Themes

Awards will be given for initiatives in seven areas:

1. soil erosion

2. improvement of extreme soils

3. water management

4. pollution control

5.farmer-support and secondary uses

6. disaster prevention

7. basic science.

Vetiver Global Initiatives

The seven Vetiver Global Initiatives were proposed by Noel Vietmeyer of the U.S. National Academy of Sciences at the First International Conference on Vetiver in Thailand in February of 1996. Dr. Vietmeyer explained the purpose of these initiatives at the end of the conference in a speech entitled, "Organizing Vetiver's Next Steps to Global Acceptance":

These initiatives are more than just ways of thinking about the plant and its promise, they are compartments of practical progress, each distinct and self-contained within itself. Of course there are overlapping borders; indeed, a complicated chart could be drawn showing all the interrelations but, for all that, each of these action-oriented topics plays on different strengths of the grass and reaches out to different audiences. In addition, each requires a different approach from us as we shoulder our burden of locating partners for mutual support and for faster progress worldwide. ....

Breaking up the subject into these seven initiatives can help generate funding, collaboration, innovation and new progress. More importantly, perhaps, it will inject backgrounds and special insights. No longer will vetiver be the exclusive domain of agriculturists; sharing our excitement will be environmentalists, chemists, engineers, hydrologists, and more. By this process of reaching out, vetiver champions can speak in seven voices, in seven forums, and stimulate outward momentum in seven directions. Also, it will give us feedback from seven different outlying visions that we now glimpse only vaguely, if at all. That will help us better use this immensely useful plant, and that will help the people of the world most of all.

Eligibility

Awards may be given to anyone (scientist, technician, farmer, NGO, innovator) who has shown initiative in advancing the usefulness of vetiver technology. The awards themselves will be granted for efforts that have yielded new, innovative, and demonstrable results; that is, projects that do not duplicate earlier work, that take a novel approach, and that can be repeated in other places.

Amount of Awards

Twnty one Awards totalling $50,000 will be made at the end of 1998. There will be three awards granted in each of the seven categories: for categories 1-6, awards of $4,000, $2,000, and $500 will be given in order of merit; for category 7 (basic science) the awards will be $6,000, $3000, and $2,000. The total value of the awards will not be decreased; however, if additional funding for awards is found the award value may be extended and the number of awards may be expanded.

Documentation

There is no award application form. You can nominate yourself or others. Applications must stand on their own merit. Documentation can consist of any type of information (personal accounts, reports, photographs, articles, scientific papers, testimonials, etc.), but be as brief and clear as possible. Please provide the Vetiver Network with the following by June 30th 1998:

1. Your name and address (phone, fax, and email if possible).

2. Award nominee name and address (phone, fax, and email if possible).

3. Project information:

- Location of project.
- Description of project.
- Accomplishments of project.
- Importance of project.

4.Supporting documentation (optional but helpful).

5.Name of someone other than yourself or the nominee who is familiar with this project

Award Selection

Projects will be judged on the basis of their merit, relevance, innovation, and application. Merit refers to the quality of thought and methods used to accomplish the project's goals. Relevance will be evaluated on the project's potential to protect the environment, lower costs, improve the quality of life, or other noteworthy benefit. Innovation can be originality in any sense, including using old ideas in new ways. Application refers to the demonstrated usefulness of the results.

Submissions will be evaluated by ad hoc award committees, who will make their recommendations to the Vetiver Network. Final selections will be approved by Directors of the Vetiver Network, whose decisions will be final. Winners will be announced in December 1998.

Topics

Any individual/project may be nominated in any topic area. The following are examples drawn from Noel Vietmeyer's Global Vetiver Initiatives:

1. Soil Erosion Projects: Probably 90 percent of all vetiver technology work to date has been devoted to some aspect of soil erosion, and the fact that the plant stops soil loss is now abundantly clear; a major goal is now to project existing knowledge to new locations and new people.

2. Extreme Soil Projects: The challenge is to make extreme soils productive, or at least more productive than at present - this topic embraces the area of land reclamation as a whole, including establishment of native vegetation.

3. Water Management Projects: The potential of vetiver on a landscape scale is little-explored; this topic area covers a broad range of watershed management, waterway stabilization, reinforcing earthen structures, sedimentation control, engineering water flow, ground water recharge, water flow management in irrigation systems, and wastewater treatment.

4. Pollution Control Projects: The goals are to demonstrate vetiver as a tool for removing toxic hazards in underground flows, soils, industrial spills, runoff, natural waters, and industrial wastewaters.

5. Farmer Support Projects: This area recognizes the need for special efforts to increase appreciation of the benefits that vetiver provides to growers by increasing income, or by making their lives easier or more secure through providing mulch, thatch, fuel, supplementary feed, improved crop yields, handicrafts, wildlife controls, boundary markers, ornamentals, screening, animal protection, traffic control, "air-conditioning" (both living and harvested plants), utility walls, weed prevention, making steep slopes usable, and similar "secondary uses".

6. Disaster Prevention Projects: Demonstration of the role vetiver can play in mitigating various natural disasters such as mudslides, floods, fires, droughts, and structural failure.

7. Basic Science Projects: The workings of Vetiveria zizanioides underpins everything else, but much remains to be learned about

topics such as environmental tolerances and responses, pest and plague resistance, heavy metals accumulation, C02 absorption, C13 absorption, taxonomy, genetic diversity, mechanisms of sterility, root growth, translocation of oxygen, mycorrhiza association, nitrogen fixation, mechanisms of hedge formation, potential for dwarfing, and myriad other issues.

Please send nominations to:

The Vetiver Network, 15 Wirt Street, Leesburg, Virginia 20176-2808

Nominations will not be acknowledged unless a self-addressed card is included.

Table of Contents

King of Thailand Vetiver Award..... **1**
From The Editors Desk..... **1**
New Networks. **3**
Support for Regional Networks **6**
Support for NGOs and Non Profit Organizations 6
Letters to The Editor..... **7**
Australian Update - Paul Truong **8**
Vetiver Research at Australian Universities **9**
An Overview of R & Dand Application of the Vetiver Grass System (VGS)..... **11**
Vetiver Grass For Erosion & Sediment Control In The Mackay Area (Australia) **13**
Vetiver Grass for Erosion Control in Forest Plantations (Australia) **15**
Vetiver Grass As A Component In A Steepland Farming System (Australia) **16**
Rehabilitation of Degraded Pasture (Australia) **17**
Vetiver Grass for Erosion Control and Land Stabilization in the Wet Tropics (Australia) **17**
Application Of Vetiver Grass In Soil Erosion And Sediment Control On The Darling Downs (Australia) **19**
Strip Cropping With Vetiver Grass, A Landholder Perspective (Australia) **20**
The China Vetiver Network. Vetiver Investigation in Fujian Province, China **20**
Effects of Applying Fertilizer to Vetiver Grass for Erosion Control in China **22**
Soil Conservation and Vetiver Grass in Puriscal - Costa Rica **26**
Versatile Grass Fights Erosion (Costa Rica) **27**
NOBS Anti-Erosion: A Company Against Soil Erosion. El Slavador **27**
Green Enterprises Find Friendly Funding El Slavador..... **28**
Vetiver Grass For Road Embankment Slope Stabilization In Nepal **29**
Use of Vetiver Grass for Engineering Purposes in Malaysia with Particular Reference to Slope Stabilization and Erosion Control. **30**
Vetiver Grass Hedge Row Establishment - Plant Spacings. (Under Semi- Arid Conditions) **33**
Farmers decide to replace hedgerow with Mora (Vetiver) Philippines **34**
Mora (Vetiver) Hedgerows in Punta, Baybay, Leyt, Philippines **34**
A Visit to Southern Africa **34**
The application of Vetiver Hedges in Soil and water Conservation Sytems: Integrated Conservation. Thailand **38**
Slope Stabilization: Vetiver Application from a Bio-Engineering Aspect. Thailand..**39**
Tissue Culture of Vetiver Grass Thailand **39**
A Study of the Ecotype Comparison of Vetiver Grass.....Thailand **39**
Study of Optimum Rows and Different Plant Spacings of Vetiver Grass for Soil Erosion Control on Sloping Land. Thailand **39**
A Test of Planting Vetiver Grass at Different Vertical Intervals for Soil and Water Conservation on Sloping Lands..... **40**
Vetiver grass for conservation in Gwembe South, Zambia **40**
USDA 1996 Workshop on Grass Hedges for Erosion Control **40**
An initiative to save the Save (Zimbabwe) **41**
KPF (Germany) Small Grants Scheme..... **42**
The World Bank -- The Small Grants Program **43**
Vetiver Network Awards for Innovative Research and Technology **45**
Zimbabwe. Vetiver and Water Photos **..... 48**
Vetiver and Construction Projects **49**
Vetiver and the Farm **50**
Distribution of the Vetiver Newsletter as of January 1 1998 51

Zimbabwe. Vetiver and Water

Spilling sill of 80m wide spillway, protected by vetiver on spillway side at left.

Above. This section is being cut by water flow. Even so vetiver roots provide mattrass to retard rate of cut. Next year this should be fully stabilized.

Right. Main flow emering at base of spillway, vetiver/water interface appears stable.

Photos by Dick Grimshaw

10,000 lt per sec emerging in channel at bottom of spillway. Fully protected with vetiver hedgerows

Close up of water flowing through and between vetiver hedgerows planted across spillway

Left: The Labat Sytsem of drain stabilization. Four hedge rows. Left top protects top of drain and adjacent farm road. Right top protects top of drain and adjacent small irrigation field channel. Two bottom hedges eventu-ally form a canopy that shades out all weeds.

Above: 12 km river, fully protected by vetiver grass hedgerow, that carries some 10,000lt per sec from one reservoir to another down stream. Rver banks now totally stable.

Vetiver and Construction Projects

Above: Buiding site in Natal, South Africa, stabilized with vetiver hedgerows. **Contractor: Tony Tantum. Photo Credit: Paul Truong**

Above: Malaysian Highway Stabilisation, close up of top right scene. The right hand end of this cut reeived additional reinforcing with vetriver. Contractor: Diti Hengchaovanich. **Photo Credit:** Paul Truong

Above: Malaysian Highway Stabilisation, **Left:** Vetiver grass stabilized the upper half of this 180 m VI slope. Lower half, conventional engineering technology. **Right:** vetiver stabilizes the weak area at interface with drainage ladder. Contractor: Diti Hengchaovanich. **Photo Credit:** Paul Truong

Above: Malaysian Highway (general view) stabilized with vetiver hedgerows. **Contractor**: Diti Hengchaovanich. **Photo Credit:** Paul Truong

Above: Malaysian Highway Stabilisation, close up of top right scene. Contractor: Diti Hengchaovanich. **Photo Credit:** Paul Truong

Right:: Young vetiver grass hedgerows stabilizing a 60m VI highway embankment in Malaysia. **Contractor**: Diti Hengchaovanich. **Photo Credit:** P.K.Yoon

Left. Road side drain in New Zealand (North Island) protected by vetiver hedgerow. **Photo Credit**: John Greenfield

Vetiver and the Farm

Above: Snallholder farm on steep land on Zomba Mountain, Malawi protected with vetiver hedgerows. **Photo Credit**: Dick Grimshaw

Above: Small holder farm in the Philippines protected with vetiver hedgerows. **Photo Credit**: Edwin Balbarino

Above: One year old Vetiver hedgerow in maize field near Lilongwe, Malawi. **Photo Credit**: Dick Grimshaw

Above: Vetiver hedgerows on steep on and degraded lands on Zomba Mountain, Malawi. This work was initiated by Stephen Carr. **Photo Credit**: Dick Grimshaw

Above: A new propagation technique in Australia. Here vetiver is propagted in a strip, held together by a mesh. At time of transplanting 1 meter of strip is dug up and set out in the field. Below: Strips set in field ready for healing in. **Photo Credit**: Paul Truong

Left:: Vetiver Hedgerow in Zimbabwe - Lowveldt - protecting small-holder groundnut crop. Note: rilling in foreground has been halted. **Photo Credit**: Dick Grimshaw

IMPORTANT

THIS NOTICE EFFECTS YOU.

DISTRIBUTION OF THE VETIVER NEWSLETTER AS OF JANUARY 1 1998

The Vetiver Network has now produced 17 newsletters and other documents since 1989. All these have been provided at no cost to the recipient. During this time we have never culled dormant receivers of the newsletter. Currently national and regional vetiver networks have been or about to be established. These networks will produce their own newsletters for vetiver network participants in their area of influence. Recipients in the USA and Europe have easy access to the Vetiver Homepage on the Internet, and are not restricted from making payments to the Vetiver Network. In most other countries recipients of the Vetiver Newsletter are either too poor or do not have access to foreign exchange, and are therefore very dependent on a hard copy newsletter for information. As a result of the foregoing the Network will institute the following policies.

(a) All current recipients of the Vetiver Newsletter are requested to complete the form at the end of this newsletter and return it to The Vetiver Network. If the form is not returned by November 1997 we will assume that the recipient is either no longer operating at the current address, or is no longer interested in receiving future issues of the Vetiver Network. So please fill in the form and return it promptly.

(b) Current recipients of the Vetiver Newsletter who fall under the newly established networks (China, Southern Africa, West Africa, Philippines, Pacific Rim and Latin America) will receive local newsletters from their networks at no cost. Those readers in these areas who want to continue to receive this newsletter - The Vetiver Newsletter published by The Vetiver Network - will in future be required to pay an annual subscription of US $20 per year, payable in US $ to The Vetiver Network, or the local currency equivalent to their local network. This policy will go into effect on January 1st 1998

(c) Current recipients in Austria, Belgium, Denmark, Finland, France, Germany, Italy, Japan, Norway, Portugal, Spain, Sweden, Switzerland, The Netherlands, UK, and USA, are requested to pay an annual subscription fee of $20 per annum if they wish to continue to receive The Vetiver Newsletters published by The Vetiver Network. This policy will go into effect on January 1st 1998.

(d) All other current recipients will continue to receive the Vetiver Newsletter at no cost until such time that a regional or national network is established for the recipients' area. As and when this occurs, then policy (b) will apply.

(e) Bonefide NGOs and government agencies using vetiver grass, wherever located, will continue to receive the newsletter at no charge.

(f) The Vetiver Network homepage on the Internet at http://www.vetiver.org will continue to operate and is accessible at no cost to the general public. The homepage fully reflects hard copy newsletters published by The Vetiver Network.

(g) All recipients who wish to continue to receive the newsletter, whatever category, are requested to send a short report (about 500 - 1,000 words) on how they use vetiver and the type of programs that it is applied to.

It should be noted that the above are combined in the form at the end of this newsletter. **IT IS ESSENTIAL THAT THE FORM IS COMPLETED IF YOU WISH TO CONTINUE TO RECEIVE NEWSLETTERS.**

Monies received from the annual subscription will be recycled for newsletter production and financial support to regional and national networks.

Countries serviced by Networks:

China Vetiver Network : China

The Vetiver Network Philippines: Philippines

Latin American Vetiver Network: all countries of South and Central America

Southern Africa Vetiver Network: (SADC countries - Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe).

West African Vetiver Network: Benin, Burkina, Central African Republic, Cameroon, Chad, Ghana, Guinea, Guinea Bissau, Ivory Coast, Liberia, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, The Gambia, Zaire, Togo.

Pacific Rim Vetiver Network: Australia, Brunei, Cambodia, Cook Islands, China, Fiji, Indonesia, Japan, Korea, Lao, Malaysia, New Zealand, Papua New Guinea, Philippines, Singapore, Solomon Islands, Taiwan, Thailand, Tonga, Vanuatu, Western Samoa, Vietnam

PLEASE FILL IN THE FORM BELOW AND RETURN IT TO (before November 30th 1997):

The Vetiver Network, 15 Wirt Street NW, Leesburg, Virginia 20176, USA

Complete Name: _____

Address: _____

_____

City: _____ State/Province: _____

Country: _____ Zip/postal code: _____

Fax: _____ Tel: _____

E.mail: _____

Type of Organization (*please check X*):

Government: ☐ NGO/NPO: ☐ Commercial company: ☐ Individual: ☐

Which vetiver network area do you fall under (*please check X*):

China: ☐ Phillippines: ☐ Pacific Rim: ☐ Southern Africa: ☐ West Africa: ☐ Latin America: ☐ Other: ☐

About YOU or your agency *(please check X):*

Do you use the vetiver grass technology? Yes ☐ No ☐

If yes, do you use it for:

Soil and water conservation: ☐ Embankment stabilization: ☐ Pollution control: ☐ Land rehabilitation: ☐

Handicrafts: ☐ Medicinal: ☐ Aromatic oil: ☐

Other: _____

_____

How long have you used the vetiver grass technology *(please check X)*:

1 - 3 years: ☐ 3 - 6 years: ☐ 6 - 10 Years: ☐ More than 10 years: ☐

If using Vetiver grass for soil and water conservation please indicate approximate land area protected: _____ ha.

Where did you learn about the vetiver grass technology *(please check X):*

The Vetiver Network Newsletters: ☐

The Vetiver Network Home Page: ☐

National Research Council's publication - "Vetiver Grass A Thin Green Line": ☐

Other Sources: _____

Do you grow vetiver grass planting material for sale *(please check X):*

Yes: ☐ No: ☐ If YES would you like the Vetiver Network to advertise your sales on The Vetiver Network Homepage:

Yes: ☐ No: ☐

Do you use the Vetiver Home page on the Internet *(please check X):*

Yes: ☐ No: ☐

Is The home Page easy to access *(please check X):*

Yes: ☐ No: ☐

Distribution of The Vetiver Network Newsletter (published by The Vetiver Network of Leesburg Virginia) after January 1 1998.

Please check X if you are a bonefide NGO or Government Agency : ☐

(If you are, you will continue to receive the Vetiver Newsletter at no charge).

If you are not an NGO or Government Agency then the following applies: ☐

If you live or work in areas covered by China Vetiver Network, The Vetiver Network Philippines, Latin American Vetiver Network, Southern Africa Vetiver Network, West African Vetiver Network, Pacific Rim Vetiver Network you will, after January 1s1998, no longer receive free issues of The Vetiver Newsletters (two issues per year) unless you specifically request it and pay an annual fee of US $20 either to The Vetiver Network or in local currency equivalent to your national or regional network.

If you live or work in Europe or USA you will, after January 1s1998, no longer receive free issues of The Vetiver Newsletters (two issues per year) unless you specifically request it and pay an annual fee of US $20 to The Vetiver Network, Leesburg, USA).

I wish to continue to receive issues of The Vetiver Newsletter*(please check X)*:: Yes: ☐ No: ☐

If Yes please indicate where you will pay the annual fee of US $20 *(please check X)*::

The Vetiver Network (Leesburg USA): ☐ (US $ 20 fee (check or money order) enclosed for 1998 payable to The Vetiver Network)

National or Regional Network: ☐ (Please send US $20 equivalent to your area Network)

THE VETIVER NETWORK

TVN NEWSLETTER

NUMBER 18 DECEMBER 1997

Highlights from the International Vetiver Conference -- Fuzhou -- China --October 21 to 26 1997

Vetiver Nails **-- "Vetiver Roots have proven to be "living" Soil Nails or dowels that can pin the soil together. Vetiver roots are capable of punching the through hardpans and weathering rock, thus improving drainage."** *Diti Hengchaovanich - CEO Erocon, Malaysia*

Root Strength **-- "Vetiver has the root strength (average 75 Mpa) equivalent to one sixth of mild steel."** *Diti Hechovanich - CEO Erocon, Malaysia.*

Vetiver and Embankment Stabilization **-- "Vetiver hedgerows have been demonstrated in Malaysia, Australia, and China to be a relatively low cost and effective means of stabilizing highway and railroad cut and fill slopes. In China the cost of stabilizing with vetiver is 10% of the cost of stone based technologies."** *Xia Hanping, South China Institute of Botany.*

Vetiver and Farmers **-- " NOBS, a private company in El Salvador that promotes vetiver for soil conservation trained a select group of small scale farmers to grow and manage vetiver for sustainable soil conservation. These farmers transferred the technology to their neighbours. Of 220 farmers testing the technology 71% of the farmers say that vetiver controls erosion, 18% have observed crop increases due to improved soil moisture. 82% will continue to use the technology for soil and water conservation."** *Ricardo Hernandez, NOBS, El Slavador*

TABLE OF CONTENTS AT LAST PAGE

Vetiver and Tea **-- "Tea yields increased by 40% when grown in conjunction with vetiver grass hedges, and vetiver hedges are much cheaper and more effective than terraces."** *Ding Guan Min, Soil and Water Conservation Bureau, Fujian Province, China*

***Vetiver and Red Acid Soils* -- "Vetiver grass hedgerows reduced rainfall run off by 32%, reduced soil losses by 21.4 tons per ha to levels of acceptable standards, and increased crop yields by 34%. It also resulted in reduced summer soil temperatures and winter frost damage."** *Lu Sheng Luan, Red Soils Comprehensive Experimental Station, Jiangxi, China*

***Vetiver and Sustainable Agricultural Development* -- "Vetiver produced large quantities of biomass which when incorporated in the soil adds significant increases in soil organic matter -- from 0.4% (before) to 1.8 % (after), thus creating a fertility base for sustainable agriculture)."** *Lu Sheng Luan, Red Soils Comprehensive Experimental Station, Jiangxi, China*

***Vetiver and Orchards.*-- "Vetiver, when planted in a citrus orchards of the Red Soils of Jiangxi Province, had a remarkable impact when used as both a hedge and a mulch. Soil moisture increased and soil structure improved. Soil bulk density decreased while its porosity, organic matter content, total N, hydrolytic N, available P and K, Ca, Mg, Fe, Mn, Zn, Cu, B, Mo and 20 kinds of amino acids all increased."** *Chen Kai and Rao HuiMao, Nanjing University and Jiangxi Provincial Government*

***Vetiver and Fisheries* -- "In the coastal areas of Fujian vetiver has been used very successfully to stabilize fish pond dikes (inside embankments) located next to the sea. In a recent typhoon those parts of a very large fish pond that were not protected by vetiver were destroyed by the waves and had to be rebuilt. Vetiver is exposed to salt spray and is growing under acid sulphate soil conditions."** *Field observations by conference participants on visiting Pintang Island, Fujian, China*

***Vetiver and Forestry* -- "Over a three year period conducted on a Eucalpytus plantation rainfall runoff was reduced by 51% using vetiver hedgerows compared to the untreated control."** *Liao BaoWen, Institute of Tropical Forestry, Guanzhou, China*

***Vetiver and Wind* -- "Vetiver hedgerows provided excellent windbreaks to prevent wind blown sand from covering farm land and blocking irrigation ditches. Vetiver also protected crops from severe wind damage."** *Zhang Jing, Pintang Island, Fuzhou, China*

***Vetiver and Water* -- "Purification of eutrophic water. Vetiver when grown on "floating Islands" on river water removed, after four weeks, 99% of water soluble phosphates and 82% of total nitrates."** *Zhen ChunRong, China*

***Vetiver and Rivers* -- "Vetiver has proven most effective in stabilizing river banks and reducing sediment movement into rivers."** *Zhou FuJian, Fujian, China*

***Vetiver and Flood Protection* -- "The present findings reveal that vetiver has many traditional uses including its great potential for use as a vegetative meansof protection of rivers and coastal embankments in Bangladesh."** *Matiur Rahman,Director of Bangladesh National Herbarium*

***Vetiver and Contaminated Lands* -- "Vetiver tolerates most heavy metals at much**

higher levels than other plants. It has been demonstrated to be a key plant for rehabilitation of contaminated sites such as mine tailings and landfills." *Paul Truong, Queensland Department of Natural Resources, Australia.*

Land Reclamation **-- "Vetiver hedges have been used most effectively as a pioneer grass in the conjunction with tree planting (Eucalyptus) to rehabilitate the so called "Red Desert" in Guangdong Province"** *Poster presentation South China Institute of Botany, Guanzhou, China*

Conclusion

"Vetiver has great potential for application for many uses over wide areas of south China. Although additional useful research should be undertaken the priority should be to develop appropriate strategies for disseminating the technology by involving a wide range of users including farmers; agricultural, forestry, and fishery technicians; conservation, highways, railroad and municipal engineers; and government agencies and policy makers from the townships up to the provincial governments" *Xu Liyu ,China Vetiver Network Coordinator, Nanjng, China*

"Vetiver is a world wide technology and belongs to everybody, it has great potential in the tropics and sub-tropics. The views expressed and the findings presented at the conference further endorse the efforts and results of thousands of users in other parts of the world. The adoption of the technology can be further accelerated through better dissemination strategies including building capacity in the private sector with the objective of securing the production of planting stock supplies, provision of technical support services, and the targeting of engineering and construction investments that require biological systems of stabilization." *Dick Grimshaw, TVN, USA*

FROM THE EDITOR

The following is an exchange of letters (some published in SAVN) on the merits and demerits of vetiver grass. In my letter to the Editor of the Southern Africa Vetiver Newsletter I have tried to bring my thoughts and experiences together. It is a sad commentary on today's world that when the need to stabilize our lands is so important that the most reluctant and cautionary users of vetiver are often the professional soil conservationists, particularly those whose grounding and education were in agricultural and conservation engineering. It is the non-engineers, who seem to understand better the value and importance of the vetiver technology for environmental improvement. The many advantages of vetiver grass so greatly outweigh its few disadvantages that tropical and subtropical countries, that are desperate to find low cost and simple solutions to their land degradation problems, can not afford to ignore it. This newsletter, #18, provides solid testimony to the extent of the value of the technology — read it well!

The name for vetiver in Peurto Rico is **PACHOLI** pronounced par-choh-lee. In the Mahajanga area of Madagascar it is called **LAMINY**

From Will Critchley, Research Coordinator, Land Management and Rural Development Programme, University of the North, Private Bag X1106, Sovenga 0727, South Africa

Vetiver - a case of over-hype?

As a professional conservationist, I greet the launch of your newsletter VETIVER. Any move towards biological methods of resource conservation must be welcomed. But may I wave a flag of caution? I have rubbed shoulders with the vigorous promotion of Vetiver over the last decade in several African countries as well as in India, Indonesia and the Philippines - and have been struck by the discrepancy between farmer adoption (generally low, especially resource poor smallholders) and the sometimes extravagant claims by the Vetiver lobby regarding its efficacy.

That Vetiver grass does have specific merits is without doubt. But a number of these are its simultaneous

undoing. Sterile? Yes, but this means time-consuming and costly planting of splits! Non-competitive? OK, but as a consequence, weeds invade. Low palatability? Agreed, but then what immediate benefit to a farmer who would rather have a barrier of fodder grass?

Speaking with my other hat on, as a keen weekend vegetable gardener in South Africa, I delight in grooming my robust and effective Vetiver barriers. It certainly has a role to play in this and other specific situations.

Surely Vetiver ought to be offered as just one potential option in a basket of possibilities - and not held up as a panacea. There is no 'quick fix' in soil conservation! So as well as the success stories let's hear of the practical problems. Let's also hear of the alternatives and complimentary technologies. Do not be discouraged, but do, please, maintain a healthy balance.

Response from Duncan Hay, Editor of the Southern Africa Vetiver Network (SAVN)

The prose is enough to render any response futile. Will, the job of editor is yours! Seriously though, I think most of us agree with you. As I mentioned in the last newsletter, vetiver technology and applications cannot fail. All that can fail is our ability to utilise the technology and apply the grass appropriately. I also agree with you on the hype versus the actual on ground applications, especially in the small scale agricultural sector. It is my experience that the usually impoverished small-scale farmer has far more direct and pressing priorities. He or she needs to put food on the table and cash in the pocket. Vetiver's contribution to these direct needs has been minimal. The current challenge in this sector, as I see it, is to promote vetiver as a crop with direct commercial value. A crop that can be sold to the Tony Tantums, Johan Swarts and Andrew Halls of the commercial application and oil extraction world, or that can be mixed with molasses and used as an effective fodder crop, or that can be used by the farmer-turned-contractor to stabilise road cuts and fills on nearby civil construction projects. Then, and only then, will vetiver realise its full value.

To the Editor SAVN from Dick Grimshaw

To the Editor,

Congratulations on the publication of your Newsletter. It is good to see the advances taking place in southern Africa with regard to Vetiver grass and its application. It is also interesting to read some quite contradictory feedback from readers on the merits and results of applying vetiver grass technology to small farmers. I particularly refer to Will Critchley's letter relating to farmer adoption of the vetiver grass technology.

First to respond to three specific points that he raises. (1) **Sterility.** This is a big plus. Vetiver is not a weed, it doesn't escape to run uncontrollably over large areas. Of course initially there is a shortage of multiplication material. Vetiver suppliers in South Africa have been charging outrageous prices. However prices will soon come down to realistic levels of less than 0.5 US cents per planting plug (3 tillers per plug). Resource poor farmers soon learn to split their hedgerows for a "free" supply of planting material. (2) **Invasion by weeds.** There is no basis for this supposition. In fact it is completely the opposite. Farmers in India and Mauritius have used vetiver hedgerows for decades too keep invasive weeds such as *Cynodon dactylis* out of their cultivated lands. (3) **Low palatability.** Yes, when unmanaged, but if cut regularly its palatability is good and so is its nutritive value, better still when there is a drought, and other grasses have died back, vetiver is available.

It should be understood that vetiver grass is a unique grass, it is very different to most other grasses in its wide adaptability, its physiology, and what it can do. It is a very special grass and has been recognized as such for thousands of years in that it is deeply embedded in Hindu mythology and in the Sandscript writings where it has always been seen, and still, is a protector of many forms of life.

From what I have seen and learned from the feedback on vetiver around the world is that where NGOs and the private sector are responsible for introducing vetiver grass technology to small farmers it is successful. Unfortunately when the big institutions get hold of the technology and become involved with its introduction, farmer response is poor (happily there are some exceptions, but not enough). NGO success can be attributed to three main reasons: First, NGOs normally work with communities and take the trouble to properly train the farmer in **all** the uses and benefits of the technology; secondly NGOs properly train the farmer in the technology's application; and thirdly the NGOs make sure that the farmer has access to initial planting material.

Poor farmer adoption associated with public institutions invariable can be traced to inappropriate interaction with the intended beneficiaries, lack of trained and motivated extension and conservation staff, and inappropriate subsidy programs which focus the farmers (and the officials) attention on the direction and use of fund flows (and what is in it for them) rather on the merits and benefits of the technology. This has been a serious problem in India, and I suspect in Indonesia too. Strangely, or perhaps not so, the best adoption responses come from countries where government intervention is minimum (sometimes government conservation and extension services hardly exist at all), and where donors prefer to work through the private sector or NGOs both of which have different objec-

tives to those of public institutions. Vetiver programs supported by the big international institutions such as FAO, World Bank, UNDP, etc. are not always successful because their primary client is the government and the latter's respective departments.

Of course vetiver grass is not a panacea for everything to do with soil conservation, but it is a remarkably good technology. Feedback to The Vetiver Network from all over the world suggests that more and more farmers are adopting the technology with success.

I have to take objection to Will Critchley's reference to "Vetiver Hype". Of course we "sell" hard because we believe in the technology, but we also have the facts (and they get better every year) to support the sales pitch. Some people refer to the sellers as activists. The world needs activists if we are to stop soil degradation, and the simpler and cheaper the technology is the more likely it will do the job. Even Will seems to like his vetiver, I suggest that he gets out and "sells" it too!! I wonder if he has ever chopped up some green vetiver leaves and some root and used it as a mulch around his vegetables. Over a hundred years ago gardeners in Louisiana did just that to prevent insects damaging their strawberries. On the subject of "selling", I remember back in 1989 we had a meeting with a group of eminent grass scientists brought together by the US Academy of Sciences to discuss vetiver grass I asked them if we should perhaps broaden our "selling" to include other appropriate conservation technologies — they all said "no". I am glad we followed their advice, particularly as the vetiver technology interests a wide range of users and is used for many different purposes, other than for soil conservation. In short when Coca Cola advertises its product it doesn't advertise Pepsi! even though both products serve the same purpose.

For Will's information, many African countries are now using vetiver with success. In your part of the world countries such as Malawi, Zambia, Zimbabwe, Tanzania, and Ethiopia all have successful vetiver programs that other people and agencies are giving increasing attention to. In Asia there are many success stories coming from India, China, Thailand, Philippines, Papua New Guinea, Vietnam and Laos. With the support of the Latin America Vetiver Network we see adoption increases in Central America, particularly as the private sector gets more involved. I am certain that our new networks at regional, national, and even at provincial and county, levels will do much to accelerate technology adoption, as is occurring in China and the Philippines (and now too in Madagascar), where networks have been holding highly popular workshops and where network volunteers have been extraordinary active in getting others interested in the technology. Even so technology information dissemination is a slow process, particularly when benefits are not immediately apparent to untrained adopters.

Currently I am writing this letter to you from Madagascar where NGOs are bringing vetiver to their small farmer clients with considerable success, and where the only constraints have been the limitations of vetiver plant supply (I found 25 km of vetiver hedgerows that few people knew about! so the supply should improve) and poor dissemination of information. Incidentally in Madagascar a farmer can plant 200 meters of hedgerow in a day, and more than often splits his own hedges as a source of plant material. Pretty cheap hedge!! At a dollar a per labour day, a hectare (which is about all he farms) can be protected for US $2 — where else can you get that sort of protection for that price? With the establishment of a Madagascar Vetiver Network (in French and Malagasy) and 6 regional support groups we can expect a much more rapid adoption of the technology.

In many parts of Africa, and here in Madagascar, much of the major sediment flow in the rivers is from point source erosion, these include: large gullies (called lavakas in Madagascar); degraded land (resulting from continued over use and misuse); roads, building sites, land around rural houses (as I have seen in ECOLINKS work area near White River), river banks, land slides etc. Vetiver has a excellent role in fixing all these problems. I am afraid, therefore, I don't entirely agree with you in your response to Will Critchley that the immediate challenge should be to promote vetiver as a commercial crop (for its oil and engineering uses). You should let Tony Tantum and other commercial growers do that!! Whilst its use in engineering is very important, an importance that is likely to increase, the Southern Africa Vetiver Network needs to give emphasis to land stabilization and reclamation in all forms. In your part of the world soil loss is immense and is getting worse. We are told nearly every day from CNN TV advertisements that South Africa is losing 400 million tons of soil a year, and the loss per unit area in higher rainfall neighboring countries is probably higher. Of course vetiver has a use for oil production, but only a very few farmers are likely to be involved and the market for the oil is highly fragile and inelastic, and sooner or later the price will collapse due to world wide over production, a cyclic event that is recurrent. Also rising labor costs are driving farmers into other production alternatives.

In summary there are many other uses of vetiver that have great interest to potential users in the areas of highway stabilization, irrigation and drainage programs, groundwater recharge, mining, and pollution mitigation. Vetiver grass is a unique grass, there are none other that have the wide range of attributes that vetiver has. It is a simple and low cost technology, is easy to use ,and has wide application. The world doesn't have many technologies that work over a wide range of conditions; vetiver is

one that does — Lets use it, and use it WELL!

Dick Grimshaw, The Vetiver Network, Leesburg, Virginia

To the Editor of TVN: From Tony O'Brien, Queensland, Australia. Fax 61-7-3821-6182
Vetiver in Maharashtra State, India.

Last year while working extensively throughout Maharashtra State I was shown the application of vetiver technology on the Agricultural Faculty farms of a number of the State Universities.

Unfortunately in all cases the technology was poorly applied, being planted on top of small banks at the edge of pre-existing terraces with considerable side slopes. Because of the low rainfall of these sites, the planting on top of the bank was m a permanently droughted situation, the reverse of what was needed in the environment. Planting in the bottom of contour ditches or ditches of contour banks would have been advantageous.

Because of the poor siting of the plantings all were very gappy. There was concentrated flow Although gaps causing erosion. The plantings were doing nothing to stabilize the terrace edges or to litter out eroded material and litter to build up terraces. They were bad examples of the technology.

In most cases these were part of experiments/demonstrations used ill student education. The 'Experiments' (nil replication) had considerable site differences between treatments, which also voided any 'results'. They were bad teaching material.

While I was proudly shown a number of such plantings by academic staff, the field officers from various Government Departments (accompanying me) were very disparaging about these plantings and the whole of the technology' as a result of such poor plantings. There was similar application of the technology in large catchment reclamation projects supervised by these academic staff (World Bank repayable loans). These were also contributing to the bad name of the technology.

I do applaud the efforts of developing country personnel to apply new technology. But I find it most discouraging to see technology badly applied by people who haven't understood all the nuances of the technology. Often they are city bred graduates who haven't the background and training to properly understand farming technology and perceive simple errors. Sometimes they don't have the resources to properly access the information on the technology.

While farmers applying the technology for centuries don't make these same mistakes, those applying the 'new' technology under the supervision of such academic staff are making the mistakes of those who are supervising them. This will inevitably lead to the abandoning of the technology by the farmers instead of the spread of the technology.

I am firmly of the belief that proper vetiver technology has a role to play in the urgent need for soil conservation in Maharashtra State and undoubtedly in India as a whole. I wonder if the Vetiver Newsletter by uncritical encouragement and praise of the use of vetiver in Maharashtra, has not set back the cause of vetiver technology in India in the long term. In how many other cases has uncritical praise of adoption set back the long term advancement of vetiver technology?

Letter to Tony O'Brien, Queensland, Australia, from Dick Grimshaw

... The problem that you raise is very real, and has always bugged vetiver conservation and even went to the point of setting a policy (now rescinded) that vetiver could only be used in rainfall conditions of more than 2,000 mm of annual rainfall!

The best work with vetiver has been done in Orissa, where government staff took the trouble to visit Thailand to learn how to apply the technology correctly. They returned home, and did the job well. I am afraid that it will take rather a long time to see change in the "academic" orientation of researchers in India.

As a general point I agree with your main point about applying the technology correctly. We see failure in many countries because of bad application. There are many reasons for this, including: designers who incorporate the technology without understanding it; contractors who are not properly supervised; lack of follow up maintenance in the first year or so; general disinterest by government officials, and so on. In my experience where the technology is applied correctly, particularly by private agencies or individuals the system works pretty well.

VETIVER NETWORK HOMEPAGE

www.vetiver.org

Orhan Baykal, a forester and artist, has kindly agreed to redisign and maintain TVN's homepage on the Internet. The homepage has become large and unwieldy, and needs some reorganizing. Orhan has a wide experience around the world, and with his artistic talent will I am sure make our homepage into avery respectable web site. If anyone has any ideas on web site improvements please contact Orhan directly.

FUTURE ISSUES OF THE VETIVER NEWSLETTERS

In the last newsletter #17 it was announced that from 1998 onwards The Vetiver Newsletter would be only sent to those who request it. This is a reminder to those who have not responded. This newsletter, #18, is the last one you will receive unless you complete the form that is at the end of newsletter #17. We want to be able to continue sending you our newsletter, so please return the completed form to The Vetiver Network. Those who have access to the Internet can find our homepage at **www.vetiver.org**. The latter includes each newsletter as it is published.

VETIVER RESEARCH AND DEVELOPMENT AWARDS

At the end of 1998 The Vetiver Network will be announcing awards valued at US $50,000 for vetiver reserach and development achievements. In addition the Network will make recommendations to The Royal Projects Development Board with respect to the potential winners of The King of Thailand's Vetiver Awards, two awards each valued at US $5,000. Notice about all these award were published in newsletters #16 and 17. All entries must be sent to The Vetiver Network by September 30 1998.

LETTERS TO THE EDITOR

From Paul Truong, Australia. Vetiver and its beautiful flowers! (Letter passed on from Mark Dafforn)

We just had a field day in our sugar area, every one welcome — wife, kids etc. After my brief introduction to our research in the area (sediment trapping) — in all seriousness one farmer said, if Vetiver is closely related to sugar cane then we should try to cross them as we need a cane variety like Vetiver. Food for thought there!!!! Then a lady asked "how often does it flower?," Answer — "once a year, about now" — Response, "a pity as it will make a beautiful dry flower combination with our native flowers,"— so I told her to take what she needs then she said she only needed a sample now, cure it properly and sent it to her agent to find out how much he is willing to pay and in the mean time can I give *her a* rough costing! So here you are Mark, don't knock these flowers too much, this is what I need for my retirement. Yesterday I spent the whole day with a camera crew (this site is about 1000 km south of the sugar lands) and introduced our friendly grass which can save environment for a children's program called TOTALLY WILD for a national TV net work. In addition to all the good things we know that Vetiver can do, the presenter (Dick, a different one but she is also blond and very nice) insisted on one point we missed so far that Vetiver's beautiful dark purple flowers will beautify the moonscape we are trying to rehabilitate, and she made me say that among all other attributes. Sorry Mark, I will send you the tape to show that I had no choice !!.

From Hu Jianye, (Red Soil Project Office of Jiangxi Province, Nanchang 330002, China)

In 1989, Mr. Richard G. Grimshaw introduced vetiver grass to us as an excellent plant for soil conservation. We conducted trials in the project area in Chongren, Jinxi, Linchuan, Dongxiang, Jinxian, Guixi Counties, as well as at Provincial Animal Husbandry and Breeding Farm, and the Provincial Red Soil Research Institute. The grass was planted on more than 200 hectares under different ecological conditions. They all grew well even on extreme soils and could stand drought, submerging, burning, animal feeding. Besides, the grass was characterized by very high biomass and strong capability of stabilizing soils and water conservation.

In order to extend vetiver technology, 20 hectares of nurseries have been established since 1990 on paddy fields, upland red soils, and sand bars, accompanied by multiple experiments and research such as reproduction technology, the effects of vetiver on soil conservation, effect of vetiver mulch on soil and water maintenance, the use of vetiver as fodder, the effect of extremely infertile soils on the growth of the grass, etc. The vetiver technology was not only extended to most of the counties in Jiangxi Province but also to neighboring provinces. In 1993 the contour planting vetiver hedges were identified as an most efficient new tech-

THE VETIVER NETWORK

nology and most important component in agroforestry systems recorded in the Evaluation Document of Red Soil Project involving in 5 Provinces as Jiangxi, Fujian, Zhejiang, Hunan, and Guangxi.

Up to the end of 1996, the contour planting vetiver hedges were widely established in the 43 watersheds in 19 counties and on provincial farms through the Red Soil Project (2nd phase) in order to control the serious soil erosion. With progress of the project, the ecological and economical benefits of the vetiver is becoming more and more obvious and considerable. Based on statistics, there were 20,000 ha red soil land protected by the grass through the Red Soil Project in Jiangxi Province. The unique function of the grass is now being recognized by more and more government officers and farmers. It is believable that the grass will be extended more widely and quickly in southern China.

From Mulatu Wakjira, Mettu, Ethiopia.

.....I have been interested to work with vetiver grass since May 1996 when I attended a training workshop organized jointly by Munchen f Munchen, an NGO, and the Illubbabor Zone Agricultural Development Department at the Kersa training center of MfM. Thanks to the Vetiver Network funding we have six nurseries in six districts, and I have the chance of working with one of the nurseries. Todate six development agents and six experts have been trained and I am one of the experts. From now on the nursery activity will be continued. Please send me a copy of the vetiver video — a very useful tool for dissemination of information.

From Temesgen Oli, Gore, Ethiopia

.....Even though in past years my region (Illubabor) had very fertile soil nowadays due to serious deforestation, burning and arable farming — all combined with high rainfall — the top soil has become bare. As a solution we practiced engineered structures to protect the loss of soil. But we can't control even a pinch of soil.

Nowadays we use the Vetiver Grass Technology, and we find it very good in its protection of the soil. The farmers are very interested and voluntarily practice the technology on their farm lands. It is one of the important technologies for extension communication with farmers.

From Allai Aina, Papua New Guinea

.... My involvement with vetiver grass goes back seven years, and during those times, whilst attached to a government organization, I was using vetiver as a means of conserving soil and moisture. I have ended my secondment with SSRDP and am currently working work the forestry department. I have raised my own vetiver nursery, and am distributing the plants free of charge to my close relatives. In future as the planting material increases I will move into large scale distribution. I like the vetiver grass technology and will continue to work with it even though I have a forestry background.

From Mrs. B. Jiji, District Projects Officer, SAFIRE, PO Box 237, Nyanga, Zimbabwe

... I work for an NGO called SAFIRE (Southern Alliance for Indigenous Resources) and I am based in Nyanga District of Manicaland Province of Zimbabwe. I am a district projects officer and I work with communities promoting sustainable and productive use of woodlands and other natural resources for economic development of small holder farmers. One of the key things that I do is to promote conservation and rehabilitation of the natural resources in the district. Having read about "Miracle Grass" — Vetiver, I decided to try it out with smallholder farmers for soil and moisture conservation in the wet uplands of Matema and the dry areas of Nyanga North.

The following is what I have done to achieve my goal of seeing vetiver adopted as a soil and moisture conservation biological/technology.

I have organized and run a one day training course for 26 agricultural extension workers (AEW), 1 NRDC roads and maintenance officer and 1 upland Matema farmer. The course was at Ruwangwe DDF vetiver nursery. The aim was to sell the idea of vetiver as a soil and moisture conservation technology so that government departments can adopt it and push the technology to the resource poor smallholder farmers. At the end of the course each AEW wanted to go back and start his own vetiver nursery in their respective wards, but the supply of vetiver slips is not readily available and are expensive. The response from the participants was very positive, and some have already started carrying out their plans drafted at the end of the course. I have I identified one Matema upland farmer and established a small vetiver nursery in February 1997 of about 1000 slips. The farmer had volunteered without knowing anything about vetiver, until he attended the training course. The farmer was excited, but his main problem was of inputs (fertilizer, tools etc.). We were not sure of the amounts and type of fertilizer to use.

I have also managed to identify three farmers to establish vetiver hedges, each have now planted one row of hedge.. The idea is to try vetiver in terrace formation and as a conservation measure in the high rainfall areas of Matema. The area has had land slides this year after extremely heavy rains, so plenty of vetiver will be needed!

I am currently establishing a nursery in a village in Nyajezi Irrigation Scheme. The plants from the nursery will be used to protect the Nyajezi

dam catchment area from erosion. Vetiver will be planted in fields, gardens and gullies of the catchment area.

I have identified, together with the Tangwena AEW, one woman farmer to try vetiver hedges on the contour for her whole farm. We have designed an action plan. The AEW is currently pegging the fields and then will calculate the number of slips that will be requires. The vetiver required will be a lot so please help me find additional supplies of vetiver.

Future programs.

I identified two farmers in the drier regions of Nyanga to try out the technology. I will also take farmers on look and learn tours to areas where vetiver has already been introduced. If any commercial farmers are willing to host such tours, please contact us.

Problems for future expansion are:

- lack of training materials
- costs of establishing nurseries and fencing
- I want to be registered as a member of the Vetiver Network
- I need help in sourcing vetiver planting material

.....Help me see my dreams come true of a green Nyanga, clean river waters, conserved fields and better food supplies (food security) for resource poor farmers in this district. I have only been in Nyanga since November 1996, but I have fallen in love with the scenery, place and people. I want to do more for them.

The field hand book"Vetiver - A Hedge Against Erosion" has recently been published in Malawi in the national language -- **Chechewa**. In Nepal it has been published in Nepali. In Papua New Guinea a modified handbook with some excellent photos has been published in **PIDGIN**. SAVN reports that the handbook has been published in **Kwa-Zulu**, and TVN expects to arrange the **French** translation to be published soon.

From Remedios Salinas, Chief Research & Development, Republic of the Philippines, National Irrigation Administration, (PAMBANSANG PANGASIWAAN NG PATUBIG), Region 10, Cagayan de Oro City

I attended the first National Conference/Workshop at VISCA, Baybay, Leyte a quite far from our place. I am very thankful to Mr. Edwin Balbarino in inviting me. During the conference/workshop we exchanged our experiences and ideas about vetiver grass and its use, not only for our environment, but also for economic improvement.

I brought the Video, the one you send me last year entitled "Vetiver Grass - The Hedge Against Erosion". It increased the interest of the participants about this grass and almost 60% of the participants made a copy of it. I am very thankful for the very useful materials and references you provided.

Todate our office has sent a memorandum to all our field personnel, especially water management technicians, for the immediate implementation and adoption of planting vetiver grass along their respective canals. I have now a plan also to disseminate this technology to our farmers clientele/irrigators association in our region on how to propagate this grass, on the basis of what I gained during the 1st Vetiver National Convention at VISCA, Leyte.

To give more details and information for farmers, asking again your favor a copy of you slide/video on the propagation and latest information about this plant.
Hoping for your kind consideration and thank you very much for your generosity.

From Jon Hellin, Apartado Postal 791, Tegucigalpa, Honduras. Tel:+504 225248, Fax:+504 379628 E-mail: hellin@gbm.hn

My research is currently funded by the British government , but funding ceases at the end of September 1997 and I will continue with my own funding as I need more data for my doctorate.

My research in Honduras is directed at the use of vegetation for better land husbandry. I am focusing on the use of live barriers on hillside farms. The idea is that the research on live barriers will complement research on cover crops being carried out in Central America by CIAT and Cornell University etc. In theory cover crops (to protect the soil from rain drop compaction; the vertical component of the erosion process) and live barriers (to retain some of the soil eroded; the horizontal component of the erosion process) are effective in reducing land degradation problems.

There are bio-physical and socio-economic components to the research. With regards to the former, in April 1996, I established 30 research plots on hillsides in southern Honduras. Each plot is 24 x 5 m and I have established live barriers of different grass, shrub and tree species along with a few plots with cover crops. The grass species being used is vetiver grass.

There are four replications of each treatment. All plots are sown with maize and there are two harvests per annum (August/September and December/August). The rains fall from May - November.

The principal objectives of the experiment are to:

Measure the soil and water runoff from slopes of different angles with

live barriers of different species.
Look at changes in the physical and chemical characteristics of the soil remaining under different live barrier (and cover crop) treatments.
Document changing maize yields from the research plots.
Document the biomass production (fuelwood and fodder) of the different species being used in the live barriers.
Calculate the costs of establishment and management of the live barriers.
Serve as demonstration plots to visiting professionals and farmers

If you would like more information please contact me.

From Vanatu

Seedlings of the Vetiver Grass multiplied from parent materials from Guam and Fiji are used in soil and water conservation, rehabilitation of degraded lands and stabilization of road embankment programs. Efforts to promote the grass for weaving and to explore other potential uses are continuing

From The Plant Genetic Resources Unit of the Agricultural Research Council (ARC) of South Africa

The Plant Genetic Resources Unit of the Agricultural Research Council (ARC) of South Africa co-ordinates all Plant Genetic Resources for Agriculture in the country. As such it maintains base collections of all plants of known or potential use for agriculture. As such we have maintained vegetative collections of *Vetiver* in the field genebank of ARC Range and Forage Institute. Material is multiplied on request from user groups and a small handling fee is charged for this service.

Ex-situ collections of germplasm are maintained with the main purpose being their utilization. This utilization can be increased by better documentation and information on the species held. As such, the Vetiver newsletters, enable potential clients to decide whether *Vetiver* is suitable for their purposes. Having this information available has definitely led to an increased demand for *Vetiver* planting material and we would be grateful to continue receiving information on vetiver grass technology

From Moges Worku. Ethiopia

Let me take this opportunity to say congratulations for the successful work done in disseminating the vetiver technology (if not too late), which I consider is making tremendous contribution in the area of natural resources conservation. Being a regular receiver though “passive”) of the vetiver news letter since 1992, I have got the chance to witness the remarkable growth of the network both in scope as well as quality of information disseminated. The network has expanded fast and the news letter is reaching almost all corners of the world. On my part I have learned a lot so far (my first exposure was the vetiver workshop held in Addis Ababa in 1992), and hope to learn much more in the future too. Congratulations again and many thanks too.

You may wish to know my involvement in the use of the technology.... In 1992 and 1993 I initiated the multiplication of vetiver seedlings in nurseries in South, West and North Shewa (Central Ethiopia) mainly for use on degraded hillside and gully reclamation sites. I was working as a senior soil and water conservation expert for Shewa PADEP VI , an EU funded project - - in the Ministry of Agriculture, at that time. In West Shewa we planted vetiver seedlings in gullies (as barriers) during the 1993 long rainy season. I remember the grass was performing well both in the nurseries as well as in the gullies until early 1994. I have no information since then as I left the project to join an NGO - Catholic Relief Services (CRS) - where I am working now.
Where I work now, we have plans to use vetiver grass as one of the interventions for the rehabilitation of degraded hillsides and gullies. We are raising vetiver seedlings in our nurseries in Southern and Eastern Ethiopia. In Dire Dawa area, a semi-arid zone in Eastern Ethiopia, we have recently planted vetiver seedlings on pond embankments for stabilisation purposes. In Southern region (Gurage area, we see a great potential for the use of this grass for gully rehabilitation purposes. Some seedlings are already planted in the current rainy season. Therefore, in the coming years we hope to share with you the information regarding the performance of this famous grass on degraded hillsides and gullies.

From Victor A. Gillespie, Engineer, P0 Box 5752, Vientiane, Lao PDR, FAX:856-21-212933, e-mail: victorg@microtec.com.la

Vetiver Activities In Luang Prabang Province, Lao PDR. My counterparts — led by Mr. Thongsavanh Boupha, Head of the European Commission funded provincial irrigation programme — and I are working on the fourth introduction of *Vetiver* into the province of Luang Prabang, Lao PDR. That we are making the fourth introduction by a foreign donor project highlights the fact that *a Vetiver* Grass System (VGS) can not be sustainable unless there is active involvement by government agencies and/or farmers - obvious but difficult to achieve.

Mr. Boupha and I believe that there is more assurance of active involvement on donor funded projects if the: (1) VGS programme is an explicit component of the technical assistance agreement and (2) target beneficiaries perceive the benefits.

We propose that the VGS be an explicit part of the technical assistance agreement, for otherwise resources will first go to activities that are an explicit part of the programme. Resources and commitment are required for a good VGS because it is difficult for farmers to perceive the

benefits. This is especially true with subsistence farmers. They do not have the luxury of planning ahead. They have to get their food now, and for most, this means planting all of the area that they can. The history of *Vetiver's* introduction into Luang Prabang province, northern Laos lends some weight to these suggestions.

Vetiver is native to southern Laos, and the Laos are aware of the plant - having a word for it in their language. Although in the field, many people confuse it with various tall grasses. From our observations, the plant is not indigenous to northern Laos. The first known introduction of *Vetiver* to Luang Prabang province was by the United Nations' Food and Agricultural Organisation project. This was in the late 1980's. Their activities centred on a Provincial Agricultural Field Station about 12 kilometres outside of the town of Luang Prabang. They planted a system of hedges. These were planted both on and off of the station. Off the station, the plantings were on the contour on farmers' land. The majority of the farmers planted *Vetiver* as part of a "Food for Work" programme. To our knowledge, the use of *Vetiver* was not an explicit part of the project agreement. Since the FAO project left the Provincial Agricultural Field Station, the farmers have dug up the hedges to plant upland rice. From this it is assumed that neither the government agency nor the farmers understood the benefit of the VGS.

The second known introduction was by a Euro-Consult technical assistance team - noted in *Vetiver Newsletter No. 6 March 1991* - in cooperation with Lao government officials. They planted a nursery and hedges at an Agricultural Fruit Research Station 8 kilometres outside of town. They also planted hedges on farmers' land nearby. When Mr. Boupha and I inspected the area in May 1997, there was only a small patch of *Vetiver,* about 1 metre by 0.5 metre, near the road. The plants in the fruit station had been dug up and those in the nearby fields either dug up or died from being shaded. It is known that the use of a VGS was not explicit in the technical assistance agreement. While the Euro-Consult team did a good job of addressing the problem of erosion, their main focus was on helping farmers to use their available land for cash crops. With this focus, the *Vetiver* hedges in farmers' fields were not sustainable because it is not a cash crop.

A third known introduction is by the Lao - International Rice Research Institute (Lao - IRRI) Upland Research Programme about 25 kilometres outside of Luang Prabang. Lao - IRRI has planted hedges on the station, and they have an active outreach programme with selected farmers. The farmers that they are working with are using a VGS because they realise that they have to manage their land or lose it.

The International Board for Soil Research and Management (IBSRAM) erosion control trial station is next to the Lao - IRRI station. They have a wide variety of biological trials. They obtained their planting material from Lao - IRRI. Both Lao - IRRI and IBSRAM are doing well with their programmes.

The fourth introduction is by the European Commission funded irrigation programme in cooperation with the European Commission funded road construction programme. Because a VGS programme is not explicit in the technical assistance programme - although recognised and encouraged by European Commission technical staff - Mr. Boupha and I have to work on our VGS programme as we can after fulfilling our mandated responsibilities.

Because we are short of resources, we are hedging our bets - pun intended - with regard to setting up a sustainable programme. We have established two nurseries. Each under different management, and each with different objectives. One is a 20 metre by 20 metre plot at the local Agricultural College Pak Xuang, which is 17 kilometres outside of Luang Prabang on National Highway 13 North. The nursery is maintained by staff and students. The objective here is to train the staff and students in how to propagate *Vetiver.* The other nursery is maintained by farmers in the Pak Pa Irrigation Scheme. Planting material from this nursery will be available in about seven (7) months. These plants are for use by the farmers to stabilise canal banks, check drain erosion into the canals, and to stabilise soil around the headwork's and structures. The Irrigation Programme and the farmers are now identifying where the material should be planted and how the work will be done.

There is no effort being made to have the farmers plant *Vetiver* on their land. It is assumed that when they see the decrease in maintenance that they have to do on the irrigation scheme, the more innovative farmers will try the VGS on their own land. The objective here is to have the farmers learn of the benefits to be gained from a VGS without first using their crop land. It is hoped that one of these nurseries will be sustained, and one of the programmes, either roads erosion control or irrigation scheme erosion control, will continue.

We are building on past work. Because there is now greater awareness of *Vetiver* among Lao government officials and donor representatives, our work is not as innovative - and thus untested - as previous introductions. With these advantages, we look for *Vetiver* to be established in Luang Prabang Province.

From. C.M.Gomes Tanzania

I am at present working on a World Bank financed, Hydropower project in Tanzania. The project is on the river Kihansi and is therefore called the Kihansi project. I am employed by the

consultant engineers, Norplan A/s, a Norwegian company. Aside from the tunnels, dam, power station, tailrace canal etc. there is also a 14 km. access road to the dam site which climbs some 800 meters from the camp at a lower level to the dam site at around 1200 meters altitude. Many sections of this road are through very poor sandy soils which have a strong tendency to slip and erode during the rainy season (April-May). It is therefore our intention to try and establish vetiver hedge grows to stabilise embankments. The problem of the cuts, which are rather steep and high, still remain, but we shall try and locate and use a creeping grass to cover the cuts.

Local grasses grow abundantly, and sprout up during the rainy season, the problem has been that the erosion has already started before the local grass takes. Besides this, most of the grasses available are not deep rooted and are very susceptible to bush fires which run wild every year in this area. We are not too sure that the grass we are using is *Vetivera zizanioides*, but it is definitely a species of vetiver. The roots have a strong, pungent though not unpleasant - smell. I wonder if this may be a means of identification. Most vetiver I have observed in Tanzania is at slightly higher altitudes 800 to 1500 meters, and which I believe was originally brought in to the tea plantations. It goes by the local name of Kus-Kus in the Kilimanjaro area. We are also pretty certain that the vetiver we are using does not produce a viable seed, which is not only our observation but also reported by the people from where we obtained the rooting material. I understand that there is a source of Vetiver in the Iringa area, which is not too far from us, could you give me more details of the location and people running the operation, and also if there is any possibility of having the strain of vetiver we are using identified positively.

Further more there is a section of the Pangani river (on which power is also generated) which has an extremely shallow bed slope due to the topography of the area. A study is presently being conducted (funded by Norway) to determine some method whereby the side banks of the river can be raised so as to contain higher flows of water than is presently possible. This problem exists in roughly a 50 Km. stretch of the river. One of the remedies suggested is the building of small bunds planted with Vetiver protection.

From G.van de Meeberg , Project advisor, St. Joseph's Family Farm Project, Catholic Mission Bwiam), PO. Box 165, Banjul, The Gambia. Ph/Fax: 220489050, E-mail Mhadji@gam.healthnet.org

We would like to express our appreciation for your excellent service by the provision of the Vetiver Newsletter.

The reason for not having contributed any items for publication has been that our project has very limited staff (8) and a multitude of diverse tasks related to food security while trying to restore the environment, leaving little time for corresponding. Our approach to cover the area of 112 villages in 6 districts has been through partnership with all relative extension workers, government or N.G.Os individual farmers, but significantly, the schools

The start of our increased emphasis on the use of Vetiver grass throughout the region came after having planted contours on a farmers plot which never yielded anything worthwhile before. Surrounding farmers, having seen the dramatically positive result, made requests for the technology and the project has been demand driven ever since. Another contributing factor for increased demand was that word went rapidly around after a series of district wide workshops for village leaders which included a video of a community which collectively built bunds allowing them to put 34.6 ha of land under upland rice cultivation. The video also recorded the visit of the Minister of Agriculture who remarked it was tile largest upland rice area he had ever seen. The concept of making the bunds permanent with Vetiver was made clear in the video although not all the bunds had been planted.

Propagation of Vetiver grass was started with a small nursery at a school site where the grass was originally planted for decorative purposes. Two project sites were added, and more schools were involved with varying rates of success. At the moment, funding for Vetiver propagation has been secured, and some extra stock which was acquired in anticipation half a year ago has been multiplied for use in other nursery sites. We are combining both the partnerships with farmers, multiplying the grass through planting on the bunds, as well as establishment of new nurseries.

We are still in the dark about the cultivars. We thought we had been using a local variety and went out of our way to acquire some we were told was *V. zizanioides*. It does not look any different! We did see a variety growing wild in large quantities up country which looks distinctly different. As we anticipate the demand for planting stock to outstrip our capability to supply, we will have to consider using it. Shade tolerance is not a major concern for upland farmland as it is mostly denuded (as yet). We would appreciate a description or illustration of the variety we suspect might *be V. nigritana* in comparison with what is possibly *V. Zizanioides*.

We were pleased to find out a regional network is in the making, but would appreciate continued receipt of the Newsletter. Without prejudice, our small project is, no doubt, the most active promoter of Vetiver in this country and just a few days ago received some publicity on National Television through a visit from the First Lady to the same village we pre-

viously mentioned. We hold many workshops and receive many visitors, where the network is mentioned, and the Vetiver newsletters are displayed. Information is also copied in hand-outs we supply to our guests and partners.

Our heartfelt thanks!

PLEASE DO NOT FORGET

IF YOU WANT TO CONTINUE TO RECEIVE FURTHER ISSUES OF THE VETIVER NEWS-LETTER YOU MUST COMPLETE THE FORM INCLUDED IN NEWSLETTER #17

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JUST A REMINDER!

ÒIT'S JUST LIKE GROWING SHALLOTS...!Ó EXPERIENCES WITH VETIVER GRASS IN A SOIL AN WATER CONSERVATION PROGRAMME FOR COMMUNAL FARMERS IN ZAKA DISTRICT, ZIMBABWEÓ

by Soren Dreyer (MSC in Geography) Conservation Adviser, Zaka District.

Background

Zimbabwe has a long and politically quite shaky history of soil conservation. Construction of standardized contour ridges and drains has been enforced by governments for decades and due to the enforcement the whole idea of soil conservation has become rather unpopular among communal (African small-holder or peasant) farmers. During the liberation war of the 1970's the concept of "Freedom Farming" was introduced by the freedom fighting armies. This involved destruction of existing contour ridges as a protest against the Rhodesian regime. Hence soil conservation became a victim in a highly sensitive and indeed political debate. Now, 17 years after independence, the standard contour ridges are to some extent still enforced, but it is now possible to establish other means of soil conservation without actually bypassing the law.

Photo # 1: Transforming a standard contour ridge & drain into a Vetiver hedge. Vetiver is planted just above the drain. This photo was taken after the first season and the hedge is already well established. After the second season the drain and ridge will be destroyed giving the farmer access to more land while the field is better protected. The photo was taken during a ÒLook & Learn TourÓ with visitors from another district.

In Zaka District, in South-Eastern Zimbabwe, a partnership between the Danish NGO MS-Zimbabwe and the local Rural District Council started 4 years ago with the objective of addressing conservation of natural resources among communal farmers. The idea was to introduce options for appropriate technologies to control soil erosion instead of blank recommendations (like the standard contour ridge). The program is coordinated by Zaka Rural District Council, and the implementing agents are Ministry of Agriculture, Dep. of Natural Resources, and the Forestry Commission of Zimbabwe. A Danish Conservation Adviser is attached to the programme.

Zaka District is a semi-arid, mountainous area with erratic rainfall averaging 6-800 mm/yr. The soils are generally poor. Subsistence farming is the main economic activity and the main crops grown are maize, groundnuts, cotton, sorghum finger millet, sunflower and pumpkins. The population density is more than 65 persons/km^2, which is quite high for a mountainous area where subsistence farming is the main economic activity. Hence the environmental consequences are over-utilization of the natural resources, deforestation and severe soil erosion.

Initially, the conservation programme introduced an alternative type of mechanical contouring, the Fanya Juu system from Kenya. By building up bench terraces and improving moisture conservation this system reduces soil erosion markedly compared to the standard contour ridges. Yet, it was felt that more alternatives were needed, and vetiver grass *(Vetiveria zizanioides)* was then introduced in 1994. In the beginning only as a pilot project, because experience with the grass in Zimbabwe's communal areas was minimal. A few nurseries (0.2-0.4 ha) and a number of demonstrations with contour hedges were established. The planting material was bought from large scale commercial farms in other parts of the country where Vetiver had successfully been used for some 20-25 years, but never re-

Photo # 2: Checking runoff. A Vetiver hedge planted across a road, which used to cross a valley bottom. The valley bottom is now a 10-12m deep gully and the road a dangerous waterway leading to the gully. Vetiver hedges were planted 11/2 year before the photo was taken, and in spite of the poor soil conditions the grass is well established and the amount of silt trapped in front of the hedge is quite impressive. The hedge also facilitates establishment of other types of vegetation, which further reduces the velocity of runoff and thereby assists the reclamation of the gully.

ally reached the communal areas.

Even within the first season, the results were quite impressive. The second largest gully in Zimbabwe, at Zishir (>300m long, 15-20m wide and 10-12m deep), was one of the main targets. Conservation of the gully catchment area with vetiver contour hedges proved to be much more efficient than the standard contour ridges. Later, waterways leading to the gully were checked with vetiver, and two more nurseries were established inside the gully to provide optimum moisture conditions.

To ensure sustainability and reduce dependency of purchasing the grass from commercial farms two large central nurseries were established at a later stage. From there, farmers will be able to purchase planting material at a reasonable price with low transport costs. These two district nurseries are still new and are not able to meet the high demand from farmers, who have realized the many advantages of vetiver contour hedges. The advantages stated by the farmers are:

- less labour compared to mechanical contouring,
- improved moisture conditions leading to yield increases,
- no erosion in the fields,
- land is released for cultivation as a vetiver hedge occupies less space compared to mechanical contouring
- availability of thatching grass from Vetiver,
- snakes are repelled by the aromatic smell of vetiver grass,

I have not come across any research on the latter issue, but cobras and mambas flourish in Zaka, so if it really works, all the better.

The statement of "no erosion in the fields" is related to the fact that sheet and even rill erosion are common phenomena's in the fields conserved with standard contour ridges. Rill erosion mainly occurs where there are breakage's in the contour ridge or where the ridge was not pegged correctly. Sheet (inter-rill) erosion *does* take place in fields with vetiver hedges, but it is reduced significantly due to circumstance that vetiver is a permeable barrier that acts like a sieve and kind of spreads runoff water right across the field and reduces the erosive velocity of runoff water. Thus, the total erosion and the visible signs of it in the field might be reduced, but the sedimentation of material in front of the hedge (which eventually becomes a natural terrace) proves that erosion in the field *does* take place. The main advantage with vetiver hedges is thus that soil is only transported within the field and not removed from it. Based on the positive results from the pilot sites it was decided to establish community nurseries in each of the 30 wards of Zaka District and at a number of schools.

Dissemination

The concept of biological contouring in the form of vetiver grass barriers immediately appears strange to a farmer who has never seen it and who in the past was forced to practice mechanical contouring. So the most efficient tool in disseminating the concept of vetiver grass hedges proved to be "Look & Learn Tours" for farmers.

On the "Look & Learn Tours" interested groups and individuals visit the pilot areas. During the visits, the farmers from the pilot areas explain in their own words what they have done, show how they have done it, and prove what they have achieved. The aspects of vegetative propagation and of managing and maintaining a permanent nursery is well displayed by simply comparing the propagation of Vetiver to that of shallots, a practice most farmers are familiar with from their gardening.

The visible proof in the pilot plots of Vetiver's viability as a highly advanced yet at the same time simple option for soil & water conservation convinces almost every visitor. After the tour, the visitors are usually very keen and are encouraged to start their own nurseries. That, however,

is not always possible and depends on the season. Due to vetiver's vulnerability to drought the first 6-8 weeks and the local rainfall pattern, nurseries and contour hedges should only be established from December to February in this part of the world; unless there is a permanent water source very near the nursery and the community is prepared to water the grass. In Zaka we have tried to establish nurseries in the dry season with limited success. There have been cases where grass planted in the dry season (even near a water source, has dried up due to negligence. One factor could be, that too heavy promotion of the blessings of Vetiver from eager extensionists (including the author!) has made some beneficiaries believe that the grass can grow even without water! But apart from the first 6-8 weeks where water is essential, nothing else seems to disturb vetiver seriously. Termite and livestock attacks are common, but in most cases the grass survives and will reshoot.

Photo # 3: ***Farmer-to-farmer extension. During a "Look & Learn Tours farmers explain to other farmers their experiences with vetiver grass. Here Mrs. Zinanga, an innovative farmer, is teaching two visitors how to manage a Vetiver nursery. Note that the "donor" in the right front is keeping quiet, listening in admiration!***

In addition to the farmer-to-farmer extension via the "Look and Learn Tours", school teachers and the agricultural extension staff of the district have also been trained in Vetiver management. This training has provided the programme with valuable resource persons scattered all over the district. Here, the little green Vetiver Handbook has been highly valuable, as we received 150 copies in 1995. They are all distributed and are being used intensively. We could use more copies, also for distribution to other districts, so an effort to have the handbook reprinted would be highly appreciated! To reach beneficiaries that are not too confident with the English language, a handout in Shona on vetiver management is now being produced.

Sustainability and Potential

By just introducing vetiver grass in Zaka District, all the environmental problems described in the first section of this paper are far from solved. But vetiver hedges has proven to be a more efficient, less laborious and easily adoptable barrier against erosion compared to mechanical contouring methods like contour ridges. And it has proven to be an almost universal and comparably cheap tool in gully reclamation. There is still a lot of areas where we need more experience here in Zaka, e.g. in soil conservation along roads, embankment stabilization and in the protection of wetlands. There is definitely more work to be done and new areas to explore...

Based on the above findings vetiver grass has a high potential of being *the solution* to the problem of soil erosion in Zimbabwe. With the recent experiences from Communal Areas (in at least 4 other districts than Zaka), and the many years of experiences on commercial farms, there should be no reason for the government and the many donors in Zimbabwe not to focus first of all on vetiver hedges as an alternative to the unpopular standard contour ridges. The grass deserves much more attention than it currently receives.

Environmentally, there is no doubt that Vetiver is one of the best solutions to conservation of arable lands as well as grazing areas. It is easy for farmers to learn the skills related to management of the grass, there are no expenses when first the grass is there, and the labour requirements are very low. The only concern we have in this programme is related to the fact that *Vetiveria zizanioides* seems to be a clone; we don't know what diseases or pests might appear one day and within a short period damage or even exterminate all the grass in the region. That would be an environmental disaster. But considering the worldwide experience and proof of the viability, the risk appears to be mainly theoretical. Hence, Vetiver grass has a lot of potential in Zimbabwe and based on the Zaka farmers' positive response it should be worth trying on a much larger scale.

REPORT ON THE VISIT TO THE PHILIPPINE (14 - 22 MAY, 1997)

by PAUL TRUONG, Queensland Department of Natural Resources, Brisbane, Australia

On behalf of The Vetiver Network (TVN) I was invited to attend the Organisational Meeting to establish the First Asia-Pacific Conference & Exhibition on GROUND AND WATER ENGINEERING FOR EROSION CONTROL AND SLOPE STABILISATION.

This conference will be held in April 1999 under the sponsorships of the following organisations:

- The International Erosion Control Association (IECA),
- Various Philippines Government Departments: Public Works and Highways (DPW&H), Natural Resources and Environment (DNR&E), the Division of Mines of DNR&E, Science and Technology,
- The University of the Philippines,
- Various professional organisations: Philippines Institution of Civil Engineers, Philippines Contractors Association, Road Engineering Associations of the Philippines and of Asia and Australasia,
- World Association of Soil and Water Conservation and
- The Vetiver Network.

I took this opportunity to establish contact with the Vetiver Network Philippines (VNP), meeting up with VNP coordinator Dr. Edwin Balbarino and VNP representatives for Luzon, Noah Manarang and Tina Jose. I also visited the International Rice Research Institute (IRRI) at Los Banos, had a meeting with Mr. L. Visorde, Director of the Bureau of Highway Maintenance of the DPW&H. The followings are my brief report on the impression and experience gained during the visit:

VNP :

Despite his very busy schedule, Edwin came up from Baybay, Leyte to spend two days with me. Dick Grimshaw of TVN has warned me of his commitment to the application of Vetiver Technology, so I was well prepared for his enthusiasm. This enthusiasm was further increased after attending my seminar given to IRRI scientists (more of this latter). I had prepared for Ed a set of mini posters on my various research and application projects and all the papers and publications of the last Vetiver Workshop in Australia. Ed said these materials would give tremendous support to the coming VNP Workshop in August. We had long discussion on the potential of vetiver for both rural and industrial applications particularly in the Philippines context.

We spent a long day (6AM to 8.30PM) looking for various vetiver planting sites, but due to bad communication we only found two sites, one at the beginning of the Subic Bay toll road and one on the Famy - Infanta Highway. Vetiver establishment was reasonable at both sites although poor establishment was noted in some areas on the Famy road. But the most disappointing point was the poor to very poor results of the road stabilisation works. Through discussions with Edwin and Noah later I found out that this was due to the lack of proper design and supervision, particularly the planting technique, as both departmental and contractor staff have not been trained on the application of the vetiver system for slope stabilisation. This was arisen mainly from the misconception that as a grass Vetiver will act as any other grasses in slope stabilisation. In Australia some specifications even listed vetiver seeding rate (40 kg/ha) for hydromulching !!!. Concerted efforts need to be applied on potential users to point out that vetiver is only a tool, like any other tools of trade you have to learn how to use them properly for best results. In my experience, if we do not apply the system correctly, not only the system will not work but in some cases it can cause severe erosion, as a well established vetiver hedge is a very effective water diversion structure, the result can be disastrous and gives bad publicity to the new technology.

IRRI.

Dr. Ken Fischer, Deputy Director General (Research) of IRRI invited me to give a seminar on my R, D & Application projects on the vetiver system to research staff and students at the Institute. IRRI is interested in the use of vetiver in their upland rice works, particularly their perennial rice project. The seminar was well received and discussions was later held with several project leaders who wanted to have further discussion on its tolerance to adverse conditions Edwin also participated in these discussions. One vetiver characteristics that particularly interests them was vetiver resistance to nematode attack, IRRI is keen to find out the mechanism of nematode resistance in vetiver so that they can select/breed/genetic engineer (?) into their perennial rice and also as an erosion control measure cum nematode protection of the perennial rice crop on steep lands. In general IRRI researchers accept the effectiveness of vetiver in erosion control, but they have not promoted it as they have found that in general the hedges systems such as alley cropping etc. are not well accepted by farmers mainly because of the lost of land on very small farms and also the time involved in the planting and maintaining the hedges, Edwin and I pointed it out to them that properly established vetiver hedges do not take

much land and require little maintenance.

DPW&H.

Dick Grimshaw of TVN informed me that on the advice from the World Bank, DPW&H has planted two trial sites on new highways to assess the effectiveness of the vetiver system in slope stabilisation instead of using the very costly 1000s of metres rock wall they are using now, and he advised me to contact the department for site visits.

Unfortunately due to bad communication, no site visit was possible, and only a short meeting was available with Mr. L. Visorde, Director Bureau of Highway maintenance in Manila. The Bureau has established two vetiver test sites, one on Famy road and the other at Neuva Vicaya. However it turned out that the site on Famy road that I visited was not the one planted by the Bureau, but by someone else, I was not sure by whom, but was told that the Bureau site was much more successful and better planned.

I discussed with Mr. Visorde the use of vetiver in highway and railway stabilisation in Australia and particularly the works done by Diti Hengchaovanich in Malaysia. I also discuss the results of the two sites I visited with him and pointed out the shortcomings and my concerns about the wrong application methods. Although it is too early to see the result (3 months after planting) of his trials Mr. Visorde was enthusiastic about the vetiver system and planned to established more nurseries to supply planting materials for other sites. I suggested to him that it may be cheaper to contract out to VNP members for supply in remote locations. He also asked me whether I could come back to evaluate his trials properly and help his staff on the use of vetiver in highway stabilisation, I promised to pass on his request to the World Bank.

BIO-ENGINEERING CONFERENCE :

Noah Manarang was appointed as the representative of the VNP on the Ways and Means Committee, helping resources allocation and field trips. With the presence of Naoh on the committee and Mr. Visorde enthusiasm I am sure that VNP will have a few suitable sites for the conference field visits.

PINATUBO LAHAR CONTAINMENT DAMS ;

On the way to the Subic Bay site we passed through several dams and discuss the merit of using vetiver for the stabilisation of the dam walls. Because of the unconsolidated nature of these lahar dams, I think it will take several years before vetiver becomes effective and the slope will probably collapse before that due to the annual monsoonal rain.

1 INTRODUCTION OF VETIVER

Observations and Experiments on the Multiplication, Cultivation, and Management of Vetiver Grass Conducted in China in the l950©.

Xia Hanping (South China Institute of Botany, The Chinese Academy of Sciences, Guangzhou, China)

The first introductory paper about vetiver was published in the magazine of Tropical Crops (in Chinese) in 1957, whose title was just "Vetiveria zizanioides". This paper covered in detail five different aspects of vetiver: 1) production; 2) the plant; 3) multiplication and cultivation; 4) harvest and processing; and 5) characteristic of vetiver oil. There are several points worth mentioning in this article. They are: China's vetiver was introduced from Indonesia in 1956. (It has been widely believed that China's vetiver was from India).

The undomesticated vetiver had been found in Hainan Island of China. (As a matter of fact, there was a much larger area, approximately 6,000-7,000 ha, of wild vetiver communities, maybe Vetiveria nigritana, found in Guangdong by South China Institute of Botany in 1957.)

Vetiver roots are 3-4 mm in diameter, and 1-1.5 m deep. It can produce dry roots 100-150 kg per mu (one-fifteenth hectare) 1 year after planting, from which can be refined 2-3 kg vetiver oil.

Vetiver grass rarely seeds, and is mainly replicated by vegetative propagation. Prior to planting their tops should be pruned to about 20 cm, and the number of tillers per slip should be 2-3.

The plant generally performs better in free and well drained soils, and best in young soils developed from volcanic ash. The oil content will decrease if it is planted in clayed soils. The grass grows best under full sunshine, and is not a shade-tolerant. The oil content of roots is generally some 2-2.5%. 18-month-old roots contain the most oil with the best fragrance. The older the root the greater the density of oil.

In addition, there was another introductory paper on vetiver oil. This paper, entitled "Vetiver Oil", introduced the production and processing of

vetiver oil in some major oil producing countries and regions including Java, Reunion, Haiti, India, and some countries from South America. It also made reference to chemical ingredients, physical and chemical characteristics, functions and uses of vetiver.

2. SOME SUCCESSFUL METHODS FOR PROPAGATING VETIVER

Since vetiver has difficulty in producing viable seeds, the general propagation approach is through division of roots. The availability of vetiver seedlings was very deficient in the late 1950s, so priority was given to experimenting on the multiplication of materials. The successful propagation methods obtained from these experiments and surveys are as follows.

2.1 **Multiplication by Stem-culm Cuttings**. No matter how many nodes, mono-, bi-, or poly-node, are contained in a culm, old culms from the first four nodes in the base part of a stem have the highest survival rate, which goes up to about. 50-60%; whereas the culms from the 5-6th nodes only have 20-30% survival rate. The further the culms are from the base part, the lower their survival rates eventually to zero. In the same nodes, those which are deprived of sheaths and have revealed "bud-eyes" and "root points" sprout more rapidly, and produce more roots, than those which are not deprived of their sheaths. This is because the bud ~eyes~ and root points in culms whose sheaths are peeled off are capable of contacting directly with moisture in soil, which promotes root points to stretch and bud-eyes to sprout. If older cuttings are put in sand with saturated water, they will show "white dots" next day, and produce new roots in the third day; if younger cuttings are used it will takes more than 20 days, but they do not become dry or dead.

2.2 **Multiplication by Pedicel-culm Cuttings**. During the period of flowering, pull open leaves lying next to the 5 - 8th nodes, and cut off the pedicel from the top 3-4 nodes. Over 5-6 days after the top is cut, prune the pedicel culm at 1-2 cm from the ground. Divide each node of the pedicel into one section, then dip the sections into 0.01 % $KMnO_4$ solution for 5 -10 minutes. After that plant them in a nursery. The nursery should well drained and fertile, water sufficient, and be in the shade. Irrigation is given 2-4 times per day, new roots will grow out some 10 days after planting.

2.3 **Multiplication by Longitudinal-slit Stems**. This method is interesting. Vetiver stems have opposite axillary buds and radicles. If a strong stem is longitudinally slit into two halves, then both can produce new tillers and roots. Longitudinal-slit seedlings should be cultivated in shade and the management must be meticulous. It is necessary to usually irrigate the bed in order to keep it wet. New roots will appear after stems have been transplanted for 6 days, and their establishment rate may be up to 100%. Furthermore, the propagation with longitudinal-slit stems has a pretty rapid tiller-formation; and can enhance multiplication speed by 2-5 times as compared to non-longitudinal-slit approach.

2.4 **Multiplication through Pruning Tops**. This is a quite novel approach. The main operation is as follows. Cut the top from the growth point when the plant grows up to 5-6 nodes; the purpose is to control top growth. Then peel off sheaths node by node to accelerate axillary buds aging. After top pruning and sheath removing, nutrients in plant will concentrate chiefly on the buds, thus new seedlings are beginning to sprout from the buds in 1-2 weeks. When the seedlings grow up to round 20 cm, pick them up with the mother buds and culms together. Then heel in them under shade to produce roots as soon as possible. After new roots come out in about one week, they can be outplanted. This propagation way usually has a establishment rate of over 95%, and its speed of forming seedlings is far faster than propagation by pedicel-culm cuttings.

3 CULTIVATION TECHNIQUES FOR PROMOTION ESTABLISHMENT

3.1 **Water-cultivation for Accelerating Root Growth.** The method of water cultivation for speeding root growth is quite simple and is accomplished by laying the cuttings or root divisions vertically in 5-centimeter-deep water (e.g. shallow pool) for 7-10 days.

The advantages of this method are as follows:

- Has quicker growth and tillering Through water cultivation, seedlings no longer undergo the green-turning process, but grow directly. Thus they can produce tillers in advance.
- Roots rapidly. Water cultivation makes seedlings strike new roots only in 2-3 days, whereas the ordinary transplanting way takes at least one week. (In spring 1997, we did the same experiment, the result was that fastest new roots were produced in 3 days, and the slowest in a week or so.)
- Increased the survival rates, and better promotion of growth and development. While cuttings are used as multiplication materials, they will not take roots and from tillers until transplanting after 10 days or a longer, respectively, even if cuttings are from the older culms. If cuttings are the younger culms, the majority do not survive after transplanting. Through water cultivation, however, old stems grow new roots and leaves only in 2-3 days; young stems also take roots only in 10-15 days, and only a few become

dry and dead.

3.2 **Heel-in for Taking Roots**. An ad hoc survey showed that the survival rate of vetiver through heel-in was 97.5%, whereas that with no heel-in was only 92.3%. Another experiment indicated no difference in survival rates in the rainy season between vetiver transplanted on the same day of uprooting and vetiver transplanted through heel-in. Therefore, it is best, in the rainy season, to plant vetiver immediately after it is dug up. In the dry season, however, heel-in for striking roots is an ideal measure to guarantee a high survival rate (Table 1). Heel-in can enhance the survival rate, but the time of heel-in is important, and it is best at 6-10 days after transplanting when new roots reach 2-4 cm.

3.3 Dipping Roots. Before planting, dip vetiver roots in 5-25 ppm 2,4-D, dilute fecal sewage, or even slurry. This method may increase survival rates, and promote tiller formation and growth. For example, the numbers of tillers and new roots whose seedlings were dipped into dilute oxfeces and water increased by 26.4% and 80.2%, respectively, compared with those seedlings not during the first three months after transplanting.

3.4 **Keeping Mother Tillers in the Soil.** When lifting from a nursery, keep 2-3 tillers from per clump in the ground to gain a more rapid multiplication rate for the next nursery. A special trial compares the tillering rate of the following 2 treatments : 1) the plants from mother plants left in soil, and 2) the plants replanted with the same mother plants. Both start with 10 tillers. After 35 days , treatment 1 goes up to 53 tillers , and treatment 2 becomes only 6 tillers. It is clear that till ring rate with mother plants left in the soil is by far the quickest.

3.5 Oblique Planting. Plant vetiver obliquely into soil when transplanting. It is possibly better to plant at an angle of about 45-600 rather than vertically.

4 MANAGEMENT MEASURES FOR ENHANCING TILLERING RATE

4.1 **Intensive Cultivation and Improved Management**. The nursery must have fertile soil, adequate moisture and sufficient sunshine. When clumps of vetiver are divided into pieces for seedlings, it would be best to tear them where they tare best, otherwise seedlings will be damaged. Basal manure and water should be applied when seedlings are planted. Number of tillers may be enhanced by 2-3 times if good, enough basal manure is applied. Top dressing, liquid fertilizer is best, should be applied twice a month. Vetiver is drought-resistant, but the nursery should be supplied with sufficient water; so irrigation should be given once per 2-3 days if there is no rain. There is a trial that indicates the survival rate of vetiver planted in a wet field is 59.8%, and tillers number per clump averages 13.4, but in a dry field both are only 57.5% and 2.7, respectively, in the same period.

4.2 Proper Pruning

After transplanting seedlings to a nursery for 10 months (August - June), the nursery was set up for 4 treatments: 1) unpruned and unfertilized, 2) pruned and unfertilized, 3) unpruned and fertilized, and 4) pruned and fertilized. The plants were cut to 30 cm, fertilization with night soil, and observation time was 1 month. The results were that treatment 2 enhanced the number of tillers by 46.4%, but treatment 1 only by 17.7%; treatment 4 increases the number of tillers by 52.6%, whereas treatment 3 only by 26.9%. However, if the plants are pruned in less than 4 months after transplanting (February - June), they will suffer physical damages owing to their young age, which retards the growth and tillering. In the experiment above, the tillers number for treatment 2 increased only by 8.2%, but treatment 1 by 41.4%, af-

Table 1 Comparison of effects of heel-in and non heel-in on the survival rate of vetiver

Weather condition	Treatment	Survival rate (%)	Note
High temperature	Heel-in	98.0	1
Drought	Non heel-in	76.8	2
Low temperature	Heel-in	92.0	3
Drought	Non heel-in	81.0	4

1) Both treatments are 500 clumps and
2) Planting on July 6, checking Aug. 4
3) Both treatments are 200 clumps
4) Planting on Jan. 17, checking Feb.10

ter transplanting for less than 4 months.

The reasons why pruning can promote growing and tillering are because: 1) Vetiver is 150 -160 cm high, and the bed's coverage usually exceeds 90% when the plants are up to this height, thereby results in closing between rows. Vetiver, the C4 plant, demands lots of sunshine for its growth and development, however. Therefore, proper pruning may lessen the closing density and heighten sunshine density in all parts of the plant, especially improved photosynthesis of the new tillers . 2) prunings comprise mainly old stems and leaves. There is no serious effect of pruning them on the plant; on the contrary, removal of old parts can diminish the consumption of moisture and nutrients. 3) Pruning also cuts off pedicels or inhibits the plants from moving into the stage of reproductive growth, which would consume a great ideal of water and nutrients owing to flowering and seeding. 4) That old parts when cut off possibly produces stimulation to the plant itself, thus can also improve its growth and tillering.

Table 2 Effects of different planting densities on tiller formation

Spacing	Net increment of tillers per clump
15 x 20 cm	3.8
20 x 20 cm	4.4
20 x 25 cm	5.6
20 x 30 cm	6.6
30 x 35 cm	7.0

4.3 **Rational Close Planting** Vetiver has a very strong ability to produce new tillers, and therefore planting density has a significant influence on growth and tillering. An ad hoc trial indicates that different planting densities, according to table 2, 1 tiller per clump, produce the tangibly different numbers of tillers in 2 months. Certainly, it does not mean from table 2 that the sparser the planting density is, the better. Generally speaking, the planting density of 20 cm to 30 cm for multiplication is pretty ideal.

5 OTHER ASPECTS NEEDING CONSIDERATION

5.1 Shallow Planting Is Probably Better Than Deep Planting. Table 3 indicates that vetiver planted 3-4 cm deep is best, 5-6 cm second, and 7-8 cm worst, no matter which aspect, survival rate or tillers number per clump. It is clear from this survey that shallow planting is better than deep planting. The crown must be buried in the ground, however. In addition, in the dry season the plants can not be inserted too shallowly, otherwise they would suffer from drought and result in a decrease of survival rate.

Table 3 Effects of different planting depths on establishment rate and tillering rate

Planting Depth (cm)	Estab. Rate (%)	# tillers/clump at 4 months
3-4	96.6	24.7
5-6	92.3	15.4
7-8	91.3	9.5

5.2 **Keeping Long Roots Is Possibly Better Than Keeping Short Roots**. An experiment tested 2 treatments: pruning roots to 15 cm, and to 4 cm. After transplanting for 3 months, the result shows that the plants with 15 cm long roots had more than more 8.2% of tiller numbers than those with 4 cm long roots. When heeling in, the former had 19.8% increase in the rate of tiller than the latter, in the same period. The difference, however, gradually dwindles as time goes on. Furthermore, effects of the two treatments had no significant effect on the survival rates. In general, 10 cm long roots are enough; too long roots are not recommended.

Table 4 Effects of different numbers planting on survival and tillering rates Treatment

# Tillers per Clump	Survival rate (%)	Net increment of tillers per clump	Net increment of tillers per tiller
1	70	1.19	1.19
2	81	1.30	0.65
3	98	2.03	0.68

5.3 **How Many Tillers Per Clump Should Be Planted**. Three treatments in an experiment were set up: 1 tiller, 2 tillers, and 3 tillers per clump. After 2 months, their survival rates and new tiller increments were sig-

nificant (table 4). Obviously, it is better to plant 2-3 tillers per clump in order to get the best establishment rate. It is certainly feasible to plant 1 tiller for each clump when seedlings are scarce. However, a rule, as mentioned above, is to tear off clumps at the place most easily-torn.

Acknowledgment

The author is grateful to Professor He Daoquan for providing some precious reference material. (19 reference 5 are not used here because they are in Chinese. Any of you who are interested in them please contact the author).

A Preliminary Study on Vetiver's Purification for Garbage Leachate

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1. INTRODUCTION

Many experiments and observations have confirmed that vetiver (*Vetiveria zizanioides*), a perennial grass, has an excellent effect in soil and water conservation, extreme soil amelioration, and other environmental mitigating uses [1-3]. Todate it has been widely used for protection of sloping farmlands, orchards, reservoirs, dikes and dams, for improvement of extreme (strongly acid, alkaline or infertile) soils, and reclamation of mine tailings and polluted areas. Vetiver grown in wetlands has good purifying and stabilizing effects on aquaculture sludge [4]. Although vetiver is not a hydrophyte, it prefers wet and water logged habitats; even if its crown and roots, even a large portion of its shoots, are submerged for relatively long periods, the grass can also grow and develop. However, to date there have not been any reports on suspending vetiver directly into water to purge sewage.

The city of Guangzhou is moving rapidly to becoming an international metropolis; however, a series of ecological and environmental problems have emerged with the development of its economy. For example, that life garbage landfill and its leakage pollute the surroundings is becoming increasingly evident. Currently, municipal garbage in Guangzhou is treated mainly through filling and burning, and some measures are taken to prevent garbage and its waste water from polluting nearby areas. However, the leachate from landfills usually has high contents of "pollutants" such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), alkalinity, organic matter and nitrogen compound, in which most plants can not survive. Although this kind of sewage is not discharged until "purified", the proper effluent standards are rarely reached; as a result farmlands and fishponds are polluted on the lower reaches to varying degrees, and the quality of lives, both health and mind, of nearby inhabitants are effected [6]. Sometimes "purified" discharges are far below the effluent standard; as a result, they have to be pumped into the filtration station for a second cycle of cleansing at high cost.

One solution would be to find some plants that could grow well in waste water and have the capability to purify it, thus providing a meaningful way of mitigating the harmful impact of urban garbage. Vetiver grass has a huge biomass and is able to tolerate adverse conditions, and its effects in ameliorating polluted soil, rehabilitating mine tailings, and tolerating poisonous heavy metals are well demonstrated. Since vetiver has so many excellent properties, it might be possible to use it for sewage purification. The question would be as to its effectiveness. This paper records and discusses an investigation into the impact of growth of vetiver by landfill leachates and its effectiveness in their purification, in comparison to *Alternanthera philoxeroides, Paspalum notatum*, *and Eichhornia crassipes*, with the objective of identifying one or two species of plants that have the ability to purify waste water.

2 MATERIALS AND METHODS

2.1 Experimental Materials The garbage leachate was taken from the sewage-purifying station of Liken Garbage Landfill of Guangzhou. This landfill, located in the northern suburbs of Guangzhou, is about 15 km from downtown. Established in 1992, it is the largest landfill in Guangzhou, and treats some 2600 t of refuse per day. The sewage-purifying station, lies below the landfill and purifies 300 t of leachate per day. The two kinds of leachate used in the trial were collected from the entrance and exit of the station; they consisted of the highly concentrated leachate (HCL) that flowed out of the landfill prior to purification, and the low concentration leachate (LCL) that had been physically cleansed and ready for discharge into the oxidation pond, respectively. Plant materials used were four herbs: Vetiver (*V. zizanioides*), *A.philoxeroides*, *P. notatum*, *and E. crassipes*. Vetiver and *P. notatum* were sampled from the nursery in South China Institute of Botany, and *A.philoxeroides* and *E. crassipes* from ditches and ponds.

2.2 Trial Designs and Arrangements The experiment was conducted with a method of water cultivation in buckets, and undertaken in the glasshouse of South China Institute of Botany. The glasshouse was ventilated and pervious to light. The experiment was arranged in three

treatments: clean water, LCL, and HCL; and three duplicates for each treatment. The operation was as follows: preparing 36 plastic buckets (4 species x 3 treatments x 3 duplicates) with a volume of about 3 dm^3 each, adding 2.50 kg of the 3 liquids above into each bucket, and putting one of the 4 species whose health and weight were basically similar into each bucket. Before the plants were put into the buckets, tops and roots of vetiver and *P. notatum* were pruned to 20 cm and 10 cm, respectively; *A. philoxeroides* was also cut into sections of 20 cm long; but only *E. crassipes* was kept intact; since the whole plant did not exceed 20 cm long. All the plants were weighed and their tiller numbers counted. Water cultivation lasted 66 days (May 12th-July 17, 1997), and observations were made of their growth in the three kinds of water and their efficiencies in purifying waste water. During the period of cultivation, clean water was added to buckets once every 2-4 days to supplement water reduced by transpiration and evaporation, but the amount added each time was no more than that removed. In addition, the two original leachates were also put into four similar buckets, each for 2 buckets and 2.5 kg for each bucket. They were set up at the same time (and were given the same arrangements as the 36 buckets) to investigate the effects of biological and environmental factors, including evaporation, irrigation, vessel absorption, and impacts of sunshine and air, on the water quality of the leachate.

2.3 Observations And Analysis Items 2.3.1 Situations of plant growth in water. Including plant height, number of tillers, biomass of shoots, and length of new roots and their net increased weight.

Items 2.3.2 Effects of plants in purifying leachate. The analytical items contained contents of Fe, Pb, Cd, Zn, Ni in the two types of leachate; and pH and contents of COD, total N, ammoniac N, nitrate N, total P, Cl in the 2 liquids, including prior to and after water cultivation.

2.4 Analytical Methods pH was measured with an acid meter. COD values were acquired through measuring the consumption of dissolved oxygen; the leachates were oxidized with KMnO4; and BOD was also referred to as the consumption of dissolved oxygen after the leachate was incubated for 5 days at 20˚C in an incubator. Alkalinity was measured with titration of double indicators, phenothalin and methyl orange. Total N was oxidized with $K_2S_2O_8$ and analyzed with an ultraviolet spectrophotometer. Ammoniac N and nitrate N were determined with direct distillation and colorimetry of phenoldisulfonic acid ($C_3(CH)_3(HSO_3)_2OH$), respectively. Total P was digestedwith $H_2SO_4HClO_4$, then measured colorimetrically. Cl_3 was determined with titration of $AgNO_3$. Metal elements were all measured with an atomic fluorescence spectroscopy.

3 RESULTS

3.1 Situations of the Water Quality of the Leachate Table 1 shows that the contents of COD, total N, ammoniac N, total P, and Cl_3– in the leachate exiting from the purifying station of Likeng Garbage Landfill were quite high, and were many times (dozens) higher than the highest allowable discharge concentrations of industrial sewage. After purifying, the contents of these items significantly decreased; and artificial purifying rates were between 30-80%. However, the concentration of the exit liquid still went beyond the effluent standard, which exceeded 100 mg/L COD, 210-240 mg/L total N, 1.6 mg/L P and 500-600 mg/L Cl_3, even compared to the second standard of "the standard for comprehensive discharge of sewage of China (GB 8979-88)"[7]. BOD of the two liquids were relatively low, and were within the effluent standard after purifying. Of all items analyzed, only nitrate N in the exit water was much higher than that in intake leachate, suggesting that the nitrification probably took place in the LCL, for oxygen in the air dissolved in the water when the leachate was mechanically cycled, thus aerobic nitrifying bacteria rapidly and greatly multiplied in LCL. Summerfelt et al. observed the contents of nitrate N in sludge from aquaculture rapidly rose from 0.057 mg/L to 45.41 mg/L[4]. Human derived garbage is different from industrial pollutants with reference to heavy metals. The contents of Zn, Pb, Cd, and Ni in the two leachates were far less than that in industrial effluents, even lower than background values in soil, and therefore they generally did not add to the toxicities of heavy metals to the environment.

Table 1 (not included) The water quality of two types of leachate from Likeng Garbage Landfill of Guangzhou and the purifying effect via the purifying station

3.2 Impacts of Environmental Factors on the Water Quality of waste water After the two kinds of leachate had remained undisturbed in the greenhouse for 66 days, it was found that the main factors relating to water quality had changed (Table 2). pH in LCL and HCL increased by 0.42 and 0.45 respectively. COD, alkalinity, N, P, and Cl, which are perhaps detrimental to, or over-nutritious to the environment, all went up or down in varying degrees. Four items that fell were, COD, alkalinity, total N and nitrate N — all were reduced significantly, in the order of 29% - 47% , which indicated that pollutants could be broken down, diluted, oxidized, and evaporated under the impacts of microorganism, rain water, atmosphere, sunshine; and thus the polluted degree of wastewater could be alleviated. The lowering of nitrate N concentration possibly resulted from denitrification.

The amounts of ammoniac N, total P and Cl_3 slightly increased (due to environmental factors as well). It is in-

teresting that the contents of total N in the two leachates went up, but ammoniac N went down. This was probably a result of amination and ammonification of organic substances, which was also perhaps the reason why water pH rose. The two chemical reactions broke down complex organic substances into simple organic and inorganic substances, lowering the amount of organic N, and accordingly reducing total N in the leachate. The products of amination, amino acid, amine and amide, increased in ammoniac N; and the product of ammonification, NH_3, was susceptible to the combination with H+ in water to form NH_4+, which made H+ decrease and comparatively made OH_3 increase.

Table 2 (not included) The changes of water quality of the 2 liquids 66 days after incubating open in the green house

3.3 The growth of the four Species of Plants in Liquids The four species selected all have the characteristics of rapid growth, large biomass, and somewhat or strong tolerance to a poor environment. The water cultivation experiment showed that they all could grow and develop in clean water; vetiver and *A. philoxeroides* were capable of surviving in the two types of liquor; but *P. Notatum* died in the HCL and was severely impaired in the LCL; *E. crassipes* also died in the two leachates.

It is thus clear that: 1) the ability of the four species of plants to resist pollution ranked as: vetiver, *A.philoxeroides* > *P. notatum* > *E. crassipes*, and 2) the sewage from sanitary landfills of Guangzhou indeed polluted the surroundings and poisoned organisms. The growth of vetiver, *A. philoxeroides* and *P. notatum* in clean water and the two leachates is tabulated in Table 3, from which it is noted that the plants, no matter what species, showed large differences in growth in the three kinds of water. It is obvious that *P. notatum* was not suitable to grow in water, and its resistance to pollution was considerably weak. The growth and biomass of *A. philoxeroides* in the three liquids produced the largest disparities, and were significantly in order of LCL > HCL > clean water. It is suggested that water being no high concentration could make *A.philoxeroides* eutrophy, which is coincident with the phenomenon that *A. philoxeroides* widely creeps in filthy sludge or drainage. The growth of vetiver assumed a trend of clean water > LCL > HCL, indicating that it is damaged gradually and becomes more serious with concentration increases.

In addition, the root:shoot ratios of the three species tended to increase with increased liquid concentrations, which was perhaps due to: 1) pollutants inhibiting roots to absorb nutrients and water; and thus their shoots could not obtain sufficient nutritients, and 2) shoots were more sensitive to pollutant toxicity than roots, and therefore the shoot biomass production was diminished more severely than the root. Root:shoot ratio of plants is a useful indicator of environmental stress, e.g. plants, under the condition of water and mineral nutrient deficiency, tend to have increased root:shoot ratios in order to increase the root surface absorption capacity[9].

Table 3 (not included) The growth situations (mean SD) of three species in clean water and two leachates

The most conspicuous feature of vetiver is its deep and massive root system . In the present study, however, vetiver did not exhibit the characteristics at all, except that it produced a slightly greater root biomass in clean water than the other two species. Vetiver was inferior to *P. Notatum* in root length, and inferior to *A. philoxeroides* in relation to net increment of roots in waste water (Table 3). It is most likely that the aquatic environment was unfavorable for the root growth of vetiver. The net increment of biomass of vetiver in clean water was significantly more than that of *A. philoxeroides and P. Notatum* (Fig. 1),which might be because the former was better than the latter two with special reference to the endurance to infertility. The biomass gained by *A. philoxeroides* in LCL was far more than in other treatments and by other plants; whereas vetiver had more biomass than *A. philoxeroides* in HCL. This suggests that: 1) vetiver is an excellent plant in its tolerance of low nutrient status and to pollution; 2) although *A. philoxeroides* grew better in water than the other two species, it had a poor ability to tolerant nutrient deficiencies, for its growth in clean water was even weaker than that of *P. Notatum*; 3) *A. philoxeroides* could take advantage of "pollutants/nutrients" in water, when the concentration was not very high, resulting in a diffusion of growth ; and 4) *P. notatum* was obviously not appropriate for the aquatic habitat.

Fig. 1 (not included) Effects of different water-cultivated treatments on biomass of the three species

3.4 The Purification of Vetiver, *A. philoxeroides*, and *P. notatum* for Garbage Sewage After cultivating plants for 66 days, the concentration of almost all "pollutants" measured in the two liquids had decreased substantially, when compared to their original concentration (Table 1), except for Cl_3 in the LCL that supported *P. notatum*, which was the only one to increase (Table 4). The element that declined the most was the content of total N in LCL supporting *A.philoxeroides*, which decreased from 293.8 mg/L to 23.9 mg/L, a reduction of 92%; the factor that had the highest reduction was alkalinity in HCL supporting vetiver, which dropped from 1882.9 mg/L to 365.5 mg/L, a reduction of 1517.4 mg/L. The results indicated that both vetiver and *A.philoxeroides* impacted positively in improving the quality of leachates. Most of the seven indica-

tor factors/elements showed decreases in concentration levels due to the purifying effect of plants than did the controls (Table 2). It is also noted in Table 4 that some items varied greatly thus significantly effecting water quality, indicating the different effect of the three species on the leachates were different. For HCL, the water quality of the leachate supporting vetiver was generally better than that cultivating *A. philoxeroides*, whereas the water quality in LCL assumed a trend of cultivating *A. philoxeroides* better than cultivating vetiver than cultivating *P. Notatum*.

Table 4 (not included) The water quality (mean SD) of two leachates 66 days after being affected by three species of plants.

The concentration (Table 2) after open incubating minus the concentration (Table 4) after cultivating plants is equivalent to the purifying efficiency of plants on the leachates. All three species had purifying impacts on the seven "pollutants" in varying degrees, their purifying rates varying from 11% to 91%, but there were no efficiencies in the purifying of P. notatum for Cl_3 and nitrate N, and of vetiver on nitrate N. Among the 7 observed items, ammoniac N was removed almost completely, at rates between 83% - 91%, suggesting that ammoniac N was directly taken up by plants as the most available N resource. Next was the purification of vetiver for P, and its purifying rates in the two kinds of leachate all were above 70%, which suggests that vetiver also had a large uptake capacity or a strong purifying impact on P. In addition, the purification by *A. philoxeroides* for nitrate N was tangibly superior to that of vetiver and of *P. notatum*. on HCL. The effects of vetiver in purifying the seven "pollutants" were all better than that of *A. philoxeroides*; particularly in COD and P, the two species produced a significant difference (Table 4,5). In LCL*, A. Philoxeroides* could make use of "pollutants" as its nutrient resource, as a result its purifying efficiency on sewage was stronger than that of vetiver and *P.notatum*, especially on nitrate N and total N; but the purifying rates of vetiver on P was still the highest.

Table 5 (not included) A comparison of purifying effects of three species on two leachates

4 DISCUSSION

In the 1950's vetiver was noted to be effective in soil and water conservation. Since the middle 1980's, this plant has been widely used through the subtropics and tropics, following its introduction and recommendation of The World Bank and The Vetiver Network. Up to now there have been at least 140 countries and regions researching, disseminating and applying the vetiver bio-engineering technology. The effects of vetiver in ameliorating soil, rehabilitating mine tailings and industrial polluted areas are also quite good. Presently vetiver has been found to have at least 31 uses (Grimshaw, 1996),and it is extensively called a miracle grass. It is clear from this study that the effect of vetiver in purifying garbage leachates was also pretty ideal, though the plant itself had been stressed and hurt by the leaching liquids. The increased biomass of vetiver gradually reduced in clean water, LCL, and HCL (Fig.1), indicating that the rate of growth of vetiver was gradually reduced with the concentration increases. However, the new increments of biomass of vetiver when grown in clean water and HCL were the highest compared to that of *A. philoxeroides* and *P. notatum*, suggesting that : 1) vetiver was the most tolerable to low plant nutrient levels; and 2) vetiver had the strongest resistance to polluted water, as it was damaged least in HCL. In addition, vetiver had a good effect in reducing levels of P (Table 5), probably due to its strong uptake capacity of P.

The previous studies have showed that vetiver planted in infertile soil was effective in improving soil [11,12]; and it could also increase the contents of organic matter, total N, available N and K in soil, but dwindle the content of available P[12]. These results suggest that vetiver is likely to be a "phosphorous-sucking" plant. Although vetiver's ability to cleanse LCL on was not as good as *A. philoxeroides*, its effect in purifying COD was tangibly superior to *A. philoxeroides*; furthermore, both had the similar purifying ability to reduce ammoniac N levels by as much as 90%. **More importantly, the effects of vetiver in removing the measured seven pollutants in HCL all surpassed that of *A. Philoxeroides*.**

Summerfelt etal. even found that vetiver established in wetland could effectively remove extra solids and nutrients in aquaculture sludge, and the removal rates to suspended solids, total COD, dissolved COD, total kjeldahl N, total P, and dissolved P were 96%-98%, 72%-91%, 30%-81%, 86%-89%,82%-90%, and 92%-93%, respectively[4].

A. philoxeroides is a special amphibious plant, having a widespread distribution in such filthy and wet areas as septic tanks and ditches. It too has pretty strong tolerance to adversity. The results obtained from our study showed that the effects of *A. philoxeroides* in purifying LCL was considered good, particularly its removal rates of nitrate N, total N, and alkalinity were even higher than that of vetiver (Table 5). Moreover, *A. philoxeroides* produced a far greater biomass than other treatments and other species (Fig. 1), indicating that LCL probably had an action of eutrophication on *A. philoxeroides*. According to Gao et al. recent report, the removal rates by *A. philoxeroides* to N and P in run-off were 77% and 64%, respectively [13]. Observations in this paper found that this plant had a higher purifying rate on ammoniac N, up to 83% - 89%, but its removal of P was not so good, and the removal rate was only 39%-48% (Table

5). Many documents have reported that the hydrophyte *E. crassipes* is an excellent purifying plant, but about its tolerance to adversity has been poorly documented. *P. notatum* is a xerophyte, and has somewhat strong tolerance to adverse conditions when established in soil. This research work showed that the resistance of *E. crassipes* to adversity was quite poor as it was in the two leachates; and *P. notatum* did not grow in water at all, and thus it was impossible to use in polluted water. In addition, both vetiver and *A. philoxeroides* were severely impaired by HCL, and furthermore the latter was probably "over-nurtured" by LCL. These phenomena all indicate that the leachates, even having been purified by the purifying station, from garbage landfills in Guangzhou were toxic or eutrophic to the environment, and therefore it needs to be further improved.

All in all, the resistance and purifying ability of the four species of *plants investigated in the paper were ranked in the sequence of vetiver> A. philoxeroides > P.* notatum > *E. crassipes*, of which vetiver and *A. philoxeroides* were capable of being used as biological measures to assist purifying waste water. When the concentration of waste water is not high, it had better be purified with *A. philoxeroides* . However low concentrate waste water perhaps has an action of eutrophication on this plant, so measures should be taken to prevent it from its invasive tendency to block the water course when *A. philoxeroides* is chosen to purify waste water. As to highly concentrated waste water, vetiver is a better choice. However vetiver is not a hydrophyte, and it can not suspend directly in water to grow as *A. philoxeroides*, but needs a prop system to fasten it. In addition to this, vetiver shoots should be trimmed for it grows rapidly and has a considerably large biomass, and only by doing so can vetiver sustainably absorb pollutants in water, and make itself become a "super-bioaccumulator".

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Canal cut at Manupali, Philippines, stabilized with vetiver grass hedge rows

DNA FINGERPRINTS (RAPDS) OF THE PANTROPICAL GRASS VETIVER, *VETIVERIA ZIZANIOIDES* (L.) NASH (GRAMINEAE), REVEAL A SINGLE CLONE, ÔSUNSHINEÕ IS WIDELY UTILIZED FOR EROSION CONTROL

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INTRODUCTION

Elite germlines of *Vetiveria* Nash have long been cultivated for their fragrant roots, which contain the essential Oil of Vetiver. This oil is clearly distinguished chemically and in commerce from Khus oil, which comes from natural (fertile) populations of V. zizanioides in the Ganges Plain of north India (CSIR, 1976) The Oil of Vetiver (commercial, essential oil *type*) has long been produced pantropically through via Vetiver cuttings. Within the past decade, vetiver occurrence has increased enormously through widespread plantings (over 100 countries) to form hedges for stabilizing soil and controlling waterflow.

One of the desirable features of most hedgerow (essential oil) vetiver is that it is non fertile (produces no seed or seeds do not produce viable seedlings), and so it must be propagated from cuttings (clumps of rootstock). Because it does not reproduce by seed, for centuries it has been a very well-behaved grass throughout the tropics and subtropics. It has not escaped cultivation or become a weed. However, the mere fact that it is always distributed by cuttings could lead to the widespread cultivation of a single clone. This could be extremely dangerous. An insect or disease adapted to a particular genotype could spread and decimate millions of erosion control terraces of vetiver. In order to investigate this concern, we assembled leaf materials from around the world and compared these accessions to known wild and related materials using RAPDs (DNA fingerprints).

Genetic variability was initially investigated by Kresovich et al. (1994), who reported on vetiver variation in the United States. They found RAPD patterns were very stable within clones, that the non fertile 'Huffman' and 'Boucard' cultivars were identical (>.99+), and that these were clearly distinct from the USDA PI 196257 seed introductions from north India (Simla, Punjab). Interestingly, they found that three samples of this USDA accession (#s 1,2,3), though similar, were genetically distinct from one-another. They concluded that RAPDs would be useful for identifying truly distinct sources of genetic diversity. Srifah et al. (in press) confirmed this in Thailand (where vetiver is ancient if not indigenous) by showing that RAPDs could easily distinguish among landrace "ecotypes".

MATERIALS AND METHODS

The reader is referred to Adams et al. (in press) for DNA extraction and analyses. However, it should be noted that a number of the accessions that were merely air dried or shipped fresh did not yield any DNA or the DNA was so degraded that it could not be analyzed. In the future, material submitted for DNA analysis should be small (actively growing) leaves, picked fresh and immediately placed into activated silica gel or other suitable drying agent.

RESULTS AND DISCUSSION

An initial screening of accessions (n=53) using 222 banding patterns found almost no variation among cultivated materials. The pattern obtained by primer 268 is typical of that obtained using primers 184, 239, 249, 327, and 346. Essentially no variation was detected in an initial twenty-seven accessions for outside south Asia, except for a quite-similar accession from Malawi.

A second series of accessions (n=68) were analyzed running only one highly discriminating primer (268). This analysis, while revealing additional variation in non fertile types, reinforced patterns that form several distinct genetic clusters. These groupings are validated by correspondence to botanical taxa and field observations (reports of fertility), see Table 1.

Of 60 total samples submitted from 29 countries outside south Asia, 53 (88%) were a single clone of *Vetiveria zizanioides*. At least two-thirds of these samples were first accessioned from traditional, in-country sources, i.e, oil producers, herbalists, botanical gardens, and other planted sites, and therefore may be considered representative of *ex situ* vetiver populations. Because vetiver is vegetatively propagated, it thus appears that one single essential-oil clone (which we are denoting as 'Sunshine' because of accession priority) is densely distributed throughout the

tropics. Its introduction[s] was done certainly before WWII and most likely before this century. For instance, vetiver has been in the United States since at least the early 19th century, although the earliest authenticated germline identifications are currently 'Vallonia', South Africa, via Mauritius, c. 1900, M. Robert; 'Monto', Australia, 1930s, P. Truong; 'Sunshine', USA, 1960s, E. LeBlanc; and MY044693 & MY081268, Venezuela, 1982, O. Rodriguez; (information from Vetiver Network members). Such a consistent identity in a spatially and temporally scattered distribution implies that virtually all of the *Vetiveria zizanioides* outside South Asia could be the single 'Sunshine' genotype, which today certainly dominates soil stabilization and waterflow control usage.

CONCLUSIONS

Based on DNA fingerprinting data, it appears that almost all the vetiver used for erosion control outside South Asia has been derived from a single genotype, which we call 'Sunshine'. Nevertheless, discontinuities of geographic and genetic patterns in our analysis imply much vetiver diversity awaits discovery. There is a critical need to screen other, reportedly non fertile vetivers to uncover additional germlines to diversify current and future plantings of this very important "hedge against erosion" (NRC, 1993). Especially needed are samples from areas on the periphery of south Asia, where vetiver has been cultivated for centuries. Common garden studies are planned using the divergent vetiver accessions in Table 2. Further promising germplasm needs to be accessioned and observed. The challenge is to assure the genetic diversity of cultivated vetiver, which is proving of immense importance to agricultural stabilization and civil engineering.

Table 1. Preliminary classification of vetiver accessions by DNA fingerprinting. A = pattern based on 6 primers: 184, 239, 249, 268, 327, and 346. B = pattern based only on primer 268.
Fertile codes: N = no, Y = yes, F = fully, L = low, + = confirmed, - = assumed, ? = unknown.
*** = botanically verified at the species level.**

Accession #	Lab #	Species	Source (other locations)	Fertile?
Vetiveria zizanioides (L.) Nash Sunshine clone (S) (= Haiti, Monto, Boucard, Huffman, Vallonia)				
SA	VET-RPA-7655	7655	V. zizanioides, Haiti, Massif de la Selle, 1600 amsl	N+
SA	VET-RPA-7659	7659	V. zizanioides, Haiti, Marigot, 8 amsl	N+
SA	VET-RPA-7660	7660	V. zizanioides, Haiti, Jacmel, 3 amsl	N+
SA	VET-RPA-7661	7661	V. zizanioides, Haiti, Jacmel, 3 amsl	N+
SA	VET-RPA-7663	7663	V. zizanioides, Haiti, Massif de la Selle, 820 amsl	N+
SA*	VET-PT-1A	7711	V. zizanioides cv. 'Monto', Australia, Queensland	N+
SA*	VET-PT-1B	7712	V. zizanioides cv. 'Fiji', Australia, Queensland (Fiji)	N+
SA*	VET-PT-1D	7714	V. zizanioides, Australia, Queensland (Western Australia)	N+
SA*	VET-PT-1E	7715	V. zizanioides, New Guinea	N+
SA	VET-RGG-PA-A	7719	V. zizanioides, Panama, site A	N+
SA	VET-RGG-CR-A	7721	V. zizanioides, Costa Rica, San Jose	N+
SA*	VET-MR-VAL1	7722	V. zizanioides cv. 'Vallonia', South Africa, Natal	N+
SA	VET-OSR-1.0	7729	V. zizanioides, Venezuela, Maracay (flowers some)	N+
SA	VET-DEKN-1001	7730	V. zizanioides, Aneityum Island, Pacific	N+
SA	VET-DEKN-1003	7731	V. zizanioides, Efate Island, Pacific	N+
SA	VET-DEKN-1002	7732	V. zizanioides, Atiu Island, Pacific	N+
SA	VET-DEKN-1004	7733	V. zizanioides, Mangaia Island, Pacific	N+
SA	VET-GVB-001	7742	V. zizanioides cv. 'Boucard', USA, Texas, (Haiti or Guatemala)	N+
SA	VET-MJ-F1	7747	V. zizanioides, USA, North Carolina	N+
SA	VET-MJ-F2	7748	V. zizanioides, USA, North Carolina	N+
SA*	VET-MRL-0001	7749	V. zizanioides cv. 'Sunshine', USA, Louisiana	N+
SA	VET-MRD-0001	7750	V. zizanioides cv. 'Sunshine', USA, Louisiana	N+
SA	VET-MRD-0002	7751	V. zizanioides cv. 'Huffman', USA, Florida (Louisiana)	N+
SA	VET-RDH-0001	7767	V. zizanioides, Hong Kong (Thailand?)	N-
SA	VET-RDH-0002	7768	V. zizanioides, Hong Kong (South China)	N-

SB	VET-JG-23	7773	V. zizanioides, New Zealand, Northland	N
SB	VET-EB-5997	7776	V. zizanioides, Netherlands Antilles, Bonaire (USA)	N
SB	VET-JGN-0001	7777	V. zizanioides, USA, California	N+
SB	VET-EAB-5262	7950	V. zizanioides, Philippines, Leyte	N
SB	VET-CXH-0001	7952	V. zizanioides, China, Guiyang	N+
SB	VET-JA-1-1	7954	V. zizanioides, Kenya, Nairobi, ICRAF	N
SB	VET-JA-1-3	7956	V. zizanioides, Peru, Iquitos, ICRAF	N
SB	VET-JA-1-4	7957	V. zizanioides, Peru, Iquitos, ICRAF	N
SB	VET-JA-2-3	7960	V. zizanioides, Peru, Iquitos, ICRAF	N
SB	VET-OSR-1-B	7961	V. zizanioides, Venezuela, Maracay (Carabobo)	N+
SB*	VET-OSR-2	7962	V. zizanioides, Venezuela, Maracay (Bajo Seco)	N+
SB	VET-HGR-01	7965	V. zizanioides, Colombia, Bogota	N+
SB	VET-TS-F1	7967	V. zizanioides, Ethiopia, Filakit	N+
SB	VET-TS-F2	7968	V. zizanioides, Ethiopia, Filakit	N+
SB	VET-TS-F3	7969	V. zizanioides, Ethiopia, Filakit	N+
SB	VET-TS-D1	7970	V. zizanioides, Ethiopia, Digitosh	N+
SB	VET-TS-D2	7971	V. zizanioides, Ethiopia, Digitosh	N+
SB	VET-TS-M1	7973	V. zizanioides, Ethiopia, Minikaba	N+
SB	VET-TS-M2	7974	V. zizanioides, Ethiopia, Minikaba	N+
SB	VET-TS-M3	7975	V. zizanioides, Ethiopia, Minikaba	N+
SB	VET-HP-01	7986	V. zizanioides, Honduras, Zamorano	N
SB	VET-HP-03	7988	V. zizanioides, USA, Florida (Louisiana)	N
SB	VET-JMJS-VC1	8000	V. zizanioides, Mexico, Oaxaca (Vera Cruz)	
N				
SB	VET-CED-0001	8002	V. zizanioides, Bolivia, Sucre (MASDAR germplasm?)	N
SB	VET-DD-A1	8005	V. zizanioides, Ethiopia, Dilla, Gedio	
N				
SB	VET-DD-B1	8006	V. zizanioides, Ethiopia, Dilla, Gedio	
N				
SB	VET-DD-C1	8007	V. zizanioides, Ethiopia, Dilla, Gedio	N
SB	VET-MB-01	8029	V. zizanioides, cv. 'Huffman', USA, Florida (Louisiana)	N+

Sunshine affinities: (S- = Sunshine pattern with one missing band, S+ = Sunshine pattern with one additional band).

S+B	VET-IPA-MUIR-001	7989	V. zizanioides, Mozambique, Maputo	?
S+B	VET-LW-0001	8048	V. zizanioides cv. 'Capitol', USA, Louisiana	N
S-B*	VET-TGAVC-002	8051	V. zizanioides cv. 'AVC', Spain, Murcia (Malaysia, India?)	N+

Sri Lanka (Chiapas) clone (SL):

SLB*	VET-RN-001	7951	V. zizanioides, Sri Lanka, Colombo	N-
SLB	VET-IMZ-AGA	7765	V. zizanioides, Malawi, Lilongwe	N-
SLB	VET-SBR-VNN-96/2	7993	V. zizanioides, Sri Lanka, Kandy	N-
SLB	VET-SBR-VNN-96/3	7994	V. zizanioides, Sri Lanka, Kandy	N-
SLB	VET-SBR-VNN-96/4	7995	V. zizanioides, Sri Lanka, Kandy	N-
SLB	VET-SBR-AN-96/2	7997	V. zizanioides, Sri Lanka, Kandy	N-
SLB	VET-SBR-AN-96/4	7999	V. zizanioides, Sri Lanka, Kandy	N-
SLB	VET-JMJS-CH1	8001	V. zizanioides, Mexico, Oaxaca (Chiapas)	N-

'Farmers Fodder' or 'Karnataka' (KM)

KMB *	VET-TGKN-003	8052	V. zizanioides cv. 'Karnataka', Spain, Murcia (Malaysia, India)	N+

'Breeder' complex (G):

GB*	VET-UCL-027	7981	V. zizanioides, India, Lucknow, CIMAP	L?

GB*	VET-HP-02	7987	V. zizanioides, India, Uttar Pradesh, (USDA PI 554617, 'Carter')	YL
'Breeder' affinities: G+, G++ = with one(+) or two (++) extra band(s); G- = with a missing band.				
G+B	VET-JGN-0002	7778	V. zizanioides, USA, California (Philippines?)	YL?
G++B*	VET-UCL-024	7980	V. zizanioides, India, Lucknow, CIMAP	?
G+B*	VET-UCL-040	7982	V. zizanioides, India, Lucknow, CIMAP	?
G-B*	VET-UCL-042	7983	V. zizanioides, India, Lucknow, CIMAP	?
G+B*	VET-UCL-045	7984	V. zizanioides, India, Lucknow, CIMAP	?
G+-B*	VET-UCL-M1	7985	V. zizanioides, India, Lucknow, CIMAP	?
Khus type of Northern India (Kh): (similar to Indian type I, cf. 7761)				
KhB*	VET-SCRC-001	8035	V. zizanioides, USA, USDA (India)	YF+
'Ganges' complex (North India), loose group with considerable banding differences.				
IB*	VET-BANG-B001	7723	V. zizanioides, Bangladesh	YF+
IB*	VET-BANG-B002	7724	V. zizanioides, Bangladesh	YF+
IB*	VET-BANG-B003	7725	V. zizanioides, Bangladesh	YF+
IB*	VET-BANG-B004	7726	V. zizanioides, Bangladesh	YF+
IB*	VET-USDA-U1	7735	V. zizanioides, India, Punjab, Simla **(USDA PI 196257)**	YF+
IB*	VET-USDA-U2	7736	V. zizanioides, India, A-3225 (USDA PI 213903) Y	F+
IB*	VET-USDA-U3	7737	V. zizanioides, India (USDA PI 271633)	YF+
IB*	VET-USDA-U4	7738	V. zizanioides, India, A-7026 (unverified) (USDA PI 302300)	YF+
IB*	VET-USDA-U5	7739	V. zizanioides, India, NBPGR Hybrid 7 (USDA PI 538753)	YF+
IB*	VET-USDA-U6	7740	V. zizanioides, India, BE-2668, NBPGR Hybrid 8 (USDA PI 538754)	YF+
IB*	VET-USDA-U7	7741	V. zizanioides, India, BE-2668, NBPGR Hybrid 26 (USDA PI 538756)	YF
IB	VET-K-Dtp-1	7752	V. zizanioides, India, Orissa	YF+
IB	VET-K-Pub-2	7753	V. zizanioides, India, Orissa	YF+
IB	VET-K-Dnk-3	7754	V. zizanioides, India, Orissa	YF+
IB	VET-K-Brk-8	7759	V. zizanioides, India, Orissa	YF+
IB	VET-U-Blp-9	7760	V. zizanioides, India, Orissa	YF+
IB	VET-U-Nlg-10	7761	V. zizanioides, India, Orissa	YF+
IB	VET-U-Gsg-11	7762	V. zizanioides, India, Orissa	YF+
IB	VET-U-Bdm-12	7763	V. zizanioides, India, Orissa	YF+
IB	VET-CWDS-01	7764	V. zizanioides, Nepal, Kathmandu (lowlands) (low flowering)	?
IB*	VET-UCL-005	7976	V. zizanioides, India, Lucknow, CIMAP	?
IB*	VET-UCL-007	7978	V. zizanioides, India, Lucknow, CIMAP	?
IB*	VET-BANG-B006-B	8037	V. zizanioides, Bangladesh	YF+
Ganges affinities: I- = Ganges type with one missing band:				
I-B*	VET-BANG-B005-B	8036	V. zizanioides, Bangladesh	YF+
I-B*	VET-TGSB-004	8053	V. zizanioides, cv. 'Sabah', Spain, Murcia (Malaysia, India?)	N
I-B*	VET-TGSBB-005	8054	V. zizanioides, cv. 'Sabik Bern', Spain, Murcia (Malaysia, India?)	N+
Grafton type (Gr):				
GrA*	VET-PT-1C	7713	V. zizanioides cv. 'Grafton', Australia, Queensland	YL+
GrB	VET-SBR-AN-96/1	7996	V. zizanioides, Sri Lanka, Kandy	?

Other V. zizanioides banding patterns (O):(various banding, each of which is different)

OB	VET-SJC-2	7775	V. zizanioides, Malawi, Zomba	N+
OB*	VET-TGML-001	8050	V. zizanioides, cv. 'Malaysia', Spain, Murcia (Malaysia, India?)	N+
OB*	VET-TGPB-006	8055	V. zizanioides, cv 'Parit Bunt', Spain, Murcia Malaysia, India?)	N+
OB	VET-JM-PV1	8076	V. zizanioides? Costa Rica, Puerto Viejo	N?

Other Vetiveria species:

V. elongata (R. Br.) Stapf (Eg): (very similar to one another)

EgA*	VET-PT-2A	7716	V. elongata, (narrow leaf), Australia, Northern Territory	YF-
EgA*	VET-PT-2B	7717	V. elongata, (broad leaf), Australia, Northern Territory	YF-

V. filipes (Benth.) C.E.Hubb. (Fp) (quite distinct, 7772 may be a different species or genus)

FpB*	VET-PT-2C	7718	V. filipes, Australia	YF-
FpB*	VET-FA-257810	7772	V. filipes, Australia, USDA PI 257810	YF+

V. nigritana (Benth.) Stapf (Ng): (very similar to one another)

NgA	VET-ISV-AGA	7766	V. nigritana, Malawi, Lilongwe (few seed)	YL?!
NgB	VET-SJC-1	7774	V. nigritana, Malawi, Zomba	YF+

Possible other Vetiveria / Chrysopogon species

PA	VET-RGG-PA-B	7720	Vetiveria sp.?, Panama, Western, site B (Costa Rica)	?
VbB	VET-BANG-B005	7727	Vetiveria sp.?, Bangladesh	YF+?
VbB	VET-BANG-B006	7728	Vetiveria sp.?, Bangladesh	YF+?

Other Genera:

Chrysopogon Trin.

CfA*	VET-CFP-219579	7769	C. fulvus (Spreng.)Chiov., Pakistan (USDA PI 219579)	YF
CgA*	VET-CGP-383762	7771	C. gryllus (L.) Trin., Turkey (USDA PI 383762)	YF
CaB*	VET-BANG-B007	8038	C. aciculatus (Retz.) Trin., Bangladesh	YF+
CnB*	VET-JVTH-ZN001	8040	Chrysopogon nemoralis (Balansa) Holttum (recv'd as Zizania nemoralis (Balansa) Camas), Thailand	Y?F?

Sorghum Moench.

ShA*	VET-AW-01	8030	S. halepense (L.) Pers., USA, Texas	YF+
SbA*	VET-RPA-8030	8030	S. bicolor (L.) Moench., USA, Texas	YF+

Not tested: (NT = not tested; D = degraded DNA, see text)

NT	VET-MJ-B1	7701	V. zizanioides, USA, North Carolina, fungus on seeds	
NT	VET-MJ-B2	7702	V. zizanioides, USA, North Carolina, fungus on seeds	
NT	VET-MJ-B3	7703	V. zizanioides, USA, North Carolina, fungus on seeds	
NT	VET-MJ-B4	7704	V. zizanioides, USA, North Carolina, fungus on seeds	
NT	VET-MJ-B5	7705	V. zizanioides, USA, North Carolina, fungus on seeds	
NT*	VET-USDA-F1	7734	V. filipes, Australia, USDA (PI 257810) (duplicate acc. under 7772)	YF+
NT	VET-K-Bdln-4	7755	Vetiveria sp., India, Orissa	YF+
NT	VET-K-Bdln-5	7756	Vetiveria sp., India, Orissa	YF+
NT	VET-K-Bdln-6	7757	Vetiveria sp., India, Orissa	YF+
NT	VET-K-Bdln-7	7758	Vetiveria sp., India, Orissa	YF+
NT	VET-JSC-0001	7953	V. zizanioides?, Cambodia (Australia)	?

NT	VET-JBH-1267	8039	C. schmidianus, Laos	?
DNA too degraded to use:				
D*	VET-USDA-B6	7706	V. zizanioides, India, Punjab, Simla (USDA PI 196257)	YF
D*	VET-USDA-B7	7707	V. zizanioides, India, Punjab, Simla (USDA PI 196257)	YF
D*	VET-USDA-B8	7708	V. zizanioides, India, Punjab, Simla (USDA PI 196257)	YF
D*	VET-USDA-B9	7709	V. zizanioides, India, Punjab, Simla (USDA PI 196257)	YF
D*	VET-USDA-B10	7710	V. zizanioides, India, Punjab, Simla (USDA PI 196257)	YF
D*	VET-CFI-554618	7770	C. fulvus (Sprengel) Chiov., India (USDA PI 554618)	YF
D	VET-EAB-5261	7949	V. zizanioides, Philippines, Leyte	?
D	VET-JA-1-2	7955	V. zizanioides, Kenya, Nairobi, ICRAF	?
D	VET-JA-2-1	7958	V. zizanioides, Kenya, Nairobi, ICRAF	?
D	VET-JA-2-2	7959	V. zizanioides, Kenya, Nairobi, ICRAF	?
D	VET-NSC-01	7963	V. zizanioides, Cameroon, Mbingo Bamenda (Nigeria)	?
D	VET-NSC-02	7964	V. zizanioides, Cameroon, Maroua	?
D*	VET-HGR-02	7966	V. zizanioides, Colombia, Cundinamarca (flowering)	?
D	VET-TS-D3	7972	V. zizanioides, Ethiopia, Digitosh	N+
D*	VET-UCL-006	7977	V. zizanioides, India, CIMAP	?
D*	VET-UCL-008	7979	V. zizanioides, India, CIMAP	?
D				
O	VET-SBR-VA-96/1	7990	V. zizanioides, Sri Lanka, Kandy	N?
D	VET-SBR-VH-96/1	7991	V. zizanioides, Sri Lanka, Kandy	N?
D	VET-SBR-VNN-96/1	7992	V. zizanioides, Sri Lanka, Kandy	N?
D	VET-SBR-AN-96/3	7998	V. zizanioides, Sri Lanka, Kandy	?
D	VET-BBG-001	8003	V. zizanioides, Ghana, Central	N+
D	VET-BBG-02	8004	V. fulvibarbus, Ghana, Central	N+

Table 2. Germplasm of high priority for maintenance and evaluation.

Type	Accession #	Lab #	Species	Source	Fertile?
SA	VET-PT-1A	7711	V. zizanioides cv. 'Monto', Australia, Queensland		N+
SA	VET-MR-VAL1	7722	V. zizanioides cv. 'Vallonia', South Africa		N
SA	VET-GVB-001	7742	V. zizanioides cv. 'Boucard', USA		N+
SB	VET-MRL-001	7749	V. zizanioides cv. 'Sunshine', USA. Louisiana		N
SB	VET-MB-01	8029	V. zizanioides cv. 'Huffman', USA, Florida		N+
SB	VET-OSR-1-B	7961	V. zizanioides, Venezuela, Maracay (Carabobo)		N+
S+B	VET-IPA-MUIR-001	7989	V. zizanioides, Mozambique, Maputo		?
S+B	VET-LW-0001	8048	V. zizanioides cv. 'Capitol', USA, Louisiana		N
S-B	VET-TGAVC-002	8051	V. zizanioides cv. 'AVC', Spain, Murcia (Malaysia, India?)		N+
SLB	VET-IMZ-AGA	7765	V. zizanioides, Malawi, Lilongwe		?!
SLB	VET-RN-001	7951	V. zizanioides, Sri Lanka, Colombo		N+?
SLB	VET-JMJS-CH1	8001	V. zizanioides, Mexico, Oaxaca (Chiapas)		N+?
CRB	VET-JM-PV1	8076	V. zizanioides? Costa Rica, Puerto Viejo		N?
GrA	VET-PT-1C	7713	V. zizanioides cv. 'Grafton', Australia, Queensland		YL+
GrB	VET-SBR-AN-96/1	7996	V. zizanioides, Sri Lanka, Kandy		?
G+B	VET-JGN-0002	7778	V. zizanioides, USA, California (Philippines?)		YL?
KMB	VET-TGKN-003	8052	V. zizanioides, cv. 'Karnataka', Spain, Murcia (Malaysia, India)		N+
GB	VET-HP-02	7987	V. zizanioides, India, Uttar Pradesh, (USDA PI 554617, 'Carter')		YL+
PA	VET-RGG-PA-B	7720	Vetiveria sp.?, Panama, Western, site B (Costa Rica)		?
OB	VET-SJC-2	7775	V. zizanioides, Malawi, Zomba (few seed heads)		?

OB	VET-TGML-001	8050	V. zizanioides, cv. 'Sabik Bern', Spain, Murcia (Malaysia, India?)	N+
I-B*	VET-TGSB-004	8053	V. zizanioides, cv. 'Sabah', Spain, Murcia (Malaysia, India?)	?
I-B*	VET-TGSBB-005	8054	V. zizanioides, cv. 'Sabik Bern', Spain, Murcia (Malaysia, India?)	?
OB	VET-TGPB-006	8055	V. zizanioides, cv. 'Sabik Bern', Spain, Murcia (Malaysia, India?)	N+

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CHINA VETIVER NETWORK VETIVER CONFERENCE
FUZHOU, CHINA
ABSTRACTS OF PAPERS

Recent Development of Vetiver Technology in China through the China Vetiver Network

Xu LiYu (The China Vetiver Network, Naning 21008)

Although it was introduced into China as early as the 1950's as a plant for extracting oil from its roots the valuable grass vetiver (*Vetiveria zizanioides*) was also identified in the late 1980's as a plant to assist the formation of soil erosion control hedges. Since the 1980's, vetiver grass has been experimented with or tested in most provinces in southern China, as in JiangXi, FuJian, SiChuan, HuNan, GuiZhou, HaiNan, GuangDong, GanSu, HeNan, ShanDong, and ZheJiang. Recently, great progress has been made in accelerating vetiver technology extension throughout China. This work was coordinated by the China Vetiver Network (CVN) in cooperation with numerous institutions in various disciplines. Some examples of work conducted by the CVN include:

(1). National information service. The national information service focused attention on the southern part of China where tropical and subtropical climates dominated. The vetiver publications (newsletters, fact sheets, and a journal) were distributed to many national universities, research institutions, government offices, provincial institutions, and also many county level and some township level extension stations.

(2). Field surveys and investigations. Aimed at disseminating vetiver technology, discovering new users and exploring new vetiver applications, field surveys and investigations were carried out in FuJian, JiangXi, GuangDong, HuBei, HuNan, and AnHui Provinces. These investigations were organized by the China Vetiver Network in cooperation with numerous multi-disciplinary institutions at national, provincial, prefec-

tural, county, and township levels. Through these investigations team members learned experiences from established vetiver application models and proposed new applications. In addition, with the distribution of more and more publications and with increasing discussion among vetiver extensionists, local technicians and farmers, more people were becoming familiar with vetiver grass.

(3) Supporting partners to test vetiver grass. The China Vetiver Network has supported partners who tested and utilized vetiver grass by providing micro-grants and information services. The followings are some examples:

- The FuZhou Soil and Water Conservation Station, FuJian Province,
- The Botanical Institute of South China, GuangDong,
- The reproduction base in the DaBie Mountains, AnHui Province.

(4). Encouraging different institutions to use vetiver. Since the establishment of the CVN in 1996, more and more people expressed their interests in applying vetiver grass based on their own budget and existing project conditions. The CVN has provided them with information, documents, and/or planting materials and encouraged them to use and extend vetiver grass technology.

(5). Preparation of new development proposals through joint efforts. Based on multiple surveys, investigations and exchange programs, several proposals or concept papers were prepared. These played and will continue to play an important role in accelerating the dissemination and development of vetiver technology throughout the country and will keep the CVN young and vigorous.

Natural Vetiver Communities Distributed in China

Xia HanPing and Ao HuiXiu(South China Institute of Botany, Academia Sinica, GuangZhou 510650)

Vetiver (*Vetiveria zizanioides*), an excellent hedgerow for soil and moisture conservation, is being widely disseminated and applied in the tropics and sub-tropics. Generally speaking, China's vetiver was introduced in the middle 1950s from Indonesia and India. The Vetiver Network has never reported any wild vetiver distribution in China, nor have any of the pertinent monographs. Our investigations, however, indicate that there have been natural distributions of vetiver communities in GuangDong and HaiNan Provinces.

As early as 1936, a botanist named Liu XinQi collected wild vetiver samples in HaiNan, and specimens have been preserved in the Herbarium of the South China Institute of Botany (SCIB). Later, in 1960, ecologists from SCIB made a survey of vegetation types in HaiNan and found natural distributions of the plant near lagoons.

A natural vetiver community with a total area of about 6,667 ha. (100,000 MU) was also found in WuChuan County of GuangDong by the same scientists in 1957 when they conducted a provincial vegetation survey. The community was situated on an alluvial plain at the juncture of 3 counties, WuChuan, MaoMing, and DianBai, within the lower reaches of the JianJiang River. This was a hygrophytic-mesophytic tropical grassland, that flooded from April through September, and was dry from October to March. During the flood period, the whole plain was inundated, while during the drought, it became an ideal place for a large multitude of *Emberiza aureoba* to live through the winter.

In the 1950's, the local people utilized the vetiver community mainly for forage and thatch, which did not alter its composition. Later, utilization and development through human activities created tangibly severe changes. These activities included digging up vetiver roots for refining oil in the 1960's, building canals and dams in the 1970's, and especially large scale reclamation for fishponds and residential areas since the 1980's. Thus, the whole grassland ecosystem has seriously deteriorated over the past 40 years. The remaining area consists only of several hundred hectares, its landscape has become discrete pieces; and vetiver coverage has dwindled from 30-40% in the 1950's to 10-15% even lower by May 1997. Obviously, the precious wetlands will be completely obliterated due to excessive development if not protected at once.

In order to preserve the highly valuable plant and germplasm resources of vetiver, therefore it is suggested that a reserve should be immediately delineated in the largest original native habitat of vetiver, WuChuan of GuangDong. If this is established, then the valuable local resources, such as *Emberiza aureoba* mentioned above and the vetiver ecological environment with its biodiversity will be effectively conserved. In addition it will provide it provide a perfect base for carrying out studies on wetlands and biodiversity in South China.

Vetiver Grass: Research and Extension

Yan LiJiao, Zheng ZhiMing and Wang ZhaoQian (Institute of Agricultural Ecology, ZheJiang University of Agriculture, HangZhou 310029, China)
Qian JianDong, Xu QinLao and Jia XiangChi
(JinHua City Office of Red Earth, ZheJiang Province, JinHua 321000, China)

According to worldwide investigations and experiments, vetiver grass, a perennial that originated in tropical and subtropical areas such as India, Sri Lanka and Myanmar, is considered a useful plant for soil erosion control. It reproduces mostly by vegetative means. With a 3 m long, thick and intertwining root system, the 2 m high grass is able to fix the soil

tightly. Besides having great endurance to drought, waterlogging, high temperature and cold, the grass is easy to plant and manage and grows well in any type of soil, in high latitudes (up to 42(N), at high altitudes (up to 2,600 m) and on steep slopes (up to 31(). Vetiver planted on sloping land functions well in soil erosion control by slowing down runoff and reducing soil losses. Planted on dikes along ditches it helps to prevent the dikes from collapse and to minimize siltation.

Vetiver planted on river banks, pond dikes and reservoir embankments may control embankment erosion and mud siltation. Even when planted on a roadside it may help to consolidate the road base. Experience in India showed that vetiver hedgerows may help to reduce runoff by 30-47%, to decrease alluvial sand discharge by 43-74% and consequently to increase cereal yield by 6-26%. Experiments in Malaysia showed that compared with a control, runoff and soil loss in sites with vetiver grass decreased by 73% and 93% respectively. People in India began using vetiver in soil erosion control about 200 years ago. However, the Indian people only started their research on the effectiveness of vetiver for soil erosion control a little more than 10 years ago. In spite of this they still remain first in the world in this research fields. Due to the recommendation of Mr. R. G. Grimshaw Director of the Agricultural Technology Division, Asian Technology Bureau of the World Bank, vetiver technology was introduced into China and initially applied to the red earth projects in JiangXi and FuJian Provinces in early 1989. Later, the technology was extended to HuNan, ZheJiang, SiChuan, HaiNan and GuiZhou Provinces. Today more multidisplinary research and extension work remains to be done. With the collaboration of technicians and farmers more scientific data and technical support can be provided for further extensive application of vetiver technology. More demonstrations in hilly or mountainous areas are needed to show farmers the effectiveness of vetiver on soil erosion control and on the growth of crops.

Distribution and Potential of Vetiver Grass in Bangladesh.

Dr. M. Matiur Rahman (Director Bangladesh National Herbarium, VARC Complex, Farmgate, Dhaka-1215)

This paper presents the findings of a survey on vetiver grass in Bangladesh during a fifteen-month period in 1995/96. The survey records information on the ecological distribution, morphological variation, and the present use of vetiver grass obtained on study visits to all of the 64 districts in Bangladesh. The study indicates that the only species found in Bangladesh is *Vetiveria zizanioides* (L.) Nash, and it is very common in a variety of habitats. Three botanical "forms" of vetiver have been identified though no ecotypic variation has been found. Several large areas dominated by vetiver grass have been identified. The present findings reveal that vetiver grass has many traditional uses including its great potential for use as a vegetative means of protection on river and coastal embankments in Bangladesh.

Vetiver Extension Methods in El Salvador

Ricardo Hernandez, William McDowell and Joaquin Santamaria

El Salvador is a Central American country with a high population density (270 people/km^2), a high rate of rural poverty, intensive competition for arable land, and severe environmental problems. More than three-fourths of the national production of basic grains occurs on small farms on marginal hillside soils.

Degradation of soil and water resources affects the household income of thousands of farmers, hydroelectric systems, sources of potable water and coastal zones. There have been increased investments in soil conservation practices in response to these problems, which has created a strong national demand for vetiver.

NOBS Anti-erosion, is a private company that promotes vetiver grass for soil conservation on hillsides. Established in 1994, it works with 140 institutions on 110 projects nationwide. The main activities include the transfer of technology, and the sale of vegetative material for living hedges. These activities are implemented through aggressive communications programs and by a team of extension specialists.

A case-study is presented on the transfer of vetiver technologies by NOBS in an area in the southwest region of El Salvador. A select group of small-scale farmers was trained to grow and manage vetiver for sustainable soil conservation. The farmers were given vegetative material for two years to establish replication plots. They then began transferring vetiver technologies to their neighbors. Currently, a group of 220 farmers is testing the vetiver technologies. Seventy-one percent of the farmers say that vetiver controls erosion. Eighteen percent of the farmers have observed that vetiver is increasing crop production due to increased soil moisture content. Eighty-two percent of the farmers will continue using vetiver for soil conservation.

The Pacific Rim Vetiver Network (PRVN)

Narong Chomchalow (Office of the Royal Development Projects Board, Bangkok, Thailand)

The creation of the Pacific Rim Vetiver Network (PRVN) was the result of a proposal made by Mr. Richard Grimshaw, President of the Vetiver Network at the First International Conference on Vetiver (ICV-1) held in Chiang Rai, Thailand, on 4-8 February 1996. Mr. Grimshaw suggested that Thailand act as the core of the PRVN with the principal objec-

tive of serving as a center to collect and disseminate information in the form of newsletters, occasional publications as well as a homepage on the internet on the use of vetiver grass. homepage on the internet. in the form of newsletters, occasional publications as well as a on the. Thailand is considered suitable because it is the site of the world's largest vetiver project, known as the Doi Tung Development Project, which has been implemented under the supervision of the Office of the Royal Development Projects Board (ORDPB), the organizer of the Conference. Subsequently, the ORDPB submitted the proposal to His Majesty the King, a keen supporter in the use of vetiver grass and an awardee of the Vetiver Network's specially-commissioned bronze vetiver sculpture, in order to obtain his comments and approval. His Majesty agreed with the proposal and commissioned the setting up of the PRVN under the supervision of the Committee on the Development and Campaign for the Utilization of Vetiver under His Majesty's Initiatives, to be administered by ORDPB.

In order to facilitate the effective implementation of the network with a common view and flexibility, the Committee established a Working Team to take care of the PRVN. It has the responsibility to manage and supervise the Network which aims to promote the cultivation and use of vetiver through the issuance of a newsletter and the homepage. The PRVN intends to serve the countries of eastern Asia and the Pacific. These include Australia, Brunei, Cambodia, the Cook Islands, China, Fiji, Indonesia, Japan, Korea, Lao PDR, Malaysia, New Zealand, Papua New Guinea, the Philippines, Singapore, the Solomon Islands, Taiwan, Thailand, Tonga, Vanuatu, Western Samoa, and Vietnam.

Thailand Country Report on Vetiver

Narong Chomchalow (Office of the Royal Development Projects Board, Bangkok, Thailand)

In Thailand, the present state of land degradation caused by soil erosion as a result of top soil being washed away after heavy rains and the resultant runoff is quite devastating. His Majesty King Bhumibol Adulyadej has realized the urgency of the problem and its cause. After careful consideration of the potential of vetiver grass , a versatile plant that can help prevent soil erosion and conserve soil moisture, His Majesty has adopted the idea of using vetiver for soil and water conservation. A simple technology will first be introduced to the hill tribes in the highlands of northern Thailand, and later to all others who suffer from the same problem of soil erosion. The vetiver grass technology (VGT) has been found to be quite effective, with little or no expense, and it requires minimum care once its growth has been established.

His Majesty started to implement his concept in June 1991 upon information received from the World Bank. This has proven to be so effective that a great deal of progress has been achieved in a relatively short time. The Office of the Royal Development Projects Board (ORPDB) has been assigned to coordinate the R & D activities on vetiver in Thailand from the very beginning. Their achievements include the following:

1. The organization of the First International Conference on Vetiver (ICV-1) in Chiang Rai, Thailand, on 4-8 February 1996, to commemorate the 50th anniversary of His Majesty's accession to the throne. It was one the most successful meetings ever organized with about 400 participants, including 102 from foreign countries.

2. The (National) Committee on the Development and Campaign for the Utilization of Vetiver under His Majesty's Initiative was established under the administration of the ORPDB. The Committee is charged with the duty of coordinating all R & D activities for all agencies in Thailand that are working on vetiver in order to ensure that they follow the policy set forth in the master plan and to evaluate the results obtained. This Committee also helps these agencies by requesting their annual budget from the Budget Bureau. A Sub-committee on Technical Issues, Planning and Evaluation has also been set up by the Committee.

3. During the first phase (1993-96), a master plan was developed giving emphasis to the following activities: (i) investigation and research, (ii) transfer of technology, (iii) demonstration and extension, and (iv) other means of vetiver utilization. There were 27 agencies cooperating under the scheme in the first phase, with considerable success in each, especially in research, although there are a number of issues which have to be monitored more effectively.

4. The Committee has already prepared a master plan for the second phase of the programme (1997-99), with the objective of coordinating activities among various agencies, arranging the budget, and evaluating the work accomplished in order to satisfy His Majesty's Initiative.

A few success stories from the results of the research and development work during the past phase will be high lighted in the present paper.

The Adaptability and Benefits of Vetiver on Hills of Red Earth

Lu ShengLuan, He XiangYi, Xiong GuoGen and Xie MeiGen (JiangXi Provincial Institute of Red Earth, JinXian, JiangXi 331717, China)
Zhen QiFang (Soil and Fertilizer Division, Bureau of Land Administration, JiangXi Province)

This paper deals with the growth and adaptability of vetiver on bare, severely eroded low hills composed of red earth. Vetiver grasses are more drought resistant, cold hardy and perform better with infertile soils than all local wild grasses. They are very effective in soil and water conservation due to their quick growth, numer-

ous tillers and fast hedge formation. Their thick leaves and stems, once returned to the soil, are advantageous to soil physical properties and soil fertility. These as well as other benefits, make vetiver grass suitable for growth on the vast red earth hill areas in southern China and are worth extending to new locations.

Vetiver Planting Experiments in Eroded Areas

Ao HuiXiu, He DaoQuan and Xia HanPing (Laboratory of Ecology, South China Institute of Botany, Academia Sinica, GuangZhou 510650, China)

In the experimental sites at WuHua, XingNing and other counties in GuangDong Province, vetiver grass, though planted in various eroded gullies, or dams or on slopes with thin and infertile soils, usually grew vigorously. Those planted in XingNing reached a height of 1 m by the sixth month after transplanting, with a average tillering rate of 10-15 slips, and a maximum of 50-60 slips per clump. Vetiver could form a closed belt in a timely manner and therefore could function well in soil and water conservation. Experiments showed that vetiver grass grew normally in eroded areas in GuangDong Province and could be extended to more areas in the future. However, further extension requires more profound research.

A Preliminary Study on Wild Vetiver Grass

Huang BuHan and Zhang JingXi (South China Institute of Botany, CAS, GuangZhou 510650, China)

This paper introduces the series of investigations, studies and experiments conducted by the authors and others in the late 1950's, on wild vetiver grass found in large areas around HuaZhou, GuangDong Province, China.

1. A great deal of information was obtained through a large scale field survey, including details of the morphological features of vetiver, distribution and the estimated reserves of wild vetiver.

2. Studies were conducted on the vetiver growing environment, i.e. landform, climate and soil conditions. Research showed that vetiver grass grew well in special local environments with alternating dry and moist conditions, growing in moist summers while flowering and fruiting in dry winters. It has shown that vetiver being a mesophyll-mesophyte type of plant with a wide range of adaptability could tolerate both water-logging and drought.

3. Research on the extraction, analysis and perfume test of wild vetiver oil and on the identification of wild vetiver fibre quality for paper making have verified the value of utilizing vetiver. As a result, vetiver grass has been put into industrial use. Tests have also proven that the quality of oil and fibre derived from wild vetiver is as good as that derived from common vetiver. The authors consider wild vetiver as a new kind of vetiver with a fine prospect for development and suggest that the authorities concerned should pay more attention to it.

4. Impacts of local environmental conditions on the oil content of vetiver roots and paper production of vetiver fibres were analyzed. Research showed that vetiver grass grew more luxuriantly in moist fields than in dry lands. However, perfume concentration of vetiver found in dry locations was higher than that from moist fields. In short, the content of available ingredient and utilization value of vetiver from dry sites was higher than that from moist fields. Research also showed that the rate of paper production for wild vetiver grass fibre grown in moist or wet depressions was lower than that found in aerated soils with less water logging. It is therefore suggested that vetiver grass be planted in loose soils without water logging to obtain higher fibre quality for paper production and superior perfume oil quality.

An Overview of the Vetiver Grass Hedge System in the Asia-Pacific and Southern African Regions

Paul Truong, (Leader, Erosion Control and Slope Stabilisation Group, Resource Sciences Centre, Department of Natural Resources, Brisbane, AUSTRALIA)

The application of the Vetiver Grass Hedge System (VGS) was first developed to protect farmlands from soil erosion. While this application of the VGS still plays a vital role in agricultural lands, its tolerance to highly adverse conditions will have a key role in the increasingly concerned field of environmental protection.

Research and development to date have shown the VGS is highly efficient in soil and water conservation in farmlands which can lead to crop yield improvement and more productive land use practices.

The vetiver plant is highly tolerant to extremely adverse growing conditions and possesses some physical characteristics which can be used for engineering purposes. The three main applications of the VGS are considered to be in the areas of:

1. Agricultural Lands: The VGS is the most efficient, low cost and effective soil and water conservation system available. Its thick growth has hydraulic properties that can be used to protect flood prone areas from flood erosion. Its roots are highly resistant to nematode attacks thereby providing some protection to horticultural and agricultural crops.

2. Engineering Applications: With a tensile strength equivalent to one third that of mild steel reinforcement, the VGS is highly effective in steep slope stabilisation. The porous barrier and hydraulic characteristics of the vetiver hedges result in a very effective diversion barrier for high water flows.

3. Environmental Applications: A very

effective filtering system resulting from the vetiver hedges provides an ideal natural barrier to trap both coarse and fine sediments. In addition, its tolerance to highly adverse growing conditions such as extreme pH or unfavorable levels of Al, Mn, As, Cd, Cr, Ni, Cu etc. provides an ideal plant species for a bio-remedy and rehabilitation of toxic and contaminated lands.

The extent and results of these applications in the Asia-Pacific and southern African regions will be presented.

Vetiver Engineering (A Biological Technique for Realizing Sustainable Development *Xia HanPing and Ao HuiXiu (South China Institute of Botany, Academia Sinica, GuangZhou 510650, China)*

Almost all studies and observations on vetiver grass (*Vetiveria zizanioides*) from around the world during the previous 12 years have indicated that this perennial has a widespread adaptation to diverse environments and a strong resistance to adversity. It is also easy to establish and maintain. Apart from its great success as a biological measure for soil and moisture conservation, vetiver also has a multitude of other functions. It can increase nutrients and moisture in the soil, enhance agricultural microclimates, aid in the recovery of deteriorated ecosystems, ameliorate polluted lands and rehabilitate them vegetatively. Planted in strips vetiver can, also, protect fishponds, orchards, dams, reservoirs, and highway prevent hills from landslides, and so forth. Vetiver itself also has many uses. For example, its tender leaves are a good fodder for livestock, and its old leaves and stems can be used as paper pulp, mulch, manure, fuel, animal bedding thatch, making handicrafts, and so on. The roots of this plant are used to refine an aromatic oil, for use in medicines and pesticides. Therefore, extending vetiver engineering, particularly in mountain villages, is an efficient measure to assist in rural sustainable development. Agricultural ecosystems in which vetiver has acted as a pivot may produce tangible ecological, economic, and social benefits.

For over 10 year now, scientists from home and abroad have conducted a great deal of research on vetiver, and attained many achievements. These will provide a staunch theoretical basis for the large scale application and spread of this biological technique in the future. Obviously, vetiver engineering is an important step toward realizing sustainable agriculture. It has a wide application in soil and moisture conservation and in establishing complex agroecosystems in the tropics and subtropics as well as in mountainous areas of southern China. It is necessary, however, to ensure that publicity, popularization, development, and utilization of this technology be more quickly and extensively spread.

Challenges and Problems in the Use of Vetiver for Watershed Management in the Sub-Mountain and Scarcity Zones of Nashik District (Maharashtra, India*)*
Prakash B. Pawar (Divisional Soil Conservation Officer (S.C.) Nashik, Department of Soil Conservation and Watershed Management, Maharashtra, India)

Soil and water are the most vital natural resources for the survival of mankind. Proper management of these natural resources on a watershed basis gives excellent results. Otherwise soil degradation is a serious environmental, social and economic problem for the agriculturist. Soil degradation is closely associated with constrained agricultural production and sustainable development. A key component of soil degradation is erosion by rain water i.e. runoff. Vast areas of fertile agricultural land are damaged every year through soil erosion caused by rain water especially in dry areas. There are major challenges in the scientific, technological and financial approaches to finding solutions. Engineering structures for managing catchments are expensive. Vegetative measures such as the use of vetiver is quite inexpensive, and it is promoted through centrally sponsored schemes in India. Accordingly, twelve watersheds comprising two agroclimatic zones with a geographical area of 52,952 hectares were identified for improvement in the Nashik District. Since 1991-1992, 4,855 tones of vetiver slips (*Vetiveria zizanioides*) were used for drainage lines and land treatment in watershed management. From this a case study of vetiver for soil and water conservation was conducted.

The results of the case study indicated that the establishment of vetiver and its survival rate were directly correlated to type of soil, depth of soil, quality of planting material and other managerial factors like the problem of stray cattle. In a scarcity zone the use of vetiver as a conservation measure failed except in a few cases of drainage line treatment. In the sub-mountain zone drainage line treatments like live check dams and loose boulder structures showed excellent results while land treatment had only limited success. Instead of planting vetiver merely as a barrier, addition of a minor engineering support gave better results. Vetiver enhanced the infiltration rate of a nearby plantation, arrested fertile slits resulting in profuse growth of vetiver. Besides, the vetiver hedges served as boundary marks which helped tillage operation, especially in dry areas.

In the sub-mountain zone, the survival rate of vetiver was highest with live check dams, supported by minor engineering structures (64.6%). This was followed by loose boulder structures reinforced by vetiver (47.9%). Thirdly, land treatment called contour vegetative hedges had the lowest survival at 41.6%. From the case study it was clearly observed that planting material played an important role in the survival of vetiver, in addition to managerial factors such as

stray cattle. The overall conclusion was that a dry spell adversely affected the survival rate of vetiver. The average number of rainy days in the sub-mountain zone was 75 while in the scarcity zone it was only 25. The dry spell after establishment and the problem of stray cattle caused the mortality of vetiver. However, vetiver in high survival situations gave excellent results in terms of soil erosion control and moisture conservation, which accounted for good returns from the land i.e. crop production. In the present study it was found that sowing along the contour with vegetative hedges gave a 35.3% increased yield of *Eleusine caracana* in the sub-mountain zone and 32.5% more yield of *Sarghrmvulgare*, *Pennisetum typhoides* in the scarcity zone as compared to non treated areas. There was also a significant increase in financial returns for farmers.

An attempt was made in this case study to compile all available information about the personal, social and economic characteristics of farmers and their association with the use vetiver in a watershed management unit.

The Role of Vetiver Grass in the Rehabilitation of Toxic and Contaminated Lands in Australia

Paul Truong and Dennis Baker (Leader, Erosion Control and Slope Stabilisation Group, Resource Sciences Centre, Department of Natural Resources, Brisbane, AUSTRALIA)

Research conducted in Queensland has established that vetiver has an extremely high level of tolerance to adverse soil conditions.

Soil conditions	Levels
Acidity	pH 3.3
Alkalinity	pH 9.5
Al (Sat.%)	Between 68% - 87%
Mn	> 578 ppm
Salinity (50% yield reduction)	17.5 mS cm^{-1}
Salinity (survived)	47.5 mS cm^{-1}
Sodicity	33% (exchangeable Na)
Magnesicity	20 Cmol/kg (Mg)

Vetiver can also withstand very high levels of heavy metals in the soil.

Arsenic	100 - 250 ppm
Cadmium	20 ppm
Copper	50-100 ppm
Chromium	200 -600 ppm
Nickel	50 -100 ppm

These characteristics make vetiver highly suitable for the rehabilitation of toxic and contaminated lands.

Results on the use of vetiver in the rehabilitation of an old landfill site overburden (contaminated with heavy metals) as well as tailings of coal and gold mines will be discussed.

Studies on Protecting Highway Slopes with Vetiver Hedgerows

Ao HuiXiu, Xia HanPing, Liu *ShiZhong and He DaoQuan (South China Institute of Botany, Academia Sinica, GuangZhou, 510650)*

Vetiveria zizanioides, a perennial grass, has broad adaptations and a strong resistance to adversity. This plant grows rapidly and produces a strong and massive root system. It has been widely demonstrated that vetiver can effectively prevent soil erosion. Introduced by the World Bank and the Vetiver Network, the South China Institute of Botany (SCIB) since 1989 has begun to carry out experiments with vetiver hedgerows, with good results on erosion control and rehabilitation of deteriorated ecosystems on slopes. In order to magnify and spread the achievements, the SCIB collaborated with the GuangDong Provincial Highway Bureau (GPHB) in 1995 to conduct a trial on prevention of highway embankment landslides with vetiver hedgerows along National Highway No. 105. After six months, the hedgerows turned the barren road embankments green, and distinctly reduced soil erosion and water runoff. SCIB and GPHB were both satisfied with the results and were willing to continue cooperating with each other. Thus, in 1996 both sides continued conducting a similar experiment with this biological treatment on a dangerous and unstable section along the First-Ring Highway around GuangZhou. Vetiver grew to 150-200 cm high and produced 18-20 tillers per clump after being planted 5-6 months. Neat and luxuriant hedgerows formed which effectively slowed down and more evenly distributed the runoff. This prominently halted the soil erosion and ended the threat of a landslide. On the opposite embankment of the highway, *Mimosa sepiaria* was planted to "protect" the slope and acted as the control treatment. However, the whole slope, during the same period, was severely destroyed. Six large gullies with an average depth of 1-1.3 m by 20 m long along with a dozen small rills formed as a result of the impetus of rain water and the impotent protection from *M. sepiaria.* The two measures formed a sharp contrast.

The trial indicates that it is absolutely imperative to plant vetiver along contour lines and less than 15 cm apart between clumps to ensure that hedgerows can effectively protect slopes. It is best to apply fertilizer to the plants, including basal manure and top dressing, for highway embankments are usually very infertile. Certainly, cutting back the tops to 30-40 cm above the ground before flowering is also a good management practice, which can reduce the consumption of nutrients and promote tiller formation. As a matter of fact, civil engineering such as sand bags and dams are usually indispensable when trying to establish the vetiver technology. Biological hedgerows can be established more rapidly and efficiently in conjunction with civil engineering.

It is much better to combine vetiver with trees, shrubs and creepers that are adapted to the local environment when employing biological engineer-

ing. This combination can make roadsides not only more stable, but more beautiful as well. There are several kinds of plants, including *Acacia auricuiformis, A. mangium, Pinus elliotii, Lespedeza formosa, Milinis minutflora,* and so on, which behaved well in the trials.

Applying biological measures for protecting and beautifying highways has produced positive ecological, economic and social benefits. The vetiver technology certainly has a broad development perspective for the whole of southern China.

Preliminary Experiment on Purification of Eutrophic Water with Vetiver

Zheng ChunRong, Tu Cong and Chen HuaiMan (Institute of Soil Science, Academia Sinica, NanJing 210008)*

The possibility of purifying eutrophic water with vetiver was tested and described in the present paper. Vetiver was grown in river water polluted by domestic sewage, in pond water and in tap water using the "floating island" technique. During a 4 week culture, vetiver grew normally in these three water bodies, but did the best in river water. Net increases in plant height were 80 cm, 60 cm and 50 cm with tillers numbering 4, 1 and 0 for river water, pond water and tap water, respectively. The sight characteristics of river and pond water were apparently improved and transparency increased after planting vetiver. For river water, the total N and water-soluble P removed was 34.1%, and 68.1% after 1 week of growth, respectively; the removal rate was up to 99% for P after 3 weeks, and 82% for total N after 4 weeks. The removal of N and P was not as obvious in pond water because of fewer contaminants (0.014 mg N/ L and 0.70 mgP/L). These findings suggested that vetiver is a good plant for purifying eutrophic water and has application potential. Changes in COD, BOD and dissolved oxygen, the optimum growth period, and treatment capacity of vetiver need further study.

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Research on the Application of Vetiver to Red Soil Development

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This paper deals with the effects of vetiver application on red soil development. Experiments of 3 cultivation models, i.e., 1) contour vetiver hedgerows, 2) contour terrace cultivation, and 3) non-contour cultivation along the slope, were located on slopes with red soil derived from Quaternary clay. Comparison among the 3 models showed the effects of vetiver on conserving soil and water, lowering surface runoff, resisting drought when used as a mulch and maintaining soil moisture in sloping red soils under different rainfall conditions.

Experimental results showed that: (1) The effect of water and soil conservation by vetiver hedgerows established on the upper part of slopes with red soil was better than that of both contour terrace cultivation and non contour cultivation along the slope. The former model reduced runoff by 11.6% and 23.9% and reduced sediment by 24.0% and 36.1% compared to that of the latter two models. The same effects were also found in the following 2 years. (2) The minimum runoff was found after rainfall in the model with the vetiver hedgerow, regardless of whether rainfall was less than 9.9 mm or a of rainstorm was more than 25 mm. Generally speaking, runoff was 1/3 and 1/4 less than those in the contour terrace model and in the non-contour cultivation along the slope, respectively. Experiments also revealed remarkable differences in sediment yields due to variation in the amount of surface runoff. The sediment yield with the vetiver hedgerow (472.7 t/km^2(yr) was close to the allowable amount (500 t/km^2(yr). This was 0.6 and 1.9 times lower than those in models of contour terrace cultivation and non-contour cultivation along the slope, respectively, while the runoff coefficients were 0.16 and 0.5 times lower, respectively. The reduction of sediment build up minimized nutrient losses in the vetiver hedgerow case. (3) Soil moisture storage at depths of 0-60 cm with a surface mulch of vetiver leaves was obviously higher than with a surface mulch of rice straw or without a surface mulch. A slow and stable loss of moisture was found in soil with vetiver leaf mulch due to slower moisture evaporation. This resulted in drought being delayed by 6-10 days when compared to soils with no mulch, while a delay of only 2-5 days was noted with rice straw mulch. Moreover, fresh vetiver leaves with certain content of crude protein and fat could be used as fodder for cattle.

These experiments were the first successful efforts toward extension of vetiver technology in phase 1 of the red soil project. The provided a good example for red soil development in southern China as well as the soil and water conservation projects in the Yangtze River Basin.

Vetiver — An Excellent Plant for Soil and Water Conservation

Guo TingFu (Department of Rural Water Conservancy and Soil and Water Conservation, Ministry of Water Conservancy, BeiJing 100761, China)

During his visit to China in 1988, Richard G. Grimshaw, the Chief of the Agricultural Technology Division, Asian Technology Bureau of the World Bank described the function of vetiver in soil and water conservation. It was through his active promotion that vetiver was introduced to some

areas in southern China.

This paper summarizes the planting efforts, experimentation and effects of vetiver in China's JiangXi, FuJian and other provinces. In order to accelerate erosion control and the development of agriculture with forestry and pastural production (agroforestry) so as to better serve the national economy and enhance people's lives, the author appeals to authorities concerned to pay more attention to the introduction and cultivation of plants, which are good for water and soil conservation, such as vetiver.

Ecological Effects of Planting Vetiver Grass in Citrus Groves on Sloping Red Soil Fields

Chen Kai and Hu GuoQin (Department of Horticulture, NanJing University of Agriculture, NanJing, 210014) Rao HuiMao, Xu LinHua and Wu HuaQing (County's Office of Foreign Capital Projects, LinChuan, JiangXi Province)

Vetiver grass (*Vetiveria zizanioides*) planted in lines along contour furrows in sloping citrus groves of red soil grew and developed quickly and vigorously with an annual yield of fresh plant matter of about 15t/hm^2. The grass was cut and used as a mulch to cover the surface soil under the citrus trees such that the air temperature and soil temperature in the citrus groves were both effectively decreased. At the same time, the relative humidity and moisture content of the soil both increased during periods of high temperatures and drought. In the summer, the strong solar radiation was partly shaded by the vetiver grass fence. There were remarkable benefits in water and soil conservation, as well as improvement in soil structure and fertility. The soil bulk density decreased, while its porosity, pH, organic matter contents, total N, hydrolytic N, available P and K, Ca, Mg, Fe, Mn, Zn, Cu, B, Mo and 20 kinds of amino acids all increased. The citrus trees, therefore, also grew and developed vigorously. Some new information was provided for regional development and comprehensive utilization of red soil resources to obtain sustainable high yields, superior citrus quality, and efficient productivity with low cost in southern China.

Preliminary Study on the Experimental Effects of Vetiver on Soil Erosion Control and Ridge Stabilization

Chen LongJiang (Bureau of Water Resources and Electric Power, XingNing 514500)

The County Bureau of Water Resources and Electric Power planted vetiver grass on ridges of sloping farmland as a form of slope protection to test its effect on preventing soil erosion and soil fixation. Two runoff plots were designed on the ridges, one with vetiver grass and the other as a control. During the period from July to December, when the rainfall was 411.8 mm, the runoff modules was 183.2 dm^3/m^2 for the vetiver plot and 259.4 dm^3/m^2 for the control, or 29% less for the vetiver plot. The amount of soil erosion was 1.6 kg/m^2 for the vetiver plot and 4.8 kg/m^2 for the control, or 67% less for the vetiver plot. Within the 0-20 cm soil layer depth, the average water holding capacity was 22.8% for the vetiver plot, and 16.3% for the control. The results showed that vetiver grass acted well in preventing soil erosion and maintaining ridge stabilization. It also aided the soil moisture holding capacity thereby enhancing soil moisture. In addition, the actual dry weight of the grass was up to 55.6 kg/ha (834.0 kg/mu). The grass could therefore also be used as a fertilizer suitable for the fruit tree.

Vetiver Hedges as a Means for Erosion Control (Some Problems with Extension)

Chai Zong and Zhang Ning (ChengDu Institute of Mountain Disaster and Environment, The Chinese Academy of Sciences, The Ministry of Water Conservation, ChengDu 610021, China)

The authors briefly introduced the results and benefits of the application of vetiver hedgerows in soil and water conservation as well as the application of vetiver leaves as soil mulch in 1) India and 2) FuJian and JiangXi Provinces in China. However, they also pointed out some problems remained to be solved when planting of vetiver grass. For example, vetiver grass returned much fewer economic benefits than other cash crops in populated areas with limited land resources when their roots could not be used to make the perfume extract. Moreover, vetiver grass planted together with other crops or fruit trees might compete for soil moisture and nutrients creating a detrimental growth effect on the other crops. Finally, vetiver grass proved to be susceptible to pest and disease attacks.

Considering the weaknesses of vetiver, the authors suggested that the following could improve vetiver development:

1. Vetiver should be planted in areas south of a line formed by the QinLing-FuNiu Mountains in Central-China at elevations < 2000 m.
2. Vetiver should be extended stressing its advantages on bare hillsides in populated areas with limited land resources.
3. Mixed hedgerows composed of vetiver and other cash crops should be developed.
4. Focus should concentrate on studies to eliminate pest and disease attacks upon vetiver.

Effects of Vetiver on Soil Erosion Control in an Artificial Eucalyptus Forest

Liao BaoWen, Zheng DeZhang and Zheng SongFa (Institute of Tropical Forestry, Chinese Academy of For-

estry, GuangZhou 510520, China)
Three experimental sites were arranged in an artificial Eucalyptus (E. ABL No. 12) forest afforested in April, 1991 in YangXi County, GuangDong Province, China. They were: (1) lines of vetiver planted between 2 lines of Eucalyptus; (2) lines of *stylosanthes guianensis* planted between 2 lines of Eucalyptus, and (3) a control with no grass planted under the trees. The runoff field was arranged to observe rainfall, surface soil and water losses. Results of a 3-year observation showed that surface runoff in site 1 was 20351 t/hm^2, 15.2% less than that in site 2 and 51.1% less than that in control site 3. Similar results were found in cases of nutrient loss in solid and liquid. It was concluded that vetiver was not only good for soil and water conservation but also good for forest development.

Contribution of Vetiver Grass to Sustainable Agricultural Development in the Hilly Red Soil Region

Lu ShengLuan and Zhong JiaYou (Red Soil & Hill Comprehensive Experiment Station, DongXiang County, JiangXi Province, 331800)

Soil erosion and soil degradation is a serious problem existing in the hilly red soil region of southern China, where an area of soil erosion has increased from 71,000 km^2 in the 1950's to 200,000 km^2 in the 1980's. Statistical data reveal that 0.7 billion tons of topsoil, 160,000 tons of organic matter and 100,000 tons of mineral nutritional elements are lost every year in the nine provinces of southeastern China which are located in the subtropical region. Massive soil erosion, which leads to declines in soil fertility and crop yield, is one of the principal obstacles to sustainable agricultural development in hilly red soil regions. Surveys and studies in JiangXi Province show that vetiver grass contour hedgerows offer one practical technology to address this problem.

1. Vigorous hedgerows of vetiver grass with their dense root system formed 1 or 2 years after the grass was planted. They constituted a biological soil moisture retention system effective for soil erosion control by fixing soil particles and conserving soil moisture. Observations at standard runoff sites in farmlands with a slope of 5-6 % showed that, compared to a control, there was a 32.7% decrease in runoff. This was a 21.4 t/hm^2/yr decrease in soil loss resulting from vetiver hedgerows of 1 m in height. Soils could be preserved in this way, providing a base for sustainable agricultural development in hilly red soil areas.

2. In fields with a vetiver hedgerow arrangement, with dry and high temperature conditions, air and soil temperature decreased and surface water evaporation decreased while humidity increased.. In cold winters adequate temperatures could be maintained and frost damage could be minimized as the convection and diffusion of cold air could be buffered by the hedgerows. An improved ecological environment with stabilized hydrothermal conditions therefore formed to promote the sustainable agricultural development in hilly red soil areas.

3. Large quantities of biomass were generated with the quick tillering of vetiver grass. As a result an increased amount of organic matter accumulated in the soils as a large quantity of vetiver materials, naturally decayed or artificially applied, entered the soil layers. Fertile soils formed in this way constituted a fertility base for sustainable agricultural development.

4. Vetiver grass does not threaten the growth of crops as most weeds do because they develop without rhizomes or creeping stems and do not propagate by seeds. Therefore, they may be planted in orchards and crop fields using appropriate designs and forming sustainable multilayered integrated agricultural systems such as fruit-grass or crop-grass combinations.

Vetiver Grass - Perfect for Soil Erosion Control

Fu DongYue and Wei XiChun (ShaWu City Office of Soil and Water Conservation, FuJian Province)

Vetiver grass was introduced in 1988 for two soil erosion control trials in a newly cultivated orchard in YueWang-Long, ShuiBe Township and in an integrated small watershed management project in DaFuGang.

(1) In the former case, vetiver grass was planted in holes along contour lines, between 2 adjacent tree lines with a hole interval of 10-15 cm. A clump consisting of 3-5 slips of vetiver was planted in each hole with a small amount of compound fertilizer (at a rate of 450 kg/ha). Eight months later, vetiver clumps had grown to an average height of 120 cm, with a maximum of. 200 cm. By August, vetiver clumps, planted in early April had tillered to 25 slips each and formed a continuous hedgerow, stopping the mud carried in the runoff. A remarkable earth ridge, consisting of mud and sand was found on the rear side of each hedgerow. It was expected that a terrace would form on these newly formed earth ridges in 5-6 years.

(2) In the latter case, vetiver grass was planted on contours of eroded sloping surfaces using the following characteristics: a) line interval: 30 cm, b) clump interval (holes): 10-15 cm, c) number of slips for each clump: 4-7, and d) amount of compound fertilizer applied in each hole while planting: 450 kg/ha. As the grass grew, sloping surfaces were largely covered by thick grass clumps thereby effectively controlling splash and sheet erosion. Moreover, soil erosion-resistance was greatly increased as the soil was fixed by the strong vetiver root system.

Three years of experiments showed that the quick growing vetiver grass was indeed an ideal and effective plant for soil and water conservation. The grass height increased an aver-

age of 1.3-1.8 cm/day when local temperatures were 22˚C or above and reached 1.5-2.0 m by the end of the first year of growth. The hedgerows formed the same year that the grass was planted and were vigorous enough to stop soil losses caused by runoff. Being adaptable to harsh conditions, vetiver grew well in very infertile and severely eroded red soils with very little fertilizer and management even after undergoing a drought lasting for 60 days and a cold period with -7.5˚C. The tender leaves of vetiver can be used as cattle fodder while old leaves can be used for perfume extraction for roof thatch, for orchard mulch or for fuel.

Vetiver Grass for Slope Stability Enhancement and Erosion Mitigation in Engineering Applications

Diti Hengchaovanich (Director, Erocon Sdn Bhd P.O. Box 10639, Kuala Lumpur, Malaysia)

Use of vegetation (grass and trees) for erosion mitigation and slope stability enhancement has been implemented since time immemorial, mostly based on successful applications of preceding cases. The increasing popularity in the last decade of a vegetative ("soft") approach by using trees for slope stabilization has gained favour over a "hard" approach of using inert man-made materials. This has been due to the concern over the degradation of the environment caused by development, coupled with the fact that more knowledge and information on vegetation have now come to light to aid in engineering designs.

Vetiver, until very recently a relatively unknown plant, possesses some unique features of both grasses and trees by having a profuse, deep penetrating root system that can offer both erosion prevention and can control movement of surface earthen materials, a precursor to slope stability solutions. Parameters obtained from recent experiments revealed that vetiver grass roots are very strong with an average tensile strength of 75 MPa or one-third that of mild steel. The massive root system also increases the shear strength of the soil, thereby enhancing slope stability appreciably. Engineers or designers working with sloping land will find it more helpful now to have some quantitative data available to provide an engineering 'answer' to stability issues, when employing vetiver grass. Successful application models of vetiver grass for slope stability enhancement and erosion mitigition measures for highway projects in Malaysia are described.

A Preliminary Report on Runoff Experiments with Different Cropping Systems on Hilly Red Soil

Zheng ZhongDeng and Huang XiuSheng (FuJian Academy of Agricultural Sciences, FuZhou, FuJian 350013)

This topic is one of the research projects from the "Second Chinese Red Soil Project" in FuJian Province. By establishing special plots for run-off experiments, the effects of different cropping systems and biological practices on soil and water conservation have been studied. There were 4 treatments including: 1): no forage grasses planted on terraces; 2) vetiver grass planted on terrace banks; 3) no forage grasses planted on slopes; 4) 50 cm wide Premier Fingergrass strips planted between tree rows on the slopes. In the treatments with grasses, terraces were planted with Pinto peanut or Wynn *cassia* in Two replications. The area for each plot was 4¡Á25 m^2 and a 500¡Á500¡Á25 mm prefabricated cement block was placed between two plots. A water-collecting (or sand-collecting) pool, for water storage was built in each plot. Also a set of meteorological observation instruments was installed in the experimental area. Plum seedlings as well as various grass species were planted before April, 1995. Since January, 1997, formal observations have been performed. Meteorological observations on the main components, run-off amounts of soil and water, and moisture content in the soil layers were measured according to the requisites issued by Chinese Agricultural Ministry.

The preliminary results of a half-year's observation showed that planting on slopes without any biological practices caused serious run-off; planting grass strips on slopes and covering the terrace surface with Pinto peanut may prevent the soil surface from erosion; not planting forage grasses on the terraces with frontal banks and rear-ditches, although eliminating serious run-off ended up with the front bank being leveled and the rear-ditches being filled with soil in the one and half year's observation. Soil erosion occurred when the torrential rains came. In the treatment where forage grasses were planted on terraces, grass barriers formed on the banks. In a half-year's time, the terraces were covered by grass, the banks and ditches were well maintained, and the run-off loss did not occur, especially in plots where vetiver grass was planted. The ground surface and soil layer temperatures were directly affected by the vegetation on the soil surface. In the treatments covered by plants and grasses, the temperature was lower in the summer and higher in the winter compare with treatments not covered by plants and grasses. Since January 5, 1997, the moisture content in different treatment plots was tested every 5 days. Data taken 39 times showed a regular pattern in which the moisture content in plant-covered plots was higher than that in the bare plots. The upper, middle and lower soil layers showed the same tendency. The nutrition loss in the run-off experiments will be analysed soon.

Introducing Vetiver to Control Soil and Water Loss in FuJian Province

Ding GuanMin (FuJian Experimental Station of Soil and Water Conservation)

Vetiver was introduced to northern FuJian Province, as well as

JianYang, and ShaoWu Counties from HaiNan Province, China, in the 1950's, when it was used as a perfume crop, with economic benefits. Afterwards, however, it reverted to a kind of wild grass. Recently, Mr. Grimshaw, Agricultural Department Chief from the World Bank, introduced the grass for soil and water conservation. FuJian Experimental Station of Soil and Water Conservation then began to conduct a study using vetiver to harness soil and water loss in JianYang County in the north, AnXi County in the south, and coastal PingTan County. The results showed that vetiver is suitable for planting throughout the province, because of its acid and alkali tolerance. It has significant effects in harnessing eroded laterite slopes, especially on controlling rock slides in granite areas. Vetiver hedges can protect the cultivated land on slopes; moreover, it can also play a role in wind protection and sand stabilization along the highways and rivers as well as in the coastal areas. The stems and leaves of vetiver can be used in the cultivation of edible fungi, which can bring direct economic benefits. At present, however, vetiver extension is still in the preliminary stages, and it is necessary to do further studies.

An Experiment on Vetiver Introduction

Cheng Hong (NanChang Water Conservancy and Hydro-Power College, Ministry of Water Conservancy, NanChang 330029, China)

Analysis of 6 experiments introducing vetiver grass, in northern China, southern China and their transition areas, showed that: (1). Regardless of high or low latitudes, vetiver grasses, planted in a standardized way, all grew normally, with a survival rate ranging from a the maximum of 100% (GuiXi, JiangXi Province) to a minimum of 61% (ChangShan, ZheJiang Province). (2). Vetiver grasses grew quickly, with 2 growth peaks during their growing period. Among the 4 experimental sites, the quickest growth was found in HaiNan while the slowest was found in ChangShan. (3). The maximum tillering number was over 20 while the minimum was greater than 6. Study also showed that the increase in the number of tillers on vetiver roots could be represented by the equation

$$y=10^{ax+b}$$

where a and b varied at different latitudes. Finally, (4) adequate pruning of the parts above the ground of vetiver in a suitable season promoted root tillering.

Impacts of Environmental Factors on theGrowth of Vetiver

Xia HanPing, Ao HuiXiu and He DaoQuan (South China Institute of Botany, CAS, GuangZhou 510650, China)

The authors deal with the impacts of some environmental factors, shading fertilization and pruning on the growth of vetiver grass.

1. Impacts of shading on the growth of vetiver. The growth and development of vetiver were remarkably inhibited by shading. Measurements of the net growth in height of vetiver grass showed a difference of 90.8 cm between grass inhibited by shading compared to no shading. This resulted even though shading was only applied for 3.5 months during the 9 month long growing season lasting from March to November. Measured during the peak of the growing season, the average dry weight of slips without shading was 2.43 times more than with shading. The number of tillers per clump without shading was 82.9% more than with shading. Experiments also showed that the removal of shading during the growing season may quicken the growth of vetiver grass. However, recovery of both height and accumulated dry matter was slower and that of tillering was quicker.

2. Impacts of fertilization and pruning on the growth of vetiver. Experiments showed that vetiver grass could grow on infertile laterite and that fertilizer (urea) application increased plant height and number of tillers. According to the second set of measurements after fertilization, the number of tillers in the fertilized clumps averaged 90% more than those without fertilization. However, ceasing fertilizer application reduced the growth rate of the originally fertilized grass clumps to the same level as those without any fertilization. Also no remarkable increase in dry matter accumulation due to fertilization was noted over this short time. Therefore, accelerating vetiver tillering will be an important topic in vetiver study.

Vetiver tillering may be promoted by moderate pruning at appropriate times. Pruning before earring could aid vetiver growth and tillering. Only limited pruning, i.e. conducted in early spring and early autumn, was considered beneficial for vetiver development.

Vetiver Grass Planted on the Aeolian Sands of PingTan Island and its Application

Zhang Jing (FuZhou City Office for Soil and Water Conservation, FuZhou 350005, China)

Situated off the east coast of FuJian Province, PingTan Island ranks 5th in size among China's islands. It often suffers from natural disasters, such as Typhoons and severe rainstorms. Since 1991, vetiver grasses have been successfully planted on the island to prevent wind damage, to fix sand dunes and to protect the coastal seashore.

1. Setting up seedling nurseries. In March and April, 1992, 555 clumps of vetiver, each including 3 slips were planted at 20¡Á30 cm intervals between clumps, in the forest at ChengGuan, PingTan. A full four months after planting, in addition to through watering, liquid manure was applied to the vetiver. By the end of July, the vetiver grass was pruned to

30 cm. According to observations in November of the same year, most of the grass had grown to a height of 180 cm and some to more than 200 cm. The clumps had tillered to as many as 117 slips each. In addition a layering trial was successful. Clumps layered on July 16 were more than 100 cm tall in November. This nursery provided a material base for further development of vetiver in PingTan.

2. Vetiver hedges as a windbreak. The windbreak hedge experiment in wind channels showed that a hedge could be formed in a short time due to the excellent growth of vetiver in adverse conditions. Vetiver could be developed even in very marginal climatic conditions.

(1). In order to form a closed vetiver hedge as quickly as possible, in the early stage of planting it was necessary to set up an artificial windbreak in the wind stream to weaken the force of the wind.

(2). In places with the strongest wind, it was suggested that vetiver rows be parallel to the wind's direction so that the wind resistance of the hedge would be strengthened. A sheltering windbreak formed as soon as the hedges closed.

In addition, technicians have succeeded in planting vetiver in cash crop gardens to minimize the wind speed and to fix drifting sands. Vetiver hedgerows have also been used to protect embankments and slopes of hills.

Observations and Experiments on the Multiplication, Cultivation and Management of Vetiver Grass Conducted in China in the 1950's

Xia HanPing (South China Institute of Botany, Academia Sinica, GuangZhou 510650)

Vetiver grass (*Vetiveria zizanioides*) was introduced to China in the middle 1950's. Since then some multiplication, cultivation and management experiments on this plant have been conducted. The purpose for introducing vetiver was the production of essential oil from the vetiver roots. Seedlings were quite scarce at that time; so experiments concentrated on two aspects: firstly, on the rapid multiplication of seedlings, and secondly on breeding roots that yielded oil of high quality and high content. This paper summarizes these two aspects of the experiments and surveys.

Besides the general practice of propagation by division of roots, other successful propagation methods included: 1)multiplication by stem-culm cuttings, 2)multiplication by pedicel-culm cuttings, 3)multiplication by longitudinal-slit stems, and 4)multiplication through pruning tops. Cultivation techniques that promoted rapid field establishment were: 1)water-cultivation to accelerate root growth, 2)heeling-in to improve root establishment, 3)dipping roots, 4)oblique planting, and 5) retaining mother tillers left in the soil.

Management measures developed from experiments that enhanced tillering rates consisted of: 1)intensive cultivation while strengthening management, 2) proper pruning, and 3)rational close planting.

In addition, several unanswered questions remained: 1)How deep should vetiver be planted, shallow or deep? 2)How long should vetiver roots be kept, long or short? 3)How many tillers per clump should be planted, one, two, three or more?

Obviously, these successful propagation, cultivation, and management methods can play an instructive role and be used as a reference for future work.

Preliminary Results of an Experiment Introducing Vetiver

Gao WeiSen, Zhang Ning and Zhang XinBao (ChengDu Institute of Mountain Disaster and Environment, The Chinese Academy of Science and the Ministry of Water Conservation, ChengDu 510021, China)

Experiments introducing vetiver were allocated to different regions in the SiChuan Basin, i.e., DeYang in the plains area, JianYang in the hilly area, PingShan and DuJiangYan in areas around the basin as well as HuiLi and PanZhiHua in mountain areas of southwestern SiChuan. Comparison analyses were conducted on growth including the date the grass turned green and tillered, growth height, etc. in 4 types of soils in the 4 different types of locations.

Results showed that: (1). Vetiver grew best in sandy alluvial soils with high fertility and good aeration; it grew fairly well in cultivated sandy yellow soils and the red soils; and it grew poorly in cultivated yellow clay soils. (2). Vetiver seedling growth varied greatly in different temperature regimes. For example, in the trial sites in DuJiangYan, a continuous rainy period with low temperatures resulted in a prolonged period of 34 days after transplanting before the vetiver turned green. Meanwhile at the HuiLi sites with adequate temperatures only a short 12 day period was needed after the vetiver was transplanted in March, before it turned green resulting in a survival rate of 70%. Moreover, an even short period of 6 days was needed with a 95% survival rate, for grass transplanted in July at higher temperatures. Experimental results showed that the optimum average daily temperature for vetiver transplanting was 17.1˚C. (3). These hydrothermal conditions directly influenced the net growth of vetiver. For example, vetiver in PanZhiHua grew under the worst hydrothemal conditions and produced less than half of the biomass of grass grown in the JianYang region which had adquate temperature and plentiful rainfall. (4). In the first year of introduction, better management including sufficient water and fertilizer application was needed to pass safely through this period of adaptation.

Effects of Fertilizer on Vetiver Grass for Soil Erosion Control

Chen XuHui and Xia JinHui (Institute of Soil and Fertilizer, GuiZhou Provincial Academy of Agriculture, GuiYang 550006, China) Ronald D. Hill (Department of Ecology and Taxonomy, University of Hong kong)

Severe soil and water losses are found in GuiZhou Province where 97% of the territory is covered by mountains and hills. Experiments showed that soil erosion might be effectively controlled and sloping fields may be gradually transformed into terraces by arranging contour lines of shrubs or perennial grasses. Aimed at accelerating vetiver growth and promoting the formation of hedgerows for soil erosion control, a study on vetiver was jointly started in 1995 by the GuiZhou Provincial Academy of Agriculture and the University of Hong Kong.

The study showed that no remarkable differences were found between the vetiver hedgerows with fertilization and those without fertilization on farmlands where vetiver grew vigorously and hedgerows formed quickly. Furthermore, it was found that the time necessary for vetiver grass to turn green after transplanting might be lengthened and survival rate of the vetiver might be reduced by fertilization at transplanting. It is suggested that fertilizer as a dressing be applied on vetiver planted on farmlands after transplanting.

As for vetiver planted on infertile sloping farmlands, organic manures were found to be much better than chemical fertilizers, but organic manures applied together with N, P and K fertilizers proved to be the best. A trial of various fertilizer prescription showed that the survival rate, the growth vigor and the biomass yield of vetiver were negatively affected by a lack of phosphorus. It was also found that when applying N, P and K, it was better to apply them separately at multiple times than to apply them together at one time with transplanting.

Fertilization was found to be helpful in promoting the formation of contour vetiver hedgerows on infertile sloping lands. According to data in 1996, surface runoff could be reduced by 25% and soil erosion could be reduced by 55% from hedgerows with the fertilization treatment in comparison to those without fertilization. It was concluded that soil and water losses on infertile sloping lands could be effectively controlled by fertilized vetiver hedgerows.

Planting Techniques for Vetiver Slips in Rainfed Vertisols

A. Muthusankaranarayanan, U. Solaiappan and S. Senthivel (Regional Research Station, Agricultural University, Arnppukkottan 626107, Tamilnadu, India)

Field investigations were carried out at a Regional Research Station, Tamilnadu Agricultural University, Arnppukkottan on various planting techniques for vetiver slips in rainfed vertisols during the rainy seasons of 1991-92, 1993-94 and 1994-95. The treatment combinations comprised four planing methods viz 1) single row planting with an *Azospirillum* root treatment, 2) zig-zag planting with an *Azospirillum* root treatment, 3) single row planting without *Azospirilllum* and 4) zig-zag planting without *Azospirillum* in the main plot with three spacing distances between the plants viz. 10 cm, 15 cm and 20 cm in the subplots. The experiment utilized in a split plot design with three replications.

The mean tiller counts were observed at both the vegetative (30.3 tillers/hill) and the flowering stages (32.4 tillers/hill) when vetiver slips were planted in the zig-zag manner with an *Azospirillum* root treatment. The *Azospirillum* treated vetiver slips planted in a zig-zag manner maintained a high level of soil moisture and produced higher seed cotton yield (352 kg/ha) compared to other planting methods.

Among the various planting intervals, a wider spacing (20 cm intervals) recorded higher mean tiller numbers at the vegetative (29.4 tillers/hill) and the flowering stages (31.0 tillers/hill). This was comparable to 15 cm spacing which maintained a higher level soil moisture profile.

Hence, it can be concluded that for better establishment of vetiver and for getting favourable benefits from the vetiver hedge, vetiver slips may be planted in a zig-zag manner with roots dipped in an *Azospirillum* solution, then planted at a 15 to 20 cm spacing between the slips, in rainfed vertisols.

Management Practices for Establishment of Vetiver Slips

U. Solaiappan, S. Senthivel and A. Muthusankaranarayanan (Regional Research Station, Tamilnadu Agricultural University, Aruppukkottan 626107, Tamilnadu, India)

Field experiments were conducted at the Regional Research Station, Tamilnadu Agricultural University, Aruppukkottan on different agro-techniques for establishment of vetiver slips in rainfed vertisols during the rainy seasons of 1993-94 and 1994-95 using a split plot design with three replications.

The main plot treatments consisted of six planting times for vetiver slips after uprooting viz., 6 hours, 12 hours, 18 hours, 24 hours, 30 hours and 36 hours and the subplot contained three root dipping techniques viz., 1) *Azospirillum*, 2) a 5% glucose solution and 3) a 5% jaggary solution. It was observed that the establishment of the vetiver slips was higher when they were planted within 18 hours after uprooting and gradually decreased with further delay in planting time. Establishment was 97.9% when planting was done within 6 hours of uprooting, while it was

81.4% when planting was done after 36 hours of uprooting. There was not much difference in the establishment rate when considering root dipping in nutrient solutions.

The mean tiller count and plant height were observed 8 months after planting. All the biometric observations were higher when planting the vetiver slips within 6 hours. Vetiver slips planted 6 hours after uprooting had a higher mean plant height (107.8 cm), and number of tillers (26.2 tillers/hill), where as, the vetiver slips planter 36 hours after uprooting had the lowest mean plant height (96.2 cm) and number of tillers (24.1 tillers/hill). Among the root dipping techniques, roots of vetiver slips dipped in the *Azospirillum* solution had a higher tiller number (27.9 tillers/hill), while roots dipped in the 5% glucose solution had higher plant height (110.0 cm) than the other treatments. Lesser plant heights (94.1 cm) and tiller numbers (21.5 tillers/hill) were recorded with the roots of slips dipped in the jaggery solution.

Hence, it can be concluded that the vetiver slips should be planted within 24 hours of uprooting for better establishment and the roots may be dipped either in *Azospirillum* or in a 5% glucose solution for better growth in rainfed vertisols.

Seedling Technology for Vetiver

Ding GuangMin (FuJian Provincial Soil and Water Conservation Experiment Station) Fang HouDe (JianYang County Office of Soil and Water Conservation, FuJian Province)

Vetiver, a perennial grass, usually reproduces by tillers. Procedures for raising seedlings in various vetiver nurseries in FuJian Province are as follows: (1) Nursery preparation: nurseries are to be arranged in sand along gentle flowing rivers and in flat or slightly sloping fields with convenient transportation and a plentiful water supply. (2) Seedling cultivation: seedlings are cultivated in flat nurseries without a table or ridge arrangement. Clumps of vetiver, 3-5 slips each, pruned to a stem and leaf height of about 20 cm with roots about 10 cm long, are planted along contours in V-shaped holes, 10-15 cm in depth and spaced at 30¡Á30 cm. The planting season lasts from March to June with the optimum time being in March. Maximum survival rate and the most vigorous growth are found in vetiver seedlings planted in March while a decreased survival rate is found in those planted after June. About 300 kg/ha of fertilizer (urea) are dressed in holes, 15 cm deep and 5 cm from vetiver clumps, when the newly planted seedlings are turning green. (3) Management: timely planting and adequate management are helpful to ensure seedling growth with a survival rate of 100%. For more tillering and higher yields, the following management measures are needed: (a) timely irrigation in the first 15 days of green up, (b) irrigation 1-2 times during drought periods; weeding and (c) fertilizing at the peak of tillering in August and September. (4) Transplanting: seedlings will be ready for transplanting the following spring. Before being taken out of the nursery, vetiver grass should be pruned as seedlings with roots 10 cm long and stems and leaves 20 cm high. A 1 ha nursery needs 7,500 kg of seed vetiver grass and can produce 52,500 kg of seedlings as well as provide protection for 40 - 60 ha of terraced fields or 70 - 100 ha of sloping fields.

Perspectives of Vetiver Application in Southern China: A Case Study in FuJian Province

Zhou FuJian (Water and Soil Conservation Station of FuJian Province)
Xu LiYu (Institute of Soil Science, Academia Sinica, NanJing)

FuJian Province is located in the southeast area of the country, 23° 33'- 28 °19' N, 115° 50'-120° 43' E, with an area of 120,000 sq km and a population of 30,000,000 (1990). About 85% of the area is mountainous or hilly. In this southern subtropical climate, a deep weathered, red crust several meters to dozens of meters thick has formed.

In addition, there is a long coast line in FuJian Province, (3,324 km) and there are more than 1,200 islands. Most of these areas are covered by white sands which contain a high level of salts and are subject to wind erosion. Therefore, plants rarely grow well or even survive.

In the late 1980's the Red Soil Project supported by the World Bank introduced vetiver technology to southern China. Since 1988, vetiver has spread to a large area involving many counties such as JianYang, ShaoWu, GuangZe, ShunChang, AnXi, ChangLe, PingTan, SongXi, PuCheng, etc. About 200,000 kg of plant materials were produced of which some were exported to the neighboring provinces of JiangXi, HuNan, SiChuan, ShanDong, AnHui, and ShanXi. Besides the National Vetiver Conference held in ShaoWu in 1989, a workshop was held in SongXi organized by NanPing Prefecture. Vetiver planting was mainly organized by the local Agricultural Foreign Investment Offices involved in the Red Soil Project and also water and soil conservation stations.

Experience showed that vetiver could grow in extreme soil.
conditions such as the semi-weathered granite materials covering a large area in southern China, where the soil was almost completely eroded. The vetiver in these areas was planted along contour-line where other plants could not survive. The trial in AnXi County showed that after 3-5 years the barren land accumulated some litter, and other grasses, shrubs, and trees gradually took hold. At last, the barren and gullied land was completely covered by multiple layers of plants, shrubs and in particular trees, Meanwhile it was difficult to find the vetiver. So, farmers called vetiver a pioneering grass.

Vetiver was used to protect orchards by the JianYiang Water and Soil Con-

servation Station and Agricultural Foreign Investment Office. They made 'hill-side ditches' surrounding the hills using a width so that a walking tractor could be operated in a screw thread fashion. Along the ditch embankments vetiver was planted in double-line at a spacing of 20x30 cm without fertilizer application. The next year the grass grew up to 3 m in length, while the roots were 1.5 m deep. The grass was cut 2-3 times a year, which promoted better growth and produced more tillers. The cuttings were used for ground mulch or pulp. About 1-2 years after planting the runoff decreased considerably. Three years after planting, the soil particles were efficiently detained by the vetiver hedges. As the outer-side of the ditches was a little higher than the inner side, the ditches effectively retained the water.

Another use of vetiver grass was with Chinese chestnut widely planted in areas of northern FuJian Province and many other provinces as well. Because of soil erosion the soil fertility declined once the original plantation had been cleared and the young chestnut trees planted. To solve this problem, the HuShan Orchard Plantation in JianYiang County established a vetiver fence on land with a slope of 12 °. They cleared the degraded Masson's pine and planted chestnuts at a 3x3 m spacing. In December 1990 instead of establishing terraces, they planted vetiver grass to build hedges along the contours at every 2-3 meters of altitude.. The results showed that vetiver hedges could control soil erosion very efficiently and saved the costs of building terraces.

In FuJian Province, with its long coast line and numerous islands there was also a critical problem with wind erosion. The soil, primarily a coarse white sand, contained very little organic mater and many salts, which made it difficult for most plants to survive. The cultivated lands were frequently buried by sand, while rivers and ditches were continously blocked. Since the 1990's farmers in these areas have planted vetiver under the guidance of technicians. They planted vetiver along ditches, roads, and seashores. In addition, they built windbreak nets of trees with vetiver surrounding the plots to control the wind and sand. Inside the plots they planted the profitable shrub hohoba to produce seeds from which a lubricating oil was extracted. Many other crops and vegetables could also be cultivated in the plots.

It is obvious that vetiver grass can be widely used for cultivation on sloping lands, for wind erosion control, and for the protection of rivers and ditches in southern China.

Hubei Province, China. Two examples of serious point source erosion. Top image shows an erosing river bank. and bottom image shows abandoned terraces that have been eroded. Both could have been stabilized with vetiver if the technolgy had been available and know. Phot credit Xu Liyu

Application of the Vetiver Grass System in Land Stabilisation, Erosion and Sediment Control in Civil Construction

(Paper prepared for the Queensland Main Roads Southern Region Symposium, Toowoomba 20-22 November 1997),Dr. Paul Truong, Leader, Erosion Control and Slope Stabilisation Resource Sciences Centre, DNR, Brisbane. Diti Hengchaovanich, M. Eng., P.E., CEO, Erocon Sdn Bhd, Kuala Lumpur, Malaysia.

1.0 INTRODUCTION

Land disturbance by construction activities has resulted in soil erosion increases from two to 40 000 times the pre construction rates (Goldman et al, 1986) with sediment being the principal transport mechanism for a range of pollutants entering water courses (Kingett Mitchell, 1995)

Although Vetiver grass (*Vetiveria zizanioides*) has been used for land protection purposes for about 50 years, its real impact on soil and water conservation was only started in the late 1980's following its promotion by the World Bank.

The Vetiver Grass System (VGS) was first developed for soil and water conservation in farm lands. While this application still plays a vital role in agricultural lands, vetiver grass unique morphological, physiological and ecological characteristics including its tolerance to highly adverse conditions has a key role in the area of environmental protection in civil construction

2.0 SOME SPECIAL CHARACTERISTICS OF VETIVER GRASS

2.1 Morphological characteristics

Vetiver grass has neither above ground or under ground runners and a massive finely structured root system, reaches down to 2 - 3 m in the first year (Photo1). This massive and thick root system bind the soil and at the same time makes it very difficult to be dislodged. This very deep root system has also made Vetiver very tolerant to drought, it did not only survive but continued to grow through the worst drought in Queensland early in the 1990's. In addition Vetiver has the following desirable characteristics :

Stiff and erect stems which can stand up to relatively deep water flow (0.6 - 0.8 m).
Dense hedges when planted close together, reduce flow velocity and form a very effective filter.
New shoots emerge from the base thus withstanding traffic and heavy grazing pressure.
New roots are developed from nodes when buried by trapped sediment. Vetiver will continue to grow with the new ground level eventually forming terraces, if trapped sediment is not removed (Truong et al, 1995)

2.2 Physiological Characteristics

Tolerance to extreme climatic variation such as prolonged drought, flood, submergence and extreme temperature from -10˚C to 48ºC (in Australia) and higher in India and Africa.
Ability to regrow very quickly after being affected by drought, frost, salt and other adverse soil conditions when the adverse effects are removed .
Wide range of soil pH (3.0 to 10.5)
High level of tolerance to soil salinity, sodicity and acid sulfate (Truong et al, 1996; Truong and Baker, 1996)
Highly tolerant to toxic levels Al, Mn, As, Cd, Cr, Ni and Cu (Truong and Claridge, 1996)

2.3 Ecological characteristics

Although vetiver is very tolerant to some extreme soil and climatic conditions, it is highly intolerant to shading. Shading will reduce its growth and in extreme cases, may even eliminate vetiver in the long term. Therefore vetiver produces best growth in the open and weed control may be needed during establishment phase.

Also because of this characteristics vetiver can be considered as a pioneer plant on disturbed lands. Vetiver first stabilises the erodible ground (particularly steep slopes), then improves its micro environment so other volunteered or sown plants can establish later. If the planted or invaded local native species, such as trees and shrubs, are taller than vetiver, these plants will shade the vetiver out, reducing its growth and in the long term (if desirable) can replace vetiver as the main stabilising agent. North Queensland and overseas results have shown that within two years local species can reduce vetiver growth substantially (Photo 3&4). Therefore vetiver is highly suitable for land rehabilitation in combination with native plants.

2.4 Weed potential

It is very important that any plants used for environmental protection will not become a weed From the three vetiver cultivars present in Australia, a sterile line was selected and rigorously tested for its sterility. This cultivar was registered in Queensland as Monto vetiver to commemorate the Monto district where the first field trial was conducted in 1990

Truong,1996).

In Fiji where vetiver grass was introduced to the country for more than 100 years and it has been widely used for soil and water conservation purposes for more than 50 years, it has not shown any weed potential (Truong and Creighton, 1994).

Vetiver grass can be eliminated easily either by spraying with Roundup or uprooting and drying out.

3.0 HOW DOES THE VGS WORK?

When planted in rows Vetiver plants will form a hedge, a living porous barrier which slows and spreads runoff water and traps sediment. As water flow is slowed down, its erosive power is reduced and at the same time allows more time for water to infiltrate to the soil, and any eroded material is trapped by the hedges. Therefore an effective hedge will reduce soil erosion, conserve soil moisture and trap sediment on site.

4.0 MAIN CAUSES OF SLOPE INSTABILITY

The main reasons for slope instability are surface erosion and structural weakness of the slope. While surface erosion often leads to rill and gully erosion, structural weakness will cause mass movement or land slip.

Normally a good vegetative cover provided by hydromulching is very effective against surface erosion and deep rooted plants such as trees and shrubs can provide the structural reenforcement for the ground. However on newly constructed slopes, the surface layer is often not well consolidated, so rill and gully erosion often occurs on even well covered slopes. For these, structural re-enforcement is also needed very soon after construction, but trees are slow and often difficult to establish on such hostile environment. Vetiver grass is fast growing and with its very extensive and deep root system can provide the structural strength needed in a relatively short period of time. In fact as will be presented in section 5.1, vetiver roots have been found to have average tensile strength equivalent to one-sixth of mild steel. *Therefore the role of vetiver in slope stabilisation should not be equated to that of hydromulching species and the cost of vetiver establishment should not be compared with that of hydromulching either.*

5.0 ENGINEERING APPLICATIONS

Due to its unique characteristics mentioned above, vetiver has provided a very effective means of steep slope stabilisation and flood mitigation.

5.1 Root tensile strength, shear strength and Steep Slope Stabilisation

Batters of both cut and fill slopes can be effectively stabilised by establishing vetiver on contour lines. The deep root system provides structural re-enforcement and stabilises the slope while the hedges spread runoff water, reduce rill erosion and trap sediment, providing a more favourable environment for the colonisation by local volunteer species.

Research conducted in Malaysia (Hengchaovanich and Nilaweera, 1996) showed that the tensile strength of vetiver roots increases with the reduction in root diameter, this phenomenon implies that stronger fine roots provide higher resistance than larger roots. The tensile strength of vetiver roots vary between 40 -180 Mpa for the range of root diameter between 0.2 - 2.2 mm. The mean design tensile strength is about 75 Mpa (equivalent to approximately one sixth of mild steel) at 0.7-0.8mm root diameter which is the most common size for vetiver roots. This indicates that vetiver roots are as strong as, or even stronger than that of many hardwood species which have been proven positive for root reinforcement in steep slopes.

In the soil block shear test, they found that root penetration of a two year old Vetiver hedge with 15 cm plant spacing can increase the shear strength of soil in adjacent 50 cm wide strip by 90% at 0.25 m depth. The increase was 39% at 0.50 m depth and gradually reduced to 12.5% at 1 m depth. Moreover, because of its dense and massive root system it offer better shear strength increase per unit fibre concentration (6-10 kPa/kg of root per cubic metre of soil) compared to 3.2-3.7 kPa/kg for tree roots (Photo 2).

In a paper presented at last year Vetiver Workshop in Toowoomba, it was also observed that vetiver can grow vertically on slope steeper than 150%, faster growing and imparts more reinforcement to the make it a better candidate for slope stabilisation than other plants (Hengchaovanich, 1996). Another less well known characteristics which sets it apart from other tree roots is it power of penetration. Its 'innate' strength and vigour enable it to penetrate through difficult soil, hard pan or rocky layer with weak spots. It even managed to punch through asphaltic concrete pavement. He added that, indeed one can say that Vetiver roots basically behave like living soil nails or dowels of 2-3m depth commonly use in 'hard approach' slope stabilisation work. However, due to the high rainfall of Malaysia (1 750 to 3 500 mm/year depending on the region) the effectiveness of the mechanical mechanism mentioned above may be reduced by the negative effect of the hydrological mechanism (increased infiltration and permeability which can induce mass movement).

The first trial on batter stabilisation in Queensland was conducted on a very steep (1:1) railway cutting in 1992 on a highly erodible sodic soil near Babinda, north Queensland. Monto vetiver planted stabilised the

batter in the first 6 months and the inter-row spaces were then completely colonised by local vegetation later. After fifteen months this highly unstable slope was stabilised by a mixture of vetiver and local native vegetation (Photo 3,4)(9).

Another trial was started in 1995 to compare the effectiveness of a native Australian vetiver (*Vetiveria filipes*), *Lomandra longifolia* and Monto vetiver (*V. zizanioides*) in batter stabilisation on an access road to Teemburra Dam near Mackay. After two years all three species established well but following a prolonged rain period in March 1997 (with 400 mm over two weeks), the sections planted with the Lomandra and native vetiver collapsed while the Monto vetiver section remained intact. These results clearly show the unique characteristics of Monto vetiver as compared with other vetiver species (Photo 5,6).

Figure 1

Where:
q = discharge per unit width
y_1 = depth upstream
S_o = land slope
N_F = the Froude number of flow.
y = depth of flow
S_f = energy slope

Currently Paul Truong is using vetiver as a major component of a batter stabilisation, erosion and sediment control program for Queensland Rail on the Murphy Creek - Toowoomba rail line.

Although Malaysia is currently leading the world in the application of Vetiver for erosion and slope stabilisation in highway engineering, Hengchaovanich conceded that the design is still some what conservative, treating Vetiver as 'a bonus' or added assurance. Once more design parameters, especially the evapotranspiration and hydraulic aspects, and track records come to light, bolder and more innovative designs maximising the full potential of vetiver grass should be adopted (Hengchaovanich, 1996).

5.2 Hydraulic properties, sediment trapping and flood mitigation

On the floodplain of the Darling Downs strip cropping practice relies on the stubbles of previous crops to control erosion from flood flow on fallow land and young crops. But during drought or when low stubble-producing crops such as sunflower and cotton are grown, very little protection is provided. Vetiver hedges can provide a permanent protection against erosive flood flows on the plain.

Hydraulic characteristics of vetiver hedges under deep flows were determined by flume tests at the University of Southern Queensland for the design and incorporation of vetiver hedges into strip cropping (Dalton et al, 1996) (Fig.1)

Flume tests showed that when fully established, the Vetiver hedges should provide adequate protection from floodwater over the 90 m spacing on 0.2 - 0.35% land slope which is equivalent to five existing strips at this particular site.

Eight rows of vetiver totalling almost 6,000 m, were planted at 90 m intervals on a strip cropped site near Jondaryan. Results over the last two years, including several major floods, have been excellent, the hedges were successful in reducing flood velocity and limiting soil movement, resulting in very little erosion in fallow strips and a young sorghum crop was completely protected from flood damage.

On the sediment trapping of vetiver hedges, the most important factors are hedge spacing and the thickness (density) of the hedge. Closely spaced hedges will minimise the quantity of sediment entrained by the flow. Dense hedges will maximise the depth upstream, the length of the back water and the settling time for particles and hence proportion of the sediment trapped. As terraces form the length of the backwater will increase and the sediment trapping efficiency will also increase - provided the hedge grows out of the sediment layer, remains dense and upright and is not overtopped by the flow (Smith, 1996).

VGS has also been used very effectively in the stabilisation of a large water cascade which was built by South Johnstone sugar mill near Innisfail on the bed of the flood prone South Johnstone River, to cool off wastewater from the mill. This 200 m long and 4 m high structure with 2:1 side slope was built mostly from the highly erodible sand and gravel material from the river bed. Vetiver has successfully protected this bank from several flood flows during the last two wet seasons.

6.0 SOME OTHER APPLICATIONS IN QUEENSLAND

VGS has also been used successfully in the following applications:

Agricultural lands

Replacement of contour banks in

steep sugarcane lands on the wet tropical coast..

Stabilisation of gully erosion in both cropping and grazing lands. When planted on contour line above gully head, vetiver hedges spread and slow down runoff water and stop the advancement of gully heads.

Stabilisation and rehabilitation of a highly erodible acid sulfate soil on the coastal plain where the actual soil pH is around 3.5 and oxidised pH is as low as 2.8 (Truong and Baker, 1996). Control of erosion on dam wall caused by wave action,

Provision of shade for sheep in treeless Mitchell grass downs in north Queensland.

Stabilisation of road and waterway in forestry plantations.

Sediment trapping .. Trapping eroded material at a working quarry. Vetiver hedges planted across waterways and drainage lines reduced erosion and trapped both coarse and fine sediment resulting in less polluted water in the dam.

Rehabilitation of contaminated lands.. Landfill sites and industrial wastes are usually contaminated with heavy metals such as Arsenic, Cadmium, Chromium, Nickel, Copper, Lead and Mercury which are highly toxic to both plants and human. As these old sites are often adjacent to residential and recreational areas, the movement of these contaminated materials from the sites must be adequately controlled. Results from works conducted at Cleveland for the Redland Shire Council have conclusively shown that vetiver can rehabilitate the highly erodible slopes and drainage lines and are also very effective in reducing leachate from an old landfill (rubbish dump) at Cleveland (Truong and Baker, 1997).

Rehabilitation of mining and industrial wastes ... Rehabilitation of old quarries where very few species can be established due to the hostile environment. Vetiver is able to stabilise the lose surface first so other species can colonise the areas between hedges.

Stabilisation and rehabilitation of overburden and highly saline and alkaline (pH 9.5) tailings of coal mines and highly acidic (pH 3.5) tailings of a gold mine.

7.0 ESTABLISHMENT REQUIREMENTS

Although vetiver grass is very tough and resilient when fully established, it needs special care during establishment phase.

7.1 Planting materials

As mentioned earlier vetiver grass has to be established vegetatively by root subdivision (slip). Each slip normally consists of 2 - 3 tillers. At the moment there are 4 types of planting material available:

Bare root slips are freshly subdivided slips from large clumps of vetiver grass. These slips are for immediate planting.

Bare roots plantlets are 4-5 weeks old plantlets which were raised in sand beds and supplied fresh for planting within a week.

Tube stocks are tubed or potted plants (4-5 week old) which can be kept in nursery and planted when needed.

Strip or band slips are strips of 1 m in length, raised in special containers for 2 - 3 months and can be kept for a few weeks in nursery before planting.

7.2 Advantages and disadvantages of different planting materials

The bare root slips are the cheapest but required splitting the large clumps before planting. These materials require most intensive watering during hot and dry periods and therefore not recommended for large scale application.

The bare root plantlets are more expensive but arrived on site ready for planting. In large projects, these plantlets can be raised in sand beds on site to reduce costs. These also need intensive watering during establishment phase.

Tube stocks cost approximately the same as bare root plantlets, but they are more bulky and heavier to transport to sites. Root damage may occur during planting and they require less intensive watering.

The main advantages of the strips are that the vetiver plants were established close together (50 - 70 mm apart), and the roots damages are minimal during planting. The other advantages are lower planting costs as they are planted in 1 m band at a time and easier to plant especially on steep slopes. Because of the smaller gaps between plants and older plants these strips provide protection sooner then other planting materials. The strips also require less intensive watering. Their main disadvantage is their slightly higher costs. To reduce cost they can also be prepare on sites.

7.3 Layout Design

In general for slope stabilisation vetiver is planted on contour lines to spread runoff water and to trap sediment. Row spacing normally varies between 2 and 0.8 m VI (Vertical Interval), but the exact layout varies between sites, depending on soil type, slope gradient, slope length and most importantly local weather.

Plant spacing is recommended at 0.15 m apart (averaging 7 plants per linear metre). For sediment trapping in drainage lines closer spacing is recommended.

7.4 Watering

It is best to plant vetiver grass into wet soil, when planted into dry soil it needs to be watered soon after planting (within that day). Therefore pre watering the day before is highly recommended. If no rain occurred watering is needed daily for the first week and every 2 or 3 days for the next 2 weeks depending on the weather (hot and dry weather requires more watering) and 2 to 3 times a week until rain.

7.5 Maintenance

It is important to have the topsoil and base materials tested to determine the fertiliser requirement at planting and subsequent maintenance. In general 150g/m of DAP (Di Ammonium Phosphate) is needed at planting and once again 5-6 weeks later. For the next two years twice during the summers.

As vetiver is particularly intolerant to shading, especially during establishment phase, weeding may be required during the first year, particularly climbing plants such as belle vine and Siratro.

Vetiver is extremely sensitive to Roundup weedicide (glyphosate), therefore vetiver should not be exposed to this weedicide. Any other herbicides, pre-emergent or post-emergent such as 2,4 D based chemicals can be used for broad leaf weeds.

7.6 Quality Control

The most important factors that determine the success or failure of the application of VGS in civil construction are in the following order:

- Good quality planting materials.
- Appropriate design layout.
- Adequate watering during establishment phase.
- Chemical analyses of both base material and topsoil to determine.
- fertiliser requirement and possible soil amendment prior to planting.
- Weed control when required

8.0 CONCLUSION

From the results of research and the successes of numerous applications presented above, it is clear that we now have enough evidence that VGS is ready to move out of the farm gate, beyond the soil and water conservation applications in agricultural lands to the protection of the environment in general, with particular emphases on the rehabilitation of disturbed land caused by civil construction, contaminated lands, mining wastes.

However it must be emphasised that to provide an effective support for engineering structures, the two most important points are the quality of the planting materials and the all important APPROPRIATE DESIGN AND CORRECT APPLICATION TECHNIQUES. Unless these strict specifications are met, its effectiveness is lost.

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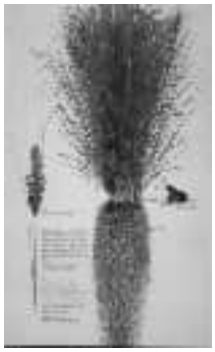


FARMERÕS OWN ADOPTION: ÒA FRAME/LINE LEVEL COMPOSITEÓ

By Jerimia Phiri, Small Farmer, Malawi.

My name is Jerimia Phiri, a small scale farmer in Nkhata-Bay district in Northern Malawi. I farm a garden most of which is on slopes exceeding 12%. I was first introduced to an "A" frame as an equipment used in pegging contour marker ridges by an agricultural extension worker who resides in our village in August, 1996. Two months later I taught the use of a line level to perform the same function as the "A" frame.

For want of a better name I have tentatively named this equipment "A/ Line level Phiri"

After using the equipment I noted several problems posed by both instruments, some of which include the following:

"A" frame

- is slow to use since the spacing between the poles is normally short
- the pendulum takes too long to settle especially on windy days
- could be obstructed by stumps or small trees etc.

Line Level

- requires more than three people to peg a contour line
- may not be as accurate because one may prefer to have the two poles at wider spacing for a quicker operation
- the string used to hold the line level has to be regularly made stiff by pulling from either side by the operators since it is not fixed

I also noted a few advantages in both instruments relating to accuracy in the "A" frame and ease of operation in the line level.

With these observations and using my experience on both instruments I thought of combining the advantages of both instruments and removing the disadvantages by making what I call a composite "A" frame/Line level equipment.

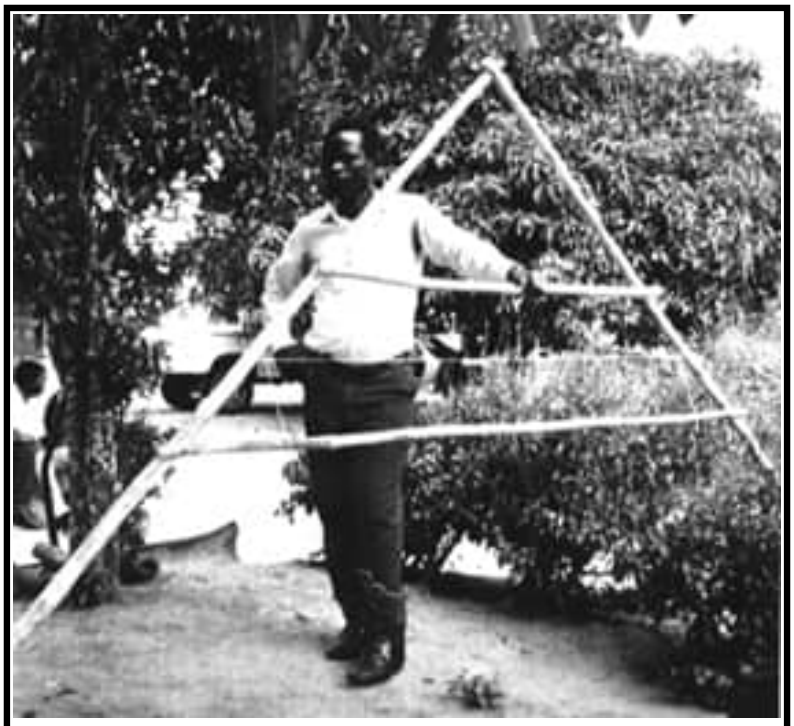
Description of Equipment

Essentially the equipment looks like an "A" frame except that it does not have a pendulum. It has two legs spaced at over three metres when standing on the ground, and two cross bars. These materials should preferably be dry bamboo sticks. The size of the frame should be dependent on the size of the person using the equipment. In-between the two cross bars a string is tied very tight from both the two legs of the equipment. The line level is fixed halfway between the string (see Figure 1).

I normally work with two "A/Line levels Phiris", one small and another slightly larger. The smaller one is used when I peg fields that do not have uniform slopes.

Calibration is done in the same way as for the "A" frame except

Mr. PhiriÕs A Frame/ Line Level Composite was used to peg out these hedgerows in northern Malawi



Mr. Phiri with his ÒA Frame/ Line LevelÓ As can be seen it is simple. Note the thin string with the line level attached

that when the construction of the frame itself is geometrically correct the line level can be fixed on any position on the string.

Pegging a contour line

Pegging a contour line follows normal recommendations, but in this case the points of equal height on a contour line are marked by centering the bubble in the line level instead of the pendulum. It must be noted that the equipment can be tilted at 45 ° or less towards or away from the operator where obstacles such as tree stumps need to be avoided.

EcolinkÕs Vetiver Grass Programme (April - July 1997)

By David Jobson,Coordinator: EcoLink Vetiver Grass Programme,POBox 727,White River, 1240, South Africa. *(First printed in SAVN Newsletter #2)*

A couple of nights ago I dropped into the 'local' and was introduced to a group of fellow cyclists from sundry parts who had descended on the Lowveld for the 15th old Mutual Jock Cycle Tour. Before I could open my mouth the landlord introduced me as the 'Vetiver man' and he and another customer began to laud the virtues of this remarkable grass. However, as our dynamic co-ordinator also haunts this part of the world it is not surprising that hardly a drinking soul has gone untouched by the message! *(Dynamic? - hardly. And I promise, I don't touch the stuff - Tony Tantum is my witness! However, I can recommend the 'local' - Gianni's - in White River. Hopefully this bit of unsolicited publicity will get me a free meal. Ed.)* I phoned the optician last week for an appointment. Although I had never met him he called me back to say he'd been retrieving Vetiver information off the Internet and could I bring him some leaflets! He did eventually get around to testing my eyes. So, by fair means or foul, including some local press coverage (English and Afrikaans), a local radio item (in Siswati), and formal and informal workshops, Vetiver awareness has invaded the Lowveld!

For one person with no agricultural credentials to make a serious impact in four months was quite a tall order. Fortunately the programme is based at EcoLink, an Environmental Education organisation established by Dr Sue Hart which has been working with traditionally disadvantaged communities in the Lowveld since 1985. Furthermore, EcoLink has been working with Vetiver since 1990 and planting with community groups and individuals for the past four years. A small nursery provides planting material and agronomist Brian Beck has been available to advise. Hence the task of 'selling' the grass to community leaders and key individuals in agriculture, roads, water affairs, mines and forestry has been a little less formidable.

Four full-day workshops and four Vetiver sessions within other programmes have introduced the grass to 246 individuals, 120 of whom are in positions to influence others - both groups and institutions. Our programme made use of local interests and expertise including Andrew Hall of Dickon Hall (essential oil production) and Johan Swart of Soil Erosion Control involved in propagation and commercial bank stabilisation. Over the period of the programme

over 30 different plantings have taken place (albeit small scale) and have include community nurseries, clinics, farm erosion control, and individual gardens. Many more of the workshop participants have promised to plant at the beginning of the summer rains (September/ October) and I hope to be following up on these good intentions.

The focus of the programme has been the soil erosion control and water retention qualities of the plant. We are well aware of the small scale farmer's resistance to a plant that does not show any immediate financial return, as was reported in a very recent programme of 'Farming World' on the BBC World Service. The farmers, spotlighted in this programme, were examining the relative merits of four different vegetative barriers. Vetiver came last as not providing any commercial return by comparison with sugar cane for example. In Mpumalanga there is considerable public awareness of soil erosion - bridges swept away, roads turned into dongas, rivers of mud and the very real problems associated with a thunderous downpoor which can sweep all in front of it and destroy a carefully nurtured garden plot in a trice. Nevertheless, soil erosion is nobodies baby! The private individual has always seen it as a part of government's responsibility even though there is little evidence of anything being done at local level. I believe we have started making inroads into this article of faith and also demonstrate that bank and soil stabilisation can be a serious income generator for the small (and not so small) entrepreneur. Understandably, the commercial aspects of the plant have generated the most interest. Mpumalanga has great opportunities for Vetiver business as those into essential oil production and bank stabilisation are aware. Even now demand outstrips supply and awareness raising has only just begun!

The four month Vetiver Network funded project has been extended for another month thanks to Dickon Hall of Nelspruit, while we seek financial support to continue this work and pursuade those in the mining, forestry, water, roads and the oil business that a little money spent now will reap considerable benefits relatively soon for the individual, society and the environment.

***Guinea**. Top two photos show new vetiver hedgerows in Guinea (a joint Sasakawa Global 2000 / West Africa Vetiver Network project). Bottom photo is of a 6 month old (very good growth) vetiver nursery located on a low lying Òbas-fondÓ Photo Credits: Linus Folly*

SPREADING THE SLIPS OF VETIVER GRASS TECHNOLOGY:

A lesson in technology diffusion from Latin America

by Vanessa Slinger (Draft paper for World Bank). The following are some extracts from Ms. Slinger©paper. The full paper is on the Vetiver Home Page at www.vetiver.org

..... Erosion - a needed sense of urgency for an insidious problem

The magnitude and effect of soil erosion is astounding. On a global scale exact rates of soil erosion are unknown and difficult to measure, however, estimates point to a possible 10 to 20 billion tons of soil lost a year worldwide; representing the equivalent loss of between 5 million and 7 million hectares of arable land (NRC, 1993). The extent of the effects of soil erosion is as great as its size. Local farmers experience untold losses in agricultural production and the health and security of their families. Further down the chain of effects the changes it brings are chronic and often irreversible: lost land; reduced productivity in forests; deminished watertables; floods; silted harbors, reservoirs, canals and irrigation works; washed out roads and bridges; and destroyed wetlands and coral reefs.

All of this destruction in turn has a negative affect on the national economy of a country.

With this kind of economic loss at stake it would seem expedient that the governments of countries be implementing drastic programs for soil conservation. However, both the causes and nature of soil erosion make it a difficult problem to address. A primary cause of human-induced erosion has been the expansion of agricultural production on to steeper slopes, with more erodable soil and shallower topsoil (Yudelman et al, 1990). This situation is exasperated by rapid population growth. The marginalization of small farmers onto steeper land is usually a result of government policies that provide incentives for extensive production, such as cattle ranching, to be placed on the most fertile bottom-lands. At the same time, small farmers, involved in intensive food production, have no option but to eke out a living on the hillsides available to them.

Even where soil conservation methods have been implemented farmer adoption and sustenance after intervention is low. The insidious nature of soil erosion often creates a situation in which neither the government nor farmers feel that there is a problem to be addressed. Except in severe weather conditions, soil erosion can be hard to perceive visually over a short period of time. Along with insignificant recognition of soil erosion, *often inappropriate techniques are* used to tackle the problem, leading to failure and total abandonment of soil conservation measures. The general approach taken tends to handle soil conservation as an engineering problem amenable by using high-cost and highly technical-assistance-intensive technologies, including engineered structures such as earth bunds, gully plugging and terraces; many of which are heavily subsidized by governments or international institutions. These technologies require significant changes in land use, farming practices and labor inputs.

Not only are there substantial initial investments, engineered measures have high annual maintenance costs (Smyle et al, 1994). These systems have been described as more expensive per ton of soil erosion reduction than any other alternative for erosion control (USDA, 1981). This engineering bias has been encouraged by strong vested interests inside and outside government and donor agencies (Yudelman et al, 1990). In India, contour banks and bunding are the main erosion control methods promoted by extension agents. Farmers only implement the banks and bunds because of the presence of subsidies given by the government. Extension agents push these big budget methods because of the financial cut backs that are possible. One result of focusing on engineering methods has been the limited use of cheaper, and perhaps more effective, alternatives for soil and moisture conservation, including vegetative measures.

Technology diffusion - to be used or not to be used

Other than limited application for soil and moisture conservation, there are other struggles that a technology, such as vegetative barriers, must face once it is on the ground. The diffusion of vetiver grass technology is limited by the fact that construction and soil conservation program tend to be run by engineers who tend to be more familiar with bunds and terraces. The diffusion of vetiver grass technology as a measure for roadside and construction site stabilization has been hampered by mistreatment of the technology. In the case of roadside stabilization failures in the use of vetiver technology have resulted from the fact that contractors and the highway authority doing the design work have no idea of the

planting specifications of the plant. Any technology implemented incorrectly will fail in its goal.

A brief review of the literature suggests that there are key elements that influence the diffusion of a new or little used technology. Those elements relevant to agriculture, and soil erosion in particular, deal with small farmer s risk aversion and also their need for the provision of recognizable benefits in the short term. Tangible benefits must be apparent if the individual is to sacrifice time and work away from other tasks. Farmers are far more likely to adopt a technology if they see that others in the community have successfully incorporated this technology and that there are clear advantages. These benefits do not necessarily have to be economic, other gains, relating to culture, security and stability can be equally important.

Studies giving evidence of program impact years after the outside intervention ended concluded that PCAD, people-centered agricultural development, a series of principles for making extension work effective, can be applied easily and effectively to the diffusion of soil and moisture conservation technologies. The basic principles include reducing the risk of adoption by teaching farmers to experiment with new technologies on a small scale; using rapid, recognizable success in these experiments rather than artificial incentives, such as subsidies, to motivate the farmers to innovate; using technologies that rely primarily on inexpensive, locally available resources; beginning with a limited number of technologies to allow resource poor farmers to get involved and to achieve the maximum possible percentage of successes early in the program; and training community leaders as extensionists and support them while they teach additional farmers, thereby creating a community-based multiplier effect (Bunch, 1996).

In reference to vetiver diffusion throughout the world and especially in Latin America, PCAD principles are already in effect. Through local NGOs, government and educational institutions, and, in the case of El Salvador, a private company, farmers are being encouraged to test this technology in small areas of their fields. With vetiver hedges limited experimentation is easy, especially compared to experimentation with alley cropping which requires restructuring the entire field. Furthermore, vetiver technology is inexpensive and requires very low labor inputs in creating and maintaining the vegetative structures (box 1.1). Well aware of the dangers of promoting the technology solely for the purposes of soil erosion prevention, these organizations are advising farmers to propagate vetiver on better soils in contour lines associated with their crops so that they will experience an increase in the productivity of their crops. A large component programs is the identification of local community leaders and innovators who are willing to set up demonstration plots in their fields.

..... Vetiver technology in action - case studies in the diffusion of vetiver El Salvador: NOBS ANTI-EROSION

The problem of soil erosion in El Salvador is severe and in need of immediate solutions. Contributing 25 percent of the country s gross national product in 1990, agriculture is one of the most important sectors of the economy (Hernandez Navas et al, 1994). As in other Latin American countries there is a dichotomy in the agricultural sector between the modern industrial plantations producing export crops on the best land and the large numbers of small landowners growing subsistence crops using traditional methods on marginalized plots. As a result of the conversion of forests into agricultural land and soil degradation, annual soil loss varies from 50 to more than 180 metric tons per hectare in critical conditions. Further down the line, sedimentation of the reservoirs of the three hydroelectric dams in the watershed of the Lempa River has reduced the effective life span of the dams from thirty to eight years.

NOBS ANTI-EROSION is a company based in El Salvador working to promote the use of vetiver hedges for soil erosion control in the agriculture, industry and construction sectors of the country. Aware of the country's serious erosion problem, NOBS ANTI-EROSION was created in 1994 as a subsidiary of NOBS HIDROFUSION, Inc. which was established during the mid 1980s as a producer of essential oils for the perfume industry. NOBS has made a commercial success of vetiver, not only through its sales of oils, but also from contracts for highway and construction site stabilization using the grass. NOBS contracts out the work of vetiver production to some farmers with privately owned or leased land on the coastal plains south of Volcan Chinchontepec in San Vincente and Volcan Chaparrastique in San Miguel. In this way NOBS currently has more than 150 hectares planted with vetiver grass for oil production and production of material for erosion control. On a yearly basis the company has about 80 hectares of vetiver grass available for sale as planting stock. Government and private construction companies have been NOBS main clients so far. To date NOBS has planted 300 km of vetiver hedges along the roadsides and slopes in El Salvador.

Vetiver grass technology has been promoted in El Salvador primarily through NOBS aggressive campaign of advertising on bill boards, over the radio and in the newspapers. As result of this broadcasting, in one year NOBS made $350,000 from the sale of vetiver grass for highway and construction site stabilization. NOBS has also donated significant amounts of its patented vetiver material (Cultivar JF 91) to local communities for soil and moisture conservation. Farmers have been encouraged to incorporate vetiver hedges with their staple

crops of corn, beans and sorghum. These crops are most commonly found grown on slope greater than 5% and can be very erosive.

In order to work with communities NOBS has networked through NGOs that are already established and accepted. In addition, the company has five extensionists associated with the organization who do demonstrations, training and advise on community projects. The green book , Vetiver Grass: A Hedge Against Erosion, has been used extensively by NOBS and its technicians as an extension tool. Other promotional and extension material for vetiver grass technology, developed by NOBS, includes flyers and a comic booklet. This booklet with drawings is directed at small farmers to explain the problem of soil erosion and how vetiver hedges can help to control the loss of soil and improve crop production. The material is mainly visual and easy to follow.

NOBS has taken care not to promote the use of vetiver roots as a material source for making perfumes and oil because of the risk that individuals will excavate the plants for their roots and defeat the purpose of the plant as a measure for soil and moisture conservation. The best advertising that vetiver grass technology has received so far in El Salvador is the word of mouth from one farmer to another (campesino a campesino). Farmers using vetiver grass not only tell other farmers about their experiences, more importantly, the hedges in their fields speak for themselves. In one farmer s field the improvement in the soil as a result of using vetiver hedges allowed a slope, that was once entirely used to meet corn subsistence requirements due to low production, partly to be put into coffee production. NOBS feels that it is very important to get farmer demonstration plots in as many communities as possible in El Salvador to spread the technology as quickly as possible.

NOBS has been raising the level of consciousness about the problem of erosion in El Salvador and the methods that can be used effectively to save the soil. Presentations to government officials and local banking institutions, such as the government bank working with small farmers (BFA - Banco de Fomento Agropecuario), has led to the adoption of reforms to their credit pre requisites such ...previous to any credit approval the farmer should show proof of some soil conservation application in his/her plot. This could be dead barriers, pineapple, izote, lemongrass, vetiver, or simply organic debris... (Vetiver Newsletter #17). Furthermore NOBS has been involved in the training of approximately 210 agronomists from BFA in vetiver technology. On the farmers level, the acceptability and desirability of vetiver as a measure for soil and moisture conservation is recognized, oddly enough, through the theft of a truck load of vetiver grass planting material, not including the vehicle, left overnight on a community roadside.

Oaxaca, Mexico: PCERS - Program for the control of erosion and the restoration of the soils of Oaxaca, Mexico.

Oaxaca, Mexico, has wide range of ecological zones, and is also home to 16 indigenous groups. These indigenous people are tied to the land in terms of their physical and cultural survival. Therefore, the issue of soil and moisture conservation is a felt need and a priority. The lack of sustenance of soil erosion control methods is sometimes due to the lack of problem recognition and definition (Fujisaka, 1989). In the case of Oaxaca, however, the people are clear on what the problem is; the loss of their soils and the increasing dryness of their lands. I asked some farmers how they knew that they were losing soil. Their answer was that they were now growing their crops on rock instead of soil and that they had experienced a decline in productivity. Erosion is evidently threatening to take these people off of their land and away from their culture.

SASO is part of a group of NGOs and a Technical Committee who are introducing the use and application of vetiver technology to communities in Oaxaca. SASO was started in 1995 with the initiation of the Program for the Control of Erosion and Restoration of the Soils of Oaxaca (PCERS), an initiative aimed at the necessity for communities to consider simple and low cost natural methods to improve their soils and reduce erosion. A Technical Committee was formed in April 1995 to coordinate, supervise activities and facilitate the institutional involvement. The Technical Committee has 20 member organizations which includes member communities, NGOs, research and training institutions and government (Vetiver Newsletter #16).

The focus of PCERS and its member organizations, of which there are 20, is to get vetiver into the hands of local farmers and indigenous communities for the purpose of (1) slowing down the rapid rate of erosion and increasing the productivity of their land and (2) acting as the supply point of vetiver to government and other agency s projects. So far other structural methods, such as terracing and bunding, have not worked in the long run. These methods are expensive, both financially and time wise, and when the subsidies are removed farmers cannot afford to continue to upkeep the structures. Vetiver is seen as a good alternative. Vetiver grass is not a theoretical technology for these people. It can be put into their hands, it is easily demonstrated and, as a vegetative measure, it fits into their cosmology. Experiments in all ecological zones of Oaxaca have demonstrated that vetiver grass can grow sufficiently or very well in the range of environments (from coastal to forest ecological types). This grass is, in effect, a unifying ingredient to a diverse region.

While some local people can be seen in western clothing, the communities of Oaxaca have a strong indigenous

culture and perceive themselves to be distinctly different. A high level of social organization has been achieved in the region that can be used to promote development and establish a forum for discussion and resolution making in which there is wide spread participation. In this way, the communities can formalize ideas and search out for assistance that meets their needs for managing their resources rather than accepting whatever assistance that happens to come their way. PCERS is an example of such social organization. Like other groups in the area, their resources are minimal but their organization is good.

The plantings of vetiver in Oaxaca are concentrated in satellite nurseries in communities, government institutions, educational institutions and nongovernment agencies. Wide spread planting of contour hedges of vetiver is expected later on this year. Experimentation with vetiver is taking place in a number of different forums. The Universidad Tecnologia de la Mixteca, a member of PCERS, is doing formal research on the effect of different natural fertilizers, such as animal manures, on the growth of vetiver. ITAO, the instituto Tecnologico Agropecuario de Oaxaca, and SEDAF, Secretaria de Dasarrollo Agropecurio y Forestal, both also members of PCERS, are undertaking research analyzing vetiver grass as an alternative for soil and water conservation. In Oaxaca, vetiver grass leaves are been experimented on as a pulp material for paper products.

One of the greatest challenges to the diffusion of vetiver grass technology worldwide comes from the mistreatment or poor planting and management of the grass. In Oaxaca, participants of vetiver grass technology (through extension by the member organizations of PCERS) have been advised to initially propagate vetiver on the better soils and not until the rains have started. The dual purpose of planting vetiver on better soils is first to improve farmers productivity as they are most likely to be growing their crops on the best lands. It has become clear, after many decades of soil conservation, that farmers resist soil conservation measures which have the aim solely to conserve soil. Instead, if farmers can see other, additional, benefits accruing from their use of a technology they are more likely to adopt and sustain that technology. Also, vetiver is ideally planted on better soils to maintain the quality of the planting material which in the long run ensures the survival and success of vetiver.

PCERS, whose future at the moment seems dubious due to lack of funding, plays an important role in linking the efforts, knowledge and interests of local communities, government and educational institutions and nongovernment agencies. This type of linkage can prevent duplication of experiments and wastage of scarce resources. In the long run, the demise of PCERS will not mean the end of the vetiver movement in Oaxaca because if a community or organization has already seen the beneficial results of the grass they will continue to use it. However, PCERS central role in the collection and dispersal of information, combination of efforts and the facilitation of exchanges through the organization of events will be lost. Specifically, PCERS can provide the following functions that are key to the diffusion of vetiver grass technology:

(1) keep contact between different organizations through questionnaires and facilitating workshops at which exchanges of ideas and information take place.
(2) Collect, archive and disperse information on vetiver grass and other soil conservation methods.
(3) Create documents that describe simply the methodology to follow for establishing and assessing experimental trials either in vetiver nurseries or hedgerows, including experimental designs, main factors to evaluate, data collection formats and data analysis tools.
(4) Promote soil conservation and the use of vetiver grass technology through radio, television and newspaper exposure.
(5) Work full time with member institutions (at present there are 13 who are working with 16 communities) developing proposals for research and funding involving vetiver technology
(6) Provide sources of planting material and extension for interested institutions.
(7) Use vetiver as a good base on which many organizations can focus and use to build on top of and add other methods of soil and moisture conservation.
(8) Create a short video detailing the use of vetiver grass technology in Oaxaca.
(9) Transport farmers for exchanges of information with other farmers who have established vetiver in their fields.

So far the major concern of PCERS and its member organizations, rather than worrying about absolute numbers of plants, has been trying to get vetiver nurseries out to all areas of Oaxaca so that there is a source of material close to communities. Communities have come to be participants of vetiver technology through several ways; their liaison with a member organization, receiving information from other communities in which the grass was already established, radio and television programs and mainly, community workshops, held to disseminate information.

The program appears to be running with little funding. However, as a result of the lack of funding there are ramifications, such as, follow up procedures are lacking, there is no money for new communities setting up nurseries with their own scarce labor, no formal evaluation of resources, no ability to transport farmers to other farmer's fields to see established areas, the inability to develop any training material, now that they have people trained in the

extension of the technology they do not have the resources to put these people out into the field.

In the meanwhile, soil is disappearing from the lands of Oaxaca and the only way to stop this from happening is to make a joint effort with as many people as possible. Despite their funding limitation, PCERS and its member organizations have accomplished much in a short time and are an example to others for their joint efforts and organization. While vetiver may not be the most ideal technology for all soil erosion problems in Oaxaca, because it may not be able to restore extremely degraded, alkaline soils under semi-arid, uncultivated conditions, it has been a good base measure to get the community focused on the problem. From this point other alternatives can be explored.

Vetiver workshop, Mbingo,Cameroon

by Ngwainmbi Simon

On February 6, 1997 at 1.00 p.m the official programme began with opening prayers delivered by the chaplain of Mbingo Baptist Hospital. This followed a brief meditation on Psalm 133 verse 1 "Behold, how good and how pleasant it is for brothers to dwell together in unity."

Mr. Ngwainmbi Simon came up to introduce the Family Association Rural Development Project (FARDP). He welcomed the quests and participants and thanked them for responding to FARDP's invitation to attend the workshop. He observed that the response was a positive sign of success since many farming groups and organisations were represented.

Introducing FARDP, Mr. Ngwainmbj said it had been working with farmers and church groups for over six years. He said, as a grassroot farmers organisation, FARDP was recently registered as a common initiative group. And that FARDP intends to work together with existing organisations in the community to propagate the use if the vetiver grass in erosion control.

Mr. Simon Ngwainmbi, introduced the goal of FARDP to participants, which he stated that, FARDP works with and assist the peasants, poor, needy and disabled in improving their yields, incomes and better quality of life. To achieve these, he continued, FARDP is working with these rural groups in crop production and improvement, crafts improvement and above all, on the spiritual aspects of evangelising and winning souls for Christ. He recounted how, with these objectives in mind, he cried out in the Vetiver Network newsletter, asking for help in order to propagate Vetiver in Kom and eventually Cameroon. The Vetiver Network (TVN) then responded to his call, and the workshop is therefore, the results of the cry he made based on FARDP's objectives.

Mr. Ngwainmbi paid tribute to The Vetiver Network for the timely response, and prayed that the established lines with TVN would be sustained, as it is only through humanitarian links and rural people - oriented development organisations like TVN that FARDP would be able to make a meaningful and sustainable contribution to the rural masses in this part of the world.

Mr. Ngwainmbi stressed that FARDP is a link to channel; resources, tested and proven relevant rural technologies to grassroot groups and farmers. FARDP in tasks would work and collaborate with individuals, churches and church groups government services, national and international NGOs achieving its objectives.

Workshop Conclusion

The organisation of the FARDP workshop on the vetiver grass was very timely. This is evident from the attendance (over 200 persons) recorded and the enthusiasm shown by participants during the workshop. Held in a background of persistent decrease in crop production over the last few years, this workshop was seen by farmers as the long awaited solution to a problem that was almost getting out of hand. Agroforesters and environmentalists came in contact with an ultimate solution to the problem of erosion which has gone unabated for decades and whose negative consequences for the natural environment has been growing from strength to strength. The fact that the vetiver grass is important came to be a unnimous conclusion but the level of appreciation of the importance and the contribution of ideas by workshop participants displayed a large margin of inequality. This is owed to the fact that the target audience was academically, professionally and psychologically very incompatible.

The three days of discussions, learning and demonstrations were adequately graced by the devotedness of the main resource person, Mr. Memu Mekonnen whose mastery of the subject rnatter backed by his struggle to employ audio visual aids was much appreciated. The inadequacy of on-the-port audio visual equipment however helped to limit the impact that had to complement his efforts.

Notwithstanding, with the awareness already raised and the seed of vetiver technology planted in the Belo cornmunity, adequate "watering" has to be done to ensure that it does not die the natural death that most. other projects die. This watering has to

include a true and detailed monitoring and evaluation of the project. Such monitoring and evaluation will ensure a proper measure of the pulse of implementation of the ideals embedded in the concept of the vetiver technology as disseminated bythe workshop.

SOIL PROTECTION AND SOIL RESTORATION SEMINAR

Mahajanga, Madagascar, November, 1997

By Criss Juliard , Managing Director, Chemonics/Project CAP, Madagascar. Email: cj@chemonics.mg

"Vetiver does not work here."

"We have never heard of that plant"

"How dare you promote a non-indigenous grass in Madagascar. It could spread like a weed and take over the country."

"It isn't good for Madagascar because it can't be used as fodder."

"You need to find ways to avoid this road from being washed out every year."

With these and other comments as background CAP/ Chemonics, a USAID funded project, in collaboration with the National Agency for Environmental Actions (ANAE) organized in mid-November a seminar with the objective to bring together practitioners and organizations actively working on soil erosion and soil conservation solutions. The objective of the seminar was to devise an action plan that would use "technical packages" tested and found effective in and outside of Madagascar, and to adapt that plan to the different regions of the country. The seminar originated with CAP/Chemonics' interest to reduce the burden on local road user associations who had been transferred the right and responsibility to maintain those agricultural feeder roads rehabilitated under the project. These dirt roads are transferred to the community-based association as an economic resource under their management. Sections of rural roads in Madagascar are often destroyed during the rainy season due to mud slides and soil erosions. The seminar brought together some 55 engineers, researchers, NGOs, development projects, environmentalists, businessmen, professors, agronomists, farmers and international.

This road on an irrigated rice project at Marovayi, near Mahajangais fully protected on the left hand side with vetiver grass. On the right there is no vetiver protection and rilling is taking place on the road (by arrow)

Madagascar is a large island nation in the Indian Ocean (about the size of France and the Benelux) that has a rich biodiversity and an ambitious 15 year environmental protection program. It is in its 6th year of the program and it is recognized as one of Africa's first comprehensive initiative to protect a country's diverse ecosystem at the same time as promoting sustainable agricultural practices. The latter is designed to help its low-income population reduce pressure on the depleting natural resource base. The country is plagued by massive erosion that further impoverishes the heavily leeched soil and by traditional agricultural practices that requires burning of hillsides and forests.

The seminar had three themes:

- community involvement in resource management
- agro-biological techniques to restore soil fertility
- use of vetiver to combat soils erosion

Fifteen papers and presentations were made at the conference and discussed in small working groups. Among the topics presented were:

- "Low tillage" agriculture (zero labour), a technique used successfully in Latin America on some 3 million ha and tried in Madagascar during the past 4 years on a much smaller scale. The work in M/car was done through a joint initiative between a French research organization and a local NGO. Good results were obtained in the field, but its acceptance by farmers has been limited. "Low

tillage" is a complex technology, requires knowledge of a wide variety of plants that have specific tasks, and production results are not rapidly seen. The technology is appropriate for flat, low-level lands, but it does enrich the soil using intercroping and a biorganic process to "till" the land.

¥ Improving fertility and texture of the soil through various organic composting, including fragmented chips and branches(BRF), mulching and village composting. Results have been good, rapid, but it requires the user to have both an abundant source of biomass (trees) and necessary equipment (chipper). The technology is particularly well adapted for restoring humus content to Madagascar's acidic, oxidol-type soils. The technology incorporates agro-forestry techniques that increase three-fold the growth and harvest potential of non-resin trees.

¥ Establishing socio-economic ties between pastoral and sedentary populations to better control bush fires and promote intensive rather than extensive livestock practices. The technique is management intensive (requires permanent presence of agents in the field), and is slow to be transmitted.

¥ Utilizing a combination of mechanical and vegetative techniques for hillside agriculture. The technique accepts that Malagasy farmers will continue to practice planting in the the "tanety" (hillside) in spite of shorter fallow intervals and decreased productivity from the less and less fertile lands. The technique, promoted mostly by a Swiss NGO is labor intensive and is not easily transferred to different regions of Madagascar.

¥ Utilizing a combination of vetiver, trees and low grass to protect roads, irrigation ditches and hillsides. The technique is being used successfully in 5 out of M/car's 6 regions, but there are constraints at the extension level. There is a shortage of plant material, and the planting technique used for the vetiver to date is not well adapted to soil conservation, but focuses on essential oil production. Vetiver has had excellent results in protecting 26 km of irrigation ditches for the past 8 years with zero maintenance in the Marovoay region where an organization manages about 20,000 ha of irrigated rice.

A vetiver hedge on "tanety" land near Mahajanga. This hedgerow is located on poor upland soil. The vetiver technology was introduced by one of Madagascar's largest NGO called ANAE. The farmers have now been using the vetiver hedgerows for some three years, are satisfied with the results, and are expanding the use of this low cost and effective technology.

The conference organized a one day field trip to three different locations: a feeder road site needing immediate soil erosion measures, a livestock research station, and a village where the combination of the vetiver and fruit tree technology had been applied. In the village the farmer association has been assisted over the past two years by ANAE, the country's Environment Action agency in the use of vetiver hedges as a way to protect their hillside cropping. Farmers indicated they saw an increase in their cassava yield, reducing their need to move from their present location, on their own initiative they planted more vetiver around their fruit trees, and they had used the cut stems of vetiver for mulching. They told the visitors that their cattle ate the stems of the vetiver when the plant was regularly trimmed. They indicated they had seen no rats among the hedges although they added that this was perhaps due to the prevalence of snakes in the area! The farmer group was most pleased to show the conference participants how they planted vetiver, and how important they thought the plant was to the economic health of their small community.

During the seminar it became evident that vetiver technology had been used in M/car for years for road stabilization, soil erosion, fodder, irrigation ditches and watershed management. Participants concluded after the 4-day seminar that the plant in fact "worked," that it was now better known, that it had been in introduced in Madagascar in the early part of the century, and since the variety cannot propagate by seed, it cannot "take over" the country. Users identified the major constraints as the lack of plant material, poor extension and poor promotion. Participants saw cattle eating vetiver along the roadside, heard farmers say they will continue to use the technology, and witnessed along an agricultural feeder road the ineffectiveness of the shallow rooted local "bouzaka" grass to prevent road-side erosion. According to the road engineers attending the seminar construction of concrete soil retention devises could have been replaced by vetiver, damages would be lessened, and the per kilometer cost could have been reduced.

Marovaoy Irrigation program near Mahajanga. This photo shows an irrigation canal protected with vetiver. The canal banks are fully protected and all weeds have been totally shaded out by the vetiver. The canal has needed no maintenance in the eight years since it was constructed.

A principal outcome of the conference was the decision to establish in Madagascar a VETIVER NETWORK with six regional representatives. Participant organizations in five regions agreed to assume a leadership role in each region. An NGO will initiate the start-up phase of the national network. The network will:

- ¥ join the international Vetiver Network in Leesburg, USA
- ¥ hold training workshops in the regions over the next 10 months
- ¥ assisting end-users to improve planting echniques and improving the quality and availability of plant material through privately operated nurseries.

By the close of the conference, the organizers had received offers from private businesses to invest in vetiver nurseries that would supply plant material to meet existing demand. In addition to having established a work plan, the nascent Network will publish a vetiver bulletin, it will contribute to the bibliography of French documents on vetiver including those translated for the seminar, and will translate several "how-to" papers into Malagasy. An experienced environmental communicator volunteered to become the editor of the Bulletin and coordinate the network's activities over the next two year. She will provide the Vetiver Network in Leesburg with French language documents that will help launch other groups in Francophone countries.

During the conference, participants had a chance to dig-up clumps of vetiver, separate them into tillers or "plugs," plant them, and help establish small nursery plots.

The spark and the catalyst of the seminar was the electrifying presentation by Dick Grimshaw. Through slides and updated images on a laptop he demonstrated with immediately transferred pictures taken in the field with a digital camera how specific problem areas in Madagascar were treated in other countries that had the same climate, rains and soils. Grimshaw's participation in the workshop completed a 4 week consultancy in Madagascar during which he demonstrated cutting edge technology to farmers and engineers with his portable compute on how to handle soil erosion, soil restoration and involve local communities through the simple and inexpensive technology. In addition to the field trips to four regions of Madagascar, Dick Grimshaw made presentations and demonstrations to audiences at CAP, USIS, the French technical center, FOFIFA (the country's agricultural research service), World Bank and European Union staff, the Chinese Embassy, USAID, road engineers and construction companies.

The International Vetiver Workshop Fuhzou, Fujian Province, China. October 21 - 26 1997

by Liyu Xu, China Vetiver Network Coordinator

Supported by The World Bank (Small Grants), The Vetiver Network (international), Natural Science Foundation of China, Chinese Academy of Sciences (Academia Sinica), Fujian Provincial Water and Soil Conservation Committee, Fujian Provincial Water and Soil Conservation Station, The Institute of Soil Science (Academia Sinica), and China Vetiver Network, The Vetiver Workshop was held successfully in Fuzhou of China, on 20-26 October 1997. As more and more foreign experts expected to participate in the workshop, the title of the workshop was changed from original China Vetiver Workshop into International Vetiver Workshop which was approved officially by the National Science Committee of China.

Vetiver hedgerows on Pintang Island used as a wind breakto protect young hohoba trees. Notice how the vetiver has a good 'bend' to it. Sustained winds here exceed 50 km per hour.

General introduction

More than 90 domestic participants attended the workshop. They come from Fujian, Anhui, Hubei, Hunan, Jiangsu, Jiangxi, Zhejiang, Shanghai, Beijing, Guangdong, Hainan, Guizhou, Yunnan, and many other provinces mostly from southern China. The participants involve in many institutions and various disciplines, such as agriculture, forestry, environment, botany, soil and water conservation, geography, livestock, ecology, etc. Some come from extension stations and others from research institutions, universities, and government offices. Therefore, the workshop played an important role on the establishment of bridging a gap between research scientists and extension workers.

The windward side of the Vetiver hedgerow. Notice the profusion of flowers and excellent mungbean green manure crop which is growing vigorously alongside the vetiver.

Foreign experts coming from the United States, United Kingdom, Australia, Malaysia, Thailand, etc. also participated in the workshop. Just before the initiation of the workshop, the organizing committee still received many applications from both home and abroad who expected to participate in the workshop. It indicates that more and more people and institutions are getting interests in vetiver technology.

Corespondents from newspapers and TV stations were also attended the workshop. Their programs created interests in wide audience. More people knew that vetiver is a magic grass for soil conservation and for environment protection.

The workshop included various pro-

grams such as plenary presentations, discussions, posters, exhibitions of publications and vetiver products, and multiple field visit. There were 28 papers presented at the workshop, including 7 papers presented by foreign experts. These papers reflected the recent development of vetiver research and development. As time was too short for the workshop to arrange such plenty of colorful programs, the participant had to use free time at noon and in the evening as well to continue their group discussion, video and computer performance which showed participants the vetiver development in the world and vetiver information service by means of computer.

In the workshop, The Collection Papers on Vetiver Research and Development (in Chinese), the Workshop Abstract (in English), Vetiver Newsletters (3 issues in Chinese and 1 issue in English), Vetiver for Soil Conservation the fact sheets (4 issues in Chinese), and Agroforestry Today Vol. 5, No. 2 and 3 (in Chinese) in which vetiver grass composed an important component in some agroforestry systems. From these publications we can see that many scientists and development workers are actively involving in the vetiver technology.

In the workshop, vetiver publications from both China and foreign countries were exhibited. Posters introducing multiple research subjects and different uses of the grass were put on display.

Vetiver hedge row used to protect upper half of sea water fish pond on Pintang Island.

Field visit

During the mid-tour, the participants visited large demonstrations in Pingtan Island. The island has been frequently attacked by Typhoon, heavy rain and sand storm. Historically, some villages were buried by wind-blown sands. Farmers there used to use rocks and other weeds to protect their farmland, homegardens, and houses as well against wind disaster. Since scientists introduced vetiver to the island just few years ago, the vetiver grass was widely spreaded in the island and voluntarily accepted by more and more farmers. They planted vetiver grass to protect river bank which was used to protected by expensive rocks and frequently destroyed by extremely strong wind. The river is called as life-keeping river as in the island the fresh water is very valuable to farmers' livelihood. Farmers had to clear their river each year, even the banks were protected by rocks. After vetiver grass was introduced, farmers no longer to clear the silts. In addition they can use the grass to feed goat. The demonstration showed that the vetiver grass can

be planted very easily and can grow quickly. The only point during the planting is that the roots of the grass should be dipped in clay paste just before planting so that the survival can be guaranteed.

The second large demonstration site is a fishery pond whose dikes were frequently destroyed by sea wave. Several old farmers visited the demonstration site along the river not long ago and then decided to plant vetiver grass around their fishery pond. They planted the vetiver grass voluntarily. The only support from outside society is limited planting materials. After that the farmers propagate the grass themselves. At the sand area just beside the sea, the grass grew very quickly. They can grow well although there was a little damage by heavy wind and strong sea wave which frequently attack this area. A dense fence can formed in several monthes. It indicated that the grass is tolerant to wind, salty sea water, and infertile soils.

The third demonstration area in Pingtan island visited by participants was to use vetiver grass to form a net system of wind-break in order to protect crops from damage. The present crop was hohoba, a high quality old extracted from the seeds can be produced. The farmers also planted vetiver to protect their vegetable plots. In the field, a free discussion was held between farmers, county chiefs, and participants. Through the field investigation, participants found that vetiver was very suitable for coast sandy area where wind is strong and often forms a threaten to crops and farmers' life. In addition, many Chinese participants realized that in China there is a large area of barren sandy land around rivers and lakes, the Poyang Lake for example, where vetiver can survive and grow well and can be used as a pioneer plant for land rehabilitation.
During the post-survey, the participants visited a demonstration area in Jianyang county of northern Fujian province. In the past decade, following national economic reform, highways at different levels have been developed very rapidly through out the country. For example, in Fujian Province 4,000 km of highways were established during the period of 1992 - 1996. The construction of highways plays an important role in promoting rural economic development, but at the same time causes environmental problem. In Fujian Province, for example, the highways were usually constructed on the deeply weathered granite, from few meters to several dozens of meters deep, and were subject to soil erosion and collapse, leading to damaged highways and new soil erosion along the highways. To protect highways engineers had to use rocks and concrete to protect critical sections of the road beds. There are 2.6 million sq. meters of road embankment slopes that need to be protected in Fujian Province. However due to financial constraints, there is only a very small percentage of the slopes protected. Therefore, to find a new measure, both effective and economical, is an urgent task for highway construction and protection. Many examples showed that vetiver has a strong fibrous root system that penetrates and binds the earth to a depth of up to 3 m and can withstand the effects of tunneling and cracking. The grass is more effective (than hard wood roots) in the mechanism of root reinforcement on soil slopes, as clearly demonstrated on extremely unstable and massive highway embankments and cuts in Malaysia as presented by Mr Diti Hengchaovanich during the workshop. In the demonstration site, the vetiver grass was planted with two models, i.e., contour aligned vetiver hedges and square mesh planting which combines vertical and horizontal hedges like a honeycomb. After few month's growth, it seems that the latter worked more efficiently. The demonstration site showed that the vetiver grass can protect the highway from collapsing and at the same time protected the paddy field from silt deposit efficiently. The demonstration was wecomed by farmers and accepted and will be supported by local highway authority.

Dry vetiver grass leaves being fed through a hammer miller and collected in large bag on left for future use as a substrate for mushroom growing. This technology has potential in other countries as an enterprize for small farmers.

Vetiver for profit generation

The common concern on vetiver is the profit. Whether vetiver can gen-

erate profit formed one of the key issues during the workshop. Trials showed that vetiver can not only be used to control soil erosion in order to maintain soil fertility and then to increase crop yield for 30% as presented by Mr Lu Shengluan during the workshop, but also can be used to feed animals, used as farmers' cottage roof materials, and to produce art and craft products. During the workshop, the vetiver products from both China and Thailand were exhibited. These products can be sold directly in the market and can create considerable profit for farmers.

In addition, the application of using vetiver to produce edible fungis consisted of a hot topic and generated strong interesting among the participants. During the workshop, the basic method of using vetiver to produce edible fungis was introduced. Besides, participants took free time to visit Fujian Agricultural University to see the edible fungi production bases just before the presentation in the afternoon on 23 October. The whole procedures were shown to the participants, including the vetiver cultivation, the harvesting, the processing of the vetiver cuts, and the cultivation of edible fungi. It is very clear that using vetiver grass to produce multiple fungis has many advantages: (1) Traditionally the edible fungis were cultivated using woods, which aggravated the degraded environment, while using grass to produce fungis can solve this problem. Because the component of the grass is the leaves and stems above the ground, the roots and the remaining stems can still control soil erosion. (2) The pruning and using of vetiver grass can promote the tillering of the grass and therefore to strengthen the function for soil erosion control. (3) It is shown that the production efficiency of using grass to produce edible fungis was much higher than that of woods. For example 1 kg dry grass materials can produce 1 kg fresh edible fungi which was 10-20% higher than using woods. (4) Studies showed that the production period of using grass was much shorter than that of using woods. Although the edible fungis can also be produced from other grasses, vetiver grass became one of the best candidates because vetiver can grow almost every places where other plants can hardly survive, and also vetiver is tolerate to pruning.

New applications and further considerations

The organizing committee received more than 20 proposals or concept paper before the workshop. The topics included vetiver for soil erosion control and commercial tree protection, vetiver for sandy dune stabilization and fuel production in Poyang Lake area, vetiver for water eutrophication control in Taihu Lake, etc. Therefore the future application of vetiver grass formed a worth component of the workshop. In the afternoon 23 October, several proposals or concept papers were presented and discussed during the workshop. The topics included the use of vetiver for soil erosion control, highway and railway protection, watershed management, deposit control for rivers and reservoirs, vetiver plantation for farmland ecology improvement and mushroom cultivation, etc.

Additionally, in the evening of 23 October 1997, a group discussion was held on the further consideration of vetiver technology in southern China. The participants proposed suggestions and comments on future application of vetiver technology. Many new users expressed their interests in the utilization of the grass in their homeland or their research area, while old users are going to start new trials on highway and railway stabilization, extreme soil rehabilitation, etc. They hope that the China Vetiver Network could do more in dissemination of vetiver technology and the coordination and initiation of various programs. They strongly suggested that the proceedings could be published as soon as possible so that more people could share the experiences and suggested that regional meetings and visit be organized in the near future.

Through the discussion between Institute of Soil Science and Mr Diti Hengchaovanich Chief Executive Officer, Erocon Sdn Bhd from Malaysia, a company was planned to be launched in China aiming at transfer the technology of using vetiver to protect highways into southern China.

To sum up, the workshop presented results and achievement of vetiver research, experiments, application, and extension in the past decade; discussed new vetiver applications and its management of extreme soil rehabilitation (seriously eroded red soil, mobile sandy dunes, toxic soils, etc.), watershed management, waterway stabilization, earth works reinforcing, pollution control, disaster prevention, etc.; proposed new application of the grass to satisfy farmers' basic needs (fuel production for example) and profit generation. The workshop bridged the gap between scientists and extension workers and between vetiver users and government officers and policy makers.

New Publications: Vetiver Research and Development: ABSTRACT

Edited by Xu Liyu and Charles (Todd) Chirko the publication titled Vetiver Research And Development was printed and distributed during the Vetiver Workshop held in Fuzhou of China on 21-26 October 1997. The workshop was organized by China Vetiver Network and supported or sponsored by The World Bank (Small Grants), The Vetiver Network (international), Natural Science Foundation of China, Chinese Academy of Sciences (Academia Sinica), Fujian Provincial Water and Soil Conservation Committee, Fujian Provincial Water and Soil Conservation Station, and The Institute of Soil Science (Academia Sinica). The ABSTRACT was selected, translated,

and edited based on the contributions just before the workshop. It includes five parts: part 1. General Introduction; part 2. Adaptability and Utilization; part 3. Ecological Effect and Erosion Prevention; part 4. Introduction, Planting, and Perspective; part 5. Planned Program.

The ABSTRACT contains 56 abstracts with 90 pages. Limited free copies are available for national and regional networks by surface mail. For airmail, please send a check for US$20 for each copy to: Liyu Xu, China Vetiver Network, ISSAS, P.O.Box 821, Nanjing 210008, China.

NEWS FROM THE NETWORKS

What's New in EuroMed-VetNet

By Mike Pease, Vetiver Network Coordinator, EuroMedVetNet.

Dick Grimshaw has introduced me to Network members through the Vetiver Homepage. I think I need say no more for you to know who I am, what my background, is and how I may be contacted. Now, I want to take this opportunity of explaining how I see my role as Co-ordinator for the European and Mediterranean Region of the Vetiver Network.

I have set myself three principal tasks, and in each case I seek the support and assistance of existing members of the Network located within our regional network.

Firstly, The Vetiver Network has provided some start up funds to get us going but I am keen to achieve a position of self financing as soon as possible. Already I have taken some initiatives towards this goal but whether these prove productive remains to be seen. Consequently, I would appreciate any suggestions and, above all, contacts that I might pursue that might lead to financial support for our regional network.

The costs involved in running 'EuroMed-VetNet' are, in the first instance, those of communications, i.e. mail, phone/fax and e-mail and linked costs such as stationery etc. There is no charge for my services; I get fun out of it. In due course, if we can obtain sufficient funds I envisage that there might be justification and demand for holding an occasional conference or similar 'meeting of minds' funded from within our regional resources. In addition, if adequate funding was available, it might even be possible to provide financial support for specific research undertakings within our geographic footprint. Naturally, if such a proposition was to be considered, it would have to be co-ordinated through the central Network to ensure that it conformed to global research strategies.

My second priority area will be to promote the dissemination of knowledge of vetiver amongst public or private bodies or individuals that show an interest and who may be able to contribute towards overall expansion of the use of vetiver or other 'living hedge' technologies within our Region.

In regard to research we would function in close liaison with the central network in the United States. However, EuroMed-VetNet covers geographic areas that are climatologically quite different to many of the areas covered by the other regional networks. Much of our region is in temperate zones and is located north of the latitudinal limits below which vetiver can be expected to prosper. Alternative 'living hedge' species may have a valuable part to play in some of these 'marginal' locations. As you will be aware from earlier Newsletters, work is being conducted in the United States along these lines. Also in our region are areas of semi-arid desert, typically in eastern Mediterranean and North African countries. Research work conducted in the semi-arid areas of Rajasthan in India and in semi-arid areas of China may well be relevant and applicable to our Region. Nevertheless, specific research is required to determine technologies appropriate to the above climatic areas.

Recently, I completed a seven-page paper, that summarises some possible areas for research for our Region. In preparing this paper I have drawn extensively on presentations that were made at the First International Vetiver Conference held in Thailand in February 1996. I have also incorporated some specific suggestions made by Dick Grimshaw. It is my intention to send copies of this paper to research bodies that show interest in vetiver as and when they can be identified. So, I would be most grateful if members within our Region would let me know names and addresses of contacts in research or allied fields that are likely to be productive and who I should contact. Of course, if any member wishes to receive a copy of the paper I would be happy to respond, preferably by e-mail.

Departments or organisations that

might be interested in vetiver research could include, for instance: agriculture, forestry, botany, biology, soil conservation and soil sciences, water sciences, civil engineering and environmental affairs.

Finally, I wish to provide some regional flavour, where appropriate, to the information dissemination that comes from the central Network. I intend to do this primarily by using the 'What's New in EuroMed VetNet' through the mirror-plus section of the Vetiver Homepage. Once again, I invite your comments and suggestions.

I have prepared a four-page paper that summarises 'The Vetiver Story'. I have written this as an introduction to vetiver and its uses and intend to send copies to those showing interest in vetiver as and when they can be identified. If any existing member wishes to receive a copy I would be happy to respond, preferably by e-mail.

On this occasion, since it is introductory, I have done the writing for our regional 'What's New' section. However, I would like that, for future editions, we use this space primarily to publicise information provided by you, the regional membership specific to our regional circumstances. So, contributions and communications will be most welcome.

The current membership of EuroMed-VetNet is about 200. With your help I think we should be able to expand it quite rapidly, especially in countries where we currently have no representation. Let's go!

The Southern Africa Vetiver Network (SAVN) Progress Report for the period February 1997 - September 1997

Compiled by: Duncan Hay, Project Manager, Institute of Natural Resources

1. Introduction

The Southern Africa Vetiver Network was established by the Institute of Natural Resources in February 1997. This initiative was as a direct result of a visit to Southern Africa by Mr Dick Grimshaw, co-ordinator of The Vetiver Network (TVN), and Dr Paul Truong, an internationally acknowledged vetiver expert from Australia. Mr Tony Tantum of Specialised Soil Stabilization was instrumental in making this visit possible. Core funding for the establishment was provided by TVN.

2. Activities and Progress

- SAVN has a current membership of approximately 300 individuals and organisations
- Two newsletters have been produced (they will continue to be produced at six-monthly intervals) and circulated to all members. The response to these newsletters has been extremely positive, especially from interested individuals and organisations in Zimbabwe and Zambia.
- SAVN has provided information on specific request to approximately 100 enquiries from members.
- A SAVN home page has been established on the Internet. It contains a brief description of the mission of SAVN, the two newsletters, and the database of members' contact details. The entire TVN website has been down loaded on to SAVN home page providing more direct access to this comprehensive information base and preventing duplication of effort. The TVN website is regularly updated by Mr Dick Grimshaw.
- Two articles on Vetiver have been accepted for publication. The first will shortly appear in the mass circulation environmental publication "On Track" and the second will appear next week as a feature that in the KwaZulu-Natal mass circulation newspaper, "The Natal Witness". A third article produced for "African Mining" is being considered. Further specifically targeted mass exposure is planned through farming, mining, civil construction and development magazines.
- SAVN funded a vetiver display at the National NGO Conference in Bloemfontein.
- SAVN has been promoting and facilitating the purchase of vetiver stock by commercial operators from small scale growers in Biyela, Northern KwaZulu-Natal. Given the increased demand this activity is likely to increase and stimulate other small growers to take on vetiver production as a commercial agriculture activity.
- The "Green Book" has been translated into Zulu and when additional funding is obtained it will be published.
- Discussions with Monsanto and various mining houses on sponsorship of the next World Vetiver Conference are ongoing.
- In the context of mining rehabilitation, SAVN has been providing advice to Premier Mine at Cullinan, and Foskor and PMC at Palaborwa on appropriate techniques, and has supported Specialised Soil Stabilization in securing rehabilitation contracts at Foskor.
- SAVN is providing support to David Jobson of Eco-Link in the compilation of a proposal aimed at supporting small grower development in Mpumalanga. This is linked specifically to vetiver oil production at Dickon Hall which is likely to fund the project.
- The Premier of KwaZulu-Natal has been approached to fund a major vetiver initiative in the province.

3. Future Priorities

- Vetiver stock is currently in short supply and existing stocks are poorly positioned. Priority will be given to the establishment of strategically positioned nurseries to supply the predicted increase in demand.
- Further articles in mass circulation publications are necessary to increase general awareness of vetiver.
- Further promotion of vetiver based entrepreneurial development linked to the mining industry is required.
- Further fund raising to support activities of the network and the establishment of nurseries is required
- Extend the membership of SAVN to 500 individuals and organisations

Latin American Vetiver Network (LAVN) Annual Report - 1997

by Joan Miller
LAVN Coordinator

During the year 1997, the LAVN has accomplished the following:

1. Publication of Boletín Vetiver.

Boletín Vetiver No. 3 was published in April 1997 and sent out to approximately 570 network members in Latin America (and includes about 10 members in the United States). Boletín No. 4 is currently underway should be mailed out in December. In addition, we sent out a 2 page questionnaire in June to our members asking about their experiences with vetiver, uses, problems, sources, etc. We had a response approaching 15% and have summarized some of the findings in Boletín No. 4. We have also asked those who did not respond to please do so if possible.

2. Membership

Since the LAVNs initiation in October 1996, our membership has increased by approximately 50%. New members are generally coming via word of mouth, occasional articles in publications, and the Vetiver Network's Homepage. New members still receive copies of the newsletters, the green booklet (Vetiver, la barrera contra la erosión), a Spanish copy of a paper written by Richard Grimshaw (The Role of Vetiver Grass in Sustainable Agriculture), and if they are English-speaking they receive the World Bank Publication #273 and the blue vetiver book by the National Academy of Sciences. For individuals who ask, receive videos with the request that copies be made for other users in their area. Larger quantities of green vetiver books are sent to those who ask, although the supply is dwindling to around 1000 books.

3. Travel in 1997

The LAVN made two vetiver-related trips. In May, a trip was made to Oaxaca to visit vetiver projects and attend a users workshop. The other travel was to make a visit to NOBS in El Salvador to learn about their various projects and involvement with vetiver.

4. Finances

The LAVN closed out the month of November 1997 with a balance of $1,384.83. Income for the year equalled a $2,000 grant from the Vetiver Network, a balance of $ 875.48 carried over from 1996, and expeditures totalling $1,490.65. Expenditures included mailing costs, office supplies, printing costs, film purchase and developing, and postal box rental for the year.

5. Some Activities Planned for 1998

- Posting of Web site for the LAVN in Spanish (currently under construction).
- Assistance to The Vetiver Network in fundraising for NGO grant program.
- Publishing of Boletin Vetiver, #5 and #6.

China Vetiver Network (CVN) Recent Development of Vetiver Technology in China

By Liyu Xu, China Vetiver Network, Coodinator, P.O.Box 821, Nanjing 210008

The proper use of soils is to ensure sustainable land productivity through conservation of water resources and prevention of reduction of soil erosion. Although there are a lot of soil conservation measures, the most outstanding of these is the use of vegetative soil and moisture conservation measures that are cheap, replicable, sustainable, and fully effective in stopping erosive degradation and increasing crop yield. Many examples from all of the world showed that vetiver as a boundary hedge to be the ideal plant to conserve soil and rehabilitate eroded farmland. The vetiver technology was recently recognized by a panel of international judges to be the best of 71 sustainable technologies that were entered for the "John Franz Sustainability Award". To speed up the extension of the technology in southern part of China, where 70% of the land is mountainous and soil erosion is a critical problem, the China Vetiver Network (CVN) was established at the end of 1996. The main task of CVN is country-wide vetiver technology extension, i.e., to extend vetiver technology to new area or to use the grass to new applications. To achieve this purpose we may divide our work into the following aspects: national information service; organization of regional surveys and investigations; supporting partners to test vetiver grass; and the development of new projects. The followings are some details.

I. Background of vetiver technology development in China

The valuable grass vetiver (*Vetiveria zizanioides*) was disseminated to

China in late 1980s as a plant for soil erosion control hedges, although it had been introduced into the county as early as in 1950's as a plant for extracting oil from its roots. Since 1980's, the Vetiver Grass has been experimented or tested in most provinces in southern China, as in Jiangxi, Fujian, Sichuan, Hunan, Guizhou, Hainan, Guangdong, Gansu, Henan, Shandong, and Zhejiang Provinces. The followings are some results:

- Some nurseries have been established and experiments were carried out or proposed on the biological characteristics; hedge establishment and maintenance; hedgerow impacts on soil fertility, moisture, crop yield, and soil losses;
- Vetiver hedgerows were established in tea, tea oil (*camellia*), or citrus plantations;
- Vetiver Handbooks was translated and distributed;
- Vetiver was used to feed fish, livestock, and to mulch ground surface of orchards.

Although there has been some progress in vetiver cultivation in China, there exist problems:

- There is little, if any, information service in the country and thousands of related institutions are still unfamiliar with the grass.
- Lack of systematic or comprehensive consideration on national vetiver extension and demonstration.
- As lacking of bridge between research and extension, most of the present vetiver-involving institutions are at higher level. So there is an urgent demand to introduce vetiver to county-level extension stations and then to farmers.
- The vetiver grass extension is restricted in limited area, Jiangxi and Fujian Provinces for example, while most of other Provinces were excluded. Accordingly, there is an urgent need to extend or test Vetiver in other Provinces in southern China.
- The application is limited in soil conservation in red earth region, while more potential uses need to be tested or explored.

Recently, great progresses have been made in improving this situation and in extending vetiver technology through out China. The work was done under the coordination by CVN and in cooperation with numerous institutions in various disciplines. The followings are the main points.

II. National information service

The China Vetiver Network was developed based on and in cooperation with the existing national agroforestry network which has been developed for more than four years with over 1,000 members. The national information service focus its attention on the southern part of China where tropical and subtropical climate dominate. The vetiver publications were distributed to many national universities, research institutions, governmental offices, provincial institutions, and also many county level and some township level extension stations. Many disciplines were involved, including soil and water conservation, agriculture, forestry, ecology, environmental protection, botany, and soil science, etc. The publications include:

- Vetiver Newsletter in Chinese, 4 issues in 1997. About 3,500 copies were disseminated.
- Vetiver Fact Sheets (Vetiver & Soil Conservation), 4 issues in 1997 totaling 8,000 copies which introduce substantial technology to extension stations were mostly distributed to county extension stations.
- Agroforestry Today, a quarterly journal in Chinese published for 5 years, in which the vetiver grass being one of the major subjects were distributed with an averaged circulation around 1,200 copies.

Besides, in order to distribute the vetiver grass more widely, advertisements were put in some popular national journals on soil and water conservation and ecology. Communication has been strengthened between CVN and vetiver users through frequent correspondence.

III. Field surveys and investigations

Aiming at disseminating vetiver technology and exploring new users and new vetiver applications, field surveys and investigations were carried out in Fujian, Jiangxi, Guangdong, Hubei, Hunan, and Anhui provinces. These investigations were organized by the China Vetiver Network and cooperated by numerous multi-disciplinary institutions at national, provincial, prefecture, county, and township levels. Through these investigations, team members learnt experiences from established vetiver application models and proposed new applications. In addition, by distributing vetiver publications and discussing with local technicians and master farmers, team members encouraged more and more people to test and use the grass.

(1) Vetiver Investigation in Fujian Province, China

Co-organized by China Vetiver Network and Fujian Provincial Water and Soil Conservation Station, a vetiver field investigation was organized on 23-31 December 1996. The investigation team consisted of 16 persons from The Institute of Soil Science of Academia Sinica, Nanping City Water and Soil Conservation Office, Jianyang County Water and Soil Conservation Station, Jianyang Agricultural Foreign Investment Office, Fuzhou City Water and Soil Conservation Office, Pingtan County Water and Soil Conservation Station, and Pingtan County Agricultural Bureau, etc. The purpose of the investigation included: (1) evaluation of the former

experiences; (2) discussion of new applications and extension measures; (3) consultation of new project proposals; (4) preparation of some details on the proposed vetiver workshop. The investigation sites included the site of vetiver for the recover of degraded barren lands, vetiver for orchard protection, vetiver for promoting nut cultivation, and vetiver for stabilizing coast sands.

(2) Vetiver Investigation in Jiangxi Province, China

Coorganized by China Vetiver Network, and Jiangxi Agricultural Foreign Investment Office, a field investigation was held on 24-28 February 1997. Eight scientists and government officers from Jiangxi Red Soil Project, The Institute of Soil Science (Academia Sinica), Jiangxi Provincial Red Soil Institute, Nanchang Science Committee, and Jinxian Agricultural Foreign Investment Office were involved. The issue of the investigation was to evaluate and explore the application of vetiver on red soils and wind-blow sandy area. In the province the red soils derived from quaternary red clay covers a large area of 162 million Mu (1 ha = 15 Mu), while the wind-blow sandy land covers 0.2 million Mu.

The investigation team visited the sandy area of Nanchang County and red soil area in Jinxian County and found a great potential of using vetiver to ameliorate these extreme soils. In addition the team prepared vetiver planting material and sent them to Anhui, Hubei, and Jiangsu Provinces.

(3) Soil erosion and Vetiver application potential in Hubei Province

Situated at the center of the country, Hubei Province has a total area of 870,700 sq.km in which the mountains and hills cover more than 60%. Under high population density the per capita cultivated land is very limited. Farmers had to clear forests for food production, which may easily cause soil erosion if without proper protection measures. It was estimated that there was a soil erosion area for 68,500 sq. km in the province, in which there was 40,000 sq. km belonging to moderately and seriously eroded area. To prevent soil from erosion, some watersheds were managed through the establishment of stone-protected terraces with considerable costs (over 20,000 Yuan RMB/ha). Therefore, the soil erosion was rarely controlled, which and other multiple factors caused many mountain areas remained in poverty with more than 3 million people with food and clothing problems. To alleviate rural poverty the government proposed 'Richnization Project through Greenization', i.e., to promote poverty alleviation by planting commercial trees in large scales. However, as there will be not any protection measures proposed, it will easily cause new soil erosion.

In addition, in the 5 years starting from 1996 the province will construct express highway and 1st-class highway for 410 km, and 2nd-class highway for 2,600 km. As lacking of fund slippage will not be well protected and new soil erosion remains to be controlled. Through the survey and field investigation coorganized by provincial water and Soil Conservation Office, Huangang Prefecture Water and Soil Conservation Research Institute, and numerous county level water and soil conservation stations, the participants investigated most suitable areas and sites where the grass can play effective function, such as river, ditches, and reservoir embankment protection, earth terrace fixing, sediment protection, etc. Vetiver nurseries are planned and going to be established. Vetiver development proposals were prepared.

IV. Supporting partners to test vetiver grass

The China Vetiver Network has supported its partners to test and use vetiver grass through providing micro-grants and information services. The followings are some examples.
Fuzhou Soil and Water Conservation Station, Fujian Province

Under financial and document support from CVN, Fuzhou Soil and Water Conservation Station continues and strengthens its tests of using vetiver to control wind erosion, to establish vetiver based agroforestry systems. They fill the gaps of existing hedges, strengthen the applications of vetiver in coast area of Fujian Province where wind-blow sand forms a threat to farm land, ditches, and rivers.

Botanical Institute of South China, Guangdong

Supported by The Vetiver Network (TVN) and CVN, scientists in the institute continue their research and extension work in spreading the usage of vetiver in Guangdong, enlarging nurseries to produce planting material. Besides, they study the effect of vetiver as feed specially for pig and fish, the possibility of using vetiver as leaven material for biogas, the vetiver cover of municipal waste dumps and industrial polluted area.

Reproduction base in Dabie Mountains, Anhui Province

To introduce and extend vetiver in Dabie Mountains, one of the most serious eroded area and poverty mountain in the country, supported by CVN, a nursery was established in Yuexi County of Anhui province, which will become a production base for planting materials in the area and is expected to produce more planting materials for the whole Dabie Mountain area in Hubei. Anhui, and Henan Provinces.

V. Encouraging different institutions to use vetiver

Since the establishment of CVN in 1996, more and more people wrote us to express their interests in applying vetiver grass based on their own

budget and existing projects. The CVN has provided them with information, documents, and/or planting materials and encourage them to study, use and extend vetiver grass. The followings are some examples:

The Anhui Provincial Agricultural Academy is actively involving vetiver planting. With financial support from Anhui Provincial 9th Five-year Plan for the Yellow and Red Earth Amelioration, they bought vetiver planting material from Jiangxi Province and plant them on chestnut plantation in red soils of Huangshan area of southern Anhui province.

Provided with vetiver planting materials by CVN, the Shuitianba Water & Soil Conservation Station, Jigui County of Hubei Province is planting vetiver in upper section of The Three Gorge. The county has 2427 sq.km land with population density of 160 person/sq.km. About 80% of the land are mountains and soil erosion is serious.

The Institute of Soil Science is starting his research on effect of saline soil on vetiver grass, and the effect of vetiver grass on saline soil improvement in Rudong County of Jiangsu Province.

The Environmental Group of The Institute of Soil Science started the trial of using vetiver grass for water eutrophication control in Taihu Lake in East China. The preliminary test was conducted in Nanjing supported by CVN. Pots were used for vetiver culture. Preliminary result was obtained.

The Forestry College of Guangxi Agriculture University focus on the soil conservation in limestone area of Guangxi province. They are also planning to use vetiver grass to control soil erosion and to establish a demonstration site for the 8 seriously eroded counties in the province.

The above examples indicate that through our networking activities more and more people are using or testing vetiver grass. The main problem at this moment is the lack of planting materials and 'seed money'. The CVN organized and provided some vetiver planting materials to distribute to Jiangsu, Anhui (Dabie Mountain, and Huangshan Mountain), and Hubei. However, caused by financial shortage only very limited materials were distributed, far from enough.

VI. Preparation of new development proposals through joint efforts

Based on multiple surveys, investigations and exchange programs, several proposals or concept papers were prepared, that is playing and will play an important role in accelerating the dissemination and development of vetiver technology through out the country and will keep CVN to be more vigorous. The followings are some examples:

- Vetiver Application and Ex tension for Soil Erosion Control and Commercial Tree Protection in Reservoirs Area of Dabie Mountain of Huaihe River Basin of China.
- Vetiver for Highway Stabilization in Jianyang County of Fujian Province: Demonstration and Extension.
- Stabilization, Fuel Production, and Sustainable Land Use of Sandy Land in Poyang Lake Area of Jiangxi Province, China: Demonstration and Training.
- Vetiver for Watershed Management in Mountainous area of Hubei Province.
- Vetiver For Water Eutrophication Control in Taihu Lake of China.
- The China Vetiver Network (CVN): A Workshop to develop a long term strategy for the dissemination of the vetiver technology in China, A Proposal for World Bank Small Grants (approved and undergone).

VII. Further consideration in vetiver development in China

Although great success has been achieved during the recent time, much remains to be done. China has a huge population but very limited per capita natural resources. Besides, caused by various factors, the limited farm land resources in China are poor in quality with a fairly large proportion under soil erosion, degradation, and desertification, etc. Therefore, the sustainable agriculture and soil erosion control is extremely important in this country. The role of vetiver planting can not be overemphasized.

At first, we should do our best to extend vetiver technology to most agricultural, environmental universities, research institutions, development agencies, government offices, and in particular various extension stations. More attention should be paid on county and township extension stations and master farmers as well in mountainous and hilly areas in southern China. Information service should be strengthened. More vivid description and instruction materials on vetiver technology should be prepared, produced and distributed as widely as possible. Training courses, demonstrations, and workshops at national, provincial, and local level are expected to be organized through joint efforts of different institutions. We should tell users that although vetiver can not enable one to be a millionaire, it does help other crops to be productive and profitable.

Secondly, we should strengthen exchange program to promote vetiver users distributed at different areas both at home and abroad to exchange their ideas and to share their experiences. Exchanging visit is ex-

pected to be organized both nationally and internationally.
Third, we should encourage scientists from different disciplines to actively engage in vetiver research on soil erosion control, extreme soil amelioration, waterway stabilization, pollution control, earth works protection and other numerous new applications, and encourage scientists and development workers to join together to extend research results to practical uses.

Fourth, vetiver reproduction bases should be established and disseminated at reasonable places to cover the whole southern part of the country in order to meet the increasing needs of plating materials, to lower transportation costs and increase survival rate.

Fifth, we should do our best to seek more financial support from different sources, international donors, governments, domestic foundations, etc.

West African Vetiver Network.

Notes from Linus Folly, WAVN Coordinator

Ghana

W.A.V.N. and its newsletter had been officially launched on 24th November at the British Council after a simple but well covered function. The event won the headline of TV3 nationwide. There should be in due course feature articles on vetiver grass in the newspapers.

A "Round Table" with national NGOs, CBOs etc, involved in Agriculture, Evironment and Rural Developmen will be held to set up a working platform for collaboration.

Awareness and Information contact will continue to be held sessions with environmental journalists.

A translation team has been put in place for publications and documentary material to be published in major local languages.

Reorganization of office location and premises for computer equipment to be installed them connected to the Internet and also to establish a homepage as well as a mirror site.

Cote D'Ivoire

Minister of Agriculture and Animal Resources has agreed to DECIA's request to organise a W.A.V.N. supported Regional Workshop under the auspices of his Ministry in December 1998 at Bouake.

Guinea

Introduction of Vetiver hedgenow technology through the establishment of a pilot project Kouriya financed by Sasakawa Global 2000/ Guinea. A proposed awareness support and training program should start early next year. This package will find technical backing from the Department of Agricultural Extension (S.N.P.R.V).

Nigeria

W.A.V.N. is in the process of making its training centre in
bio-engineering, the College of Natural Resources and Environmental Management of the Federal University of Agriculture in Abia State. This is due to facilities at the college as well as the amount of experience on vetiver technology gathered by the Head of that College, Dr. P. E. Okorie.

International Workshop

Dr. Linus K. Folly, Coordinator W.A.V.N., has been invited as a resource person to the F.A.O/TCDC Sponsored Workshop on soil erosion control from 8-10 December, 1997 being organised by the Soil Research Institute in Kumasi, Ghana. His presentation will dwell on the role of vetiver hedgerow technology in soil loss control. This workshop being attended by participants from the Republic of Benin and Burkina Faso will be an occasion to discuss prospects
and constraints in the promition of vetiver grass in the region.

CEDIA

CEDIA, as a development NGO playing a key role in promoting vetiver hedgerow technology in Ghana and other West African states, has transformed its operational structure to respond to the new challenges, its awareness program had brought up. Nevertheless CEDIA's field programs continue to suffer from an acute lack of support. This is creating a major setback in the Plan of Action. The organization is renewing its appeal to all stakeholders in Agriculture and Environmental Management to support CEDIA's initiative.

The Pacific Rim Vetiver Network

By Narong Chomchalow

The Origin of the Pacific Rim Vetiver Network and the newsletter "Vetiveria"

The Newletter "Vetiveria"

As the organizer of the First International Conference on Vetiver (ICV-1) held in Chiang Rai, Thailand, on 4-8 February 1996, the Office of the Royal Development Projects Board (ORDPB) was requested by the President of the Vetiver Network, Mr. Richard Grimshaw, to establish a regional network for the Pacific Rim with the principal objective of serving as the center to collect and disseminate information on the use of vetiver for the benefit of the member countries. ORDPB, with full support and agreement of His Majesty, King Bhumibol Adulyadej, agreed to the request.

One of the responsibilities of the Pa-

cific Rim Vetiver Network (PRVN) is to publish a newsletter as a means of information exchange among scientists of the member countries. It has been proposed that the newsletter be issued quarterly. As for its name instead of using a rather long name like 'The Newsletter of the Pacific Rim Vetiver Network', or its acronym, 'PRVN Newsletter', the editorial staff prefers to use the name "Vetiveria," which is the name of the genus to which vetiver belongs. It is a latinized word derived from a Tamil word, vettiveru, which means a coarse grass.

Being a regional newsletter, "Vetiveria" should contain information from as many member countries as possible. Such information can be obtained directly from the scientists working in these countries, or indirectly and effectively, from their Country Representatives (CRs) who would act as a focal point in their countries. The Editor extends his cordial invitation to the readers to send contributions (articles, news, views, etc.) to be published in future issues of "Vetiveria"

The Pacific Rim Vetiver Network (PRVN)

The creation of the Pacific Rim Vetiver Network (PRVN) was the result of a proposal made by Mr. Richard Grimshaw, Coordinator of the Vetiver Network at the First International Conference on Vetiver (ICV-1) held in Chiang Rai, Thailand, on 4-6 February 1996. Mr. Grimshaw suggested that Thailand act as the core of the PRVN with the principal objective to serve as the center to collect and disseminate information on the use of vetiver grass in the form of newsletters, occasional publications as well as homepage on the internet. Thailand is considered suitable because it is the site of the world's largest vetiver project known as the Doi Tung Development Project which has been implemented under the supervision of the Office of the Royal Development Projects Board (ORDPB), the organizer of the Conference.

Subsequently, ORDPB submitted the proposal to His Majesty the King, a keen supporter of the use of vetiver grass and an awardee of the Vetiver Network's specially - commissioned bronze vetiver sculpture - in order to obtain His comments and approval. His Majesty agreed with the proposal and commissioned the setting up of the PRVN under the supervision of its Committee on the Development and Campaign for the Utilization of Vetiver under His Majesty's Initiatives, to be administered by ORDPB.

In order to facilitate the effective implementation of the network with a common view and flexibility, the Committee established a Working Team to take care of the PRVN on May 6, 1997. The working team consists of Mr. Manoon Mookpradit, Deputy Secretary-General of ORDPB, acting as the Chairman of the Team and a number of experienced officials from the concerned agencies and renowned institutions. The Office of the RDPB itself functions as the secretariat of the Team.

The working team on the PRVN has the responsibility to manage and supervise the Network which aims to promote the cultivation and use of vetiver through the issuance of a newsletter and homepage. The PRVN intends to serve the countries of eastern Asia and the Pacific. These include: Australia, Brunei, Cambodia, Cook Islands, China, Fiji, Indonesia, Japan, Korea (Rep. of), Lao PDR, Malaysia, New Zealand, Papua New Guinea, Philippines, Singapore, Solomon Islands, Taiwan, Thailand, Tonga, Vanuatu, Western Samoa, and Vietnam.

Membership and Subscription

Current members from the Pacific Rim countries under the Vetiver Network are automatically registered as PRVN members which at present amount to about 800. Others who want to join the Network can apply directly to its Secretariat Office. No application form is necessary. Those who are interested just identify themselves with name, current position, place of work, and mailing address. Email address, and other information are welcomed.

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* These are representatives from member countries of the Pacific Rim Vetiver Network. Confirmation is needed for those with **. Nominations are requested from: Brunei, Cambodia, Cook Islands, Fiji, Japan, Korea (Rep.of), Singapore, Taiwan, Tonga, Vanuatu, and Western Samoa.

Other Networks

No recent newsfrom the Philippines Vetiver Network. However VETNETPHIL has been very busy. It had an excellent workshop in August

where the vetiver technology was fully endorsed. Further it has produced two very professional newsletters. Ed balbarino the Network Coordinator has appointed three regional coordinators to help him cover the far spread world of te Phillipines.

A new network has been established in Thailand forThai speakers. The Network is coordinated by Dr. Veerachai NaNakorn, Director, Queen Sirikit Botanical Organization, Chiang Mai, Thailand.

Also a provincial vetiver network is to be established in Fujian, China.

Table of Contents

Highlights from the International Vetiver Conference -- Fuzhou -- China --October 21 to 26 1997	1
FROM THE EDITOR	3
VETIVER RESEARCH AND DEVELOPMENT AWARDS	7
FUTURE ISSUES OF THE VETIVER NEWS LETTERS	7
LETTERS TO THE EDITOR	7
"Its Just Like Growing Shallots" Experiences with Vetiver Grass in Soil and Water ConservationProgramme for Communal Farmers in Zaka District, Zimbabwe.	14
Report on a visit to the Philippines by Paul Truong (14 - 22 MAY, 1997)	17
Observations and Experiments on the Multiplication, Cultivation, and Management of Vetiver Grass Conducted in China in the l950's.	18
A Preliminary Study on Vetiver's Purification for Garbage Leachate	22
DNA fingerprints (RAPDs) of the pantropical grass vetiver, Vetiveria zizanioides (L.) Nash (Gramineae), reveal a single clone, 'Sunshine', is widely utilized for erosion control.	27
Vetiver Conference, Fuzhou, China. Abstracts of Papers	33
Application of the Vetiver Grass System in Land Stabilisation, Erosion and Sediment Control in Civil Construction	48
Ecolink's Vetiver Grass Programme (April - July 1997)	54
Farmer's own adoption: "A Frame/Line Level Composite"	55
Vetiver workshop, Mbingo, February 1997 Cameroon	60
Soil Protection and Restoration Workshop, Madagascar. November 1997	63
The International Vetiver Workshop, Fuhzou, China. October 1997	65
NEWS FROM THE NETWORKS	68
What's New in EuroMed-VetNet	69
The Southern Africa Vetiver Network (SAVN)	**70**
Latin American Vetiver Network (LAVN)	71
Recent Development of Vetiver Technology in China	71
West African Vetiver Network.	75
The Pacific Rim Vetiver Network	75
Other Networks	76

THE VETIVER NETWORK

THE VETIVER NETWORK

TVN NEWSLETTER

NUMBER 19 AUGUST 1998

Chemonics International Wins USAID Environmental Contract In Madagascar.

USAID has awarded an important environment project in Madagascar, that includes a vetiver grass technology component, to Chemonics International. The project which aims at protecting Madagascar's biodiversity particularly in and around diminishing tropical forests, and improving stability and productivity of its agricultural lands will continue to promote the use of vetiver grass technology. Vetiver grass technology is used by Chemonics in its present Commercial Agricultural Promotion project as a major technical innovation in expanding sustainable agricultural practices and infrastructure rehabilitation.

The Vetiver Network, through its expertise and information, helped create the basis for a very rapid acceleration of the adoption of the technology in Madagascar based on world wide vetiver research and field results, most of which are relevant to Madagascar's diverse ecology. Initially, Richard Grimshaw ignited the vetiver flame through a 3 weeks general information and training tour. This was followed 8 months later by the trip of Dr. Paul Truong of Australia, who provided technical assistance to the use of vetiver in specific road design in flood prone areas.

Madagascar: Mr. Alain Pierre (right), agricultural manager of Project CAP, and an NGO colleague, looking at a well developed vetiver hedgerow protecting a cassava field. This technology will be used by the new environmental project for Madagascar. Photo credit - - R.Grimshaw

Madagascar has an operational vetiver NGO, and vetiver newsletter, and a wide net of collaborating partners in the use and production of vetiver. More information is available from Project CAP, Madagascar through "Criss Juliard"<cj@chemonics.mg>. ***Criss Juliard***

TABLE OF CONTENTS ON BACK PAGE

From the Editor

Vetiver grass technology continues to be adopted at an accelerated rate. Latest news from Ethiopia is that an estimated 500,000 farmers may be using vetiver grass for soil and water conservation. In the Philippines the highway authorities are showing increased inter-

est in vetiver for highway stabilization, and small and poor farmers are raising special containerized vetiver for highway stabilization. In Papua New Guinea farmers can't get enough planting material to stabilize their cultivated lands on very steep (60 degrees) and high (4,000 m) mountain sides. In China vetiver is being used to stabilize saline lands, and in Australia gold mine tailings that when dry turn into wind blown arsenic laden dust is being protected by vetiver grass -- so the vetiver story continues. Just recently Chemonics International has been awarded a large environmental contract in Madagascar -- Vetiver is one of the key technologies in that project.

El Nino has shown us just how extreme the weather can be. Vetiver has done well under both dry and wet El Nino conditions. We have reports from the Philippines indicating that vetiver survived the extreme drought conditions in that country. In California vetiver has stabilized steep hillsides and has thus protected some construction sites from the heavy rains attributed to El Nino. We understand that the famous Johnny Carson who lives in Malibu, California, planted (effectively) three lines of vetiver above his tennis court to stop the hillside spewing debris and soil on to the court. Those countries in tropics and subtropics that are effected by the extremes of El Nino should seriously consider using vetiver technology for embankment stabilization, flood control, and of course erosion control.

This newsletter contains information about a grass, *Achnatherum splendens*, from north China, that behaves similarly to vetiver when grown outside its natural saline swamp habitat. Importantly it is winter hardy, and survives extreme cold. It grows from the Caucuses to Inner Mongolia, and would also grow in the Unites States. Those conservationists in Russia might want to look into it potential.

TVN will be awarding individuals US$ 50,000 for research, development, and promotion achievements. These awards will be made by December 31 1998. In addition two US $5,000 awards will be made by His Majesty, The King of Thailand, for vetiver research and development.

We have had a poor response to TVN's funding proposal (Vetiver 2000), unless we receive some grants from potential donors we will have to reduce TVN's current role in vetiver grass technology promotion to that of only maintaining a homepage on the Internet. Under such circumstances the next newsletter #20 may be the last!!

Next year the International Erosion Control Association (Email: ecinfo@ieca.org) will be holding two important conferences, the first in Nashville, Tennessee, and the second in Manila, Philippines. Vetiver grass technology will feature in both. ***Dick Grimshaw***

Achnatherum splendens -- A Potential Conservation Hedge Grass For Extreme Cold Winter Climates

Some years ago when visiting China's Loess Plateau I came across the grass *Achnatherum splendens* or 'jiji sao' — 'Lovely Achnatherum grass'. The grass has a number of similar features to vetiver grass, but most importantly it can withstand extreme winter cold. It is used for embankment stabilization by local farmers. In May I was back in China, and took another look at 'jiji sao'. I and some of my Chinese colleagues, in particular Professor Xu Liyu, who heads the China Vetiver Network, are convinced that 'jiji sao' could be used to solve

China : Achnatherum splendens, alias 'jiji sao'. Stabilizing a steep slope in Baode County, Shanxi Province. Farmers use it for slope stabilization, fodder and broom making. Inset on left shows jiji sao leaves and roots. Photo Credit -- R. Grimshaw

many conservation problems in northern China where it is too cold for vetiver. 'Jiji sao' grows naturally on the saline soils of Inner Mongolia, surviving pH's of 9.5 and more. Under these conditions it is used for forage and broom making. However for many years now villages in parts of northern Shanxi (Baode, Heque, Pianguan) have grown 'jiji sao'; for special purposes. We interviewed a number of farmers and have found that 'jiji sao':

- grows extremely well on upland non saline soils;
- survives extreme cold;
- has good longevity and is not invasive (if it were it would be found all over the place, but appears to be confined only where man has planted it in the upland areas);
- does not compete with adjacent crops;
- has a deep and very strong root system;
- is used for steep bank stabilization, fodder, broom, curtain, mattress making, fodder, and medicinal purposes;
- is propagated vegetatively by plant division, but can be propagated by seed;
- is extremely drought tolerant; and
- can be used as mulch

'Jiji sao' appears to have many similarities to vetiver, although there are some very distinct differences, including a less dense and weaker leaf system. However there are enough similarities, as well as farmer experience and knowledge, to suggest that 'jiji sao' could be key to long term embankment stabilization (terraces, dams, and roads) in north China, and other countries where summers are hot and winters are extremely cold, if planted as a closely spaced in-line hedgerow across the slope of embankments as has been widely proven for vetiver. It also may well be possible to use it as an effective contour hedgerow on unterraced sloping lands. The prospects are exciting. Farmers have shown interest in using the technology when explained the value of its many uses and the correct field application. It also appears that some officials are at last realizing that something must be done about stabilization and appear more interested and confident in using the technology.

China: The crown, roots and leaves of 'jiji sao'. Photo credit -- R.Grimshaw

We identified a number of farmers and officials that are prepared to cooperate, and work has now started. The approach taken includes:

- establishment of a practical pilot initiative on terraces, dams, and sloping land;
- agronomic, taxonomy, and physiological assessments of the plant; and
- standard runoff trails to determine its potential to reduce runoff and soil loss on sloping lands.

China: Achnatherum splendens (jiji sao) used for the stabilization of 15km of highway embankment in Luliang Prefecture, Shanxi Province. Photo credit -- Xu Liyu

Professor Xu Liyu of the Institute of Soils, Nanjing, who is the coordinator of China's Vetiver and Agro Forestry Networks is providing technical documents to provincial officials. He will also assist in promoting the technology, and will work with project officials and give them some guidance from time to time. Institutions in the Loess Plateau area have been identified to carry out the agronomic assessments and conservation trials mentioned above. Mr. Xu reports that in Shanxi Province he found 15 km of highway shoulders succcessfully stabilized with jiji sao. ***R.Grimshaw***

Taxonomy: *Achnatherum splendens*.

The species is often included in the genus Stipa but is distinguished by the following generic characters: Spikelets laterally compressed (not terete); lemma margins not overlapping; lemma firmly membranous; callus long but obtuse; awn straight or curved, scabrid, not articulated with the lemma. The species itself has the following features:

Height up to 250 cm; panicle up to 50 cm; ligule c. 6 mm; spikelet 5-6 mm; lower glume as long as the spikelet; upper glume 0.75-0.8 as long as lower; lemma as long as spikelet.

Its distribution is: Caucasus (E. Ciscaucasia, Dagestan, Great Caucasus, E. & S. Transcaucasia), W. Siberia (S. Irtysh, Altai), C. Asia (widespread except Pamir), Iran, Himalaya, Jungaria-Kashgaria. ***Dr. T. A. Cope**, Herbarium, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AE, United Kingdom.*

The Vetiver Network Annual Report for 1997 (text only)

Annual Overview

1997 has been an extremely busy and fruitful year for The Vetiver Network (TVN). The use of vetiver grass for erosion control, stabilization of engineering works, land rehabilitation and pollution control has steadily expanded during 1997. Extended applications, backed by confirmatory research results, have further underscored the usefulness of the vetiver grass technology. There is no doubt that in the years ahead this unique grass, when planted as a narrow barrier hedgerow across the slope of the land, has a very important role to play for the mitigation of a wide range of environmental problems related to natural resources management.

The highlights of the year have centered on TVN's Vetiver Network Support Project (VNSP) that is being funded through generous contributions of the Royal Danish Government, the Amberstone Trust (UK), and the World Bank. VNSP has achieved all its 1997 objectives and more. Specifically it has:

- assisted in, and in most cases funded, the establishment of nine regional and national vetiver networks. These include regional networks for Europe and the Mediterranean, Latin America, Southern Africa, West Africa, and the Pacific Rim; and national networks for China, Madagascar, the Philippines, and Thailand;
- supported with grant funds non profit organizations in Cameroon, China, Ecuador, Ethiopia, India, Mexico, Nepal, the Philippines, South Africa, Tanzania, and Venezuela to initiate and develop vetiver programs for soil erosion and water conservation ;
- supported, with grant funds, vetiver related research in China and Australia;
- published and distributed (4000 per edition) two comprehensive newsletters (#17 and #18);
- supported numerous development organizations and users with the provision of slide sets, videos, books, CD-ROMS and other papers;
- redeveloped TVN's homepage site on the Internet; and
- provided special support (visits by TVN coordinator) to southern Africa, China, and Madagascar to pursue the development of new vetiver initiatives in the regions and countries concerned.

The Vetiver Network Support Project (November 1996 through December 1998) has thus far cost US $242,000 of which US$ 226,000 was expended on two year support programs for: regional and national networks, non profit organizations, special research programs, and information generation and distribution; and US$ 16,000 on administrative overheads. US$ 143,000 of the grant from the Royal Danish Government was expended during this period. New commitments are likely to be made during 1998 to support non profit programs in Cameroon, India, South Africa and Haiti.

Support to Regional and National Networks

As planned these networks are turning out to be critical for the expansion of the use and application of the technology by users. The operational results of these networks have been excellent, and all of the networks are doing more than originally expected of them. Not only are they publishing newsletters, but they are taking on independent activist roles in vetiver promotion. The China and Philippine Networks have held important workshops for training and awareness purposes; additional funds have been raised to expand local activities, regional coordinators and committees have been established at various sub-levels to support local interest groups, and a wide range of activities have taken place including both research and development. Liyu Xu (CVN) and Ed Balbarino (VETINETPHIL) are two extraordinary dedicated coordinators who with their colleagues have

actively promoted vetiver in their respective countries. Ed Balbarino states "that in all his 30 years of development work the vetiver technology is by far the easiest technology to promote"

The West African Vetiver Network, after a slow start, has picked up considerable momentum and with its Newsletter "The Ideal Farmer" is making itself well known in that Region. Special efforts have been made in Guinea, in conjunction with Global 2000, where vetiver is now seen as an important conservation technology. We can expect an even greater demand develop in 1998. Linus Folly, the coordinator of WAVN, has been working tirelessly in the dissemination of the technology, and has established an excellent rapport with communities and policy makers in many of the regions countries.

In southern Africa the Southern Africa Regional Network has published three newsletters and is starting to put into place some new initiatives in South Africa itself (Mpumalanga and Kwa Zulu-Natal). Reports from elsewhere in the region indicates considerable activity. Special efforts have been made in Malawi, Zambia and Zimbabwe. Duncan Hay, SAVN's coordinator, has rightly placed most of his efforts to date in South Africa itself, where, outside of the mining industry, the technology is the least developed. The biggest hurdles are improving the dissemination of information and the availability of vetiver planting material.

The Latin America Network, that publishes in Spanish, has greatly expanded its membership in Central America, and hopes to do more in South America in the coming year. Joan Miller, the network's coordinator, has done much to expand information flows about vetiver, and her Spanish written newsletter has received a very good reception in the region. Some excellent work has been carried out by the private sector company, NOBS, in El Salvador where it is meeting the needs of marginal farmers and government engineers. NOBS has show clearly that the commercial sector has an important role in vetiver development. In Nicaragua NGO operations are expanding, and in Costa Rica there seems to be a wide spread acceptance of the technology. In Mexico and Venezuela NGOs are developing sound vetiver programs with the focus on soil conservation and have the full support of TVN and LAVN.

The Pacific Rim Vetiver Network has published two newsletters, and is working on some other technical publications for distribution. Dr. Narong Chomchalow is the editor of the newsletter, and has made his presence felt throughout the region. Some outstanding development of the use of vetiver on large scale engineering projects in Malaysia have been demonstrated by Diti Hengchaovanich, CEO of the construction company EROCON. In Queensland, Australia, under the guidance of Paul Truong, we have seen expanding agricultural, highway, and mining interest in the technology. The latest development is the use of vetiver for the rehabilitation of large coal mine tailings area.

In Europe and the Mediterranean area the small EUROMEDVETNET, coordinated by Mike Pease, has been super active in searching for potential vetiver adopters, and is about to move into a trials and demonstration program across the Mediterranean area, if funding is made available by the EEC. This work will be an important step forward to testing vetiver's utilization in dry areas with winter rainfall. Todate the plantings in southern Spain have proven successful.

Late in 1997 a major TVN initiative was made in Madagascar in conjunction with the local World Bank Office, USAID, Chemonics International, and Project CAP. As a result a Madagascar Vetiver Network has been established, and the first Newsletter in French (this will be helpful to WAVN French speaking participating countries) has been published. Government agencies (particularly highways and railroads), NGOs and the private sector are working together to expand the use of vetiver for a wide range of agriculture, land rehabilitation and engineering purposes. The new Network is being organized by Criss Juliard and Ms. Akawangi of CAP. Their enthusiasm is infectious and they are deadly serious about how the technology should play a key role in stabilizing Madagascar's resources.

New networks are now being considered for Viet Nam and India, we hope to report more on these in the 1998 Annual Report.

Detailed annual reports from some of these networks can be found at annexure 1, and make good reading. Overall the regional and national networks have shown their capability and local advantage of dealing with vetiver related issues and for innovative initiatives in moving the technology forward. In both Philippines and China the networks have made mini grants to users and practical institutions to test and develop vetiver applications. Special acknowledgment should be made of the work of Xia Hanping and his colleagues from the South China Institute of Botany who have aptly demonstrated the use of vetiver for highway stabilization and pollution waste control, and Madam Zhang's work in the coastal areas of Fujian Province where vetiver has been used to stabilize coastal sand dunes, and for crop protection against strong winds. The mini grant concept is a good one, and is well within the capability of the local networks to administer.

All the network coordinators understand that the biggest constraint to

the further adoption of the technology is technology dissemination, training and the supply of planting material. Priority is being given to these important topics.

The networks have used TVN funds well, and have made a few dollars go an extraordinary long way. The message is clear that there are lots of capable people within the networks who are interested in sustainable agriculture and natural resource conservation and who can be very effective if provided a minimum and catalytic supply of funds. US$ 15,000 per network per year is not a lot of money, but it has been used very effectively to leverage additional funding and to provide the impetus to get started. **These networks are by no means self supporting and will, like TVN, need further funding support beyond 1998.**

Support To Non Profit Organizations

TVN has funded 15 organizations and overall the performance has been good. TVN has received adequate reports that indicate that funds are being used as intended, i.e. the initiation of vetiver programs at local and community level. In most instances TVN funds have been used as a catalyst to get things started. The fact that TVN made a grant has made it easier for the organizations to attract other funds or to allocate some of their general budget resources to the vetiver programs. In the end TVN funds are only a small part of overall expenditure and effort provided by the non profit organization. In each case the user organization and its key staff were convinced of the value of vetiver prior to receiving the grant. Some, such as Munchen fur Munchen working in Ethiopia, had already taken a leadership role in disseminating the technology beyond its immediate area of operations. As a result of TVN's support it is expected that most of these vetiver programs will have impact on a much wider audience than originally projected.

Cameroon.
The Cameroon initiative is led by Mr. Ngwainmbi Simon, a medical worker for the Baptist Church. With virtually no funding, but with guts and tenacity, and great faith in his people Mr. Simon has worked tirelessly on promoting vetiver technology for the past seven years. In 1997 TVN provided funds for a workshop in the NW Province for 250 attendees, and for the key resource person — Mr. Alemu Mekonnen of Ethiopia. As a result of the workshop a project was developed by the local people — Belo Rural Development Project (BERUDEP). BERUDEP has developed links with some 15 other organizations for the promotion of the technology. TVN is satisfied with the progress that has taken place and will provide BERUDEP with a further US$ 12,000 for 1998 and 1999 for the development of additional nurseries in the Bamenda area and for the training of more NGO's and technicians.

Ethiopia.
TVN has made small grants to three organizations in Ethiopia — Menchen fur Menchen; Inter-Aide France; and a regional Integrated Food Security Project. In all three cases funds were used for establishing vetiver nurseries, provision of plant material to users, training of technicians and users in the technology and its application. Feedback from Ethiopia indicates that there are now many government agencies and NGOs using vetiver in Ethiopia. Vetiver is probably the most important and effective conservation technology that should be used to protect Ethiopia's land and infrastructure assets.

South Africa
TVN funded a well established NGO, ECOLINK, located in Mpumalanga Province (the former Easter Transvaal), for the training of community leaders. Three workshops were held and a general awareness program was initiated for the people of the province. Vetiver planting material was used for demonstration plantings in the White River area. As a result of these efforts, and the interest that has been shown by the commercial sector, farmers and communities, a project is now under preparation which will move the program forward on a much larger and wider scale. The Project will be under the auspices of the Eastern Diocese of the Anglican Church with support from the Southern Africa Vetiver Network. Funds (US$ 120,000) will be raised locally, and key support will be provided by commercial enterprises such as Dickon Hall and Sons (one of the largest producers of processed fruits in the area and a distiller of vetiver oil) and by TVN. TVN will provide US$ 10,000 to help get the project started. This will be a key project for South Africa and it will run in parallel to a similar vetiver program in Kwa Zulu-Natal. Both programs will impact on poor farmers on marginal and degraded land (previous "homelands").

Tanzania
TVN has supported the Kaengesa Environmental Conservation Society (KAESO) in the highly eroded but potentially fertile area of Sumbawanga (Lake Rukwa area) of Tanzania. KAESO established a central vetiver nursery and has trained staff and users at a vetiver workshop. It has given video (TVN video) shows and has trained farmers in 10 villagers. Additionally 560,000 splits of vetiver have been distributed to farmers. This is sufficient for 18 km of hedgerows. A lot of enthusiasm has been generated amongst local farmers. KAESO is receiving technical advice from Mr. Alfred Mbegu, a local resident who previously worked on a vetiver program elsewhere in Tanzania. TVN has allocated additional funds to KAESO for 1998 to enable this ini-

tiative to continue and expand to new villages.

Nepal

TVN has supported the Community Development and Welfare Society (CWDS) in Nepal. CWDS works primarily in the hills. Vetiver has been planted to stabilize farm terraces. The vetiver handbook has been translated and published in Nepali, and is being distributed widely to users. Although the program todate has not been spectacular, a solid start has been made, and we can expect to see wider adoption in 1988.

Venezuela

TVN support to Sociedad Conservacionista Aragua (SCA) is leading to a well planned investigation of vetiver in Venezuela and for its future use for conservation. SCA has been recognized nationally for its vetiver initiatives. In its first year SCA has identified traditional sources of vetiver in the interior of Venezuela, has run a number of workshops, established demonstrations, and has worked with LAVN in the dissemination of information about the technology. SCA is working with other NGOs and agencies to establish vetiver propagation units and to train potential users. TVN videos (in Spanish), slides and other teaching material has proven very useful in SCA's work.

Mexico

TVN awarded a two year grant to the NGO "LASOS" for vetiver initiatives with communities located in Oaxaca. LASOS is working as part of the Program for Erosion Control and the Restoration of Soils of Oaxaca (PERCES). LASOS is working in 10 locations with small farmers groups, (4 women's groups, 2 local farmers groups, 2 community authorities and 2 NGOs). In the past two years 5 km of hedgerow were planted, 33 nurseries, 30 demonstartion sites, 17 research projects have been established in 5 regions. More than 300 farmers, researchers and extensionists, including 40 women, have been involved in workshops, trainings, planting and maintenance activities. Vetiver hedgerows have worked well, and reports of their effectiveness for soil conservation seem well founded. The PERCES vetiver program has shown what can be achieved when a comprehensive and coordinated approach is taken, and where the communities are seen to be central to the program and its success. Jim Smyle and Joan Miller (Director and Coordinator of the Latin America Vetiver Network) have visited Oaxaca and have provided technical assistance to PERCES and LASOS. The program provides an excellent lesson as to how communities, NGOs, Universities and government agencies can work together to achieve a common objective — it is the common vetiver technology that provides the focus.

As a result of the success in Oaxaca, the PERCES members are a supporting and providing training for a major erosion control project in the State of Mexico where vetiver will be a major component.

Ecuador

TVN is supporting the Ecuadorian NGO Fundacion Golondrinas (FG). Because of the impact of El Nino there were serious fires in the project area, and the program has not progressed as well as expected. However, it has shown the need for good demonstration, if farmers are to be persuaded to adopt the technology and the fire tolerance of vetiver hedgerows. FG will therefore focus on establishing demonstrations that show the impact on vetiver protection on pineapples.

Special Vetiver Support Grants

TVN provided special support grants to the South China Institute of Botany (Mr. Xia Hanping) and the Queensland Department of Natural Resources (Dr. Paul Truong) for vetiver research programs. Mr. Hanping and his colleagues, received a US$ 5,000 grant from TVN, and have undertaken practical vetiver research on highway stabilization, purification of leachates from municipal garbage sites, a study of a natural colony of vetiver wetlands, and a review of vetiver propagation techniques developed in China in the 1950's. The studies and findings have been reported on in TVN newsletters and on TVN's website. The results have application in China and elsewhere.

The vetiver grants to Dr. Truong, one of the networks leading vetiver research and development specialists, who has carried out some outstanding work on vetiver's tolerance to high levels of heavy metals and its consequent application for pollution mitigation, have been used to assist graduate students at Central Queensland University undertake research. The research that is currently underway includes: stabilization of prawn farm bunds (vetiver has proven to perform well in mangrove habitat); scanning electron microscope studies in salt stressed vetiver plants; ecological studies of vetiver; studies of endomycorrhizal fungi for vetiver grass; and modeling the flow through vetiver grass hedges on steep slopes. The results of these experiments will be shared with regional and national networks.

Vetiver Network Newsletters And Other Means Of Disseminating Information About The Vetiver Technology

TVN has produced two newsletters during 1997, and these were distributed to about 4,000 people. These newsletters are also placed on TVN's homepage at www.vetiver.org. TVN has been conducting a survey of newsletter readers, and todate it would seem that with the establishment of regional networks and the production of newsletters in local languages

that TVN will be able to cut back significantly on the number of newsletters printed and distributed. It is estimated that the 1998 newsletters will be distributed to less than 2,000 recipients, and follows the plan out lined in the 1996 annual report. The newsletters are large and comprehensive and provide for the publishing of most papers that are written on vetiver. The TVN newsletter is recognized as one of the best technical newsletters in circulation.

It is TVN's intention to supplement (and part replace) the newsletter by expanding the TVN web site, by producing CD-ROMs that contain key information such as all back issues of the newsletters and photo images of vetiver applications (one has just been produced containing some 700 vetiver images); and the establishment of an ftp site (ftp://ftp.vetiver.org) that can be used, amongst other things as an accessible public archive for vetiver research literature. These actions should be the cheapest and most effective way of storing and disseminating information to those who have access to the Internet and who use computers (it is cheaper to make and send a CD rom than it is to print and mail an 80 page newsletter).. The regional and national networks have shown conclusively that they can produce relevant and readable hard copy newsletters in the appropriate local language, and they can all access our Internet sites electronically. TVN has the capability of doing all these things, and is in the process of doing them.

Conclusions Drawn From 1997 Operations

TVN's decision to move its operations downwards and outwards has been fully justified. As a result many more potential users of the vetiver technology have been identified and are now participating in vetiver activities. The regional and national networks have proven, even in their first year of operations, to be competent and effect operators, and all have a deep commitment and belief in the technology. The Networks have the capability of producing good information for dissemination and all are "activist" in their approach.

TVN's support to non profit organizations appear to be worthwhile. Not only do these non profit organizations' activities support and benefit the immediate communities, but they also provide concrete evidence to other agencies and potential users in a particular country that the technology is sound and meets the needs of the users, particularly those who are very poor and are getting poorer due to their degrading assets. Farmers who use the technology correctly, at very little cost, can improve and sustain their incomes and their land when they use vetiver grass hedgerows. Evidence from most of those awarded TVN grants support the latter conclusion. In future it would be better from a selection and monitoring point of view that these small grants are administered by the networks with some review and assistance by TVN.

TVN's move to improve the flow of information through high tech methods makes sound sense, and has already paid off. The access to TVN's homepage site has more than doubled over the past year, and the use of CD-Roms is proving a useful and cheap way of moving bulk information and images to vetiver "organizers" around the world. The reduction in the number of newsletters to be printed and distributed in 1998 is fully justified.

By the end of 1998 TVN's Vetiver Network Support Project will be completed, and TVN will have little funding resources available for future operations. What has been achieved by everybody is magnificent, and it must continue in order to get this unique grass and associated technology out in front of the public. TVN's Board of Directors requested the TVN coordinator to seek additional funds for a second phase VNSP for the years 1999 - 2001. Based on our conclusions funds are needed to expand the number of networks, to support NGO operations via the networks, to support research, and to assure that the relatively low cost high tech flow of information continues. To this end TVN will, by end April 1998, put out a proposal to international donors for funding support.

TVN 1998 Activities

TVN will focus on the following:

- Providing technical and funding support to the existing nine regional and national networks and fifteen non profit organizations.
- Funding four new identified vetiver initiatives managed by nonprofit organizations.
- Publishing two newsletters, and further develop high tech transfer of technology as outlined above.
- Prepare a funding proposal for support by international donors for the second phase of the Vetiver Network Support Project — 1999 - 2001.
- Review research and development submissions for the Vetiver Awards Program ($50,000).
- Working with the Southern Africa Vetiver Network to prepare the ground work for the Second International Vetiver Conference to be held in South Africa in 2000.

1997 Accounts

The audited accounts and the independent auditors report are attached at Annexure 2. The Network com-

pleted 1997 assets of US$ 241,000 (including a cash balance of US$ 78,000 a commitment of US$ 150,000 from the Royal Danish Government). Since the end of the 1997 accounting year we gratefully acknowledge the receipt of a US$ 60,000 grant from the Amberstone Trust (UK). These latter funds are already committed to, amongst others, supporting four non profit organizations initiate new vetiver development and training programs.

In accordance with the rules relating to grants made by the Royal Danish Government a special schedule is included in the audited accounts that sets out the expenditure of the Danish grant funds.

1998 and 1999 Budget

The budgets for these two years are at Annexure 3. The 1998 budget of US$ 245,000 has assured funding, and the greatly reduced budget of US$ 41,000 for 1999 is 75% funded to cover US $16,000 committed to non profit organization vetiver programs, and the absolute minimum to administer TVN. It does not in include any funds for the second phase of VNSP. The 1999 budget will be modified later this year as a result of the responses that we receive from potential donors for new project

Research and Development Paper

It has become customary to include in each annual report of the Vetiver Network an article or paper that has the Vetiver Coordinator considers to have had a great impact on the adoption of the vetiver technology. This year the honor falls on Mr. Diti Hengchaovanich, CEO of Malaysia's EROCON construction company, who investigated the engineering properties of vetiver grass and the technology that is associated with it. He has used vetiver extensively for highway stabilization in Malaysia and his research into the tensile strength of vetiver roots and their impact on improving the shear strength of soil has been very instrumental in persuading engineers in other countries to take vetiver seriously as a biological system that meets engineering criteria for slope stabilization by Diti Hengchaovanich's paper is at Annexure 4.

Richard G Grimshaw, President and Coordinator

Letters From Some Key People Promoting Vetiver In The Field

The following are a selection of some of the communications with vetiver organizers in the field. The letter are printed as received in order to give readers a 'real' time taste of what is being done by people that are committed to soil and water conservation improvements and the use of vetiver.

From Edwin Balbarino. Coordinator Vetiver Network Philippines (VETINETPHIL)

Sorry for not having been "on line" for the last few days, I arrived back in the Philippines before Christmas, and have been traveling since then, because when I arrived back there were so many requests for meetings and visits. In fact when I open my computer now there are already 75 e-mails in it. I had a meeting with Mag-uugmad Foundation in Cebu regarding their possible involvement in the Vetiver program. They are still not so enthusiastic about Vetiver at this time because their farmers are engaged in small scale livestock production, but they will try vetiver and participate in the network. I had also met with Mr. Kennedy of the International Institute for Rural Reconstruction (IIRR) of Silang, Cavite and he is going to try Vetiver in the project on the island of Marindugue. The place is far from ViSCA thus we have problems in transporting the planting materials. I am going to survey nearby areas in Marindugue for Vetiver stands. Today (the time now is 5:00 am) I am going (in fact ready to sail to Cebu and catch the first trip of the SuperCat fast boat) to meet Jun Talpis and company to discuss the project proposed by the

Philippines: A woman weeding her containerized vetiver plants in her nursery, prior to selling the plants to highway contractors for stabilization purposes. Photo Credit -- Ed Balbarino

Bureau of Public Works and Highways for CARE Mindanao to contract the planting of Vetiver in a Mindanao highway (BPWH). I will tell you the results of our meeting tomorrow or Monday upon arriving from Cebu. I have not answered letters from the members yet. Activities are on the line.

later .....

I have been out for more than 2 weeks. I traveled to Western Visayas Provinces to visit VETINETPHIL members and attend the National Irrigation Umbrella Program which is a priority program of the new administration under the Agriculture and Fishery Modernization Act (AFMA) which was signed by President Ramos last year and will be implemented by the Estrada administration starting next year. Irrigation is getting 30% of the total 120 billion pesos AFMA budget for 6 years. I presented to Dr. David -- the program coordinator the role of VGT in the program. (I now have to make the proposal and submit it to Dr. William David of University of the Philippines at Los Banos).

I have also visited Mindanao, and CARE has started establishing nurseries for the BPWH project in Ozamis. CARE is also involving Post farmer cooperatives in the program.

The planting materials produced in Leyte have already been hauled to Cebu in several truck loads. Each load accommodates only about 10,000 bagged vetiver. Our farmers produced 50,000 bags for the EPZA project and they are ordering more. The vetiver has to be transported by big trucks which will be ferried, truck and vetiver, to Cebu and a long land trip to the project site in Naga. I have to visit the project soon to supervise the planting. But I have already briefed their two engineers on the proper method of establishment and monitoring procedures. We have agreed to make the project a model VGT project for Central Visayas.

I noticed that a number of private persons (I am sure business men) are engaged in buying and selling vetiver slips. Yesterday I received calls from Laguna from certain Dr. Manuel and he is ordering 1 million slips but I feel bad because he will only pay the farmers 5 centavos per slip (about US $1 per 1000 slips). I told him to look for Vetiver in Luzon. I gave him Noah , Lito and Tina's address. The network is buying slips from farmers at 50 centavos (US$ 1 per 80 slips) for our nurseries/production farms for distribution to farmers who have no money to buy the materials. This time we have started harvesting vetiver for our farmer-trainees. We have one training session per week (every Friday) and I targeted to cover 30 groups this year. I also heard that a certain Engineer Peteros is searching and buying vetiver in Region 8. I am calling a meeting of my coordinators to discuss some issues especially on the quality and pricing standards and monitoring of vetiver application projects.

Philippines: El Nino has created serious drought problems in the Philippines. Vetiver survived it well and will protect the dry and bare soil when the heavy rains arrive. Photo credit -- Ed Balbarino

We have ordered reprints of the Mora (vetiver) technoguides because of the high demand. This 30 - 31 July is ViSCA anniversary and Farmers' Day and we are expecting thousands of farmers/visitors to attend the activity. We are putting up a display of the Vetiver technology (posters and model contour farm) and distribution of posters, technoguides and newsletters. VETINETPHIL and AFRVN have also distributed (mailed) these throughout the Philippines.

This time we have linked with Local Government Units and NGOs in the promotion and application of VGS. I have successfully demonstrated in out demo-training center in Inopacan the effectiveness of Vetiver in controlling erosion. Farmers and local officials are brought to the center to see for themselves what I am talking about.

We have to orient the new DENR (Department of Environment and Natural Resources) officials about the technology. I hope Noah and the rest of our DENR friends will not be affected by the recent government re-organizations.

The real rain has finally come and we saw a lot of people and projects, planting vetiver this time. Whew!!!

For me I and my wife are so happy. We got a baby girl (a cute girl) by adoption. She adds color to our

lives. ***Edwin***

From Ken Crismier — Vietnam Vetiver Network
"phu xanh dat trong doi nui troc" ("greening the empty land and the barren hills")

I very much enjoyed the recent exchange of viewpoints between readers and editor in TVN Newsletter #18. As one who has been "sold" on vetiver -- even while being concerned in a general way about the danger of being personally oversold, since I am not a professional in the field -- you can surmise which viewpoint of the exchange I most strongly share!

I just returned from 2 months in Vietnam, where a main focus of my interest was vetiver and propagandizing about it. As has been noted time and again, in Vietnam too, the small vetiver establishment I was able to discover seems too concerned with proving the case for vetiver first, when the case seems to have been proven already. The case is not that vetiver is a panacea, but that its value as already proven by extensive world-wide research and experience is far more than sufficient to justify continuing to prove its case by observing it and testing it in actual use, rather than just in small, isolated, un-productive, academic, "objective", "scientific" tests and pilot plots.

(This is not at all intended to be critical of my friends: It is much easier for an outsider to see that there is a mold to be broken out of, and much harder for an insider first to perceive that a restrictive mold of habit exists, then even to try to break out of it. This is particularly true in a country such as Vietnam, where consensus before action is absolutely paramount, and individual initiative is generally frowned on by the culture.)

As I mentioned, the vetiver establishment I have been able to discover in Vietnam is small. So it was with interest that I noted your comment that "in Asia there are many success stories coming from India, China, Thailand, Philippines, Papua New Guinea, Vietnam and Laos." Since I am trying to "sell" vetiver in Vietnam - or rather, trying to light a fire where I've seen only a little smoke so far! - I and those I am talking to would certainly want to know from the outset about others who are working with vetiver, so as to be able to push vetiver more strongly, working from the broadest and firmest foundation possible. Any information you or readers can supply about vetiver and its proponents -- and detractors?! - in Vietnam would be much appreciated!

Ken Crismier, *4850 156th Ave NE #395, Redmond WA 98052, USA*
Tel: 425-869-8595; Fax: 425-644-7670; Email: kencris@gte.net

From: Criss Juliard, Madagascar
A British chap who lives next door just recounted this story to me.

He was on a field trip two weeks ago and was in a 4x4 that got stuck in a muddy ravine. The driver hooked up the winch of the car to a nearby tree, and slowly as the winch turned, the tree uprooted, leaving the car unmoved. Next, he extended the winch cable to the pylon of the nearby bridge, and very slowly turned in the front mounted electric winch. The bridge was either too old or too weak, but the pylon ripped off and part of the small bridge collapsed.

Nearby were some large clumps of grass, and one of the passengers suggested as a last resort -- I am not making this up -- to tie a rope around the grass at the base and use that as a footing. The driver hooked the winch cable to the lassoed rope, and proceeded to slowly pulled the car out of the ravine. This British person (Andrew Taylor) who had just been reading documents about vetiver I had given him verified that clumps were in fact *Vetiveria zizanioides*.

From: Glenn Allison, Project Manager, POPPA, Lilongwe, Malawi. (European Union funded project)
Thanks for your e-mail of 25 Feb 1998 and for the CD Rom which looks very interesting. The vetiver situation in Malawi is as follows:

The Ministry is pushing on slowly with vetiver nurseries; but this project (POPPA) which falls under the Ministry is moving faster. We now have about 215 ha of nursery spread around the country. Most of the material in the centre and north is *V. zizanioides* while in the south it *is V. nigratana*. We have seen some profuse seeding and germination of *V. nigratana*, but do not expect it to become a serious weed problem. In each catchment where we work we are training a committee of farmers to take responsibility for getting the vetiver out of the nurseries and into the contour markers which are generally spaced 15-20 metres apart. Payments for the nursery work are only made once the material has been satisfactorily transplanted. In order to demonstrate the benefit of planting a whole catchment in the same year we are planning to enter into a contract with farmers for them to complete transplanting into the markers by 15th January, thereafter we guarantee to deliver nitrogenous fertilizer to every participating farmer at the rate of 100 Kg/per 500 metres of hedge established [500m will protect one ha if the distance between hedges is 20m]. The administration may be a bit difficult but we expect the idea to work because the need and demand for fertilizer is so great. The contract will be a one off deal - at least the fertilizer will be going into properly conserved land rather than into cultivation ridges which are often off contour.

We are pushing on with our promotion of Reduced Tillage (RT). You remember the sequence - peg contour markers using the improved A frame, construct cultivation ridge on contour, establish vetiver hedges on

markers and then move into RT using *Tephrosia vogelii* as the legume to punch through the cultivation pan which have been formed with years of ridging an furrowing cultivation systems. Most of the NGOs are now in to vetiver as well. Farmers are beginning to use vetiver to patch up gullies without prompting from extension workers.

Our extension service is operating a protection racket - denying us access to the farming community unless we pay all sorts of heavy allowances, so we are now encouraging the farmers to hire their own extension person who they will pay with proceeds from their vetiver nurseries.

We are developing other enterprises from which they can also raise money to pay for extension. For example some will start growing sunflower for vegetable oil expelled with the Bielenberg hand press. Later they will use the same machine to expel both Jatropha and Moringa oil. We are promoting the planting of these species on a wide scale for cash purposes but also for conservation. The idea is to plant the trees above the vetiver hedges. Can you do anything in the vetiver newsletter to help popularize Jatropha and Moringa. The former oil proves to make a goo spray for controlling boll worms on cotton and is also reputed to have value as a base for lipstick manufacture.

A French cosmetics company is buying Moringa oil from Tanzania for use in face creams. We do not know how big the market is but will grow I suppose.

We sent a vetiver root to the fellow *(Bob Adams)* who is doing the DNA fingerprinting so that he can grow it to see if our zizanioides is really of Sri Lankan origin.*Salaams*, ***Glenn***

From: Naming'azi farm Training Centre (NTTC), Zomba, Malawi

NTTC has been using vetiver technology for almost 5 years now. The previous managers planted vetiver on the demonstration farm to stabilise our embankments. Based at the foot of the Zomba Plateau we farm hilly terrain so there are many problems with soil erosion, water loss and nutrient depletion. Vetiver has helped in counteracting these problems,

NFTC is working with 23 local villages to tackle soil and water conservation, soil fertility and land conservation. Presently agricultural production is very low because of runoff, high fertilizer prices and lack of knowledge for tackling such problems. The training centre demonstrates compost making and application as well as use of contour ridging and vetiver At least one village has developed a vetiver nursery and others are keen to implement vetiver technology.

Not many of the local farmers have animals because of the cost of quality feed and also theft. At NFTC cuttings of vetiver are fed to our goats or used in compost making. It is hoped the integrated use of vetiver will inspire and give hope to the farmers for the future.

Papua New Guinea: CARE, Australia, under Rob Shelton's leadership, is amongst other things intoducing vetiver technology to the local farmers. It is a very popular technology. Here farmers have just planted, using an "A" frame to set the contour, a vetiver grass hedgerow on a very steep mountain side. The two sticks are used to make the holes to plant the vetiver slips in. Photo Credit -- Rob Shelton

From: Rob Shelton, CARE -- Papua New Guinea

This is very late. Mail to this part of the world from your part of the world is pretty slow and I hope that we can continue to receive the TVN Newsletter. Some of the recent research is very Interesting.

Osman Farouk from the World Bank was here a couple of weeks ago on a supervision mission looking at a larger project of which my project is a small part. I was able to show him some of the vetiver grass hedges established, with our help, by traditional subsistence agriculture farmers. He said he was considering asking you to come out here to look at what we are doing and to give us the benefit of your wide vetiver grass experience. It would be great if that could happen. I doubt that there are many other places in the world where farmers are producing food, in the long term, on slopes that are usually over 40° and often up to 60°

At the beginning of 1997 we started introducing vetiver grass to farmers in the Gembogl District in Simbu Province following up our previous work over 3 years in 3 of the other

districts in the Province. This area has the highest mountain in PNG, at 4059 m, and is very precipitous, but has a high population density. Farmers quickly realised the potential of the VGS and saw it would complement the traditional methods they use for erosion control. In the nearly 18 months since we started, over 2,000 farmers obtained planting material and have either vetiver grass hedges in their gardens or nurseries so they can make future plantings. All this activity occurred in spite of the worst drought in living memory, which prevented any grass being planted in the last six months of 1997. Grass that had had enough time to establish a reasonable root system (2 months from planting) before the drought hit generally survived the dry with no difficulty. In some gardens I saw, vetiver was the only plant that was still green or alive during the height of the drought.

We have had good rains since the end of 1997 and the grass has come into its own. We have been inundated with requests for planting material and instruction in its establishment and management. We supply limited amounts of grass for free and find that farmers really use what they get. Farmers are beginning to recognise the importance of planting the hedges on the contour, rather than in the traditional straight lines. Some have mastered the use of the A Frame to mark out the contour lines.

Recently, we set up a demonstration block for the Department of Works so they can see how vetiver grass could be used to help them stabilise roadside cut-and-fill areas. Given our mountainous terrain, there are many road verges that could benefit from its use. So that hedge establishment will be quick in these vulnerable areas we have been growing the grass in meter long strips in the nursery so that the root system is well established by the time we plant it out. In an attempt to reduce the cost of nurserying the strips we have tried large diameter lengths of bamboo, split lengthwise into halves and filled with soil, rather than using sheets of plastic to form folds to hold the soil for rooting. Results to date are encouraging.

The booklet in Melanesian Pidgin that we have produced has created a lot of interest in the VGS among people we would not ordinarily have been able to contact. Each of the over 100 Community Schools in the Province have been given sets of the booklets for use as class readers. This gets across the VGS message as well as providing the schools with enough books for each student in the class during reading lessons. Many schools did not previously have enough books for a whole class. I have included a couple of the books for your interest.

My photographs, which I have included, show some of the gardens where we have established vetiver grass hedges and the obvious effects of the drought.
Rob

From: Methodist Relief and Development Fund (MRDF): Africa Link Newsletter #17 June 1998.
Bob Mann
Vetiver grass hedgerows for conservation in farmers fields -- Gwembe Valley, Zambia. Headman Siapanyika and his son Patrick, of Jomezya village, accompanied us down to see the fields of David Sizechelo and his family where they have been using vetiver grass very successfully to reinforce contour bunds, and so slow down and halt soil erosion. When asked what were the advantages of using vetiver grass hedgerows, Headman Siapanyika said (i) it provides fodder for animals, (ii) it makes excellent thatch grass, and (iii) it prevents the erosion of soil and keeps rainwater in the crop fields.

Vetiver grass raised in pots at Kanchindu nursery, and planted out at a 10cm (4") spacing alongside the contour banks in January '97, has now reached 1.5 metres in height and has already filled out, the clumps now joining and forming a thick hedgerow. On another part of the farm, the use of vetiver grass was completely successful in stopping up a wide gully in just 16 months from the time the vetiver grass was planted, and the amount of soil which had collected behind the contour bund and the vetiver grass hedgerow had reached a depth of *0.5* metre when measured from the ground-level below the bund.

Getting vetiver grass established in areas of poor rainfall. In the last newsletter, number 16 of November 1997, we described the advantages of using vetiver raised in nursery pots, in that it has the best chance of survival when planted out under conditions of poor rainfall, and the resulting establishment in the field can be rapid because the root systems are intact at planting time. That method is undoubtedly the best, but it is expensive, and takes much time and labour, both in the nursery and when transporting the potted plants to the field. Even if small-holder farmers do wish to grow vetiver grass in pots themselves, they may not be able to get the poly-pots, and the pots are expensive.

Vetiver grass can be multiplied most cheaply by growing it in clumps in a nursery. At planting time, the clumps are dug up, and the plantlets separated by pulling from the clumps, followed by trimming. This process strips all the root hairs from the plant, so that re-sprouting has to take place in the field after planting out. With this method, long periods without rain after planting out can cause the vetiver grass plantlets to simply dry up and die. The survival of vetiver grass plantlets depends on how much moisture one can retain

in the soil. Rainwater harvesting is essential. This is where the contour bunds being introduced by SAP are so useful.

In May 1998, we went with Peter Suntwe, SAP Nursery Worker, to Sikutecka village, meeting Billy Siakasonda, Community Agricultural Worker (CAW), and then went on to see a 2.5 hectare field belonging to Samuel Sijakube, together with his wife Ester, and their 14-year old daughter Lita. The field has 3 main contour bunds to prevent run-off, and vetiver grass (bare-root from Kanchindu nursery) was planted in the 2nd week of January'98 alongside and behind the bunds. A large gully in this field has already been repaired by the combined effect of the contours and the vetiver grass. The silt and rainwater run-off trapped behind the contours had increased the soil-moisture to the extent that the vetiver grass (even bare-root plantlets) had a good start in spite of the long dry periods during what should have been the growing season. So the bare-root planting of vetiver grass can be successful in drought-prone areas, providing that one makes a particular effort to harvest all possible rainwater and to keep it right there in the field.

From: Debela Dinka, Menchen fur Menchen, Mettu, Illubabor, Ethiopia

During the past few months normal vetiver nursery management activities has been ongoing. These include cultivation of the established vetiver clumps, proper fertilization, trimming irrigation and other related management activities following the technical recommendations given during the training period.

The nurseries are being managed by district level (Woreda) agricultural development office experts who are again supervised by zonal level experts. The routine day to day work, however, is being operated by daily labourers who are paid on bimonthly basis. To this effect a total of 169 person days (PD) has been utilized which has costed a total of Birr 1351 which is covered from The Vetiver Network grant.

Further more, the awareness creation as a whole and the selection of farmers who are willing to participate in the vetiver hedge establishment program on their own farm fields is underway. This activity is being carried out by Development Agents of the respective woredas of Zonal ADD who were trained in the vetiver technology.

As per our schedule, we have made all arrangements to carry out a training program which will deal with the uprooting of vetiver clumps from the nurseries, transporting and splitting the material into appropriate number and size of slips and establishing a permanent hedge along the contour line on the farm plots. It is planned that 60 farmer beneficiaries and 12 farm level ADD development workers will participate in the training program mentioned above. The selected farmers will be able to teach other farmers through proper demonstrations of the technique on their own fields

Finally it is worth mentioning that the popularity of the technology is so great, and has gone deep into areas where we, MfM, are not yet working. The questions forwarded to us by farmers, living near and around our operation areas, are becoming so demanding that we need to look for additional fund in order to respond to these farmers.

A Man At Work - Alemu Mekonnen Initiates A New Vetiver Program In Northern Ethiopia -- Current Activities And Hopes For The Future

Following its introduction in the early 1970s to Ethiopia, Vetiver grass technology had a very low exposure, and was not well know. In the 1980s the State coffee sector played a key role in the introduction of the grass. Moreover some NGOs had also reputedly extende the technology to the smallholder sector. It is probably only after the commencement of the Vetiver Newsletter's circulation since 1990 that more people became aware of this wonder grass as a cheap and efficient means of erosion control. As soil erosion on arable land is the major cause for the deterioration of agricultural productivity, Vetiver Grass Technology (VGT) is nowadays accepted as the best remedy for soil & water conservation.

Though the adoption of VGT in Ethiopia is encouraging, it is largely confined to special user groups, and its expansion and adoption is scattered and unplanned. Until recently, it was unknown in the northern regions (Amhara and Tegrai) where environmental deterioration is very severe.

In 1996, the soil conservation research station of the Amhara Regional State and the Amhara Development Association brought 3 truck loads of

vetiver grass from MfM for initial propagation in their nurseries. However due to poor management and lack of attention only 1-2 % of the grass survived. Nobody including the scientist who brought the grass tried to test it on crop land for SWC!!

In 1997 I left MfM and joined GTZ, where I brought up the issue of VGT to higher officials at the Regional Bureau of Agriculture level and transported two truck loads of vetiver grass from my former organisation MfM, and started propagating it in three nurseries, and established hedges on 50 farms as a SWC measure.

Ethiopia: These wheat and teff fields are protected by vetiver hedgerows placed on the contour in the South Gonder Zone of the Amhara Integrated Food Security Project that is funded by GTZ. The Vetiver Network provided funds to start the vetiver initiative on the project. Photo Credit. -- Alemu Mekonnen

Nursery Establishment

Now there are 18 Nurseries established in South Gonder zone with technical and input assistance from IFSP. In total these nurseries cover 7 ha and comprise 460,000 clumps, of which 115,000 are containersied polybags. The nurseries are located over a range of altitudes from 1,800 m to 3,100 m.

Awareness programs

As stated above, VGT is new to the northern part of Ethiopia. In order to introduce the technology, beside establishing nurseries, the project used the following approaches to create awareness of this easy and simple technology:

- Organising visits -- A group of experts from Zonal Agriculture Departments visited a successful project outside the region.
- Participating in regional workshops, seminar and training. -- Alemu Mekonnen made presentations about VGT.
- Accessing higher officials and influential people in the Region. To mention some: A workshop for regional conservation strategy formulation, the regional environmental action plan seminar, annual conference of development program for the region. Training: subject matter specialist at Regional & Zonal level, District extension agents annual training and Monthly Development workers training sessions.
- Articles -- Two articles on VGT were published in the local newspaper in Amharic.
- Local Radio -- two press interviews were given to local radio.
- Printed papers. — two to three page leaflets about the technology of the grass were prepared and distributed to development workers.
- Demonstration -- direct application of VGT to 50 farms was made in June, 1997. The success is so far encouraging.
- Field days -- A field day was organised for neighbouring farmers in the above 50 farmer fields.

Ethiopia: Farmers checking their newly planted vetiver hedgerows in the South Gonder Zone of Alemu's Integrated Food Security Project. Photo Credit -- Alemu Mekonnen

An additional 20 nurseries will be established for the 1999 season by supplying the initial planting material.

The Amhara Regional State has 9 zones, South Gonder is one of them. In 1998 the program is functional only in this zone. Today many requests are reaching us for support of material and training. Therefore, I propose if possible, to ar-

range a six days training (July, 1998) possibly in S. Gonder Debre -Tabor town for the remaining 8 zones. This will be the appropriate time to conduct training and the participants can get planting material from the project.

A three days Regional workshop will be organised for the regional president, Bureau heads and all higher official in Bahir-Dar, (the regional capital). At the workshop, policy and directive to other Administrative zones will be addressed.

Monitoring and Evaluation of the programme

There are 105 districts in the Amhara Regional state. If we succeed to reach and introduce the technology to 50 Districts there must be a system where by one could monitor and evaluate the progress in a given fixed time. For this, a Monitoring & Evaluation system must be devised to control, assist and expand the technology as required. Hence a short term consultant will be needed to prepare the format and assist the process.

Photograph Exhibition

Parallel with the regional workshop a three day photographic and poster exhibition will be arranged by collecting material from successful projects (photos and posters). Beside this a computerised diskette will be displayed.

Establishing a Regional Vetiver Network (RVN)

It is the right time to established the Amhara Regional State Vetiver Network to benefit 14.4 million people. From my informal discussion with Agriculture Bureau Head of the Region **(**Dr. Belay Damesse) and the Deputy Head for Environment program there is a support from their side if RVN could be established. Hopefully it will be chaired by the vice president of the Amhara Regional state or by the Regional Bureau head for Agriculture. It will be arranged at the time when the regional workshop will be held.

Application of VGT on farmers field and road side embankment

This year we expect to produce 459,600 Vetiver clumps to be planted in the coming rainy months of 1998. Of these, 100,000 will be supplied to the proposed 20 New nurseries to be supported by the project, 439,600 clumps for direct application on farmers land and road side embankments in the project areas, and the remaining 20,000 will be left for-propagation in our nurseries for the 1999 programme year.

Supply of planting material

All planting material for initial propagation will be supplied free of charge to other projects outside the zones from the project. NGO's will arrange their own transport to fetch the grass where as, GO's will be assisted by the IFSP transport facilitates. All costs for transport will be covered by the project.

WORKSHOP

A workshop, the first of its kind for the zone and the region, was held in Debretabour town, (zone capital for the South Gonder and where the IFSP project is situated), between October 8 -11 1997.

Workshop objectives

- Introduction of Vetiver grass to the participants;
- Exchange of experiences, if any, on vetiver grass technology among the workshop participants;
- Discuss the prospects of vetiver grass technology (VGT) for soil and water conservation in the zone;
- Identification of main issues/ problems that need further attention, develop possible strategies for the promotion of the technology extensively

Workshop preliminaries

It was officially opened by the vice chairman of South Gonder administrative zone. In his opening remarks he called for active participation of the participants and wished best success to the workshop objectives. The workshop was then addressed by the head of the Department of Planning and Economic Development for the zone. In his address he expressed that:

- His office acknowledges and appreciates the significant role the IFSP contributed to organise this valuable workshop and the sponsor agency the TVN;
- This workshop will create a conducive environment to increase the involvement of other concerned in the adoption and implementation the technology at large in the zone and further in the region
- He hopes this zone will be one of the model sites in the region to demonstrate the VGT which is believed and proven to be effective for SWC in other part of the country

Participants of the workshop

A total of 45 participants from different institutions attended the workshop. Institutionally they were from: 20 from zone and districts agricultural offices, 6 from NGOs, 6 from bilateral agencies, 3 from Zone and District Administration Offices, 3 from Department of Planning and Economics, the balance from selected influential people (elderly, religious and youths).

Workshop expectations

- To exchange experience with other related organisations on the usage of VGT (none were there);
- To know more about the ecological and economical advantages of this technology for SWC over the others;
- Vetiver propagation techniques;
- Vetiver disadvantages if grown with other crops;
- Labour cost of VGT starting from nursery to planting compared with engineered measures;

- Vetiver advantages for soil fertility improvement;
- Its agro-ecological limitations;
- its usage's for road side embankment stabilization;

Workshop presentation

- Theoretical. -- A high light of the morphology and physiology of vetiver grass, to different educational, and experience groups was presented by plant science experts.
- Visual presentations -- video cassettes, slides and printed films and posters from TVN and local sources were on display
- Visits --to near by nurseries and farmers fields were organised.
- Working groups -- At the end of each session and day, working groups were formed, expectations and opinions were finalised and consensus reached.
- Evaluation - lessons learned -- An evaluation paper was circulated to participants of the workshop to evaluate the relevancy of the workshop and its importance to the natural resource conservation strategy in the zone. The general recommendations were finalised and presented by organiser of the workshop.
- Relevant points and recommendations from the workshop participants.

Some general points from the workshop

Vetiver grass is believed to be promising for conservation of crop land and road sides stabilisation. Though, it is only the IFSP which is currently devoted to and involved in introducing the technology in the zone and the region. It is recommended that all the concerned institutions working in the field of environmental conservation programmes propagate this grass in their nurseries and start a pilot demonstration programme on selected farmers crop lands and roadsides. Like the IFSP assisted nurseries, they should also raise the grass in containers which will encourage better survival and enhance immediate effect. The first planting material should be provided by IFSP.

Special institutions It is difficult to disseminate this technology to the majority of needy farmers. Therefore, it was agreed, special education programme must be arranged for rural based schools for easy transfer of technology through students to parents. Thus the local radio station should participate and IFSP and others would arrange the necessary material for presentation.

Demonstrations. Seeing is believing. Like other demonstration plots for cereals crop**,** this technology must also be demonstrated at different agro-ecological and altitudinal ranges on cropland and road embankment . Different techniques and usage will be observed and tested.

Policy. Without any hestitation the technology must be included as one component of the existing extension programmes. Therefore, whoever is involved in natural conservation programme must start the system and include in their plan of action for 1998.

Rodents. Vetiver grass is expected to repel rodents. Rodents are one of the major problems in areas where conservation measures were built with stone. Because of the damages caused by rodents on both standing and stored crops, and to avoid the nesting of rodents in the structures, check dams and bunds constructed with huge labour and inputs (NW) are now being destroyed by the land owner. This is a great wastage of labour and resources. In order to tackle this, the grass should be widely planted on the bunds in order to minimise the crop damage and to make use of the productive area a occupied by the bunds. With this, the resistance of farmers will be resolved.

Hedgerow management. During the field visit, it was observed the hedge rows planted on some farmers fields were overgrazed as the result of the common open grazing system in the zone In order to achieve the required effect in a given time, all field workers should strictly advise farmers not to let their cattle into recently / newly planted hedgerows till the grass gets well established.

Propagation. One can conclude in the coming two or three years this grass will be demanded by majority of farmers for SWC. However, when we evaluate our production capacity of nurseries they can only satisfy the needs of very few farmers. In order to satisfy this, it is advised to find efficient and quick means of propagation.

On the job training. After selecting model and willing farmers to practice this technology on their crop lands, on the job training was arranged both for direct applicants and for neighbouring farmers. The training included planting and management of hedge rows and organised and conducted at different stages of growth.

LATE NEWS VANUATU SOUTH PACIFIC

An update on my Vetiver work in the Vanuatu archipelago is that Vetiver hedgerows survived a cyclone in March (370mm in 12 hours) with almost no damage.

The vetiver is trapping large quantities of sediment with over 500 mm depth of material retained in one year. I intend to present a technical paper on the project at the Manila Conference in Apri 1999l. ***Don Miller***

Vetiver Grass Throughout Zimbabwe - Protection Of Rural Roads.

by Jorg Stoll. E-Mail: stoll@africaonhine.co.zw. ***Stange Consult,*** *REGIONAL OFFICE HARARE, 33 Bayswater Road, P0 Box HG 635, Highlands Harare, Zimbabwe. Phone:0263-4-793385; Fax:0263-4-495083; E-Mail:stco@mail.pci.co.zw*

Introduction

Desertification and drought are some of the main reasons for erosion problems. These problems are of global dimension, and it must be the obligation of both, the affected and the developed countries to combat desertification and mitigate the effects of the drought. This is why the "International Convention to Combat Desertification in Those Countries Experiencing Serious Drought and! or Desertification, Particularly in Africa", calls for effective joint action at all levels. These efforts shall include action programmes, scientific and technical cooperation and supporting measures. The Government of Germany, through the Kreditanstalt fuer Wiederaufbau (KfW), supports Zimbabwe in its efforts to combat the effects of the erosion by financing the **Erosion Control for Rural Roads Programme** (ECRR - Programme).

Zimbabwe is one of the countries which have experienced severe droughts during the past years. As a result of these droughts and the population increase, the vegetation cover, especially in the rural areas, has decreased substantially. Heavy rains following the extended droughts have caused substantial soil erosion problems, which also threaten and damage the roads constructed under the Rural Road Programme.

Currently, the District Development Fund is finalising the establishment of a maintenance system to look after some 21,500 km of primary roads. The successful establishment of the maintenance is threatened by these erosion damages, which require major repair work and financial inputs. In order to reduce the effects of the erosion on the roads, the Erosion Control for Rural Roads Programme was launched in January 1997.

It is based upon the experience from a Pilot Study carried out in Manicaland province during 1995/ 1996 with the objective of identifying appropriate erosion control methods and creating a general needs assessment. It continued with the implementation of erosion control methods countrywide, in all 8 provinces. Since a fully operational set-up for maintenance and construction of rural roads exists within the local District Development Fund, the implementation of the programme is through this established infrastructure. It is intended to form Erosion Control Units (ECU) all over the country (7 have already been created during the Pilot Study). Sufficient Vetiver Grass nurseries will satisfy the demand in planting material. The ECU fall under the responsibility of the Road Engineering Division.

Currently, some 20 million plants of Vetiver Grass are available annually in 79 especially established nurseries and 431 Vetiver fields at Maintenance Camps of the Road Engineering Division countrywide. It is our target to have the number of Vetiver plants doubled by the year 2000.

Besides the actual control of erosion problems, a major part of the programme is "awareness building" among the local population with regard to the importance of erosion control and the work done by the DDF. The erosion often emanates from land usage problems and requires the combined action of all institutions in sensitizing the local community about erosion problems. Close co-operation with local authorities (District Councils, Ministry of Agriculture) and schools forms part of the programme.

Erosion Control Activities in Manicaland Province

Since 1995, when the pilot study was initiated, ECU have been established and erosion control activities carried out in each district of the province. In addition, nurseries have been built in all districts to provide Vetiver Grass for the erosion control work. Maintenance camps have also been expanded to produce Vetiver Grass.

The work in Manicaland continues with three main activities

- The operation of Vetiver Grass nurseries, i.e. producing Vetiver Grass for the implementation of the erosion control measures.
- The erosion control activities, i.e. the actual implementation of various erosion control measures along the roads covered by the Rural Roads Programme (RRP).
- The expansion of Vetiver Grass supply areas i.e. establishment of Vetiver Grass fields at maintenance camps

On places with minor erosion damages it is often sufficient to plant Vetiver Grass hedges. On major damages, i.e. gullies, the ECU build

a system of gabion structures and Vetiver Grass hedges.

The work programme for the ECU is based on erosion surveys which are carried out by the senior staff of the road engineering division after every rainy season.

The construction of gabion structures is mainly done during the dry season from May to November every year, while the planting of Vetiver takes place during the wet season (November to May). The maintenance of Vetiver Grass as well as any necessary repair work on gabion structures is done throughout the year.

Zimbabwe: A roadside gully stabilized with rocks, gabbions, and vetiver grass. Ultimately the rocks will be washed out leaving the vetiver grass as the prime means of protection. Photo Credit -- Stange Consult

Implementation of Erosion Control Countrywide

Since January 1997 the German Government through the Kreditanstalt fuer Wiederaufbau has financed the implementation of the erosion control programme countrywide.

The "Three Phases" of the programme and the overall targets.

- Phase I took place during 1997, and is now effectively completed.

- Phase II started in early 1998 with the procurement of the unit equipment, followed by the sourcing and training of the units' staff, distribution of equipment etc. The setting up of additional 50 ECU across the country is a major task.

- Phase III which will be carried out in 1999 and 2000, will see the implementation of the erosion control countrywide. Activities in Manicaland, where 7 ECU are already operating, are a trial phase for this Phase III. At present various trials are carried out with these units, both in the erosion control methodologies, as well as in the organisation and operation of the units. This will provide the necessary experience for the implementation of the phase in 1999.

The implementation of the erosion control programme requires a reliable and abundant supply of VG in every district. It has been estimated that some 40 million Vetiver Grass Plants must be available to ensure the sustainability of supply. This figure has been targeted for the year 2000

Effectively, the vetiver grass needs to be available all over the country in a large number of nurseries or supply areas.

The main reasons for the necessity of a widespread network of Vetiver Grass supply within the districts are:

- Keeping supply distances for Vetiver Grass from source to planting site to a minimum so as to reduce the transportation needs.

- Reducing the number of staging areas where the Vetiver Grass has to be stored prior to planting.

- Shorter transport distance means quicker movement from source to planting site, which enables Vetiver Grass slips to be used rather than plants in containers.

The Vetiver Grass nurseries (one or two in each district) are the main supplier of grass. Their main function is to provide Vetiver Grass both, as slips and as potted plants for maintenance camps, schools and other conservation establishments as well as for the various erosion control activities. The nurseries have a set fenced area and a permanent and reliable water source. 79 nurseries have been established so far.

Unlike the Vetiver Grass nurseries which are built up to uniform standards, the Vetiver Grass supply areas at maintenance camps vary according to local conditions (water source, layout of camp, land availability etc.). Currently there are 431 fields in existence.

In January 1998, the formation of the ECU started. This involves

- Procurement of equipment and tools for 50 units (preparation of specifications, preparation, letting and evaluation of tenders,

organisation of payment and delivery).

- Distribution of equipment and tools to the 50 units spread over the country.

- Selection of staff for 50 ECU.

- Training of staff, including RED staff and erosion control unit staff in organisation, administration and implementation of erosion control.

- Survey of erosion control requirements for all roads.

- Preparation of erosion control plans and programmes for each district.

The following staff have been sourced or recruited to man the ECU. They now have to be trained in technical and administrative aspects of the erosion control:

- 50 ECU supervisors.
- 50 ECU Tractor Drivers.
- 500 Casual Labourers.

Training is a major part of the project and is necessary to ensure that the erosion control is properly established and sustainable. The training will need to cover:

- Operation of the ECU, including its set-up, job descriptions of the unit's staff and the administration of the unit.

- Erosion control activities, preparation and carrying out of activities.

- Reporting and monitoring of erosion control activities.

Gabion Construction:
Gabions are structures, and as such have to be designed and constructed to set standards. The gabion construction is strictly controlled by the province. Training covers classroom training for standards and specifications and practical on-the-job training. The collection of rocks is included in the gabion construction. This is done by contracting local residents to stockpile agreed amounts of selected stones. Personnel is also trained in preparing and implementing these contracts.

Vetiver Grass Planting:
In order to ensure maximum survival and the quickest establishment of vetiver grass, certain procedures and techniques need to be observed in regard to how, when and where the Vetiver Grass is planted, and most important the maintenance after planting

Awareness Building
The objective of the Awareness Building is to sensitise the local population and relevant authorities to the importance of erosion control and the work been done by the District Development Fund.

As erosion often starts from land usage problems, it is essential to gain the cooperation and understanding of the people who can influence and correct these problems The Awareness campaign is mainly aimed at Local Authorities (District Councils, Agritex) and Schools.

District Councils as part of the Local Government have a key responsibility in supporting Erosion Control measures and disseminating information to the local populace.

Agritex (Ministry of Agriculture) is responsible for monitoring and advising on the agricultural land usage in rural areas. Agritex has direct responsibility for drainage control (contouring) of crop lands. Therefore, it is important to coordinate with them efforts regarding control of water flows.

For any long term erosion awareness it is essential to involve as many people as possible. Hence, this type of operation is ideally suited to school children. The awareness targets headmasters by providing information about erosion control and also assisting in practical projects through supply of Vetiver Grass to the schools. The Vetiver Grass could be used for school gardens, agricultural projects etc.. This grass, once established, can be propagated and then taken home by the students and used on their own farms.

Vetiver Network Awards

If you still wish to send in nominations for the Vetiver Network Research and Development Awards, you may do so up to September 30th 1998. The winners of the Awards will be announced before December 31 1998

New Publications

Papua New Guinea: Wetiwa Gras -Lukautim Graun Buk namba 6 (CARE - Australia, OO Box 568, Kundiwa, SP, Papua New Guinea.

Vietnam: Vietnamese Translation of "Vetiver Grass A Hedge Against Erosion". Ken Krismier,4850 156th Ave NE #395, Redmond WA 98052, USA

Mine Tailing And Railroad Stabilization In Queensland Australia. Some Photos By Paul Truong

Gold Mine — Old Tailings

Vetiver will be used to rehabilitate this extremely acidic old gold mine tailings where pyrite has concentrated over time in 'plumes' 'where no vegetation could be established even with high liming rates. Although vetiver was not at its best, only about 70% of its potential, (pH=3.6), this is a lot better than any other species trialled. The

Australia: Old Goldmine tailings -- an 8 year old pyrite plume. Left photo shows bare vegetation except for a control of untreated vetiver. Right photo shows vigorous vetiver growth after treatment with 20 t/ha of lime and 735 kg/ha of DAP. Photo Credit -- Paul Truong

depressed growth could be due to Arsenic toxicity, as the total As level in this tailings is at 950 ppm (Vetiver tolerance level to As was at about 250 ppm established earlier). Further works are being undertaken to ascertain the cause

Goldmine — New Tailings

Last year glasshouse trial showed that vetiver could be established and successfully grown on this extremely poor tailings, without any fertilisers! The mine has now agreed to use vetiver as their principal wind erosion control measure. Planting will start shortly at 10 m spacing in 100-500 m long rows, with the provision to reduce to 5 m spacing if 10 m is not effective enough. Once the surface is stabilised native grasses and trees will be established inter rows. The first few km planted this year will be planted by hand but balance will be done by machine planting

Railroad Embankment Stabilization

Over the past two years work has been conducted in cooperation with Queensland Railways to stabilize access roads, railroad cuttings and cross drainage works.

Australia: New gold mine tailings showing wind blown dusts laden with arsenic and other heavy minerals. Photo Credit -- Paul Truong

Australia: New gold mine tailings. In this scene sorghum has been planted as a temporary measure to prevent dust, however sorgum lasts only six months -- vetiver will be a permanent solution for rehabilitating this site. Photo Credit -- Paul Truong

Australia: Railroad embankment stabilized with vetiver grass hedgerows. Vetiver is also being used in Madagascar by USAID funded project CAP for railroad stabilization, and has been used successfully in China for the same purpose. Photo Credit -- Paul Truong

Australia: Railroad culvert stabilised by two lines of vetiver grass hedgerows both on the inlet side (to reduce sediments and therefore desilting costs) and on the outlet side to stop erosion and drainage floor cut back. Photo Credit -- Paul Truong

Australia: Railroad cutting stabilised by vetiver grass hedgerows. No other plant would grow on the cutting. As a result of the hedgerows the railroad bed drains no longer need extensive and costly annual cleaning -- Paul Truong

Vetiver At East China Highway Conference

The East China Highway Conference was held in Xiamen of Fujian Province, on 8 -11 June. There were 60 participants coming from Jiangxi, Jiangsu, Shanghai, Zhejiang, Shandong, Fujian, Anhui Provinces. They were highway bureau officials, engineers, and university professors, and vocational school teachers. Some came from highway planning and design institutes, and highway maintenance departments. The main topic of the conference was the highway greenization. Mr. Xu Liyu, coordinator of China Vetiver Network, was invited to attend the conference. A paper titled Vetiver for Highway Stabilization and Greenization which was prepared jointly by engineers from Jiangsu Highway Bureau and Jiangsu Communications Planning and Designing Academy was presented during conference accompanied by a set of slides. He introduced the vetiver application in Malaysia, Thailand, Australia, and in China in particular. Since 1989, vetiver technology has been introduced to highway departments in Guangdong and Fujian Provinces. It was shown that the grass played an important role in highway stabilization in mountainous area, which covers around 70% of southern part of the country. Since then more and more engineers from both highway and railway got involving in vetiver.

During the conference, most of the participants were keen to hear about the grass. The vetiver technology generated great interests in the meeting and the participants hoped to get more information. The engineers from Fujian, Anhui, and Jiangsu Provinces decided to test vetiver grass for their newly built highways.

It was suggested that an international meeting on the application of

China: Under the leadership of Mr. Xu Liyu, China Vetiver Network's Coordinator, there is an increasing interest in using the Vetiver Grass Technology. In this scene from the Province of Herbei farmers are bagging vetiver planting material prior to transporatation. Photo Credit Xu Liyu

vetiver technology for highway stabilization be held in late 1999 in order to invite more engineers to involve in the technology and to reduce expenses used for stabilization with engineering measure instead of biological means which can not only protect highway from soil erosion damage but also protect environment. The participants realized that vetiver could be a hot topic among engineers, as during the period from 1994-1996 there was 34,000 km of highway constructed in the country, many of these need to be protected and greenized. ***Xu Liyu, China Vetiver Network Coordinator***

South China Water And Soil Conservation Meeting Held In Xiamen

Organized by South China Water and Soil Conservation Association, the South China Water and Soil Conservation Meeting was Held in Xiamen on 10 - 12 June 1998. About 80 participants mostly from provinces in south China attended the meeting. Mr. Xu Liyu, coordinator of China Vetiver Network, and his colleague Ms Zhang Jing were invited to attend the meeting. Mr. Xu introduced the recent development of China Vetiver Network and the applications of vetiver technology for engineering purpose. The very good examples generated by Ms Zhangjing in Fujian Province were introduced, e.g. vetiver technology for the protection of coastal dikes, river banks, fish pond, and vetiver for sand dune stabilization, saline soil amelioration, and edible fungi cultivation, etc. Following national economic reform many new constructions were carried out, which caused serious new soil erosion and became a key issue in soil erosion control in the country.

During the meeting a recognized expert Dr. Mien-Chun Liao from Taiwan pointed out that it was very necessary to use biological measure to protect earth terrace which was not protected by stone. The grasses will be very useful for terrace stabilization. ***Xu Liyu, China Vetiver Network Coordinator***

Grass Barriers In Cassava Hillside Cultivation: Rooting Patterns And Root Growth Dynamics

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1.Introduction

Cassava adapts to a variety of ecological conditions and tolerates low soil fertility. drought and pests, rarely experiencing complete crop failure. This is why the crop continues to hold an important position in traditional tropical cropping systems of small farmers, who are increasingly displaced to marginal, sloping lands that are unsuitable for large-scale mechanized cultivation. Cassava cultivation on slopes steeper than 15%, together with highly erosive rains, frequently leads to high soil losses. Burgos (1987) measured soil losses of 101-111 t ha in recently tilled cassava plots in Costa Rica and recommended intercropping cassava with fast-growing crops.

Soil losses of the same magnitude were recorded by Howeler (1985) in cassava plots on slopes of 40 to 50% in the Central Cordillera of Colombia. In these trials, erosion was drastically reduced by either mulch-

ing with maize straw or interplanting strips of well-adapted grasses.

Several studies discuss the benefits and problems of grass barriers for soil protection in long-season crops such as cassava and coffee (Lal, 1977; Webster and Wilson, 1980; Aristizabal, 1988; Cadavid-Lopez, 1990). None, however, quantitatively assess crop-barrier interactions, using growth patterns both above and below ground, across space and time. Knowledge of the underground structure of plant communities is necessary to understand their ecological interaction (Schubert, 1982). For barrier-crop interactions, this understanding is particularly significant for interpreting the ecological and agronomic success or failures of soil conservation technologies and their adoption or rejection by farmers. In this context, estimating possible degrees of below-ground interaction for individual cassava-grass combinations thus appeared important. The objectives of this study were, therefore, (i) to describe rooting patterns and spatial root distribution of cassava and grass species commonly used as live barriers in soil conservation, and (ii) to determine root growth dynamics over time by quantifying weekly and cumulative root length increases.

Table1. Soil chemical properties of root-observation profiles for cassava-grass systems, Santander de Qailichno, Colombia

Depth (cm)	pH (H_2O) (SoiI-water 1:1)	Organic matter (gkg '1	Total N (gkg ')	Bray II-P (mgkg I)	Exchangeable cation (cmol kg^{-1} Ca	Mg	K	Al
0-20	4.0	76	2.2	4.4	0.74	0.31	0.21	4.4
20-40	4. I	54	1.3	1.4	0.61	0.21	0.11	3.0
40-60	4.9	24	0.8	1.2	0 30	0.07	0.05	2.0
60-80	5.3	13	0.2	0.8	0.18	0.04	0.03	2.4
80-100	5.3	12	0.4	1.4	0.21	0.04	0.04	2.6

2. Material and methods

2.1. *Experimental conditions*

Field research was conducted near Suntanned de Quilichao, Colombia, at the research farm of the Centro Internacional de Agricultura Tropical (CIAT). The area has an average annual temperature of 23.8°C. Rainfall and evaporation data for 1972-1988 indicate that the average annual rainfall of 1799 mm exceeds the annual potential evaporation of 1589 mm. However, during June through September and in January, potential evaporation exceeds precipitation. Rainfall intensity occassionally exceeds 100 mm h^{-1} and rainy periods can be interrupted by dry spells lasting a week or longer, even during peak rainy seasons. The experiment was carried out on a Typic Dystropept soil (IGAC, 1976), which has a clay texture, high organic matter, and low fertility (Table I). The field was located on a slope of 13%.

2.2. *Grass and cassava planting*

On May 30, 1991, guatemala grass [Tripsocurn andersoni J.R.Gray], lemon grass [Cymbopogon citratus (DC. ex Nees) Stapf] and vetiver grass [Vetiteria zizanioides (L.) Nash] were planted in rows across the slope. Each grass species was planted in a row 20 m long, and separated from others by 1.9 m. Within each row, the tillers were planted at 10-cm intervals. After full establishment was reached on August 12, 1991, 10 weeks later, the soil between grass barriers was loosened with a hoe and tiled with a rotorvator to a depth of 25 cm. Once the soil was prepared, grass was removed from the row every alternate 5 m. The cassava variety M Col 1505 was then planted in double rows between grass barriers at a density of I5,038 plants ha 'Untreated stakes, 20 cm long, were planted vertically at 55 cm from the grass row, leaving 80 cm between the two cassava rows. Along the row, the stakes were planted at 70-cm intervals. Thus, an individual plot (4.9 x 1.9 m, Fig. 1) consisted of 4.9 m of grass row (present or removed) with 7 cassava plants on either side of the grass barrier.

[Fig. I. Planting arrangement of grasses and cassava in individual plots for root length and growth studies, Santander de Quilichan. Colombia, 1992. *Not included*]

Each treatment was replicated twice, so the field design comprised 12 plots, half consisting of grass-cassava systems, half consisting of cassava sole crops established by removing the grasses at cassava planting time. No mineral fertilizer was applied, but the trial was irrigated during dry spells: 50 mm on August 16, 30 mm on August 28 and 30 mm on January 8, using a sprinkler irrigation system.

2.3. *Grass barrier management*

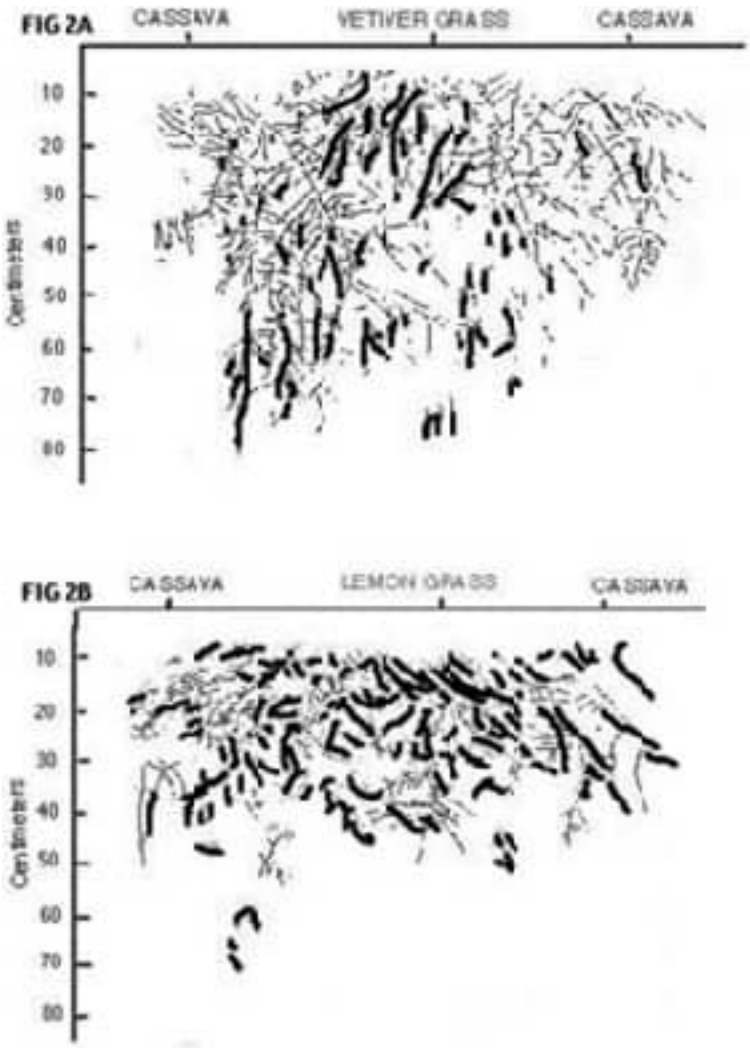
The grass barriers were cut back by machete on November 18, 1991, 24 weeks after grass planting (WAGP);

Guatemala grass to ground level, vetiver grass and lemon grass to 25 cm. On April 1, 1992 (44 WAGP), Guatemala grass was cut to ground level a second time. Vetiver grass and lemon grass were not cut to ground level, because they recover too slowly, especially in dry periods.

2.4. *Root observations*

For two weeks after cassava planting, root observation pits - 1 m deep, 1.3 m wide and 1 m long - were dug in the "cassava with grass" plots only. One long wall of each pit spanned two rows of cassava with one grass row in-between (Fig. 1). This wall was made vertical with a metal blade specifically made for this purpose. Small unevenesses in the profile wall were corrected with a spatula before a 5-mm-thick acrylic sheet, measuring 1.27 x 1.00 m, was installed against it. When the wall was not in use, it was covered by a black plastic film to prevent light from affecting those roots growing against the acrylic sheet. In addition, a 60-cm-thick styrofoam board, measuring 2 x 3 m covered the whole pit to protect against fluctuations of light and temperature. A corrugated plastic sheet protected the pit from rain.

Transparent 1.0 x 1.2 m acetate films were fixed to the acrylic sheets and, from September 3 (14 WAGP) to January 22 (34 WAGP), rooting patterns and root length increases were traced on the sheets at weekly intervals. Drawings were done with different coloured markers to distinguish roots of the two plant species and individual root growth increments from one week to the next. After tracing, the acetate films were taken to the laboratory, where the drawings were copied on semi-transparent paper, using various blue tones for cassava roots and various red tones for grass roots. Thus, by the end of the observation period, a complete picture of both cassava and grass rooting patterns was available.



Figs. 2A and 2B. Comparison between vetiver grass and cassava (2A) and lemon grass and cassava (2B). Cassava roots shown as thin lines, vetiver and lemon grass shown as dark thick lines

The last drawing showing cumulative root length, was used to obtain information on root length distribution. A transparent acetate film, marked with a 15 x 20 cm grid, was placed on top of the drawing and root lengths were measured in each grid, using a hand-held distance scanner (Fa. Thoma, Erlangen, Germany). The grid was placed so the centre of the grass barrier could be taken as the zero reference point. Starting from zero, root lengths were measured every 15-cm segment up to 60 cm on both sides of the grass barriers and every 20 cm in depth down to 80 cm. Hence, root length was recorded in metres either at a depth of 20 cm across a width of 1.2 m (or 15-cm portions thereof), or within the total exposed surface of 80 cm (depth) x 1.2 m (width).

3. Results

3.1. *Rooting patterns*

Distinct root development and dis-

tribution patterns occurred for each cassava-grass combination. Both replicates produced very similar rooting patterns. The least intermixing of the two root systems was found in the cassava-vetiver grass combination (Fig. 2A) While cassava roots spread profusely in both lateral and vertical directions, roots of vetiver grass showed clear tendency to grow vertically down the profile with little lateral spread or tendency to branch. However where cassava and vetiver roots met, they grew close together over long distances with no signs of root avoidance. A good downward root penetration of both species was found over the whole depth of the profile.

In the cassava-lemon grass plots, both species showed profuse root development only in the upper part of the profile (Fig. 2B). In the lower part of the profile, there were few cassava or lemon grass roots. The dense growth and ramification of lemon grass root apparently did not prevent cassava roots from also exploring the upper segment of the profile. However in the grass area (centre of figure) cassava roots were noticeably less dense than in the cassava areas (left and right side of the figure) and, equally, grass roots were fewer under the cassava rows than under the grass row.

The rooting pattern of the cassava-guatemala grass combination was different again, showing strong penetration of grass roots in all directions of the profile (Fig. 2C). Cassava roots developed their usual strong lateral and vertical spread, and close contact was observed between cassava and grass roots. The root system of guatemala grass was vigorous, deeply penetrating and consisted of many thick roots with little ramification.

3.2. *Root lengths and distribution of grasses.*

Root growth of all three grasses was greatest in the 0-20 cm segment of the exposed profile, with few differences between upslope and downslope root development (Fig. 3 NOT INCLUDED). By the experiment's end, root lengths were 2.70 m for vetiver grass. 7.49 m for guatemala grass and 9.04 m for lemon grass. Vetiver grass typically produced 96% of its root length to a distance of only 30 cm on each side of the barrier. In contrast the root lengths of the two other grasses decreased only gradually with increasing distance from the grass barrier. At 20-40 cm depth, root lengths were shorter than those in the first 20 cm of the profile: lengths were 1.64 m for vetiver grass, 5.65 m for guatemala grass, and 5.88 m for lemon grass. Both guatemala grass and lemon grass roots were longer on the upslope of the grass barrier than on the downslope.

In the 40-60 cm segment, root length was further diminished, with the strongest reduction in lemon grass (88%) (Fig. 3). Very few lemon grass and guatemala grass roots could be found in the lowest segment (60-80 cm), and root lengths were only 15 and 39 cm, respectively. Consistent with its characteristic rooting pattern, vetiver grass showed considerable root growth at this depth, with a total root length of 1.37 m, most of which was downslope.

Statistical analysis of grass root length distribution showed a significant ($P<0.05$) "depth x grass species" interaction, confirming that the grasses have different exploration patterns with depth.

3.3. *Root length and distribution of cassava*

Cassava tended to produce more roots away from the grasses than near them (Fig. 4). In the 0-20 cm segment, the longest cassava roots were found in the cassava-vetiver grass combination, totaling 5.99 in. followed by cassava lemon grass with 5.41 in and cassava guatemala grass with 2.83m. (fig 4). in the 20-40 cm segment, root lengths of cassava with lemon grass and guatemala grass were somewhat reduced, whereas roots of cassava with vetiver grass were longer, totaling 7.31 m - more than 1.3 m longer than in the top 20 cm. The increase occurred mostly downslope.

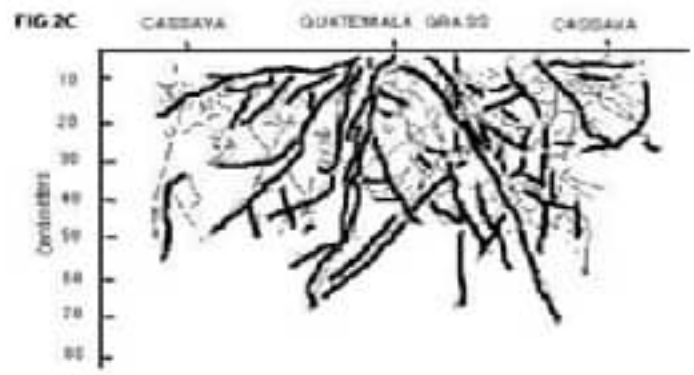


Fig. 2C. Comparison of Guatemala grass (thick lines) and cassava (narrow lines) roots

In the 40-60 cm segment, cassava root growth was further reduced but, again, the total root length with vetiver grass (3.36 m and 76% down slope) was considerably greater than in cassava-guatemala grass or cassava-lemon grass (2.00 m and 0.71 m respectively) (Fig. 4). Few cassava roots reached the 60-80 cm segment, except for those of cassava with vetiver grass, where the downslope length was 86 cm.

Cassava root lengths were statistically significant (P<0.0l) for the ''distance x grass species" interacation, indicating that the type of grass significantly influences lateral exploration by cassava roots.

3.4. *Root growth dynamics*
Cumulative grass root lengths over time (Fig. 5) showed further differences in root growth dynamics, vetiver grass roots grew slowly and steadily, reaching 7 m for the total exposed surface, the smallest of the three grasses. Both lemon and guatemala grass roots grew more rapidly during the period 16-24 WAGP. Lemon grass roots started earlier, resulting in significantly greater root lengths, compared with vetiver grass at 17 and 19 WAGP. Guatemala grass, however, was slower, reaching similar values at 20 WAGP, followed by almost no growth at 25-29 WAGP, possibly because of the first cutback. After the cutback, both lemon grass and guatemala grass resumed rapid root growth. The total final root length of each of these two grasses was as much as two and a half times that of vetiver grass. During the active early growth of grass roots, cassava roots grew very little, becoming active only during the lag phase of grass root growth after cutback. With vetiver grass, cassava roots began growing rapidly as much as 3 weeks earlier than with the other two grasses (data not shown), resulting in a total final root length of 17 m, which is 70% greater than that in either of the other two cassava-grass combinations.

4. Discussion

4.1. *Soil penetrability*
The soil was readily penetrated by roots down the whole depth of the observed profiles. Roots did not encounter physical obstacles, such as a hard pan or clay layer, that inhibited root growth or deflected roots laterally. Neither were there chemical barriers, root behavior being consistent with increasing pH and decreasing aluminum availability at lower depths. A concentration of plant nutrients in the first 40 cm probably explains why most grass and cassava roots were found exploring only the upper part of the profile.

4.2. *Rooting pattern*
The greatest spatial separation of grass and cassava roots was observed in the cassava-vetiver grass combination. This resulted from the predominantly, downward direction of root growth in vetiver grass which occupied a root zone resembling an inverted ''U" centred below the grass row. A near-complete separation of grass and cassava roots was observed in the top 40 cm of the profile. This was associated with cassava's greatest root length, particularly at 20-40 cm. Further-more, cassava roots spread both laterally and vertically throughout most of the profile, suggesting that vetiver grass roots did not inhibit cassava roots from exploring the same soil volume.

The root-zone separation in the cassava-lemon grass combination was not so clear. Lemon grass showed more lateral expansion than did vetiver grass. Cassava roots also spread laterally but root density in the area below the grass row decreased. The lower part or the profile was less intensely explored by lemon grass roots than by grass roots in the cassava-vetiver grass or the cassava-guatemala grass combinations. Cassava root penetration was also less deep, suggesting that unidentified minimal changes in soil chemical properties may have caused the shallow rooting.

More so than in the other two combinations, guatemala grass roots aggressively expanded in all directions down the whole depth of the observed profile. Cassava roots also explored the whole profile, including the area immediately below the grass row. However, final total cassava root lengths were only about half of those observed in the two other combinations.

In plant systems with strong and weak competitors, root systems of the weaker components are often reduced and their development is particularly inhibited in zones close to the stronger competitors (Baldwin and Tinker, 1972). This may be related to the depletion of water and nutrients around the roots of the more competitive species, which are then avoided by the root system of the weaker competitor. If no alternative soil volume can be explored, then normal root growth may be inhibited (Duncan and Ohlrogge, 1958; Klute and Peters, 1969; Rogers and Head, 1969; Trenbath, 1976). In our study, cassava roots did not avoid the soil volume explored by guatemala grass, but root growth was clearly reduced. This suggests that cassava is the weaker competitor in the cassava-guatemala grass system.

4.3. *Root growth dynamics*
When comparing the dynamics of root growth of grass with that of cassava, periods of greatest activity were different. In the cassava-guatemala grass system, grass root growth was very active until 24 WAGP, contrasting with hardly any activity in cassava. This was followed by a period of less root growth in guatemala grass and more in cassava. Contrary to this pattern, vetiver grass showed a slow, steady root growth throughout the 14-34 WAGP period. This apparently allowed cassava roots to develop ac-

tively, starting as early as 25 WAGP, whereas in the other two systems, cassava roots showed an accelerated growth only after 28 WAGP.

5. Conclusions

Based on these observations, we suggest that vetiver grass has the least competitive root system, with the shortest root length in the upper 40 cm of the profile and a root distribution that concentrates closely to each side of the grass barrier. These factors, together with a slow but continuous root growth over time, may have allowed cassava roots the most undisturbed exploration of the remaining soil volume, so producing the greatest total root length of all three systems. Both lemon grass and guatemala grass produced longer roots in the top 40 cm of the profile and showed a more active early root development up to 24 WAGP. However, only with guatemala grass did this lead to restricted cassava root growth, particularly noticeable in the top 20 cm. This spatial and temporal root growth pattern may indicate possible competitive effects as cassava is most likely to absorb most of its water and nutrients from this part of the profile. Despite the dense rooting of lemon grass in the first 20 cm, cassava root growth was scarcely reduced in this system, compared with the cassava-vetiver grass combination. This may have resulted from a synergistic effect that allowed cassava roots to explore, to some extent, those parts of the soil profile immediately beneath the grass barrier. Hence, both vetiver grass and lemon grass do not compete strongly with cassava, although for different reasons: the former for a non-interfering spatial distribution of roots and the latter for a possible synergistic effect. The guatemala grass thus remains the most aggressive of the components tested, possibly reducing the soil volume available for exploration and therefore of nutrients and water availability to cassava. **References** (*not included)*

Experimental Results Of Using Vetiver Grass Hedgerows On China's Red Acidic Soils.

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On the basis of the experiments on vetiver in Jiangxi Province, aimed at problems such as soil and water loss and ecological environment degradation etc., it was considered that vetiver cultivation was a practical and effective way for the sustainable development of agriculture in the red soil hilly because it possesses the priority of strong adaptability, rapid growth and quick formation of hedges, and large biomass etc., and also has marked effects on soil and water conservation, moisture and heat stability, and ecological environment improvement

Key words: vetiver, hedges, red-earth hills, ecological environment, sustainable development of agriculture

Introduction

The red soil hilly area in South China is rich in natural resources and has a large potential for agricultural production. Hence, it plays an important role in the development of agriculture and economy in China. However, owing to high temperature, excessive rainfall, strong weathering of soil, population expansion as well as poor land use, its ecosystems become worse and its environment is being degraded. Soil erosion, in particular, is the most serious problem here. The eroded red soils increased from 71,000 km2 in the 1950's to 200,000 km2 in the 1980's. According to statistics, the amount of annually eroded surface earth in 9 provinces of the middle subtropical zone in China was estimated to be 0.7 billion tons. 160,000 tons of soil organic matter and 100,000 tons of N, P and K etc. soil nutrient were washed away every year. As a result, the problems such as nutrient deficiency, soil acidification, puddling, compact, arid, environment deterioration and soil degradation in this area are becoming more and more serious. For the sustainable development of agriculture it needs prompt settlement. Studies of years by the Experimental Area and Jiangxi Institute of Soil Science showed that biological measure with a combination of tree, shrub and grass cultivation is the most effective.. Among them, vetiver was paid attention to because of its easy cultivation, low cost, rapid growth and effects on erosion control. This paper attempts to discuss the role of vetiver in the sustainable development of agriculture on the basis of the systematical studies on its biological characteristics, strong adaptability, cultivation technology and ecological effects.

1. With strong adaptability, vetiver is suitable for widely planting in red soil hilly area

1.1 With strong resistance to acid, nutrient deficiency, puddling and compactness

Red soils in the hilly area, especially in severely eroded region, are acidic, poor, puddly and compact which restricts crop growth and high yields. Vetiver belonging to C4 plants is more acid, puddle and compact resistance, than all local dominant grass. With strong photosynthesis and developed root systems it performs better with infertile soils. For example, in an eroded gully with a depth of 1-2 m the soil net-like horizons are exposed. In the layer of 0-20 cm, the soil pH is 4.54; contents of total carbon, total N, P2O5 and K2O, available P and K are 1.51 g kg-1, 0.454 g kg-1, 0.186 g kg-1, 14.27 g kg-1, 1.15 mg kg-1 and 49.00 mg kg-1 respectively. On such an eroded red soil vetiver grew better than Cogon grass, Satintail, Africa Bristle grass etc. During three years of growing, vetiver had an average of 49.9 cm in height and 2.66 tillers /hill greater than Cogon grass. (96.9% and 41.9% respectively).

Table 1 Effect of vetiver hedges on soil and water conservation Measures. Runoff Amount of soil erosion
(*not inluded*)

Note: The grasses were contour-cultivated with a depth of 30 cm and clump spacing of 20 cm. 375 kg/hm2 Calcium Magnesium P was applied after cultivation.

Vetiver planted on a level terrace of red soil cultivation for 20 years (A), a cultivated slope in the initial mellowing stage (B), initially cultivated slope (C) and land with medium and high fertility grew better than that in thin red soils with little organic matter (D) and strongly eroded net-like red soils (E). The growth rate of vetiver planted in the land of medium and high fertility was double or dozens times better than on land of low fertility. It could form hedges after 1-2 years of growing. Hence, vetiver can be planted in different type and different fertility red soils.

1.2 Tolerates drought, water logging and flooding. Although the rainfall in red soil hilly area is high, its distribution is uneven. Water logging and flooding in the rainy seasons and drought in the hot summer and autumn occur frequently, which severely affects the growth of crops. With high concentration of protoplasm and more salt in the cell and developed roots more than 2 m deep in soil, vetiver has a strong ability to take-up moisture. Meanwhile, because of dense and overgrown stems and leaves, smooth surface of leaves to use moisture efficiently, it possesses the strong ability against drought. For example, during the three weeks, from middle to the late July in 1990, the rainfall was only 2.3 mm, and there were 7 days with average daily temperature of 32.2°C and the highest of 38°C. Even in such hot and dry conditions, vetiver grew better than the other grasses. In the red soils with moisture deficiency and low fertility at the hill tops, the height and tillers of vetiver still increased. Even in the strongly eroded land, its height still increased by 7.5 cm, but Cogon grass decreased by 10.1 cm to the contrary, and with many withered leaves. Another report showed that after continuous 8 months of drought, vetiver still grew well. Thus, it can be seen that vetiver possesses strong drought-resistance ability. On the other hand, vetiver also tolerates both water logging and flooding. In the rainy season, it grew well and was less affected by water logging. It can tolerate flood for one and a half months as long as the water does not over its top.

1.3 *Being hot and cold resistant, it can survive both cold winters and hot summers*

A severe freezing, which was the worst in the past century, hit the province in 1991. Citrus failed to survive the disaster, however, vetiver again sprouted and grew in the next year. In the July of the year, its height doubled that of Cogon grass, which was least affected by the freezing among the local grasses, and its tiller number each clump were 0.3 more. In normal years, vetiver can survive winter even more safely. In hot summer, vetiver can tolerate the scorching sun and heat. Under the atmospheric temperature of 38°C and land surface temperature of 60°C, vetiver height still increased by about 0.5 cm/day. It showed even stronger ability of high temperature tolerance and produced larger biomass with being cut in time. Therefore, vetiver can be cultivated in red soil hills with different altitudes, meanwhile, it does not set strict demand on light, it can grow well in orchards, forest and slopes, etc., showing the advantages of under or interplanting.

2. The ecological benefits from vetiver's cultivation in the red soil hilly area

2.1 Intercepting runoff and conserving water and soil

With the strong adaptability, developed root systems, multiple tillers and growth in clumps, vetiver can quickly form dense hedges when planted as a strip. If planting vetiver in red soil slope with a clump spacing of 20 cm and 2-3 tillers each clump, in the late autumn, the clump area would reach to 324.7 cm2, and formed hedges in the same year. In strongly eroded area, the clump area of two-year-old vetiver was 79.8 cm2 and 28.3 cm2 greater than that of Cogon grass and Africa Bristle grass respectively; the root range was 5 times and 3.2 times larger; and the depth of roots was 3 times more. The hedges formed by vetiver's large and deep roots and dense stems and leaves are like a biological dam to block the runoff on slopes. According to the data determined by the Jiangxi General Com-

pany of Red Soil Exploitation at a Standard Runoff Observing Site established in 1992 in a newly cultivated red soil with a slope of 5%, on Quaternary red clay in Chongren County (Table 2), in 1993-1994 with the average rainfall of 1966.0 mm, compared with the control, vetiver hedges decreased runoff by 32.7% (7280 cm3/km2) and soil erosion by 63.8% (2141 t/km2); and compared with the level terraced field by 11.6% (1960 cm3/km2) and 27% (454.2 t/km2). Another experiment showed that the soil moisture content in the orchard of red soil slope with vetiver hedges was 2-3% higher than that without vetiver cultivation. It indicated the remarkable effects of vetiver on blocking runoff and conserving soil and water. .

Table 2 Effect of vetiver hedges on soil and water conservation Measures Runoff Amount of soil erosion. (*not inluded*)

* The data in the table are average values of 1993-1994, and the annual rainfall 1766.0 mm was an average of the two years.

2.2 Stabilizing moisture and heat regimes and improving ecological environment

In hot dry summers, vetiver could decrease both atmosphere and soil temperature, restrain moisture from evaporating, and improve atmosphere humidity in fields; in winter, on the contrary, vetiver hedges provides a natural defense to prevent the convection and diffusion of cold air increasing the temperature of citrus garden 1-3°. Lowering temperature in summer, keeping warm in winter, storing water and preventing drought could be achieved by mulching the fruit root or crop interrows with vetiver grass. According to Hu Jianye et al, after continuous 5 or 16 sunny days, soil moisture loss by evaporating in the layer of 0 - 60 cm of the red soil orchards covered (mulched) with dry vetiver (12 kg dry vetiver/tree) was one times less than that without dry vetiver; and 33 - 44% less than that covered with equal amount of straw (Table 3). In hot summer, the moisture capacity in the soil covered with dry vetiver was 17.4 mm, more 17.9% than that without vetiver covering and more 4.5% than that covered with equal quantities of straw; while in the late autumn, the former was 103% and more 27.8% than the latter. Covering vetiver on the surface soil of orchards decreased both the mean and the highest temperature in summer by 5.10C and 19.10C, and decreased the daily temperature range by 20.80C. Therefore, vetiver planting could improve the ecological environment in the red soil area, and benefit the sustainable development of agriculture there.

Table 3 Comparison of moisture loss in the layer of 0 - 60 cm soil under different covering (mulching) materials. (*not inluded*)

2.3 Large biomass and its role on soil improvement.

Vetiver grows fast. It can grow 0.5 - 1.0 cm high each day during the peak growing season of June to September, and can grow 4 - 5 cm per day after being cut. The annual height of vetiver in highly fertile soils can surpass 2 m, and each clump can tiller 40 - 60. Vetiver hedges in the second year after planting should be cut when they reached about 1 m high, and they could be cut 3 - 4 times annually. According to the determination, the land of every 100 hundred square metres could produce 800 - 1500 kg fresh vetiver material annually. Its biomass is considerable. According to the chemical analyses, the contents of total C, N, P2O5, K2O in stems and leaves of vetiver were 4.22 g kg-1, 0.170 g kg-1, 0.005 g kg-1 and 0.075 g kg-1 respectively, and that in roots were 4.019 g kg-1, 0.021g kg-1, 0.006 g kg-1 and 0.058 g kg-1 respectively. During 1990-1992, the author carried out an experiment of burying vetiver in the farmland in order to reclaim and fertilize the soil. The result (Table 4) showed that application of 4.5 and 2.25 tons of dry vetiver stems and leaves.

Table 4. Effects of vetiver application on the physio-chemical properties of an early mellowing red soil Treatments. (*not inluded*)

The data in the columns of volume weight and total pore space are the difference pre- and post-experiment contents of soil organic matter, total pore space, total N and P, and available N and P in the second year increased, and soil volume weight decreased. Compared with the control the yield of the experimental crop — corn, increased by 34.8%. According to Chen Kai, (1993), in an orchard of red soil as vetiver has grown for two years the soil pore space increased by 3.8% , pH by 0.65, and organic matter, total N, water soluble N, available P and available K by 0.46 g kg-1, 0.30 g kg-1, 17 mg kg-1, 2.4 mg kg-1 and 51 mg kg-1 respectively. This indicated that as vetiver grow naturally without moving by cutting, its stems, leaves and roots would return to soil and improve soil fertility.

2.4 Does less harm to farmland and cannot cause a weed threat.

Vetiver has neither root-shaped stems nor stolons. It only depends on tillering to propagate. Moreover, though it can form ears and bloom, vetiver fails to bear seeds, hence it will do less harm to farmland, which is one of the remarkable advantages for to planting widely. Meanwhile, its roots always extend down instead of horizontally though it has developed root systems. Hence, it is easy to control the width of vetiver hedges to less than 0.5 m by ditching and cutting. Therefore, vetiver would occupy less land and do less harm to farmland, and its cultivation is practical. In addition, its tender leaves and stems can be used to feed cattle and the old leaves are the ideal materials for fuel and making paper because of its high content of fiber, which will play an important role in the development of

husbandry and ease the tension of resource shortage.

3 Conclusion

Vetiver makes no strict demands on light, heat, moisture and soil. With wide adaptability and strong ability against adversity, it can be cultivated in severely eroded red soils. Vetiver also possesses the advantages of rapid growth, large biomass, multiple tillers, easy formation of dense hedges and no weed threats etc., and it can be utilized persistently after being planted. In red soil hilly area, vetiver has the remarkable effects on conserving soil and water, stabilizing the regimes of moisture and heat, improving the ecological environment, keeping moisture against drought by covering and making soil fertile etc. Owing to the less cost and rapid effects, vetiver cultivation would be an effective way to prevent environmental degradation and soil and water erosion in red soil hilly area. Therefore, vetiver can be cultivated in different kinds of land in line with local conditions, forming the models of forest-grass, fruit tree-grass, crops-grass, fruit-crops-grass etc. In order to take full advantages of natural resources in red soil hilly area, improve material cycles and water and heat conditions and ecological environment, it is important to achieve the sustainable development of agriculture with high-yield, superiority and high efficiency.

Effect Of Grass Bunds On Erosion Loss And Yield of Rainfed Rice - Orissa, India

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Introduction

The rainfed farming characterized by high rainfall, requires measures to tackle the problems of water erosion and management of rain water for maximization of production. Mechanical measures like bunding and terracing are usual practices in arresting water erosion. But high cost involved in construction and maintenance of these structures limit their use for widespread adoption in critical areas. An attempt was made to evolve a low cost easily replicable technology as an alternative to mechanical bunding. In this process, different vegetative barriers were studied in crop field to establish their effectiveness in checking erosion, increasing moisture of soil profile and enhancing production on sustainable basis in slopy and red lateritic soils of Orissa.

Materials and Methods

The experiment was conducted at research farm of All India Coordinated Research Project for Dryland Agriculture, Phulbani, Orissa, during three kharif seasons of 1994,1995 and 1996. The experiment was laid out in randomised block design with three replications. Size of each plot was 25m x 3m, having 2% land slope.

Different grasses such as Cynodon dactylon (Bermuda), Vetiveria zizanoides (Khus), Eulaliopsis binata (Sabai), Stylosanthes hamata (Stylo) and Hybrid napier were used as vegetative barriers in crop field at horizontal interval of 8m. The grass bunds were of 30cm width and comprising of three rows. Other treatments include broadcasting and planting on contour without vegetative bunds. During cropping season, daily runoff was monitored with the help of multi-slot devices, water samples from runoff collection tank were collected periodically to analyse sediment content and hence the soil loss (Anonymous, 1997). Test crop adopted was extra early variety of rice (Heera). Seeds were sown on contour except in treatment of broadcasting. The recommended package of practices were followed during crop period. Runoff, soil loss and crop yield were recorded.

Results and Discussions

Effect on runoff

From the results (Table 1 *not included*) it was observed that the broadcasting method recorded higher runoff (22% of rainfall) as compared to contour planting with or without vegetative barriers. Least runoff (14.3% of rainfall), was recorded in case of contour planting with vetiver hedgerows which is significantly higher than control. Vetiver and napier hedgerows registered a reduction of runoff by 35% and 31% respectively, over control practice of broadcasting. Whereas both Sabai and Bermuda vegetative barriers responsible for runoff reduction by 27%. It can also be noted that only contour cultivation was capable of reducing runoff by 12% over control. Another observation was that vegetative barriers on an average recorded a reduction of runoff by 19% over no vegetative barriers. Figures 1,3 &5 showed the runoff pattern in crop fields with or without vegetative bunds during rainy seasons of 1994, 1995 and 1996 respectively.

Similar results were also obtained by Subudhi and Senapati (1996) from the study conducted at Beheraguda farm of Kalahandi district of Orissa during 1993. They reported that surface runoff was reduced by 22%, 19% and 18% in rice fields when planted with vegetative bunds of vetiver, napier and sabai grass respectively.

Effect on soil loss

Basing on the experiments conducted over three years (1994-96) it was observed that broadcasted field recorded highest soil loss (l0 t/ha) followed by contour cultivation with no vegetative barrier (8.4t/ha). Grass filters of different kind showed a lower soil loss. The contour cultivation practice reduced soil loss by 17% over control practice. It was observed that contour planting with vetiver bunds performed well as it reduced soil loss significantly by 60% over control. Likewise, soil loss reduction by 57%, 50%, 48% and 43% were recorded in case of vegetative bunds of napier, bermuda, sabai and stylo respectively, when compared with farmer's practice. Figure 2, 4 and 6 showed the pattern of soil loss variation in crop field during kharif season of 1994, 1995 and 1996 respectively.

Similar results were also obtained by Subudhi and Senapati (1996) from the study conducted at Beheraguda farm of Kalahandi. They indicated that soil loss was reduced by 36%, 32% and 23% due to vegetative bunds of vetiver, sabai and napier respectively over no vegetative bund. Another study at Bangalore (1994) showed that soil loss was reduced by 43% and 31.5% due to vegetative barriers of vetiver and napier, respectively.

Effect on yield

It was pertinent to note that treatment with vetiver bunds registered highest yield i.e. 2077 kg/ha, followed by 1877 kg/ha using hybrid napier. Farmers practice of broadcasting recorded lowest yield over the years, averaging only 1073 kg/ha. Significant increase of production by 93% was recorded due to vetiver bunds when compared with control practices. Likewise, there was increase of production by 74%, 75%, 66% and 56%, when fields were treated with vegetative filters of napier, sabai, stylo and bermuda respectively over control. Also only contour planting practice was indicated an increase of 29% yield over broadcasting. A study of Sagare and Meshram (1993) indicated an increase of cotton seed yield by 25.5% due to vegetative bunds of vetiver over contour cultivation, which is similar to present findings.

References *(Not included)*

Prospect And Problems In Use Of Vetiver For Watershed Management In Sub Mountain And Scarcity Zones. (Maharashtra, India)

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Introduction

Land and water are the most important natural resources for the survival of life and mankind. Land is one of the most precious resources, where population pressure per unit of land is very high and is highly sensitive to human disturbances. Hence it is essential to adopt suitable conservation measures in order to get higher and higher agricultural production without deterioration of land. Conservation of soil and water for sustained production and restoration of environment is essential with the objective to achieve them with better benefit cost ratio. Among various methods of soil and water conservation vegetative methods are found very effective and cheaper. These methods are drawing greater attention during recent years. Grasses which form effective hedges check the speed of runoff water resulting in the settlement of soil particles at the live bunds. The live bunds particularly of grasses act as filters through which water with very less soil particles flow at reduced speed.

Research and studies in various countries and in the state of Maharashtra (India) clearly showed that *Vetiveria zizanioides* and a few local grasses are very effective in the formation of live bunds for soil and water conservation, deposition of silt and clay and development of soil under favourable rainfall conditions and effective management with good socio-economic response, vegetative hedges can be established within a crop season. Andhra Pradesh Agricultural University in India (1989) found that when Vetiver hedge established across the slope with castor—bean can reduce runoff water and improved crop yield. In China, Xinhao (1992,) reported that vetiver grass in potatoes areas can reduce runoff water and soil loss about 56% and 95% compared to farmers practice plot. Bharad (1990) observed that 55.4% , 28.5%, 14.49 % increased productivity of crops in very shallow soils (on farm), shallow soils (on station), medium deep soil (on station) respectively when cultivation and sowing was along contour vegetative hedge line. Surface runoff was also reduced by 46% in shallow soils and 16.7 % in medium deep soils.

Government of India has started National Watershed Development Project for Rainfed Areas (NWDPRA,1991) in which main

emphasis is given to vegetative or biological methods for conserving soil and water as low cost techniques instead of using high cost techniques as mechanical / engineering measures which disturb the soil structure. The states and the central government are laying stress on vegetative methods, especially on the cultivation of Vetiver in soil and water conservation programs. Hence, it is essential to evaluate the efficiency of Vetiver planted during the last few years. Keeping this in view and the hydrology in a changing environment, the present investigation was undertaken.

Material and Methods

This study is not based on research data. It is based rather on a huge practical and field experience, gained during the frequent field visits for technical inspection, guidance and assessment of the quality of works completed by the field staff working at watershed level. The study confirmed to NWDPRA and use of vetiver for soil and water conservation in Nashik district. Since 1991 — 92 twelve watersheds with a geographical area of 52,952 hectares is treated with 4855 tones of Vetiver slips for drainage line and land treatments. Up to the end of 1995-96 monsoon season, Contour Vegetative Hedges (CVH) are completed on 1 0466 hectares area; similarly 9320 numbers of Live Check Dam (LCD) and 2434 1 numbers of Loose Boulder Structures (LBS) are completed. Out of these on going watersheds, seven are selected for the study. These are Wadivarhe, Talegaon(T), Thanapada and Rashegaon from sub-mountain zone and Patpimpri , Karajgavan and Shingave from scarcity zone. The sub—mountain zone has an annual rainfall between 850 and 4 000 mm, the soil is reddish brown to black tending towards lateritic nature with varying depths and textures. The cropping pattern is mainly dominated by Kharif cereals mainly paddy (Oryza sativa) followed by Ragi Elusine coracana . The scarcity zone receives less than 750 mm of annual rainfall.

With uncertainty and irregular distribution the agriculture in this region is very unstable coupled with low productivity. Cropping is dominated by *Pennisetum typhoides* followed by *Sorghum vulgare*. By using randomised sampling techniques some treatments and areas are selected for observations, each from submountain and scarcity zone. Two identical small watersheds having about 15 - 41 ha. geographical area, from Thanapada, Rashegaon, Patpimpri are selected and named as T1 (non treated) and T2 (treated) for crop productivity, surface runoff and soil loss measurement.

Results And Discussion

A) Survival of vetiver

Planting material plays an important role in the survival of Vetiver. It is recommended that the proper stage of Vetiver slips for transplanting is at the age of 16 - 23 weeks and transplanting should be completed within 24 hours after uprooting the slips from the nursery. It is observed from field experience that the Vetiver used for planting during the year 1991-92 was transported from a long distance and it was about one and half years old, which resulted in low survival percentage. The Vetiver used during 1991-92 is therefore omitted from the study. During the years 1992-93 to 95-96, the Vetiver slips used for transplanting were of proper stage and transplanting was completed within a couple of days. The survival was recorded during the month of January of the same year. Under almost all treatments the survival percentage was 75 (Table- 1). This clearly showed that tine age of the planting material and the time gap between uprooting and transplanting play a very important role in the survival of Vetiver

Table - 1 - Average survival percentage of Vetiver under different treatments *(not included)*

It is evident from the data regarding precipitation during the seasons that rainy days (Table 2) did not show any relationship with the survival of Vetiver. During the different years under study there were variations in the total rainfall and rainy days, however there were not many differences in the survival of Vetiver. Similarly the survival percentage in different watersheds in the submountain zone were of the same order though there was maximum rainfall in Wadivarhe watershed and minimum in Rashegaon watershed. The number of rainy days also could not show any significant effect on survival. When the survival and maintenance of Vetiver were recorded in successive years it was observed that the survival percentage declined progressively though it was more pronounced during the period between January and May. It may be mainly because of higher atmospheric temperature and low residual soil moistures. The soil depths and soil types did play important role in the survival and maintenance of Vetiver during the succeeding years after plantation. The locations where soil depths were more and soils were medium with higher water holding capacity showed more survival compared to shallow and light soils. The soils in watersheds at Rashegaon and Thanapada are of better types with better water holding capacity compared to those of Wadivarhe and Talegaon (T) watersheds as a result of which rainfed crops are grown on large areas in Thanapada andRashegaon Watersheds. The survival percentage of Vetiver are more than those of the remaining two watersheds, which shows the important role of soil types on survival.

Table - 2 : Average rainfall and rainy days. *(not included)*

The rainfall in the scarcity zone is

scanty and uncertain. The survival of Vetiver planted in three watersheds was found low i.e. about 50 percent compared to that in watersheds of sub-mountain zone. The survival after 2-3 years after planting was more than 50% in sub-mountain zone and only 25% in the scarcity zone.

When the treatment effects were compared it was observed that among the three treatments that of LCD supported by 0.18 sq.m. stone bund was better than the remaining treatments i.e. LBS amid CVH during all the observations in all the four watersheds in sub—mountain zone. The survival percentage under all treatments was the maximum in the month of January about six months after plantation. The survival was successively and progressively reduced further. However, the mortality of Vetiver was at a faster rate during summer i.e. between the period of January and May. After a period of about two years the survival percentage became steady. And in addition to these factor one more factor which plays a significant role in increasing the mortality of the established Vetiver is the free grazing of stray cattle which disturb and destroy the established Vetiver. All the watersheds under study are located in rainfed areas where there is Kharif oriented cropping system. In time watersheds of Rashegaon and Thanapada the soils are medium and medium deep with a better water retention potential and double cropping. Kharif and Rabi crops are sown in quite a substantial area in these two watersheds. In all these watersheds cattle are let free once the crop are harvested These animals are let free for grazing in all watersheds except those of Rashegaon and Thanapada from November - December onwards. These animals wander freely and destroy the established Vetiver mainly by trampling and partly by uprooting while grazing. As a result the survival ofVetiver in such areas is lower compared to that in watersheds of Rashegaon and Thanapada where Rabi crops are also grown on a large area where animals are let free for grazing only after harvesting of Rabi crops, i.e. after February. Thus uncontrolled grazing of cattle is a major constraint for maintenance of the established Vetiver and free grazing needs to be checked for the better survival and maintenance of established Vetiver in the succeeding years. It is clearly evident from the data (Table—1) that the survival of Vetiver six months after plantation is about 75 % which decreases progressively with the passage of time.

Table - 3 : Average survival percentage of vetiver at the end of Jan.-96 under different treatments *(not included)*

B) Effect of treatments on survival of vetiver :
It is observed that the overall survival percentage of Vetiver for the four years (1992-96) in sub-mountain zone was about 51.33%. From table 3 it is also observed that LCD supported by 0.18 sq.m. section small stone bund secured the highest survival percentage (64.56%). It is followed by LBS which is reinforced by Vetiver as 47.87%. Thirdly land treatment named CVH gave the lowest survival at 4 I .56%. In scarcity zone the survival percentage of all treatments are about 25 % due to low rainfall situations

C) Crop Productivity :
It is observed that (Table -4) the effect of Vetiver as conservation measures in the treatment of CVH the crop yield of *Elusine coracana* increased by 35.3% in submountain zone. In scarcity zone the crop yield of *Pennisetum typhoides* was increased by 32.52 % and *Sorghum vulgare* by 28.69
%.

Table - 4: Effect of vetiver as conservation measures on crop. productivity (CVH) *(not included)*

D) Surface Runoff :
It is found that the surface runoff of shallow soils in submountain zone was reduced by 47% and in scarcity zone it was reduced only by 8% because of low intensity of rainfall. In medium deep soils runoff was reduced by 23% (Table-5)

E) Soil Loss :
The soil loss a long with runoff water as sediment was estimated . In submountain zone it was found that the soil loss in shallow soil was 24.30 tones/ha, while in deep medium soil it was 32.50 tones/ha. In scarcity zone soil loss was only 10.55 tones/ha as there was very low rainfall with less intensity and resulted in low surface runoff. Soil loss reduction in sub-mountain zone and scarcity zone was 42.68 % (mean) and 12.79 % respectively by treating watersheds with Vetiver. (Table - 5)

Table - 5: Effect of vetiver as conservation measures on surface runoff and soil loss. Year - 1994-95 (not included)

Conclusion

This practical field experience clearly shows that though vegetative barrier as a low cost technique plays an important role in —situ moisture conservation by conserving rain water as well as by arresting soil particle, there are some limitations.

Vetiver grass has root system that penetrates deep into the soil (up to 3m.). the roots effectively act like a net, holding the soil in place and thus preventing eroding. Moreover the stalks of vetiver grass helps to control waterflow, regardless of the slope of the terrain, by restraining the silt that rainwater normally carries away.

The cultivation of crops along with CVH gives 35.30 % and 32.52 %

Importation Of Vetiver Plants. Phytosanitary Requirements, Customs Clearances, etc.

increased productivity. respectively in submountain and scarcity zones. The surface runoff reduction due to use of vetiver in CVH is 35% (shallow soil 47%; medium deep soil 23%) and 8% in submountain and scarcity respectively. The soil loss that is arrested is a very remarkable amount when using Vetiver Hedge line. It is 31.35% in submountain and 12.79 % in scarcity zone.

On behalf of a group in mainland Portugal, Spain and the Açores I arranged for the importation of a consignment of vetiver from Jano Labat of Vetiver Grass Stabilization (pvt) Ltd, Chiredzi, Zimbabwe. The quality of the plants was excellent and they arrived (mid-March) moist and well packaged. The consignment arrived on time but, over a week-end so the plants were held in cold storage pending collection on the Monday. Since there were 12 members in the group (official bodies, NGO and private) my wife and I were allowed to repackage for each individual's collection at the airport. One component had to be reconsigned to the Açores. Whilst all turned out well on the day there were a number of issues that arose which could have resulted in serious problems. For information, these are passed on below:

1. Accompanying the consignment must be <u>the originals</u> of: the bill of lading noting flight details etc.; a dated invoice showing cost of plants and cost of shipment as separate items; and the phytosanitary certificate. Emphasis is placed on the documents being originals and properly dated, signed etc.
2. Separate to the above, copies of each of the above documents should be sent to the purchaser by fax for onward transmission to the receiving cargo handling agent or alternatively direct to the latter. This allows the agent to put meeting arrangements in hand, arrange for cold storage if necessary and to arrange with agricultural staff for phytosanitary inspection.
3. The agricultural staff may likely wish to take some specimens of the planting materials for whatever testing they wish to undertake.

The above may sound simple and obvious but failure to fulfil these requirements exactly could result in the authorities refusing clearance with the likely consequence being deterioration or loss of the plants.

Note that phytosanitary requirements may vary country to country.

Other data relative to our importation may be of use to others:

- We imported 0.75 cu. meter planting material. This yielded approximately 2,500 slips each of 3-4 tillers. Thus 1 cu. meter could be expected to yield 3,500 slips each of 3-4 tillers. We were very satisfied with the quantity of slips we received per cu. meter.
- The total cost per slip was US$0.55 of which the plants cost US$0.10 (19.2%), the air freight US$0.27 (48.6%), clearance charges US$0.11 (20.2%), and administrative costs (tel/fax, collection etc) US$0.07 (12.0%).
- Total costs were somewhat inflated in our case by the fact that approximately 40% of the consignment had to be transhipped to the Açores involving additional agency charges.
- Note that cost per slip will reduce with larger consignments where overheads (clearance and administrative overheads) will be lower. Conversely, the cost of importing a small consignment results in very high clearance costs per slip. For example, EcoGroup of Florida generously gave us 20 plants for demonstrational purposes. These had been produced by tissue culture and were also of excellent quality. We split each slip into two on arrival but the cost of the resulting 40 plants to us, purely clearance and collection, was approximately US$3.65 per slip.

This is perhaps an opportune moment to emphasise that we should maintain a 'squeaky clean' image regarding vetiver plant importations however small the quantity. I know that some enthusiasts wish to bring in small quantities of plants in their travel baggage. I suggest that, at the very least, a phytosanitary certificate be obtained even if it is only held for production if requested by customs authorities on arrival.

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Vetiver and Rubbish Dump Clean Up

Photo 1: China: This rubbish dump In Guangdong Province had a very terrible habitat and strong smell. Except for rats nothing else could survive on the dump (March 1997). Photo Credit -- Xia Hanping

Photo 2: China:Vetiver was planted as an eco-engineering solution, and by July 1997the Vetiver was well established, by October 1997 the dump was fully covered with vetiver and there was no smell. Photo Credit -- Xia Hanping.

Photo 3 on page 40

Table of Contents

Chemonics International Wins USAID Environmental Contract In Madagascar. 1
From the Editor 1
Achnatherum splendens -- A Potential Conservation Hedge Grass For Extreme Cold Winter Climates 2
The Vetiver Network Annual Report 1997.....4
Letters From Some Key People Promoting Vetiver In The Field 9
A Man At Work - Alemu Mekonnen Initiates A New Vetiver Program In Northern Ethiopia -- Current Activities And Hopes For The Future 14
Vetiver Grass Throughout Zimbabwe -- Protection of Rural Roads. 18
Mine Tailing And Railroad Stabilization In Queensland, Australia. Some Photos By Paul Truong 21
Vetiver At East China Highway Conference
South China Water And Soil Conservation Meeting Held In Xiamen 24
Grass Barriers In Cassava Hillside Cultivation: Rooting Patterns And Root Growth Dynamics 24
Experimental Results Of Using Vetiver Grass Hedgerows On China's Red Acidic Soils. 28
Effect Of Grass Bunds On Erosion Loss And Yield of Rainfed Rice -- Orissa, India.. 32
Prospect And Problems In Use Of Vetiver For Watershed Management In Sub Mountain And Scarcity Zones. (Maharashtra, India) 33
Importation Of Vetiver Plants. Phytosanitary Requirements, Customs Clearances, etc.....36
Directors And Officers Of The Vetiver Network..... 36
Coordinates Of Regional And National Vetiver Networks 37

Photo 3: China: Why is vetiver such a miraculous plant? Here you can see vetiver roots penetrating through hard paper, cloths, plastic. leather and even iron sheets, forming a huge root mass (December 1997). Photo credit -- Xia Hanping

THE VETIVER NETWORK

TVN NEWSLETTER

NUMBER 20 APRIL 1999

Vetiver and Disaster Mitigation

We have evidence from those countries that were effected by Hurricanes Georges and Mitch that where vetiver grass hedgerows were planted damage to road structures and landscapes were minimized. Prior to these two 1998 hurricanes, that impacted the Caribbean, The Vetiver Network learned of cases in Natal (South Africa), Philippines, and China that clearly demonstrated that vetiver provided excellent protection against cyclones and typhoons.

We have also learned from the Latin America Vetiver Network that vetiver will be used extensively in the rehabilitation of agricultural land and roads in Honduras. These natural disasters, although creating mayhem in the countries concerned, do offer opportunities to use the most appropriate technologies for the protection against future catastrophe. The Vetiver Grass Technology (VGT) is one such technology. We know that it will do the job of stabilization and rehabilitation. In addition it is a very low cost labor intensive technology. Its application in the disaster zones will not only provide a very good long lasting solution, but it could also provide employment for tens of thousands of people who have lost their jobs.

This newsletter provides more feedback from users, and it demonstrates the impact that regional and national vetiver networks are having on accelerated adoption rates. Technology innovation and promotion requires good organization and leadership. Readers will see the impact of people such as Ed Balbarino (VETINETPHIL), Liu Xu (CVN), Criss Juliard (Madagascar), Joan Miller (LAVN), Paul Truong, Diti Hengchaovanich, Ken Crismier, Ngwianmbi Simon and others whose work with vetiver are significantly impacting their areas of operation. I would like to make special mention of Ken Crismier who, accompanied by Paul Truong and Diti Hengchaovanich, visited Vietnam twice in the last six months and has now generated a lot of interest in vetiver in that country. Ken has carried most of the cost himself, including the publication of "Vetiver Grass – A Hedge Against Erosion" in Vietnamese. It is people like him who see the potential in the technology, and who does something about it, that make our vetiver initiative work. Another was Kevin O'Sullivan who sadly died last year – a tribute to him appears later in this newsletter – Kevin brought the technology to the poor of Oaxaca, Mexico, together with some excellent ideas on involving communities with the technology.

During the past few months a number of good vetiver related publications have been produced. Special mention is made of two technical papers by Diti Hengchaovanich (highway stabilization) and Paul

FIRST ANNOUNCEMENT

Vetiver and the Environment

The Second International Conference on Vetiver To Commemorate the Sixth Cycle Birthday Anniversary of His Majesty the King of Thailand

Phetchaburi, Thailand, 17- 21 January 2000

See Page 61 for details

Table of Contents See Back Page

Truong(pollution mitigation) that have been published by the Pacific Rim Vetiver Network (PRVN). The latter has also published the proceedings of the First International Vetiver Conference in Thailand. The Chinese Vetiver Network has published the proceedings of CVN's international vetiver conference held in Fujian Province in October 1997. LAVN, MVN, SAVN have produced newsletters (accessible on our home page at www.vetiver.org). VETINETPHIL is about to publish a new bulletin on vetiver in the Philippines. It is good to see that the networks and people in those networks are now taking initiatives that will make The Vetiver Network (TVN) redundant in the not too distant future – this is how it should be. Electronic Internet communications assures this devolution as it allows instant lateral communications between partners.

New networks are being developed in Vietnam (Crismier, Truong, Hengchaovanich), Seychelles (Barker) and Cameroon (Simon) with minimum support from TVN. We hope that other people will take initiative in other countries to establish networks. If readers want to get involved please contact TVN and we will help where we can. TVN unfortunately has been unable to raise funds to support existing and new networks, so you will have to raise funds locally – difficult but correct!!

In December 1998 The Vetiver Network awarded US$ 50,000 in prizes to winners in seven categories of awards (see below). There were some excellent entries. Awards were decided on quality, field performance, and the impact of the work on the vetiver initiative as a whole. Paul Truong (Australia) and Diti Hengchaovanich (Thailand) led the pack. Overall those countries in the Pacific Rim Vetiver Network made significant contributions to vetiver technology. ***Dick Grimshaw***

TVN Research and Development Awards -- 1998

The Vetiver Network announces the recipients of its 1998 Research and Development Awards totaling US$50,000.

CATEGORY 1. SOIL EROSION PROJECTS. First Prize: (second and third prizes not awarded) shared equally between: *Liyu Xu (China), Alemu Mekonnen (Ethiopia), Paul Truong (Australia), Edwin Balbarino (Philippines), Joan Miller (Costa Rica), Department of Land Development (Thailand)*

CATEGORY 2. IMPROVEMENT OF EXTREME SOILS. First Prize: (Second prize not awarded**)** shared equally between: *Zhang Jing (China), Paul Truong (Australia).* **Third Prize:** *Ngwianmbi Simon (Cameroon)*

CATEGORY 3. WATER MANAGEMENT. First Prize: (Second prize not awarded*): shared between Jano Labat (Zimbabwe), and P. A. Dalton, R. Smith and P. Truong (Australia).* **Third Prize:** shared equally between: *Project CAP (Madagascar), Stang Consult (Zimbabwe)*

CATEGORY 4. POLLUTION CONTROL. First prize: *Paul Truong and Dennis Baker (Australia).* **Second Prize:** (Third Prize not awarded)**:** *Xia Hanping and Ao Xuixui (China)*

CATEGORY 5. FARMERS SUPPORT PROJECT. First Prize: *Kevin O'Sullivan(Mexico)* **Second Prize:** *NOBS (El Salvador)***. Third Prize:** shared equally between: *Zhang Jing (China), B.B. Ghaley and Karma Tenzin (Bhutan)*

CATEGORY 6 DISASTER PREVENTION. First Prize: *Diti Hengchaovanich (Thailand)*. **Second Prize:** *Xia Hanping and Ao Xuixui (China).* **Third Prize:** *Ngwainmbi Simon (Cameroon)*

CATEGORY 7. BASIC SCIENCES. **First Prize***: Diti Hengchaovanich (Thailand) and N.S. Nilaweera (Malaysia).* **Second Prize** (Third Prize was not awarded): shared between *Paul Truong (Australia) Robert Adams and Mark Dafforn*

SPECIAL PRIZE FOR TECHNOLOGY INITIATIVE. *J.Phiri (Malawi) Development of an improved "A" Frame for leveling.*

Congratulations to all prize winners. All have had their work and ideas published in TVN newsletters and web site over the past three years. Thank you for sharing your research and innovative development approaches with us. May you all innovate further with this unique technology. In addition to the above awards some 50 "Certificates of Appreciation" were presented to persons that had contributed significantly to the promotion of the technology. These are the people who do a lot of the daily work that receives little recognition. Thanks to all of you we progress! ***Dick Grimshaw***

A Tribute to Kevin O'Sullivan

Dr Kevin O´Sullivan arrived in the southern Mexican state of Oaxaca in 1990 to work with communities and small farmers. He touched the hearts of many throughout Oaxaca and from his friends discovered that the loss of soil and its fertility was the most serious and basic problem in almost all regions of the State. In searching for solutions, he remembered vetiver grass. Through friends, he found a source of the grass in the neighboring state of Chiapas, brought the first slips to Oaxaca in his rucksack on the bus, and started giving it away and talking about it.

Kevin was a founder member of *Soil Water and Seeds of Oaxaca* (SASO), an NGO set up to seek alternative solutions to combat erosion of soils and the loss of native seeds and traditional knowledge, and through which the grass is being promoted. SASO, with the support of *the Oaxaca Commission for the Defense of the Ecology*, started the *Program for the Control and Restoration of the Soils of Oaxaca* in April 1995 with the participation of communities and local farmers groups, research and education centers, NGOs and state and federal government agencies. Now there are more than 50 nurseries and demonstration sites throughout Oaxaca and vetiver is spreading in 7 other Mexican states.

Winning the first prize of the TVN 1998 awards for farmer support is just recognition of the work of this remarkable man. Kevin died in January 1997 and his ashes rest in the first vetiver nursery which he set up. He is still working with us. ***Nick Dolphin***

Vetiver Network Appoints Representatives for Europe and The Far East and Pacific Areas

The Vetiver Network has appointed Cornelis des Bouvrie of The Netherlands to formally represent the Network in Europe. Paul Truong of Australia has been appointed representative for the Far East and South Pacific. These appointments have been made as part of a devolutionary process, as well as to save our precious funds. Cornelis' main role will be to help TVN to raise additional funds, and Paul's will be more technical and promotional in his region.

Vetiver Grass Hedgerows Likely To Be Key Solution For Stabilization Of Central American Watersheds

Tom Throw of Texas A&M University (email: **t-thurow@tamu.edu)** leads a Soil Management Collaborative Research Support Program in Honduras. The pre- Hurricane Mitch results are written up in Technical Bulletin No. 98-2 April 1998 (Technical Bulletin No. 98) available from: Department of Rangeland Ecology and Management, Texas A&M University, College Station, Texas 77843-2126 USA. **Full paper on web site at www.vetiver.org**.

This research shows the effectiveness of vetiver grass hedgerows (in conjunction with mulch) on slopes ranging from 55 - 63% slopes for reducing runoff and soil loss. The reductions are very significant. (Note the research was carried out on micro catchments of between 0.12 and 0.27 hectares — these are much larger and more "real" than the standard 22m x 2m plots that are generally used. The standard runoff plots are never able to replicate water movement and accelerating velocities of water similar to that occurring on farmers' fields. Thus in the table below the more realistic data from small fields show the significant impact of vetiver hedgerows as compared to other practices and in particular shows that mulching alone is not the total answer (Editor)

Tom recently emailed me the following comment and feedback from farmers following the Hurricane Mitch devastation.

QUOTE
I don't have any recent pictures of our catchments and the surrounding areas, but I have some good quotes from the local farmers. I think USAID Frontlines may do something with them, but feel free to use them as well if of interest to people in the Vetiver Grass network. **They tell the story best**. I'll send by regular mail some of our publications that give an overview of what we are doing in southern Honduras. Briefly, I think the combination of **mulch and vetiver grass is indeed a winner**. Most of the erosion that occurs on these steep hillsides is associated with landslides. Mulch helps break the raindrop impact, but what is really needed is some mechanism to tie the soil into the hillside. Much research in the tropics only uses small plots (USLE size — 22 m by 2 m) at largest. Such small plots show that leaving crop residue is a good solution — such plots, however, do not detect the much more important aspects of soil erosion that occur on a field

Estimates Of Soil Loss During The 1995 Wet Season As Affected By Catchment Size And Management Practice, Los Espabeles, Honduras.

Catchment Characteristics Area			Management Practice	SoilLoss (tons/ha)		
Area (ha)	Length (m)	Slope (%)		Actual	USLE	RUSLE
0.272 field	70	63	Mulch	19.7	671.6	74.4
0.004 plot	22	55	Mulch	0.5	293.9	34.3
0.122 field	60	57	Slash and Burn	92.0	1019.1	111.6
0.159 field	60	55	Vetiver Contour Strips & Mulch	0.7	447.1	52.1
0.004 plot	22	55	Continuous Bare Soil Fallow	760.6	1896.0	927.4

scale. It is an expensive and logistically imposing challenge to do field level work, but these field level data show best the realistic and important benefits of using a live barrier such as vetiver grass. Below are the quotes. (Throughout the text below, LUPE refers to the USAID Land Use Productivity Enhancement project that was implemented in conjunction with the Ministry of Natural Resources. The LUPE program ended in Dec. 1998.)

Cupertino Galindo, hillside farmer, Los Espabeles, Honduras
I am 84 years old and have seen many hurricane storms. I was happy to work with LUPE to install rock terraces on my farm10 years ago because I know the benefits of keeping soil and water on the field. During the hard drought of last year, my neighbors envied me because my terraces produced enough basic grains to feed my family; the deep soils behind the terraces held enough scarce water to fill the heads of the maize and sorghum with grain. The heads of my neighbors crops did not fill because their crops ran out of water before the grain could develop. Their soils had washed away in previous years and could not hold enough water for the dry times. Now during this horrible flood, my fields have remained intact while many of my neighbors without conservation have lost their whole crop. Neighbors took refuge in my house during the flood because they were afraid their (unprotected) fields would slide and crush their houses. My neighbor lost part of his house that way.

Questioner: If rock walls are so good, why doesn't everyone build them in their fields?

Cupertino: I am not sure you know how hard it is to build rock walls on these hillsides (60% slope)? It is damn hard to lift rocks and carry them on the hill and put them into place! LUPE organized a crew of farmers to work together therefore it was not so hard on any one person. They provided food to keep up our energy and allow us not to have to seek work off-site to earn money to buy things like sugar, cooking oil and beans. They also gave us sardines in cans. They did not have enough funds to help everyone get rock walls established. In fact, they ran out of money for the effort when the walls were only half way across my field. Everyone in these hills who had rock walls built has maintained them because we value them, but it is too insurmountable of task to start on your own.

Miguel Gomez, hillside farmer, Los Espabeles, Honduras.
I have worked closely with LUPE and have seen the benefits of vetiver grass or rock barriers positioned on contour in the fields. Vetiver grass is easier to establish but we needed help in getting good grass into these hills. LUPE helped us establish plantations from which farmers could take grass and plant on their own. There were concerns about competition with crops and concerns about not being able to use fire or graze livestock during the dry season. There were concerns about having to prune the vetiver grass at a busy time of the growing season. These concerns have proven not be so serious in our experience over the past several years since we established vetiver. The fact that these sites held the soil during this flood has convinced many that having vetiver in our fields is good.

Forests are good too. Down the road there are very steep hillsides that had landslides which closed the road every time we would have a big rain. About 15 years ago a GTZ project reforested these hillsides. You see now that the forest had no landslides, but cropland on gentler slopes has covered houses. But people have to eat. Maybe forests should be replanted on exceptional slopes and projects should help us establish conservation structures on our fields.

Martin Guido, hillside farmer, Los Espabeles, Honduras.

I like my rock terraces — once soil accumulated behind them I planted fruit trees and make more money than growing basic grains. I grow basic grains on adjacent fields and am gradually extending my rock walls there. The field on which I left crop residue and did not burn according to LUPE recommendations washed away anyway. I need terraces on all my land, but during the dry season when there are not crops to tend, I must send my sons to work (out of the region) in the melon fields and chicken factories and thus do not have the manpower to make much progress on my own.

Simeon Gomez, hillside farmer, Los Espabeles, Honduras
On my field with vetiver grass contours the hillside remained perfectly in place. The fields without grass contours have had their crops and soil washed away. I have been trying to use vetiver cuttings from this field to plant on my other fields that are several kilometers away, but it is hard to transport the amount that I need. Now I have lost my crops and some soil on those fields, but I need to plant vetiver to save what is left. Does the project have a truck I can borrow to transport cuttings?

Hector Santos, former LUPE technical specialist.
When people realized that the USAID-LUPE project was terminating, and that no follow up was considered in the near future, they were very discouraged. In the situation these farmers, LUPE technicians that visited them were a source of hope and courage to continue with the hard work of stabilizing their hillside fields. People know it is important to conserve soils, but their primary concern is what they're going to eat this afternoon, tomorrow at the most. They have to work off-farm instead of installing the rock walls or Vetiver because they need the cash. They don't have time to think what will happen in ten years. A hurricane like this puts them in a great hazard for surviving next year. They lost their crops and don't have the money to buy their maize. That is the reason why they continue working on the hillsides. They do not have any other option, they need to feed their families. The farmers feel that now that LUPE is gone, they are abandoned on their own, orphans of the people who were showing them a light at the end of the tunnel. Just the technicians visiting these farmers gave them a sense of importance and pride, and the hope that we all need to keep working everyday towards a better living.

Downstream, the shrimp farmers are now realizing how much sediment from hillside farming goes into the rivers. This sediment eventually gets to their ponds, reducing their efficiency and increasing their costs. They don't think it is fair, they want a remedy, they are exploring solutions through the government, but the country is poor, and there are many needs. END QUOTE

I*t is interesting to note that in Ethiopia farmers say the same thing: "vetiver hedgerows are very effective, terrace building is costly and backbreaking!!" — Dick Grimshaw*

Letters, Feedback, and Vetiver Chat

From Dale Rachmaler As a professional agronomist with 25 years of African experience with USAID, I would like to add support to the growing use of vetiver grass as a means to stop soil erosion, safeguard infrastructure against degradation, sequester heavy metals, promote revegetation of native species on denuded land, provide missing organic matter in tropical low fertility soils to mention a few uses.

It is not often that you can persuade rural folks to try something new and then see it work in a very short period of time. Planting a tree today is super but it takes years and years to become established and longer to provide beauty or wood. Vetiver on the other hand begins to impact the environment within the first year and from then on. Once established it cannot be burnt out, it does not spread, i.e. it stays where you put it, it cannot be flooded out (remains viable even after 12 months underwater), it provides forage, mulch and its leaves can be used to weave baskets, hats and other artisinal goods. It sequesters heavy metals and is ideal for reclaiming mine tailings, it can grow in the full range of soil ph 3 -11. Its essential oil is used in perfumes and has such a complex chemical nature that it has yet to be synthesized.

There have been few technologies that I have seen over the years that have so much to offer.

From Noel Vietmeyer — Vetiver Grass and Greenhouse Gasses
Vetiver grass, *Vetiveria zizanioides*, offers a way to benefit the earth's atmosphere as well as its surface environment. This tropical grass sequesters large quantities of carbon dioxide from the atmosphere — it may, in fact, be the ideal plant for the purpose. But hedges of vetiver also stop soil erosion, rejuvenate degraded lands, keep pollutants in their place, and much more. Nobody yet knows how much greenhouse gas vetiver can remove, but is likely to surpass anything generally imagined.

A rough estimate can be gained from measurements made on a closely related grass, *Andropogon guyanus*. In 1995, CIAT (a respected international agricultural research institute in Cali, Colombia) reported that this species and another deep-rooted African grass grow so widely and so prolifically in the savannas of South America that they "may remove as much as 2 billion tons of carbon dioxide from the atmosphere yearly." *Andropogon guyanus* roots penetrate 1 meter into tropical soils and CIAT scientists found that the plant sequesters

as much as 53 tons of carbon dioxide as organic matter per hectare per year.

Vetiver roots, by contrast, are more extensive and penetrate tropical soils to depths of 5 meters and beyond. Its rate of absorbing the gas is likely to be at least twice that of its botanical cousin. Back-of-the-envelope calculations suggest that a single vetiver plant may absorb 2 kg of CO2 a year. International efforts to propagate vetiver grass are underway in more than fifty countries. To give one example, the Chiang Rai Land Development Station in northern Thailand produces new vetiver plants at the rate of 100 million a year, which means that its annual output of plants might be removing 200 million kg of carbon dioxide. According to CIAT, that's as much CO2 as emitted by 40,000 gas-guzzling cars, each driven 20,000 km. Vetiver's many advantages include the fact that it:

- Thrives in acid, tropical soils that now support little or nothing;
  Is adapted to widely different conditions and climates;
- Thrives in the tropics where the year-round heat fosters tremendous biomass growth;
- Produces root matter rapidly;
- "Buries" CO2 so deep as to keep it out of the atmosphere for decades;
- Benefits the soil and surroundings;
- Provides multiple benefits in addition to any greenhouse-gas removal;
- Is easy to use and understand;
- Can protect roads, pipelines, natural-gas wells and other installations;
- Can stabilize spoil from mining and other industrial operations; and
- Is adapted to the most erosion prone, hunger prone and forest-depleted regions.

These days, interest in planting vetiver is widespread throughout the tropics. People want to plant it for their own benefit — it doesn't have to be done for them. Small amounts of funding can therefore be put to immediate use without overheads or delays. The funds can produce huge multiplier effects. They can, for instance, be used to establish nurseries, which then go on producing planting materials in a self-sustaining manner into the foreseeable future. Vetiver seems like an exceptional tool for sequestering CO2. It can be propagated by the millions in tropical lands, and could be used **to trade off** against considerable volumes of emissions made elsewhere in the world. All in all, this remarkable plant has the ability to turn large amounts of greenhouse gases into underground solids — all the while benefiting local soils and environments. Vetiver hedges will likely hold their stored carbon for decades. They will also benefit the lives of millions in the parts of the world that most need help.

From Alemu Mekonnen, Ethiopia. Greetings to you. After the long rainy days in Ethiopia, of course good for my project, I am writing you this letter. I have succeeded in completing our planned activities on vetiver grass promotion for my project area and distributed the grass to other projects outside ours. I have applied the technique you advised me i.e. early planting, and found successful for better survival (99%). I am very much pleased with it.

Included are photos from one of the project sites where vetiver is planted for soil and water conservation, gully control and for roadside stabilization. I hope you will like it much. The altitude is 3200 masl, the soil is wet and the average temperature at this rainy day's is -2ºC and during dry season 23°C. The plants are raised in polythene tubes.

I am also sending you a videocassette; you will see and admire how vetiver is serving the poorest of poor farmers in the region, particularly the women households. There you see women carrying the seedlings & planting. This has encouraged me so much to work more on Vetiver, for this poor country to solve the problem of land degradation on large scale.

We had an award ceremony on 17/08/98 for 12 farmers received a Quintal (100 kg) of fertilizer each from the project. I will let you know the exact number of beneficiaries, the area covered and other related issues next month Sept. or the beginning of October1998.

I am now busy in propagating the grass in all the old nurseries and have recently established three nurseries. My goal is to produce 2.5 million clumps of vetiver grass, of which 75% will be containerized in polythene tube.

The videocassette I sent you is not edited. You can select the best part and edit it. I like particularly the vetiver in solving the gender issue, because it is easy to be used and propagated by women householders. In the past because of their poor physical strength they were not participating in SWC programs which dealt with engineering SWC (stone, soil bund). But now, thanks to the Vetiver grass that is gender sensitive, they are now conserving their land easily with less labor and input.

From Fesseha Gedamu Ethiopia
weaf@mail.telecom.net.et
Women Empowerment and Assistance Forum (WEAF) is at the moment working on soil conservation projects and it is felt that the construction of soil conversation structures are very difficult for women and are planning to introduce the use of vetiver grass to the project. We have already allocated a nursery for the production of vetiver seedlings on a largscale. I will give you a feed back on its progress in the future.

From Nat, Fiji. I am from Fiji and

am a lecturer in Soil Science at USP School of Agriculture which is located in Apia, (Western) Samoa. I am involved in the Pacific Land (PFL) Network of which Tony Dowling is the regional network coordinator.

I understand that vetiver has been in Fiji for quite some time - since the 50s if I remember correctly. It's use is now being re-encouraged via the Pacific Land Network and the Agriculture Department's efforts. I understand that from Fiji it has been introduced into the Solomons. I heard that some Tongans were also interested in getting vetiver from Fiji but I am not sure whether they finally obtained some planting materials or not. Vetiver is also doing well in PNG as I have seen it on PFL plots in PNG.

With regard to our PacificLand project, I have been talking recently with some top people in the Agriculture Dept. here - Acting Director, Head of Research, Head of Extension, Head of Forestry and others - telling them about vetiver and the need to try tit out in Samoa. Those I talked with sounded keen and I will be discussing quarantine requirements and other matters with the relevant authorities. However, an Australian consultant that was here recently (he's the one that allegedly introduced vetiver into the Solomons), suggested that I ask Pacific islanders (including Fiji, Solomons, etc) to write us of their experience with vetiver - to help the Samoan authorities finalize their decision on whether to go ahead with my proposal or not - regarding the introduction of vetiver.

For the above reason I would be very grateful if you could share the results of your study with us.

(If anybody working on the south Pacific is interested please get in touch with Nat. Looks to me like a promising vetiver development. There is an article in Newsletter #15 page 26 that wil answer most of your queries ……. Editor)

From Joachim Boehnert, CIERs-ES, Caixa Postal 77, Nova Venecia – ES CEP 29.830-000, Brasil 31 31.08.98.

After some delay, we finally have finished our small publication about "Capim Vetiver - a Barreira Vegetal contra a Erosao: perguntas & respostas e proximos passos".. For your information I am enclosing a copy with this letter.
The small booklet was published with 1000 copies. If you need some more, please inform me via email. I will send copies to the members of the Vetiver network in Brazil, an NGO network for alternative technology (REDE-PTA), and colleagues from my service (DED - German Development Service), here in Brazil. Any new member in Brazil and/or Africa (I got a request from Mozambique) can contact me for copies here in Brazil, as long I am here (until the end of 1999).

Mainly to avoid a double-effort of publications, I was sending an 'open letter' to the members of the Vetiver network, the NGO-network REDE-PTA with 31 NGOs and 25 German colleagues from the DED, inviting comments and suggestions. Nobody answered me!

To me this shows two things:

- that it was the first time that this articles from the Book "Vetiver Grass - A Thin Green Line Against Soil-Erosion", Nacional Academy Press, 1993," was translated into Portuguese; and
- that the interest for Vetiver, despite the need and potential for Vetiver in soil & water conservation in Brazil, is still very limited.

Nevertheless, maybe this small booklet can help to extend the use of Vetiver in the state of Espirito Santo and Brazil ….

From: Julio Alegre, ICRAF-Pucallpa, Peru
j.alegre@cgiar.org

I would like to communicate some of the progress that we have done with Vetiveria in the humid tropics of Peru (Yurimaguas, Pucallpa, Iquitos) and arid areas (Ica, Huancayo, Cajamarca). Now the Peruvian government is very interested to get the planting material for the arid areas of Peru for soil conservation in the areas along the main road that crosses from Chile to Ecuador. We do not have enough material to supply it but we are investigating the propagation of this material in the humid tropics of Peru with many farmers and they can sell it.

As you now the *Vetiveria zizanoides* is planted by native people from the Amazon region (locally known as pachuli in Peru and Brazil). In Iquitos, Peru the roots are used as a medicine (a lotion with alcohol to avoid lost of hair) and in Brazil they prepare a lotion and perfume. Also dry roots are used to protect clothes from being destroyed by insects.

Four years ago I brought with me just 10 slips from Nairobi, Kenya, and propagated this material and I have distributed to several places in the Amazon and the arid regions of Peru. According with the DNA analysis that has been done the species from Iquitos, Peru and the one I brought from Nairobi were the same species (*Vetiveria zizanoides*) being the ones that do not produce seed.

Now I have implemented in the region of Pucallpa, some conservation technologies with agroforestry systems and I have included vetiveria mixed with legume multipurpose trees under contour row. Farmers are propagating the vetiveria and are still in the process of testing the benefits for soil conservation on steep poor acid soils (Ultisol). We have produced several colored tripticos (short bulletins) and one is exclusive for Vetiveria. I will send you by mail a set of these bulletins

for inclusion in the Boletin vetiveria and the World Bank technical reports.

In all the literature and reports mentioned that this *Vetiveria zizanoides* does not produce seed but recently in Pucallpa, some plants started to produce seeds (very few plants). I have collected the seeds and I have done some germination test and until now (20 days) none of the seeds have germinated. Do you have this experience. In the Yurimaguas (2,200 mm annual rain) area where I started to propagate vetiver four years ago, up till now no plants have produced seeds. However in the new area of Pucallpa where we have less rain (with 1,800 mm annual rain and only 3 months of drier periods) some plants are producing seed. I hope this is not a problem because one of the main characteristics that we are disseminating is that will not become a weed. Please advise. Please send me training materials about vetiveria. *(this limited seed productionthat is raised by Julio is often a common occurence, but all evidence indicates that the seeds are sterile, and if a few germinate they are not a problem -- most do not survive. .... Ed)*

To: Edwin Balbarino (VETINETPHIL) (email: vnp-ed@mozcom.com) from Robert A. Arevalo.

We are currently undertaking several coffee plantation activities for upland areas and I feel that the vetiver technology will be a big help to protect slopes and prevent erosions. I wish to include also vetiver in our large scale commercial coffee nurseries which we are setting up in San Juan, Batangas, Aritao, Nueva Viscaya and Palawan. We are now producing cloned coffee planting materials in coordination with Nestle Philippines for upland planting. Can you please advise me where I can secure the initial vetiver planting materials for multiplication purposes.

To: Edwin Balbarino (VETINETPHIL) From: Bro. Alois Goldberger, Regional House Ubbog, Bangued, Abra, 2800

I am enclosing some pictures from our river control work as well as the protection of irrigation canals. In our mountainous areas we use Vetiver to control gully erosion, as well as for contour lines, for protecting the rice terraces. Thank you in advance for your assistance in our Vetiver work here in Abra.

Ed Balbarino responds to Dominic Ackerman.

Vetiver *(Vetiveria zizanioides)* has been used in the Philippines for several years now. A network (VETINETPHIL - Vetiver Network Philippines) has been formed in 1997 with about 300 members who are users, researchers and promoters of the Vetiver Grass Technology. VGT is now used in the highways, irrigation canals, dams, upland farms, mining sites, site development projects and other projects that require soil erosion control, embankment stabilization and land rehabilitation. We have now 8 vetiver production farms nationwide and about 40 nurseries operated by private businessmen, farmer organizations supply vetiver planting materials anytime and any place in the Philippines. We are also producing Vetiver Technology Guides for free. I am confident to tell you that if you need a technology to stabilize earthen dams, VETIVER is the answer.

From Mike Pease (Coordinator EMVN) mikepease@mail.telepac.pt):

Early Establishment of Vetiver.

Vetiver has a built-in dormancy factor so that, depending upon weather conditions, new plantings may not show aboveground signs of growth for up to 8 weeks. Old leaves die off and appear as 'dried straw', old roots similarly tend to die off and are primarily retained at planting time purely for anchorage, hence the standard recommendation to leave say 10 cm of roots on new slips.

Early establishment can be critical to successful vetiver hedge establishment especially under stressful climatic conditions and where topographic circumstances are such that plants must be established with good new rooting to resist flooding and erosion. This particularly applies to such circumstances as steep slopes of cuttings and embankments on highways, dam walls, and disturbed lands around construction projects.

The following lists 4 methods of reducing the period between planting and firm establishment of vetiver hedges.

'Manure Tea' Two slightly different approaches to 'manure tea' are described

(a) Horse tea container. Use a 40 gallon drum and cut the end (bottom) out that does not have the drum "cap". The cut end will now be the top of the drum. Place 3 or 4 bricks in the bottom of the drum and place the cut out "bottom" on the bricks. This enables you to fill the drum with manure, but keeps it out of the very bottom from which you draw the tea. Get some pipe with an "L" elbow in it and a tap and screw the pipe into the "cap" hole. Then stand the whole contraption on a couple of concrete blocks, so as to be high enough off the ground to permit you to get a bucket under the tap when drawing off the tea. Fill the drum with dry horse manure, then fill with water and leave for a day or two. You can then draw off all the tea. Refill with water and repeat. You can get about seven cycles before you have to replace the horse manure. Of course, pig or cow manure will do just as well.

(b) When multiplying and roots have been cut back soak (submerge) the plants in "cow tea" for 6-8 days. Cow tea consists of dried cow dung and water, although one

can use up to 25% pig manure. When doing the soak drill, cut the leaves back to 40cm. and observe the new growth. When new leaf growth appears from the center of the plant and you see the beginnings of a new tiller, then it is time to replant the tiller. The process can cut back the dormant period 2-4 weeks. The Chinese originally developed the technique for rapid multiplication in the 1950s. However, they used just water.

Sand Pots In this method, a horticultural pot of any convenient size is used, three quarters filled with sand. Slips are divided into 1 or 2 tillers and planted in the sand to a depth sufficient to just cover the crown. Plant the tillers about 5 cm apart. Length of roots is not of great significance. A small quantity of fertilizer or manure is desirable. Water well. Leave for about 4-6 weeks and plant the individual tillers in the nursery close together, at normal nursery spacings, i.e. 30 cm.

Strip Production This method is ideal for producing lengths of planting material in one section for planting on steep slopes**.** Use as a base heavy duty, black polythene sheeting. Create depressions in the sheeting about 10cm high with bricks or boards and about 1m long and push the sheeting into the depression. Half fill the depression with soil, ideally mixed with some potting soil or manure. Then cover with a layer of fly screen, the stronger the better. Above the fly-screen place a layer of potting soil or planting mix and plant individual vetiver tillers at about 5-7cm spacings into this mix. Apply some fertilizer, Diammonium phosphate is ideal, and water frequently. The vetiver roots will grow through the screen and will bind into a solid strip. After about 10 weeks cut the strip which is now bound together by the fly screen from the depression into convenient lengths for handling, 30-40cm. These strips can then be planted on the slope to create an immediate hedge.

Individual Pots Plant three good quality tillers in small size pots, 3 tillers per pot, using potting soil. When the plants are sufficiently well grown, with 3 actively growing tillers, usually after about 4-6 weeks lift from pot and plant in the field at 10-15 cm spacings. This method is ideal for steep slopes such as on highway embankments and cuttings.

From Duncan Hay (Coordinator of SAVN) Email: c.za" hay@inr.unp.ac.za.

It hasn't helped that I have been appointed a director of the INR and have had to take on some rather unplanned responsibilities. My personal engagement in vetiver **will not** be effected.

I have raised R 120 000 for establishing community operated vetiver nurseries, as well as to supplement David Jobson's (Mpumalanga Vetiver Project) existing funding which is good news. I have also had fruitful discussions with African Gabions, a subsidiary of a huge Italian company specializing in engineering stabilization. They want to explore complimentary technologies and vetiver is an obvious choice. We are going to run joint seminar sessions in Cape Town, Johannesburg and Durban targeting engineers and the mining sector. David Jobson returned recently and I will be meeting with him next week to develop our joint strategy for next year. It is my firm intention to move the funding of SAVN within South Africa as of some time next year, and will be approaching funding agents early in the new year. We need to stand on our own feet sooner rather than later. That is not to say that any amounts allocated from TVN will not be gratefully accepted!

Tony Tantum also reports that they had about 150 mm of rain over a short period at one of the mines near the Kruger National Park where he is carrying out rehabilitation. Where vetiver is established the soil has held but in areas without, gullies up to 2 meters deep have formed. I have asked him to get photos.

To all the wise men from Duncan Hay Does anyone have any idea what kind of nasties one is likely to find in the mine tailings from an antimony mine? Tony has been approached to carry out some stabilization at a mine and needs some preliminary information before they take samples. Any information greatly appreciated.

From: Ken Kramer, Soil Conservationist, Saipan Field Office, Email: saipanfo@ite.net . SUBJECT: Vetiver activities in the Pacific Basin.

My purpose in writing to you is to inform you of the activities in which vetiver grass is being used, and to describe the progress that has been made to disseminate the vetiver technology in the Pacific Basin. Until fairly recently, I was unaware that the Vetiver Network existed; nevertheless, I have been promoting the use of vetiver throughout the Mariana Islands from the United States Territory of Guam to the Commonwealth of the Northern Mariana Islands (CNMI). A variety of vetiver called, Louisiana Sunshine, was extensively tested by Robert Joy, NRCS Plant Materials Specialist, at the NRCS Plant Materials Center in Molokai, Hawaii; and then, it was released to the Plant Materials Site on Guam, where it was further tested for many years. All this testing was designed to select a strain that can only be propagated by the direct intervention of humans; signifying that the seeds are not viable, and it can only be propagated by digging it up, pulling it apart, and planting the slips. The first, major use of vetiver on Guam was in the Ugum Watershed Project, where I assisted Robin DeMeo and Colleen Simpson (both from NRCS, Guam), in planning and planting vetiver in the

badlands of southern Guam.

On both Rota and Saipan in the CNMI, I have established Plant Materials Sites to propagate and maintain a place for useful erosion controlling grasses (vetiver); propagate and maintain several species of pasture grasses; and to use the site as an information/educational tool to teach farmers and ranchers what plants are available to assist them. In 1994, I introduced Louisiana Sunshine vetiver to Rota, where it was planted at the Rota Plant Materials Site and in the badlands on Rota. Plantings of vetiver were conducted in the Talakhaya Watershed in experimental trials to determine which kinds of vegetation were best adapted to growing in the nutrient poor, acidic, low organic matter, Akina Badlands Complex soils.

In 1996, vetiver was brought to Saipan, from both Rota and Guam, and established at the Plant Materials Site located in Kagman at the Department of Lands and Natural Resources' Division of Plant Industry. From this source of vetiver, several farmers have experimented with it, including Clifford Sakamoto, who used it for gully erosion; and Jesus Sablan for sheet and rill erosion. In addition, it is used in the Lau Lau Watershed Best Management Practices (BMP) Demonstration Project.

To date, the Lau Lau Watershed BMP Demonstration Project remains the best demonstration of vetiver technology in action in the CNMI; it is sponsored by the CNMI Division of Environmental Quality (DEQ) and funded through an EPA 319 grant for non-point source pollution. Susan Burr, a Marine Biologist at DEQ, and I have worked on this project from its conception; moreover, the project has been a model of cooperation between the CNMI government and the USDA/NRCS. The vetiver is planted at the top and bottom of a 2 acre site donated for use by Donald Flores, a member of the local Saipan & Northern Islands, Soil and Water Conservation District (S&NISWCD). The project location is characterized by steep (24%) slopes, volcanic, acidic, poor soil, consisting mostly of saprolite parent soil material, in an area in the Lau Lau Watershed, above Lau Lau Bay, which is a popular tourist attraction for scuba divers. In August of 1997, Robert Wescom, NRCS Forester, Guam, and I conducted a resource assessment of the Lau Lau Watershed with the purpose of documenting the existing conditions, identifying sources of non-point source pollutants that are adversely affecting the surface and marine water quality, and to implement a small demonstration of the conservation practices required to control, reduce, or prevent non-point sources of pollution. Vetiver vegetative row barriers are an integral component of this revegetation effort. Other BMPs include the use of mulch from the Lau Lau Golf Course; a ground cover of the nitrogen fixing legume, siratro, *Macroptilium atropurpureum*; tree planting with *Acacia auriculiformis*; and wattling, or the installation of live fascines, with *Gliricidia sepium*, otherwise known as the madre de cacao.

The last of the vetiver for this project (150 ft. of vetiver on the contour) was planted on September 12, 1998, at the top of the slope with the assistance of: Susan Burr, Jack Olesch, Kimiko Link, and Brian Bearden from DEQ; and Tom Pritchard, an Agriculture Teacher at the Marianas High School, and his agriculture students. These students and their teacher are Earth Team Volunteers with NRCS, and as such, they have helped us implement this project. Without the help of these 23 Earth Team Volunteers, the Project would not have succeeded as it did; and by assisting us, they learned about their island environment and the ways to preserve and protect it for future generations. This was an educational aspect of the project that has engendered a deeper respect for the environment for all those concerned with it.

The latest news concerning the use of vetiver, comes from Brian Bearden, DEQ Engineer, who is considering the possibility of to incorporating vetiver into the earth moving, permitting process. Finally, a major project is under consideration to encircle the Puerto Rico Dump on Saipan with vetiver grass to filter out the sediment, and, perhaps, absorb some of the nutrients.

From Nick Dolphin – SASO, Oaxaca, Mexico

I met a friend today to whom Kevin O'Sullivan gave a few clumps of vetiver in1995. He is planning to use the grass in bales for making houses. Apparently, people in the village where he lives were interested in using straw bales but these have proved too expensive (fortunately). *(There is an interesting web site at: www.cohousing.org/structm/msgo562.html that promotes straw housing, vetiver straw should be excellent as it is long lasting and insect resistant -- a possible area for practical reserach .. Ed)*

From Joan Miller – Coordinator LAVN Email: hamilton@sol.racsa.co.cr

Just wanted to thank you for getting out the certificates of appreciation to the "other deserving individuals". We just got a letter from one of the recipients today and he says:

"I don't have the words to tell you how grateful I am for the honor that you have awarded me a certificate so beautiful and that signifies much for me. Never did it occur to me that I might receive such an award and nonetheless I accept it with great happiness and with the promise to continue to advance in the dissemination of the Vetiver Technology..." He's been working with communities and projects, making copies of

the video, giving out booklets, etc. In the mean time he's been trying to finish up his thesis on Soil Characterization in a National Park, but he's got great interest in development and implementation alternative technologies for small, subsistence farmers. He's been one of our very active, independent workers in the field.

From Calvin Bey — Vetiver Network Haiti.
Email: cfbey@erols.com

The photos were taken before Hurricane Georges. The damage due to Georges was minimal on the site. In fact, we do not know how much rain was received at that site. And apparently there was not much wind. We have some flimsy structures that were not damaged at all. This surprised me. There was essentially no accumulation of soil at the vetiver line. I now have a rain guage at the site with someone to record each rain event. I do not have the contrasting "after-Georges" photos.

We do have one valley, away from the garden area that drains a watershed of 100 or more acres. Our next major vetiver project on the site will involve putting vetiver in that valley. Then when we get some heavy rains, I expect to see some significant soil accumulations. The site is so badly eroded that there is really very little soil left, so it may take some time to see the effects.

We will be extending the work to other groups in 1999. It seems to go painfully slow at times, but it is moving forward and many that visit the site are impressed. In a few years this will be a real showplace. Our next plans call for putting in orchards, forest trees and more edible bushes, vines, etc. I am building a good network of others who are working in the tropics and am encouraged that vetiver can be a major help in soil erosion and for storing water. Both are critical on our site.

From Ken Schlather e-mail: ks47@cornell.edu phone: (607) 844 4460

As a follow-up to Roland's (Roland Bunch) message on soil erosion/ landslide damage caused by the recent hurricane Mitch in Honduras: I was able to visit limited areas of the southern part of Honduras in mid-December and had observations similar to those of Roland. I too wish to point out that I have not been in the North part of Honduras and so cannot speak about conditions there. A team of FAO people did go to the North and I believe they prepared a report but I have not been able to obtain a copy yet.

I must admit I was impressed (and dismayed) at the apparent inability of mulch alone to protect agricultural soils from catastrophic rainfall events (a conclusion already very well documented prior to this storm, by the way, by researchers from Texas A&M university in S. Honduras as well as by the FAO project in Lempira Sur in Honduras).

The presence of trees or rock walls (where the rock walls began 30-50 cm below the soil surface), and in some cases vetiver grass, very clearly reduced landslide damage, in terms of frequency. Indicating that the soil needs to be tied into the hillside, again information that Texas A&M and FAO have already documented.

Other points:

- Deforestation clearly increased susceptibility of slopes to landslides as most of the slides occurred on deforested slopes. From the few cases we were able to document there appears to be a correlation between landslides and length of time that a field was without forest.

- There were large variations in the pattern of landslides, indicating that there are underlying causes, which should be identified (see section on damage assessments for details). Some of the possible causes of variation include parent material of the soil, slope angle, percent of forest cover. It may be possible to determine some of these causes using high resolution
- satellite photos or aerial photos combined with information in GIS databases and local observations.
- Landslides frequently occurred on the edges of fields that had soil conservation measures implemented but which were located next to fields without soil conservation measures. This would indicate one or both of a lack of training in how to drain runoff off the fields and lack of cooperation between neighboring farms. These should be addressed in any future programs.

I'll be happy to send copies of any information I have on storm damage and future needs related to soil conservation in Honduras to any of you.

From Criss Juliard (Madagascar) <cj@chemonics.mg> to Mark Dafforn.
Email: VetiverNet@aol.com.

I am delighted to have established contact with you. As you might suspect, your report (Vetiver Grass – A Thin Green Line Against Erosion) was perhaps the most important document I read on Vetiver; well written, documented, and extremely useful. About 125 copies have been distributed in Madagascar. It, along with a series of other publications on vetiver, documents, drawings, and pictures have moved the vetiver agenda to a point where it has reached "critical mass:" — engineers are using it!

Last year when Dick Grimshaw came in October/November, there were not many vetiver users, although the plant had been around for decades. It was brought here from La Réunion for the essential

oil business, and was used sporadically by several road contractors 25 years ago. Tom Bredero (known here as Monsieur Vetiver), mentioned in your report, was murdered here in 1994/5, and not very much happened after his untimely death. The project that I manage fortunately was able to build on the strong foundations he laid. We were able to mobilize people and resources since we are both an agricultural intensification and an agriculture feeder road project. For both, we have the funds and the manpower to protect watershed basins, hillside erosion and hillside agricultural plots.

Our objective last year was to build up the capacity of private suppliers to produce large quantities of quality vetiver. We succeeded, as we now have a network of 15 suppliers, from relatively small NGOs to relatively large nurseries capable of producing a million plants. There are approximately 12 ha. of vetiver nurseries at the moment.

We then set our sights on developing the market, and have been lucky in finding receptive ears among the potentially principal consumers of vetiver. The World Bank financed roads, as well as the European Union, the Ministry of Public Works and Min. of Rural Development have all stipulated that vetiver clauses must be included in all contracts. We have used the media effectively to promote the technology and it's multiple uses. We have trained the ag. extension service, members of the Water and Forestry Ministry, Boy Scouts, the Peace Corps and have organized "journées du vetiver" for schools in areas where we rehabilitated roads. We have a vetiver network, a newsletter, brigades of committed people, and a Vetiver NGO.

On the application side, we have conducted interesting experiments, none scientific. But based on approximately 800,000 plants planted, we have reached the following observations about vetiver usage in Madagascar:

- vetiver planting must be done from plants that are grown in nurseries in polybags. Transplanting should not be done from bare root tillers (since there is a high mortality rate), but always through tillers that are several months old which have already experienced primary root growth;
- multiplication is quicker and more reliable if tillers are first soaked in "cow or pig tea", a mixture of water and manure for 7- 10 days. The manure should be preferably female manure since it contains greater amounts of hormones that accelerate root growth. The
- ''pralinage" process reduces the resprouting time by about 4-5 weeks.
- spacing should not be more than 10 cm, and preferably 8 cm to establish rapid hedgerows. We calculate a minimum of 10 plants to the linear meter or 10,000 plants to the km.
- In Madagascar vetiver should be planted only between November and April; which is the rainy season, the warm season, and days are longer. Planting during short, cool dry days reduces success rates down to 40%.
- Farmers will not buy plants commercially. To get people started in an area, initial stock must be given and used by demonstration farmers. Even after that, individuals will not pay for the plant. The technology will spread mostly through uses along roads, railroads, irrigation canals and publicly funded projects. Plantation owners are the best vectors of extension.
- While the technology is easy, training must be continuous, and supervision constant.

Vero, who is responsible for our road program, is more a road engineer than a vetiver agronomist who has seen the advantages of biological protection for hillside stabilization and cost reduction for maintenance. Road maintenance is how we got involved with vetiver. The rural roads that we rehabilitate are turned over to rural associations that manage the maintenance of the roads. We had to find a way to reduce maintenance costs for these associations and reduce the destruction of rural roads during cyclones and rainy weather usage. Vetiver presented the ideal technology - inexpensive, simple to apply and lasts for a very long time.

From Criss Juliard <cj@chemonics.mg> to Mike Pease (Portugal) and Dick Grimshaw.

Your picture of the cliffs of Lagos (Portugal) are exactly what our roadside looks like in Bealanana (Madagascar), the 50 km stretch we have worked on for three years in the North. Dick visited the place. We are planting more than 1/4 of a million plants along the worst stretches. Plants in polybags are the ONLY way to work on such terrain, just as you said, since they contain good potting soil to help the plants during the difficult first two months.

I was interested in your comments about Almond orchard and vetiver. One of the things that almonds don't like is water. In fact, many newcomers to the Algarve plant flowerbeds under almond trees then water them religiously. The almond tree subsequently dies. Almonds have to go through a drought period to survive. Too much humidity destroys the roots. On the other hand vetiver rings could be used around fig, alfarubera and citrus orchards. Grape vines are also very receptive to vetiver rings. I planted vetiver around my grape vines here in Antananarivo, and have seen more than a doubling of production this year. It is phenomenal.

The good news about Ambato Boeni is that the government has provided funds (about $500,000) for the road

you worked on, but only parts are going to be done in vetiver. The not so good news is that Bernard Crabe's trials with vetiver have not been convincing. I am not sure how they planted trial plots on the digues, but apparently the latest rains carried off the plants on their demo digue. I am told they planted bare root tillers, which I think is a mistake. As I may have told you, we have completely abandoned the transplant of tillers, and require that only rooted, vigorous 6-week-old plants be used for erosion control. This is reflected in our contracts, and in all of our presentations and training. We don't recognize suppliers who provide plants as tillers, but only those who sell in polybags. In a road site planted last year, we put down potted plants for 10 meters, and then direct tillers for 5 meters. This year, the potted plants are all up and about a meter high. The tiller plants are about 25 cm high, dry, brown and about 30% died.

CAP ROADS: Results of vetiver on our roads have been good, especially to protect cement works, culverts, bridge abutments, drains, and gabions. We have also been successful in protecting areas where fill dirt has been extracted. Where we have not been successful enough is on steep hillside stabilization. The earth is often too fragile. Heavy rains wash away or bury the planted material even if it has been rooted. For the time being, we are acquiring about 30% more plant material than we need so that we have adequate replacement, and we avoid the trap of increasing spacing under the pretext we have insufficient plant material..

We are using three types of contracts for planting vetiver for:

- construction firms that are/have done satisfactory rehabilitation work and for whom we amend their construction contract to include planting vetiver. They buy the plant material under their contract;
- construction or landscape firms that provide the labor, transport and organization, and we provide the planting material. This cuts down on per meter cost;
- associations for which we provide the technical support and the plant material.

For the first two, we have prepared "public tender" contracts that conform to government contract format and regulations. These are complex documents (legalese left over from the French), and I would like to find simpler models. Do you know how I could get a hold of a Ministry of Public Works sample contracts to compare what is included. As I mentioned to Mike Pease, I think the contents of contracts, and having clauses that define exactly how to plant vetiver is critical to assure quality application of the technology. Such clauses for our supervisory engineer who signs off payment vouchers describe how the ground has to be prepared, how deep the furrow has to be, the mixture of fertilizer, quantity per meter, heeling, what the planting material has to look like, how to dispose of the plastic polybags, how to count and control linear meters (we pay by linear meter, what about you?). But we still seem to run into problems. Do you know anyone else who has prepared such documents. It would be interesting to compare.

From: Criss Juliard (Madagascar) <cj@chemonics.mg> to Joan Miller (LAVN Costa Rica).
Below are responses from Criss Juliard to a series of questions from Joan Miller.

Q. To what do you attribute the extremely high mortality in the planting of unrooted slips?

A. Poor soil, inaccessibility to watering, drought, or heavy rains. All of these factors enter into the problem but they may be particular to Madagascar. Direct, unrooted plants are a "quick and dirty" way of planting. It can work, and you can reduce the incidence of mortality. But since most of our work to date has been in isolated and hard to get hill sides, or dirt roads, hand watering cannot be assures, plus it is expensive. We have a rainy season, but it is not always constant. If you have 7 or 8 days of no rain after planting the slips, you risk losing a part. Since we are trying to instill a bioengineering technology that is simple but rigorous we thought it would be better to encourage planting from rooted source. Potted, rooted plants have an edge because they don't go through the drying out phase, they have a little ball of good soil to get started, and the plant does not go through a shock.

For your information we have had lower mortality rates in some areas. Last year we reached 85%. But that is still too high. I want 100% success rate or close to that as possible, otherwise people will focus on the weakness of the technology, or say it doesn't work.

I would say that if the land is relatively flat, rains are relatively sure or watering is easy, the soil is not too erodible, and you plant 2 - 3 tillers per plant, then go ahead and plant directly. In steeper, poor soils, or when protecting cement works, river embankments, watersheds or eroded soils, go for the pots. When participants are given the option, they will go for the cheaper and easier - which are direct tillers. In our work, we wanted to reduce the choosing of an option that tends to have a higher failure rate, so we encouraged rooted, potted plant material. In our roadwork, we require it.

Q. Do you see this same mortality in the plantings of unrooted slips in farmer's fields ?

A. No, as mentioned above, farmers, on relatively level lands, are more likely to take care of the plants

than if we are protecting a large watershed basin or a steep slope (on one, we have to lower the labors costs to plant the vetiver. In that instance we don't dig trenches, we dig holes at 45 degrees slants, and plug in the plants, just like a cork).

Q. What size container do you use in the nurseries and do you have any guidelines on the potting mix?

A. We have clear guidelines. The pot cannot be less than 15 cm high and 10 cm circumference. (We actually go out and measure randomly in each lot of delivered plants). There has to be 2-3 tillers per potted plant. It must be 6 weeks minimum in the pot, roots must be protruding, the plant must be vigorous, and the tillers will have been soaked in "cow tea" or "pralinage " for 5-7 days, which is a mixture of water and a bit of cow manure. The soaking stimulates and accelerates root growth.

The potting mix should be composed of 1/3 soil, 1/3 manure, and 1/3 sand. It must be firmly compacted. The plant must not be planted more than 3-4 cm from the crown, must be watered daily, and the nurseries must weed the pots, and place plants in the sun. Pots should be preferably black polybags, although we have used clear plastic that comes in rolls and have no bottoms. This is to be discouraged, but in Madagascar they are less than the price of black nursery bags.

Q. Do you have any cost data that you could share with us on: **(i) nursery costs, (ii) per linear meter planting costs, and (iii) years 1 and 2 maintenance and supervision costs**

A. (i) nursery costs Land rental, soil, bags, water, labor, plant material, capital immobilization per 10,000 plants runs about 5 cents per pot. They are sold at farm gate at about 8 cents per pot. Black polybags are cost about 1 cent when ordered in large quantities. A reasonably well organized operation should be able to produce 200 to 300 pots per day per person, provided the soils are well mixed, the tillers are well , and there is an assembly type operation.

A. (ii) per linear meter planting costs. Isolated areas, $1.50 to $1.80 per l.m.; in more accessible, $.40 to $1.00 per l.m. N.B. these prices do not include the price of the plants. As I may have mentioned before, it is better to have two separate parties and suppliers; one for the plants, and one for those who plant. We insist on a minimum of 10 plants per l.m. and in some places we are putting in 12-13 per. Our theory has been to be oversupplied with vetiver, and not to skimp on the plant material. Plus, I have wanted the hedge to form in one rainy season. I don't want to chance growth over two or three years. We want instant gratification!! People here need to see the effect this year, not 2-3 down the line. A well-organized crew can plant about 150 l.m. per day on difficult grounds, and up to 200 on easier soils.

A. (iii) years 1 and 2 maintenance and supervision costs. I don't have these since there is very little on our part. If you plant the plants close together (10-14 per l.m.), and the weeding is done at the nursery and one time after planting (2 months), then the only maintenance we have had to do so far is to cut the plant back one or twice a year.

From Criss Juliard (Madagascar) <cj@chemonics.mg>.

I have been sending you a lot of copies of things. I will also send you more pictures. But here are three of handicrafts that have been made out of vetiver roots. Not bad! The producer wanted to know if you could post them on the vetiver web site.

We are extremely busy, more so than ever before. We are mostly operating on the Infrastructure component, with Vero and her crew trying to accelerate completion of roads. Massive vetiver planting needs a lot more organization than I had expected, especially when compressed within several months. The number of contracts that have to be written, negotiated, then followed, and provisionally accepted, then definitely accepted, the modifications, replacements, and unexpected. Up in Bealanana, we had two contractors sign contracts to plant 100,000 potted plants each. We had provided a supply base of 240,000, but rains washed out one bridge and swelled another river so that one of the firms had to hand carry and ford 55 tons of vetiver plants to the plant site, while their proposal expected to all be done with trucks. Labor costs, time to completion and mortality rates all increased geometrically. Then we could not get money to the place because of isolation. Workers refused to work. It is not only technical issues that we are confronted with.

I just came back from the Bekobay road, the place where you visited and really gave us an eye opener on bioengineering. This place you would be proud. We have planted close to 240,000 plants on the site, and found some nifty ways to protect eroding curves, large erosion canals, and bridge embankments. There are over 100 culverts on the 42 km stretch. Each is now protected.

We have put in over 1 million plants, most of it in pots. That's more than 100 km of vetiver hedgerows. Most of it was financed under our road rehabilitation contracts. We have a vetiver clause in all new contracts. We find, as I may have said before, that a separate company should grow the vetiver from the ones who build the roads, and preferable separate from the ones who plant

the vetiver since these people should be more agro oriented than cement pourers!

The three docs round out the contract for establishing a vetiver nursery according to specifications and standards we have established for Madagascar. Unfortunately they are in French, but the requirements regarding size of pots, mixture of potting soil, the state of the plant before it can be accepted as a vigorous plant is well defined. There is a lot of extra language in the contract clauses, but that is the way we have to construct a "public contract" under public contracting regulations. You might cut out a lot, but things like litigation, and payment schedule can be eliminated or adapted to the country applied. *The contract documents are posted on the web site at* ***www.vetiver.org***

From: Md. Abu Syed, Asst. Conservator of Forests, Dhaka Forest Extension Division, 33 Bailey Road, Dhaka 1000, Bangladesh. Email: Farid Uddin Ahmed farid@citechco.net

Thanks for sending me the Vetiver Network Newsletter No.19, August 1998. I am really sorry for delayed response. I hope you will be glad to know that I have some very encouraging results in using Vetiver as a hedge crop in "Participatory Strip Plantations" (Plantation along rural earthen roads, embankments, railroads, regional and national highways). In rural earthen roads Vetiver arrested 26 cm sediment (on an average) along a 6 km planting strip (along rural earthen road). On the other hand performance of main plantation species is also excellent with vigorous growth. Participants are delighted as they are now getting plenty of Vetiver thatching materials and fuel materials. Now I am preparing a detailed technical paper on the project. Any type of printed/ electronic material would be of much help to me for consultation and reference. I hope you will help me in this regard by ensuring a few materials (prepared on specific Vetiver research project like mine)

From: Emil to Joan Miller.

Sorry for the delay in updating you on my Nicaraguan trip. Bill Schaller was unable to make the trip, so I was there by myself from Feb. 3-10. I traveled the Pan American Highway from our meeting in Zamorano to my workpost with the Universidad Nacional Agraria in Managua. This was a good opportunity to see the havoc that Hurricane Mitch wrought on the highway and areas along it. I spent most of my time in Managua working with UNA professors on curriculum assessment and a restoration plan for several rural communities (El Ojochal, Los Apantes, Las Quebradas, and Los Mangles) in Telica, a near the Casitas volcano in León. I did spend a couple of days in the field looking at the damage and talking with residents, municipio officials, and representatives of relief agencies. I was especially interested in finding out how the soil and water conservation measures implemented in a couple of the communities (mostly with Dutch assistance) held up during the hurricane. Unfortunately, the practices were employed much less extensively than I had anticipated. And although one of the local officials who had been involved with the conservation work told me a few of the farms in the area had experimented with grass hedges, we didn't find any vetiver strips. Our time was limited, and some of the areas are still relatively inaccessible. They showed me mostly gandul (pigeon pea) strips and stone rubble terraces in areas that weren't subjected to the torrents of run-off from the denuded old volcanic cones in the area.

It's unlikely that any conservation measures could have averted all the damages inflicted by such a volume of rain in such a short duration. One of the old volcano cones, Cerro Olivo, was owned mostly by a coffee cooperative and was pretty well covered by shaded coffee plantations, native forest vegetation, and extensively grazed pastures. The vegetative cover reduced the erosion on the cone, but the areas below still had huge gullies and a lot of deposition as a result of the volume of run-off.

Let's hope the area won't have to endure another assault like Mitch for least another century. But if the relatively good colluvial and alluvial soils around the foothills and basins surrounding these cones are to be made and kept productive, reforestation of the slopes and use of extensive grass barriers on the foothills will be essential. There is definitely a role for vetiver in any long-range plan. And while it isn't likely that any agency would sponsor the costs of grading and shaping the steep walls of the new gullies—many 2-3 meters or more in depth and some 25-50 meters wide—vetiver could play a role in stabilizing these as the steep walls slough off naturally.

From: Philippe Grandjean (Madagascar) - Ph_Grandjean@compuserve.com

I intend to send you a review of our Vetiver plantations this year in Marovoay and surroundings, it will be around end of March and in French. Brief news from the projects : New applications of Vetiver have started on the hill sides as an attempts to help control erosion on the tanety, results will be available at the end of this year as the hedgerows were only established in January. Brochures in Malagasy prepared by Project CAP/ Chemonics have been distributed to about 20 Water User Associations (WUE) in January 1999 and Vetiver plantings along canals/drains are now routine items listed in rehabilitation contracts between FIFABE and WUA.

F*rom Piet Sabbe, BOSPAS, Quito, Ecuador, "piet sabbe" <bospas@hotmail.com>*

The Vetiver program goes on as

before. Even better, I have set up a small company called BOSPAS — independent from Fundacion Golondrinas. One of the activities of BOSPAS is to promote and distribute Vetiver and provide technical assistance in the application of the grass.

In the last two months I attended several fairs and congresses. As a result there are some interesting requests from coastal authorities. The effects of el Ninio are still there, one and a half years after the catastrophe. A 'Programa de Reconstruccion de la Costa' was set up by the government — their main focus was to get the road system working again. And to a certain extent the roads are indeed passable again. But still very vulnerable to new landslides when another rainy season comes. Now they realize that they should work on the causes of the disaster…but there is no money.

I have been approached by an institution that wants to set up a pilot project in soil conservation with Italian money. They look for a cheap solution.

Answering your questions:

Positive success stories??. Beside our own field of 10 hectares I cannot mention any success stories yet. Neighbors are very reluctant in applying Vetiver. It needs more time apparently. Only Patricio Fuentes is 100 % convinced and works with it.

Problems that have emerged from the technology and its use??
We are still in the phase of 'discovering' the use of Vetiver, and it is too early to see problems. Hopefully, with the upcoming program on the coast, we will be able to learn more.

Research needs **I have been very busy planting batches of Vetiver at altitudes** ranging from 3000 m asl to 1000 m. Vetiver does grow up to 2,600 meters, as the literature mentions, but the difference is enormous between a plant at 2,600 m and one at 1000 m. My conclusion is that Vetiver does not have the vigorous growth and strength that is needed to be able to form a hedge above 1,200 m. The higher up in the mountains the lower the performance of Vetiver. At 2,200 m the plant doesn't grow higher than 40 cm., does not form culms, has no deep root system, etc. In brief all the elements that are the reason to use Vetiver grass are absent. I am always surprised to read reports about people who say that they successfully used Vetiver at 2,000 plus meters. I believe these people never came down the mountain to see a real grown-out Vetiver hedge that is holding up 40 cm of sediment in just 2 years. At least I have never seen this kind of situations above 1,200 m here in Ecuador. Mr. Marcelino Pita of DFC (Desarrollo Forestal Campesino) in Riobamba states clearly that in his area (3,000 m to 1800 m) Vetiver is not performing well. Another grass, Milin *(Palaris tuberosa*) is doing very well at that altitude. Also King grass, but this grass tends to become a weed if not controlled. I remember from one of your personal reports from China that you may have found a grass *(Achnatherum splendens – jiji sao … Ed)* there with similar characteristics to Vetiver but growing at high altitudes (or in temperate climate *??). (A. splendens grows under very hot summers, and survives very cold winters of north China. Altitude is not the problem, high summer temperatures are critical to good growth, same with Vetiver … Ed*). Did anything new come out of this discovery ? It could be of great value for the Andes region. For my own experiences I do not promote Vetiver anymore in the Andes region. I focus on the coastal zones now (1,000 meters and down to the seashore). Our experimental site is at 1,000 m and we are very satisfied with the grass, but even here we see a difference in growth and strength between the batches I planted at the same time in Chone (Ecuadorian coast - 60 m) and on our site. The plants in Chone were double in diameter and one meter higher in just 10 months time. Conclusion : research is needed to find out precisely in which countries Vetiver can grow to what altitude and still show the strong characteristics that are needed to call it a 'hedge against erosion'. (*Readers working with Vetiver at high altitudes might like to respond direct to Piet, please copy to TVN … Ed)*

From: Jim Maynard Email jmaynard@cnmailsvr.nmsu.edu
Just an update to let you know I'm still plugging away out here in New Mexico. I have Vetiver in culture and am working out the protocols for disinfestation and in a couple of weeks will begin some work on establishment of embryogenic callus. Once I get those things worked out I can begin working on the development of a cold tolerant variety.

I am still working with erosion and streams in the pinion-juniper and am hopeful that someday in the future that Vetiver will be available for rehabilitation in these temperate areas.

From: Joseph Boonman <Boonman@compuserve.com>
My only direct experience is from S.W. Uganda, where a colonial officer must have been working hard at the grass, of which you can still see the remains on contour lines. On the Congo side of the border, Vetiver was grown for the oil in the roots. Both events I date back to the 1950s. See my 1993 book, published by Kluwer.

I think the general situation is in brief the following:

- In East Africa there are quite a number of satisfactory (in the eyes of the beholder) grass al-

ternatives for contour lines and terraces.

- Livestock people want the above-ground parts for feeding.

- I have the working hypothesis that subtropicals do not fare too well at the Equator and vice versa. They head too late because of lower vigour – or the other way round - at widely distant latitudes.

- There is apathy towards grasses among the donor institutions now in love with projects promoting legumes, whether these are herbs or trees. I do not know whether we should be very sorry about the grasses being left out, because affairs of this type are not only ephemeral but can be lethal. CSIRO, the one-time leading global contender on the tropical-herbaceous legume platfom, has virtually closed down its legume work. Seed sales were no more than 200 tons annually, that is 2 tons per scientific worker. Grasses continue to be sold unabated, but these are the species that existed before CSIRO opened its doors. Others institutions may soon follow the CSIRO lead.

- Grasses are not looked upon - though quite wrongly - as miracle bringers. They are considered too ordinary, too local if not as outright weeds (Imperata or couch). The image of overgrazed range land has not helped much either.

- We would make a stonger platform if we did not exclusively concentrate on one species. We could include Paspalum, Eragrostis and others, even creeping ones.

From: "June Walker"
junewalker@malawi.net
Our local forestry assistant is very pleased that his first few cuttings from me have now produced a 3 ton truck full for the last rains. I see PROSCARP is on them network, maybe they know something. They visited me nearly a year ago but there has been no feedback from them yet.

From: "Miczaika, Christian
Christian.Miczaika@fao.org
I am just back from a mission to India for the ICR of the Bank-supported Tamil Nadu (India) ADP. Vetiver has been planted successfully under that project, and I can provide you with more information on this, should you be interested. One observation was made that livestock in Tamil Nadu do eat it, so it needs to be protected.

I also read your booklet and am wondering whether Vetiver grass might grow on my land in Tuscany. If so, I would like to get some and try it out. What do you think? Elevation 400 metres above sea level, rainfall around 800 mm p.a., 2-3 dry months in summer with practically no rainfall (but I could provide some irrigation, if required), temperatures below freezing with 2-3 days of snow, say, during four weeks in winter. Soil erosion is a continuing problem in Italy, see the muddy rivers and slides after heavy rains, and I would be keen to experiment on a limited scale. I know that my neighbors are always interested in my experiments, too! *(Can anyone respond to Christian on this last paragraph .. Ed)*

From: "A.M. LOUIS"
AMLOUIS@compuserve.com
We planted roughly 800 meters (distance between plants: 15 cm.) of Vetiver on different sites here in Gabon. Part of the material came from South Africa, the rest was from Vetiver found in country. The overall results are not very good: At first we observed young shoots developing, but they stayed small, and did not look very vigorous. Growth is generally very slow: after two years still no 'hedge' formation, and quite some die-back over the time. Any counsel is appreciated. *(We need to know more about the sites .. sounds a bit like Madagascar – see Criss Juliard's comments above … Ed).*

From: Otto M. Bundy, CEO and President, EcoGroup International Corporation, Parrish, Florida, USA. Email: <ecotech1@gte.net>
Our success story involves the establishment of a protocol for our cultivar of Vetiveria ziznioides "Florida Sunshine" (Ft. Polk) and maintaining it in the laboratory and cold storage. We are upgrading the micropropagation laboratory to produce over 800,000 plants units in the year 1999 and vetiver will be included in that number.

Marketing of vetiver deals with a global environmental economic-political set of criteria that will have to be addressed as the plant is further identified and proven to contribute to environmental preservation and restoration. Plant quality, quantity and function will take on a different meaning as vetiver works its way into the design for "environmentally sustainable agriculture". The Vetiver Network should look at the benefits of marketing and shipping so that the industry continues to advance and develop standards among themselves.

Research for of the improving vetiver cultivars starts with the cultivars that have DNA fingerprints and from those develop a new set of criteria that allows bio-engineering and genetic engineering as necessary part of preparing the vetiver of the future for broader use in the world environmental community. Specificity of cultivars and functions will be important, for we see plant function as a prerequisite for long term maintenance. Review and establish new indices for the best vetiver cultivars. there is excellent data excisting answering to these

objective but research must continue.

Cold storage and investigation of other storage methods of vetiver cultivars could be designed to extend plant life in marketing and shipping.

The Vetiver Network is a excellent clearing-house for these issues. Visit our web site: <http://www.ecomgmt.com>http://www.ecomgmt.com

From: Gueric Boucard "TEXAROME, INC." <texarome@hctc.net> Subject: Re: vetiver root mulch

I refer to the recent e-mail on the use of distilled vetiver roots. Perhaps we can offer some input to the network. We just put in a plant in Jacmel, Haiti to process vetiver and other agricultural raw materials. (See our website: www.ktc.net/jacosa). We process 2 tons of vetiver per day now, to be increased to 5 tons/day before the end of the year. The spent vetiver is simply spread out to dry in the sun and then used as boiler fuel in our specially designed boimass furnace. (the furnace also burns bagasse, spent amyris wood, and other biomass waste collected in the area).

We estimate the btu value of dried vetiver roots at 7000 btu/lb. In Haiti 1 ton (250gal) of No.6 fuel cost US$189.00. One pound of No.6 fuel delivers 20,000 btu's. Hence, it would take roughly 3 lbs of dried vetiver roots to compare with 1 lb of No. 6 fuel, which means that the comparative fuel value of vetiver or any other biomass is189/3 =US$63.00/ton. Haitian natives happily sell us waste biomass such as coconut hulls and leaves, drift wood etc. for US$10.00 per ton. This means that we are firing our boilers for 1/6 of the cost of No.6 fuel.

Having demonstrated the fuel savings, we are now trying to endoctrinate the Haitian native to a new way of thinking, to wit:

Why fatten the already fat white man by buying high price fossil fuels from him while the the Haitian farmer is starving to death. (in Haiti, calling foreigners "white man" is a term of endearment). We will show you how to plant vetiver fields and harvest 30 to 40 tons of dry leaves per acre to fire boilers to produce electricity. Electricity produced with fossil fuels or even with hydro power does not create any jobs to speak of.

Biomass electricity can produce massive employment in agriculture, which is what is needed in an "agrarian society". In Haiti where labor is cheap, biomass electricity would come at the same price or cheaper than fossil fuel electricity.

A biomass fuel crop in Haiti, be it bamboo or vetiver, will produce roughly the same tonnage per acre as sugar cane which has a poor yield for lack of fertilizers. Sugar cane is purchased standing in the field for roughly US$15/ton. Biomass fuel in the form of vetiver leaves could be purchased for up to US$20.00/ton and still be a third as cheap as No.6 fuel. Sugar cane is hardly grown in Haiti anymore because all sugar mills shut down. Their owners make more money importing sugar by the ship load and retailing it. What's left of the sugar cane goes to make cheap Rum (moonshine style - very inefficient). But all the "moonshine distilleries" are shutting down because it is cheaper to import cheap ethyl alcohol to mix with water and some flavorings to sell as artificial Rum.

The other crops are just subsistence crops because no large scale agriculture can be practiced. The reason: there are no roads and no transportation to take the crops to market. And there is no power to process crops into secondary export products. Citrus fruits and other goods often rot on the ground. Most rural areas have no power at all. Cities and small town that have small diesel power plants, usually provide power 4 to 8 hours per day. But total black outs can last several days.

What better use for (underutilized) Haitian arable land than biomass fuel to produce electricity? And what better biomass crop for Haiti than vetiver? The large vetiver fields could also produce roots for oil extraction. And seedlings for erosion hedges all over the island.

We have proposed a 2 Megawatt biomass power plant for the Jacmel area, based on vetiver fuel. It is now being reviewed by various NGO's and the Haitian government. Unfortunately, they don't seem to get it. Can anybody help?

From: "Ted Winston" <twinston@znet.net.au> Australia

Thank you for the note. In my local consulting work in North Queensland and Northern Territory I am working mainly with fruit tree crops (Mango, lychee, longan, avocado and coffee). Most are grown either on reasonably level land and/or farmers have taken good erosion control methods. I find little need for Vetiver under these conditions.

However when I was in Laos from 1993-1995 working on a Rural Intergrated Development project. We organised importation of 3 small truck loads of plants from Thailand. These were taken to a "research" station about 80 km of Vientiane. I along with local counterparts planted the Vetiver in several fields on the farm. Soil sandy loam, denuded rainforest country with a series of small hills. Soils are very subject to erosion in tropical downpours. The vetiver was planted near the end of my time in Laos, but I know that it had survived when I departed. Non irrigated conditions with a very pronounced

dry season. I don't know how well the vetiver has progressed since then as there was a complete change of staff at the station. I know that the station head was not very interested in vetiver as he stated that neither the cattle orhumans could eat vetiver. He wanted something that they could eat to help them survive. In some other areas of the station lemon grass was planted and this was looked upon much more favourabily as it could be used in cooking. THere are a number of areas where vetiver could be of benefit.

I was in Brunei earlier this year for a brief period and saw many areas where land development has led to erosion problems. Some of the land perhaps should not have been cleared. The smarter people at instigation of local horticulturist were planting lemon grass. I could see vetiver also having potential. I hope to be returning there within the next year and will suggest vetiver. There must be a limit to how much lemon grass the market can take!

Recently I was in Papua New Guinea and Tom Kukhang of the Coffee Research Institute was planting some vetiver on the edges of some coffee plots. I believe he is hoping to incorporate vetiver within some of his work. Thanks again for the note. I appreciate the Newletter.

From: Noah Manarang <noahvet@planet.net.ph> Philippines

Haven't written to you in a while. I would just like to tell you that more and more, Vetiver is being accepted as an effective technology here in the Philippines. I would also like to inform you that I'm now full time into Vetiver propagation. Vetiver Farms Incorporated now has 6 nurseries nationwide. Just recently, JG Summit Corporation who contracted us to plant vetiver hedgerows in their coral surfaced slopes where their factories stood, were very happy with the performance of the hedges after 3 months and they want us to plant their whole facility with the grass (approximately 200,000 seedlings). Forest Hills Golf Course where we did a test area was also very happy with the results and their consultans (Americans) conceded that Vetiver is better than hydromulch and tiger grass. I wish I could find time to sit down and do the documentation of these projects (these are just some).

Anyway, what do you think of using Vetiver on the Banawe Rice Terraces? They now have a bad case of erosion problem due to the giant worms. The Banawe Rice Terraces is one of the worlds heritage sites in the Philippines. My friends from Ateneo de Manila University (Science Education Center) would like to do a test of Vetiver there and would like to see also if the roots' aromatic properties could possibly repel the worms for good. Weena de Vera (another retired World Bank staff member) is linking us up with the Department of Tourism who is in charge of the terraces but I dont know what to propose to them. What do you think? How do we approach this? I believe that this is a very good opportunity for Vetiver not only here but internationally. Im sure funding agencies will be interested to fund any activity that could save this international treasure. I think its really high profile and Vetiver would have a lot of mileage out of this aside from that, I think Vetiver is really the answer to this problem.
Please let me know your thoughts on this.

AUSTRALIA

Report from Australia

Paul Truong, Resource Sciences Centre, Queensland Department of Natural Resources, Brisbane, Australia <Truong@uq.net.au>, truong@mailbox.uq.edu.au

The application of VGT has gained great momentum in Queensland, Australia in 1998, both in the applications and research fields.

APPLICATIONS

Infrastructure protection. The major breakthrough in VGT application here is the acceptance of VGT by the Queensland Department of Main Roads for both routine maintenance work and new roads. Following my presentation at the North Queensland Main Roads symposium in Cairns I was invited by the Department to work with the design team to incorporate VGT in the design of the upgrade of the Cooktown Development Road north of Cairns. This was the first time in Australia that VGT was incorporated into the design of a new road and specified for batter and abutment stabilization, drainage channels and other concrete and rock structures protection. The first section of this road is now being built and 23 500 linear meters i.e. 188 000 vetiver slips are needed for a short section of about 10 km of this road. Other road stabilization works are in Mackay, Central Queensland and Toowoomba, Southern Queensland.

Environmental Protection. Mining rehabilitation has gained great momentum here, with the use of VGT to control wind erosion (dust storm) from a 300ha gold tailings dam. Mine tailings often contain heavy metals that can readily pollute the surrounding environment through both wind and water erosion. With Vetiver's very high levels of tolerance to soil pH and heavy metals, VGT is ideally suited for the rehabilitation of these contaminated sites.

In addition, the Regional Environmental Officer (south) of the Mine and Energy Department has also adopted VGT as the main method of stabilization, erosion and sediment control of small mines in the region. These include gold, arsenic,

and bentonite mines; clay pits and quarries. Interest was also received from Western Australia on the application of VGT in mining rehabilitation

RESEARCH

Three areas of research are being conducted in Queensland.

Mycorrhizal fungi. The fact that vetiver can grow in a wide range of soil conditions indicate that this species may be benefiting from symbiotic association with mycorrhizal fungi. To date, plant and soil samples have been collected at several locations and different habitats in Queensland and mycorrhizal fungi have been identified. One of the major findings to date is that both the number of species and populations of mycorrhizal in intensively cropped land are much lower in comparison to those from the poor degraded lands. This may be due to the effect of agrochemical on mycorrhizal population. The implication is that for heavily contaminated land (e.g. mine tailings and landfill) mycorrhizal inoculation may be needed to ensure good and sustainable growth. Work is continuous to identify and isolate the most efficient mycorrhizal strain for inoculation purposes.

Trapping Agro-chemicals and nutrients Trials are being conducted to determine the efficiency of vetiver hedges in trapping agro chemicals and nutrients in run off; sediment eroded from sugar cane fields and irrigated cotton farms.

The following chemicals and nutrients are being monitored:

- Insecticides: Lorsban, Endosulfan.
- Herbicides: Atrazine, Prometryn and Trifluralin.
- Fertilisers: N, P, K, S, Zn.

Phyto-degradation in wetlands. Some plants have the capacity of breaking down agro chemicals under wetland conditions. A trial is being conducted firstly to determine whether vetiver has this capacity and secondly if it does, how efficient it is in comparison to other species.

INTERNATIONAL CONFERENCE

TVN is one of the major sponsors of the First Asia Pacific Conference on Ground and Water Bio-Engineering for Erosion Control and Slope Stabilization in Manila, Philippines in April 1999. Paul Truong is presenting TVN on the Organizing Committee and he is also a member of the Technical Review Committee. VGT will be well presented at the conference, with several quality papers from Australia, China, India, Philippines and Thailand. In addition Paul will also coordinate a training course and will chair a Panel Discussion on vetiver and VGT at the conference.

Resistance Of Vetiver Grass To Infection By Root-Knot Nematodes (*Meloidogyne* Spp)

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Introduction

Vetiver grass (*Vetiveria zizanoides*) is well known for its tolerance to adverse soil conditions and is used as a contour hedge to prevent soil erosion on steep slopes in some countries. Anecdotal evidence also indicates that when grown adjacent to orchard trees for soil and water conservation purposes, Vetiver appears to improve tree growth.

In Queensland, Vetiver grass is being used to stabilize soil on slopes in sugarcane and pineapple plantations. Since root-knot nematodes (*Meloidogyne* spp.) can be a problem on both crops (Spaull & Cadet 1990, Caswell et al 1990), the status of Vetiver as a host of root-knot nematode was of interest. This work aimed to answer that question.

Materials and Methods

Two Vetiver varieties were screened for resistance against five root-knot

Table 1 Mean number of eggs produced per plant when five populations of *Meloidogyne* were inoculated onto *Vetiveria zizanoides Meloidogyne* populations

Vetiver cultivar	Ma	%*	Mi (B1)	%*	Mi (B2)	%*	Mj	%*	Mh	%*
Monto	489	0.16	238	0.09	70	0.28	1343	0.45	464	0.44
WA	147	0.05	15	0.01	17	0.07	410	0.14	23	0.02
Tomato	310110		274245		25228		296100		105930	

*Indicates the resistance status, determined by the number of eggs produced as a percentage of the number of eggs on tomato.

Table 2 Status of various grasses as hosts of root-knot nematodes, as indicated by the number of eggs produced on the grass as a percentage of the number of eggs on tomato.

	Meloidogyne populations		
	M. arenaria	***M. incognita (B1)***	***M. javanica***
Susceptible			
Maize:-			
cv. FSS	-	34.1	26.5
cv.Hycorn 82	-	24.7	58.6
cv.SSC 38	-	24.0	11.4
Moderately Resistant			
Maize:-			
cv. H5	-	4.9	9.1
cv. XL80	-	1.9	0.1
Setaria:-			
cv. Narok	8.3	2.7	0.8
cv. Solander	2.1	0.5	1.7
Panorama millet	6.4	3.0	2.9
Resistant			
Forage sorghum:-			
cv. Jumbo	0.00	0.08	0.00
Rhodes grass:-			
cv. Callide	0.32	0.09	0.07
cv. Nemkat	0.01	0.01	0.00
Pangola grass	0.34	1.22	0.04
Panic:-			
cv. Gatton Panic	0.00	0.03	0.01
cv. Riversdale Guinea	0.01	0.00	0.36
Vetiver grass:-			
cv. Monto	0.16	0.09	0.45
cv. WA	0.05	0.01	0.14

nematode populations. The populations are representative of the main genetic groups of *Meloidogyne* in Australia and consist of four species (viz. *M. arenaria, M. incognita* [populations B1 and B2], *M. javanica* and *M. hapla).* They were identified using DNA technology (Hugall et al 1994). The two Vetiver varieties used were Monto, a sterile selection, and a non-sterile type from Western Australia. The test plants were grown in the glasshouse in 200 mm pots in a sterile sand mix. Once they were established, five replicate plants were inoculated with 10,000 root-knot nematode eggs. A susceptible tomato cultivar (cv. Tiny Tim) was used as a standard for comparative purposes. Plants were harvested 6 weeks after inoculation, when egg masses on tomatoes were mature. Roots washed free of soil were immersed in a 1% NaOCl solution for three minutes and eggs were collected on a 38mm sieve and counted.

Results and Discussion

Both Vetiver varieties were highly resistant to all five root-knot nematode populations. Reproduction was approximately 1000-fold less than on the susceptible tomato (Table 1). Vetiver also compared favorably with other grasses that

have been found to be resistant to root-knot nematode in similar tests (Table 2).Our results confirmed those of de Moura et al (1990) who found that Vetiver was "immune" to both *M. incognita* race 1 and *M. javanica.*

Conclusion

Since the grass was resistant to all major species of *Meloidogyne*, Vetiver is unlikely to exacerbate problems caused by root-knot nematodes when used as a cover, companion or hedgerow crop.

Soil Moisture Competition Between Vetiver Hedges and Sorghum UnderIrrigated and Dryland Conditions.

Paul A. Dalton[a] and Paul N.V. Truong[b]

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Abstract

Soil moisture competition between Vetiver hedges and crop could potentially affect crop yield. To date conflicting results have been stated and very few quantitative studies on this topic have been reported.

This paper presents the effects of Vetiver hedges on soil moisture and sorghum yield under various growing conditions. Treatments include soil types (Vertisol and Alfisol) and moisture regimes (dryland and irrigated).

Gravimetric soil moisture and sorghum yield was recorded for each single row.

Under irrigated conditions on both soil types, mature hedges depleted more soil moisture than the sorghum crop, but sorghum yield was not significantly affected by the presence of mature Vetiver hedges.

Under dryland conditions on Vertisol soil, the presence of a mature hedge significantly depressed sorghum yield of the first two rows adjacent to the hedges. Yield of row 3 and further beyond the hedges was not affected.

The above results indicate that moisture competition does occur between mature hedges and the first few rows. However crop yield is only affected when soil moisture availability is very low. Under irrigation or adequate soil moisture conditions, Vetiver hedges did not adversely affect yield of adjacent rows.

Introduction

Grimshaw (1994) found most evidence indicates that Vetiver does not significantly reduce the yield of adjacent row crops. The works of Laing and Ruppenthal (1991), Yoon (1993) and Sagare and Meshram (1993) support this view. However these experiments look only at the global yield of the crop rather than the effect of Vetiver hedges on crop production in the area close to the Vetiver hedge.

At the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) in India, Rao *et al.* (1992) investigated the effects of Vetiver hedges on maize production. It was found that maize grain yields were lower with Vetiver hedges (and other vegetative hedges) because of the competition of the hedges. The crop rows on either side of the hedge were reported to have produced no grain at all. Comparing this to a stone bund system of soil conservation it was found that Vetiver reduced runoff considerably more than the stone bunds due to increasing water infiltration. However the grain yield measurements indicated that the competition of the Vetiver for soil moisture outweighed the water conserved in the soil through increased infiltration in the vicinity of the hedge and also on the overall crop production. It should be noted that in this case the trial was performed in a semi-arid climate.

On a global field size scale runoff is reduced by Vetiver hedges and therefore soil moisture and sediment is conserved where Vetiver grass hedges are planted for soil and moisture conservation (Rao *et al.*, 1992 and Rao *et al.*, 1993). This in effect can give greater crop production on the global scale due to increased infiltration. However in the vicinity of the hedge the competition for soil moisture by the hedge may reduce the crop yield near the hedge.

The evidence suggests that the impact of Vetiver hedges on crop production cannot be generally stated as insignificant. It appears from the literature that increases or decreases in crop production depend on many factors including climate (arid or humid), agronomic practices (eg row spacing) and crop type. In this paper the effects of Vetiver grass hedges on soil moisture status and sorghum production for different soil types (Vertisol and Alfisol) and soil moisture regimes (irrigated and dryland farming) were trialed in South-East Queensland, Australia.

Methods

Field Sites

Three experimental field sites were used for the assessment of the sorghum yield and soil moisture encroachment of Vetiver. The selection of the Toowoomba and Gatton field sites was such that two different soil types and therefore moisture holding characteristics could be studied. Irrigation water was available at these two sites so that the sorghum crop and Vetiver could be raised unstressed and a wet profile established for the soil moisture analysis. The third site (Jondaryan) was used to monitor the effect of Vetiver on crop yields in a dryland farming situation. Soil moisture was

not monitored at this site. Fertiliser was applied at a rate commonly used for sorghum production

The Gatton Site

A mature Vetiver grass hedge, approximately 18 months old and almost 2 m tall was already established at the irrigated, Vertisol site near Gatton. Next to this hedge two replicates of sorghum crop were planted in 10 m lengths. The sorghum was planted using an accurate eight row cone planter at row spacings of 0.75 m and at the same spacing from the Vetiver hedges. Sowing rates were based on plant spacings of 50 mm. The young crops were maintained free of weeds using an inter-row cultivator and regular irrigations were scheduled to the crop over the dry summer period.

The Toowoomba Site

The Alfisol irrigated site for the soil moisture and yield experiment was established at the University of Southern Queensland agricultural field station. A mature Vetiver grass hedge, approximately 1 year old and 1.5 m tall existed at this site. The sorghum was planted next to this hedge at row spacings and sowing rates similar to the Gatton site. The site was managed by hand weeding, provision of sufficient fertiliser and regular irrigations to ensure good growth.

The Jondaryan Site

The Jondaryan field site was used to monitor the effect of Vetiver hedges on sorghum in a dryland farming situation. The soil is a typical black cotton soil (Vertisol). The site was planted to Vetiver hedges as a large scale soil conservation monitoring site in December 1993. In January 1995 sorghum was planted at 1 m row spacings adjacent to the Vetiver grass hedges. This site has experienced a prolonged dry period. During the growing period of the trial, only 235 mm of rain fell which is well below the long term mean of 314 mm over this period. The previous two years rainfall were only 358 mm and 382 mm respectively (annual mean is 624 mm).

Monitoring

The soil moisture was monitored in the Vetiver and crop rows to find the zone of influence of the Vetiver on the crop. At the two irrigated sites there were young Vetiver hedges planted at the time of the trial as well as the existing older hedges (as described in the field site description). Yield was measured by harvesting single sorghum crop rows.

Soil Moisture

Monitoring soil moisture in the Vetiver grass / sorghum crop environment was performed using the CPN Hydroprobe (503DR neutron moisture meter) at the irrigated Gatton and Toowoomba field sites. At the Gatton and Toowoomba sites field crops were kept unstressed with irrigation up to the critical stage of flowering. The plot was irrigated to the saturation point of the soil profile and the decline in soil moisture in the crop and Vetiver rows was monitored for several weeks using the Hydroprobe to give an indication of the competition of Vetiver on crop soil moisture over the yield critical crop stage. Soil moisture was measured from the soil surface to a depth of 110 cm in the root zone to give a soil moisture profile within each of the Vetiver and crop rows. Combining each profile across the plot a grid of soil moisture used by the Vetiver and the crop was obtained.

Yield

Over the life of the crops visual observations were made as to the effectiveness of crop growth within the Vetiver hedgerows. After monitoring the soil moisture drying cycle over the final stage of the crop life at Gatton and Toowoomba each of the four crop rows next to the Vetiver hedges were harvested to get the sorghum yield. The mature grain heads were hand cut and threshed for each row. At the Jondaryan site each of the four sorghum rows planted next to the Vetiver hedges were harvested individually using a grain header.

Results

Soil Moisture

Irrigated Vertisol at Gatton

Figure 4 shows the moisture status of the rows of sorghum and neighbouring 18 month old hedge on the Vertisol at Gatton near the end of the crop growing cycle. The Vetiver and neighbouring four rows of sorghum were monitored with “sorghum 1” being the row nearest to the Vetiver hedge.

Figure 3: Soil moisture status of the irrigated Vertisol at Gatton on day 1 after saturation irrigation.
Figure 4: Soil moisture status in the irrigated Vertisol at Gatton on day 22 after saturation irrigation.
Figure 5: Water depleted from the Vetiver and sorghum rows over a 22 day period of drying on the Vertisol at Gatton.

Figure 4 shows the moisture profile of the Vetiver row is much drier in the top 50 cm than the crop rows suggesting that the water usage of Vetiver is greater than that of the crop in the upper region of the soil profile. Within the crop rows there is no trend of greater drying occurring in the crop rows nearer the hedge.

Figure 5 describes the water depletion in the sorghum and neighbouring Vetiver row over the 22 day period of soil moisture monitoring. At day 1 the soil profile is regarded as full and from there the drying out of each row is described in terms of a depth of water depleted from the 110 cm measured soil profile. The soil in the Vetiver row was depleted of water at a greater rate than the sorghum rows and therefore the profile was much drier after the period of measurement. The

maximum difference in the soil moisture depletion of the sorghum rows is approximately 10% over the 110 cm profile. This difference is significant however there is no trend in the soil moisture depletion with distance from the Vetiver.

Irrigated Alfisol at Toowoomba

Figures 6 and 7 show the soil moisture status of sorghum and neighbouring Vetiver hedge at saturation point and after 44 days of drying on the Alfisol in Toowoomba. As in the trial on the Vertisol Figure 7 shows the soil in the Vetiver hedge row is significantly drier after the period of monitoring. The next driest row is the first sorghum row. This row is not significantly different to the rest of the sorghum rows to conclude competition for soil moisture by the Vetiver in that row.

Figure 6: Soil moisture status in the irrigated Alfisol at Toowoomba on day 1 after saturation irrigation.

Figure 7: Soil moisture status in the irrigated Alfisol at Toowoomba on day 44 after saturation irrigation.

Figure 8: Water depleted from the Vetiver and sorghum rows at Toowoomba over a 44 day period of drying on the Vertisol.

Figure 8 shows the moisture depleted in the Vetiver row to be significantly different to the sorghum rows. The soil in the Vetiver row was depleted of water at a greater rate than the sorghum rows and therefore the profile was much drier after the period of measurement. The sorghum rows are significantly spread in their soil moisture depletion. However no trend appears in the data at rows at incremental distances away from the hedge to conclude competition by the Vetiver hedge for soil moisture in the crop rows.

Yield

The effect of Vetiver hedges on crop production was measured under irrigation on a Vertisol at Gatton and an Alfisol at Toowoomba and under dryland conditions on a Vertisol at Jondaryan.

Irrigated Crop

The sorghum yields for the irrigated Gatton and Toowoomba trials are presented in Table 1.

There is a small yield reduction in the first sorghum row but statistical analysis indicates that the difference between this row and the other rows is not statistically significant at either trial site.

Dryland Crop

Table 2 shows the results of the sorghum yield analysis at the Jondaryan dryland field trial. Statistical analysis of the yields in each row neighbouring the Vetiver show that row 1 and row 2 are significantly different in yield to the next rows. Thus it can be concluded that under drought conditions Vetiver hedges affect crop production into the second neighbouring sorghum row. Beyond the second row differences in crop production are insignificant.

Discussion

It appears from the review of the literature that the effects of Vetiver hedges on soil and moisture conservation in a runoff event are very advantageous. The trails performed

Table 1: Sorghum yields of rows adjacent to Vetiver hedges at irrigated sites.

Sorghum	**Vertisol (Gatton)** Yield (t/ha)	Alfisol (Toowoomba) **Yield (t/ha)**
Row 1	1.985	1.789
Row 2	4.123	2.294
Row 3	2.358	2.318
Row 4	2.990	2.182
L.S.D.*	not significant	not significant

Table 2: Sorghum yields of rows adjacent to Vetiver hedges at dryland Jondaryan site.

Sorghum	**AverageYield (t/ha)**	**Significant Difference Level***
Row 1	0.144	c
Row 2	1.729	b
Row 3	2.356	a
Row 4	2.283	a
L.S.D.(5%)		0.491

(*The letters a, b and c denote statistically significant difference at the 5% level)

at Gatton and Toowoomba have shown that there is very little effect of a Vetiver hedge up to 18 months old on the soil moisture of the neighbouring sorghum crop rows. The soil moisture use of the Vetiver itself at this age is however significantly different to that of the sorghum crop. The grain production of the sorghum rows neighbouring the Vetiver is not significantly reduced at this stage of the Vetiver maturity. It should be noted however that in these two trials, the sorghum crops were kept unstressed by regular irrigations until the time of monitoring the drying of the soil. The only time of competition of the Vetiver with the crop was only over the final stages of the crop life. Hence from these two trials only reasonable conclusions on the effect of Vetiver on crop soil moisture can only be made. Any conclusion of the effect of Vetiver on crop yield from these trials would not be realistic.

In contrast to these two sites the Jondaryan trial showed that Vetiver hedges can effect sorghum yield under the typical arid dryland farming conditions and climate experienced in that region. Slashing of Vetiver hedges at planting may offer a partial solution to the water competition problem.

In a humid climate the availability of soil moisture may be less limited and therefore the effect due to the moisture conservation or competition of Vetiver grass hedges is negligible. However in an arid climate where the soil moisture levels can be marginal for crop performance the conservation of soil moisture due to reduced runoff and increased infiltration may be beneficial to crop yield on the broad farm scale. However in the localised region of the crop and Vetiver grass hedges the limited availability of soil moisture may cause the Vetiver hedges to compete with the crop. The overall positives and negatives within the spectrum of humid and arid environments needs to be considered before the Vetiver system could be classed as having a positive or negative effect on crop yield.

Conclusion

Vetiver hedges do use more soil moisture than sorghum row crops. However in irrigated conditions soil moisture and yield are not significantly reduced in the adjacent crop rows. However in dry conditions Vetiver does reduce the yield of sorghum in the adjacent two rows. Under favourable soil moisture conditions in good seasons of rain or under irrigation Vetiver will not reduce adjacent sorghum yield.

Acknowledgement

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Vetiver in Wetland Research in Australia

Paul Truong, DNR, Queensland.

Due to its ability to thrive under water logged and flooded conditions, vetiver is currently being used in 2 wetland research projects in Queensland:

1- Pesticide Run-off Control Using Artificial Wetlands

Background and importance

A study into the use of wetland plants as bio-filters for pesticide contaminated run-off water is to be conducted as part of the BRIA (Burdekin River Irrigation Area) Wetlands Project. Pesticides applied to farmlands are essential to control weeds in crops, unfortunately the externalities that are involved in such practices dictates that the effects are wider reaching. For example, atrazine is recommended to be applied at a rate of 4-6L/ha as a pre-emergence weedicide to control broadleaf weeds. Consequently, the expected atrazine concentration rate in run-off water is 200 ug/L (Rice et al., 1997). This is considerable high as atrazine inhibits algal growth and photosynthesis at concentrations less than 1.0 ug/L (Spawn and Siefried, 1997).

Pesticide residues from weed control will primarily accumulate in sediments but other examples of adversely affected accumulators are algae, zooplankton and fish. The need for wetlands to control the amount of pesticides in run-off is essential for all aquatic life. Wetlands have demonstrated to be effective in reducing BOD, suspended solids, coliforms, nitrogen and sometimes phosphorus in controlled flow events (Raisin and Mitchell, 1996). Therefore it is not unreasonable to expect that a wetlands system will reduce pesticide concentra tions in run-off from farmlands as

well. The concentration of pesticides found in water bodies that enter wetlands depends on the amount of removal by volatilisation, photo-decomposition, microbial degradation and uptake by aquatic organisms. The ability to reduce the amount of pesticide in waterways by plant removal is of particular importance in this study.

The two pesticides under investigation are atrazine and diuron (both active ingredients) due to their use in sugar cane crops in not only the BRIA but also throughout Queensland and NSW. In particular, atrazine has been detected in the water and sediments of the BRIA Wetlands Project site at Clare Agricultural College, where artificial wetlands have been established since 1995.

Diuron and atrazine are formulated to control grasses and broadleaf weeds in pre-emergent plant and ratoon cane crops. Diuron is noted as being more persistent than atrazine in field situations (Hamilton, 1996) creating concerns for more than one run-off event containing detectable levels of diuron. Atrazine has a higher leaching potential than diuron therefore mobility within the soil profile is at a slower rate. This leads to surface layers containing unevenly larger amounts of diuron susceptible to run-off movement.

Objectives and Methods

The purpose for this study is to investigate the effects of pesticide addition to the growth of 4 emerged macrophytes: *Phragmites australis* (common reed), *Typha domingensis* (cumbungi), *Vetiveria zizanioides* L. (Nash) and *Schoenopliectus validus* (river clubrush). This study centres on plant growth parameters, for example leaf area index and water usage, as indicators to the viability of certain plant species in tropical wetlands. Further study into the quantification of pesticide uptake into the shoots and roots of Vetiver will also be undertaken.

The factorial pot trial will simulate wetland conditions, as plants will be growing in pots surrounded by a constant free water level (1.5cm). Each pot will be subjected to a single dose of atrazine or diuron at a zero, low (20 ug/L), medium (200 ug/L) or a high (2000 ug/L) rate. The pesticide will be applied to each of the four species, once adequate establishment of plants has occurred (approximately 6 weeks). Comparison within each species to pesticide rate responses is made possible using 3 repetitions.

Desired Outcome

During the course of the experiment it is hoped that plant growth will respond sufficiently under various rates of pesticide This will allow for future research into strategically placing these plant species into wetlands to reduce the effects of pesticide contaminated run-off. Vetiver may not only be suitable for bank stabilisation but also acting as a pesticide filter in the deeper margins of the wetlands.

Result to date

In a preliminary trial conducted to select suitable species for this trial, it was found that vetiver grew at least 4 times faster than other species in terms of leaf area and dry mater. The same growth rate is being recorded for the current trial where all species are planted in pots where the water level is kept constantly at 20mm above ground level. This is a very impressive growth and if found resistant to weedicide in run-off water as well vetiver would be an ideal plant for wetland application.

2- Atrazine Degradation in Wetland Systems.

In conjunction with the above study an additional experiment is being conducted into atrazine degradation in wetland systems. This will centre on the use of 3 wetland plants: Iris, Shoenoplectus and Vetiver, to determine the rate of atrazine degradation by these species as apposed to a non-plant system. Many studies have shown the ability of the wetlands to remove herbicides such as atrazine (Kadlec, 1994), but very little research has been done to investigate the specific role of wetland species in the degradation process. Redox potential will also be a factor in this experiment as under anaerobic conditions, found in wetland soil environment, the rate of atrazine degradation will be slowed compared to an aerobic system.

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VGT Applications in Queensland

From Paul Truong

Infrastructure Protection
The access road built to service a mountainous section of the railway between Brisbane and Toowoomba collapsed when torrential rain broke the drought in Southern Queensland in 1995.

Most unstabilised sections of this road cracked and landslip occurred resulting in heavy sedimentation of local creeks and streams and also blocking rural roads.

VGT was introduced as a low cost solution to the problem, in the stabilisation of road shoulder and steep batter, diversion of runoff water to stable outlets and trapping sediments. Results of these works were put to the test this summer (February 1999) when the region received the highest ever rainfall recorded over a one month period, with falls well over 100 mm (4 inches) overnight at times. VGT passed with flying colours, the access remained opened with only minor slips occurring in unprotected areas. The streams remained clear and both the local population and railway workers were very happy and impressed with the results.

By protecting the road from erosion, VGT also improved the safety of the railway workers and enhanced their work efficiency as water was drained off quickly, reducing drying off time.

In another project in tropical Queensland (Cape York Peninsula) Queensland Main Roads Department for the first time designed a new road section incorporating VGT as the main batter stabilisation method. The first planting was carried out on a highly erodible soil, which is highly dispersable and becomes powdery in dry conditions (bull dust), resulting in severe road shoulder and batter erosion.

Again the results have been outstanding, 3 months after planting both road shoulders and batters were stabilised by VGT despite occasional heavy rain including a small cyclone.

Mine Rehabilitation
On another front, VGT is gradually gaining ground in mine rehabilitation. Vetiver has been used successfully in Gold mine rehabilitation work to control both water and wind erosion, coal mine waste dumps (quarries, clay and sand pits) and most recently a Bentonite mine.

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CHINA

Recent Trials with Vetiver in Hong Kong

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Vetiver has been used in Hong Kong for erosion control for almost 10 years, as has been reported in earlier issues of the *Vetiver Newsletter.* However, it has not been widely adopted for several reasons. First is the high cost of labor, about US$45 per day for unskilled workers. This has meant that Vetiver has no cost advantage over the well-established methods of hydro-seeding grass on bare slopes or planting trees, usually species of *Acacia.* Second is that there is a small but active contracting "industry" using hydroseeding, the proprietors of which, having invested in mixers, pumps and hoses, do not wish to use an alternative approach, especially one that is necessarily labor-intensive. Hydroseeding, usually onto cut slopes stabilized with geotextile, is regarded as effective, even though it suffers from some serious defects. The species used have flaccid leaves, especially when young, and while they offer reasonable protection from raindrop impact, they are not effective where concentrated overland flow develops and, of course, require about six weeks to become effective at all. A further disadvantage is that hydroseeding involves the pumping of a slurry of macerated paper, fertilizer and grass seed. It is thus limited to areas accessible to truck-mounted equipment though these probably account for four-fifths of the slopes to be treated.

The third reason why Vetiver has not been widely adopted is the desire by government agencies, which do most of the tree-planting, for a "one-shot solution", in a word, plant the trees and forget them. It seems easier to do this, using contractors, than to plant Vetiver hedges, which, to obtain optimal performance, require periodical cutting (burning is regarded as too dangerous) and fertilizer application. Contractors also view contour planting as "troublesome".

Fourth, there is the perception that the formation of terracettes behind Vetiver hedges may lead to a localized increase in the static load upon the slope and thus to slope failure. This is despite the fact that in nearly 10 years of trials, both by the author and by Dr Richard Webb under government auspices, there has never been any case of slope failure precipitated by slope overload.

tain virtually no nitrogen, are indurated when dry though friable when wet. They have low permeability. Whether moist or dry overland flow has been observed to begin within 10-20 minutes of the commencement of the area's characteristically sharp showers. Most of the slopes have lost between half and one and a half meters of material, more in gullies, as evidenced by vegetated "islands" perched above the general "soil" surface.

The main thrust of recent work has been to improve strike rates following planting, for these have been quite variable from site to site probably in response to weather conditions. Although Hong Kong receives an average of 2,224 mm per year, variability is substantial. However, whatever the total fall may be, the number of rain-days lies in the 90-120 day range annually. Dry spells can occur at any time of the year, the months of September through December sometimes having no rain at all. (However, earlier work has shown that there is probably sufficient residual moisture until October for Vetiver planting to succeed).

Until now bare-root planting, despite the major disadvantage of slow root development, has been the norm for several reasons. First would be the substantial labor cost of preparing slips and "pre-rooting" them in a nursery. Second is the cost and difficulty of obtaining soil for this process. Third would be the additional cost of transporting, say, polybags of slips and soil or mulch, to the actual planting site.

Experiment These considerations led to the decision to experiment with the use of a newspaper mulch for pre-rooting and planting out. Clumps of Vetiver were uprooted from the nursery and pulled apart into their constituent tillers, old or very young ones being discarded with stalky and dead material, the tops being cut to 20-25 cm and the roots to 5 cm. Newspaper mulch was prepared with tap-water in a commercial blender using torn-up paper. Three tillers were then bundled with about 100g of wet mulch, wrapped in newspaper and secured with a rubber band. Four treatments, each applied to 40 bundles of slips (i.e. 120 slips), were employed as follows:

A. no treatment (control)
B. 1g granular NPK fertilizer per bundle, applied when wrapped
C. 5m1 stock solution of 1GA rooting hormone (diluted at lml/l from solution as supplied), per bundle, applied when wrapped
D. 1g NPK and 5m1 1GA stock solution per bundle, applied when wrapped

The bundles were placed in separate trays and left out-of-doors in full sun of 21 days, following which the bundles were pulled gently apart and the number of new roots on each tiller counted. The bundles were then reconstituted using new wrappers and planted out on site three days later.

The results are set out in the following Table.

Number of new roots per tiller: Frequency by treatment

#	A	B	C	D
0	10	24	2	19
1	19	21	13	21
2	31	22	25	21
3	26	23	29	27
4	16	7	23	19
5	11	10	16	8
6	3	7	7	3
7	3	3	1	2
8	1	3	2	-
9	-	-	1	-
10	-	-	1	-
Total	120	120	120	120
Mean*	2.7	2.4	3.3	2.4
Mean				
SD*	1.0	1.2	1.0	1.5

*Calclated hill-by-hill

The treatment with rooting hormone (C) is clearly superior with no treatment at all (A) being quite satisfactory. The use of granular NPK, whether alone or with rooting hormone was not satisfactory. The granules were only partly dissolved and it was observed that in a number of cases the roots were chemically burnt. In addition the bundles in treatments B and D smelt strongly of sulphur compounds, presumably formed or released in a reaction with the newsprint as a result of the treatments. (Sulphuric acid is used in the manufacture of cheap papers and a residue remains after the paper is made). The implication of this is that fertilizer should be applied after planting out, not with the bundles.

Analyzed bundle-by-bundle similar results are obtained: A, average 8.1 new roots per bundle, B, *7.5,* C, 10.2, D, 7.2. Had the more time-consuming method of measuring the length of the roots been used, it is likely that the differences would have been even more striking for with treatment C many bundles had roots several centimeters long growing through the wrappers. This is important not only supplying nutrient from the soil but in quickly establishing resistance to flowing water which might dislodge the newly-planted slips.

It was intended that the bundles be planted out on site in a regular pattern that would enable their identification as to treatment, A-D, as they subsequently grew. Unfortunately, an error by an assistant at planting out has made such identification difficult. A further trial will therefore be made to monitor performance after planting out.

Vetiver For Water Eutrophication Control in Taihu Lake of China

Background of Taihu Lake Taihu Lake, one of the largest lakes in China is located at around N31.20' and E120.16' with a total area of 2,420 sq. km, total content for 4,870 million cubic meters, and inputted

Finally, there is a general reluctance amongst slope stabilization engineers to experiment with a method that relies upon natural processes to revegetate the bare slopes between hedges, one that if it fails may leave them financially liable. This fear to some degree applies even to hydroseeding and many engineers prefer to use "Chunam", a cement/clay mixture applied by pump to slopes as an almost dry plaster which immediately and effectively seals them. Aesthetic considerations do not enter into the equation.

However, there are significant areas distant from road access, where Vetiver can be used though erosion control has a much lower priority than in and near populated areas. In such areas the "traditional" approach has been to plant trees, in the past usually the local *Pinus massoniana,* now usually Acacias such as *A. confusa, A. mangium, A. auriculiformis.*

On some sites this has been reasonably successful though it usually takes 3-5 years for a closed canopy to form and even then it is clear that significant erosion continues. The architecture of Acacias is such that they initiate substantial stem-flow, certainly tens and possibly even hundreds of liters a day during rain. This results in local scouring. However, as the Acacia canopy closes, light levels at ground level clearly fall and this appears to reduce the ground cover often leaving only a thin litter of abscissed leaves. On steep slopes this readily washes downslope leaving the soil exposed to drip from the leaves and branches of the canopy. Work by Zhao in south China suggests that at high rainfall intensities drip is even more erosive than direct exposure to rain.

These considerations have led the author to persist with work on Vetiver hedges, especially on highly-eroded nutrient-poor substrates derived from weathered granite. These con-

flow of 195.0 cubic meters/sec., involving Jiangsu Province, Zhejiang Province, and Shanghai City. The Taihu Lake includes numerous smaller lakes, rivers, and channels. The Taihu region is a relatively developed area in the country with high population (986 persons/sq. km). Under subtropical climate, it has a mean temperature of 10∞ C and mean rainfall of 1,100-1,400 mm. With intensive land cultivation farmers harvest their crops 2 to 3 times a year under high chemical fertilizer input (N 345 kg/ha and P 18 kg/ha in average annually).

Water Eutrophication in Taihu Lake Based on the research in 1982-1990, the agricultural non-point nitrogen pollution in Taihu Lake was as high as 35,000 t N/yr, accounting for 25.20% of annual total N application, resulting in water eutrophication, while phosphor content and chemical oxygen consumption (COD) was relatively low. The water eutrophication is usually concentrated in the closed or semi-closed lakes and slow-flowing rivers (flow speed less than 1 m/min.), which account for about one third of the whole Taihu Lake. The eutrophication led to high content of N, P, and C elements in the water and nearby soils and resulted in rapid growth of blue algae, green algae, etc. Consequently, the algae blooms occurred while the water transparency and soluble oxygen content was declined, leading to the dead of many water living beings. In many places, a terrible smell was released from the water, influencing people's life.

Studies showed that in the period of 1981-1988, the content of NO3-N in the water of Taihu Lake was doubled. The content of NO3-N in the water of wells and rivers during dry seasons was increased, Ge Lake and Jiu Lake, the mean annual inorganic nitrogen content in the water was more than 0.25 mg/L, which was 2.5 times of national parameter of surface water. As a result, to control water eutrophication of Taihu Lake becomes a critical environmental issue in the region. ***Liyu Xu, Coordinator China Vetiver Network Email: lyxu@ns.issas.ac.cn***

Vetiver Grass For Water Eutrophication Control

Research indicated that vetiver cansurvive and grow well in wet land. It can grow much faster in the soil rich in nitrogen. Besides, vetiver has dramatic biomass up to 176,798 kg/ha to 353,596 kg/ha in 6 months (P.E. Lgbokwe, 1991) which can consume nitrogen considerably in the soil along the lake and in the area where water surface fluctuate seasonally. Because the high nitrogen content is more concentrated in the water near the banks of rivers and lakes, planting vetiver grass in wet land along rivers and around lakes can relief eutrophication problem as vetiver contains 0.44-0.68% crude protein and 0.068-0.076% P (R.D.Hill, 1992). The vetiver grass planted on banks and slopes along rivers and around lakes can reduce soil erosion caused by backwash generated by boat traffic. Besides, the grass will be harvested for pulp at a price of 80 Yuan RMB /ton dry matter (about USD10), which can increase farmers' income.

The research will include plot tests and in situ study and last 2 years supported by the Institute of Soil Science, Academia Sinica. ***Liyu Xu, Coordinator China Vetiver Network. lyxu@ns.issas.ac.cn***

Vetiver at China Super-way Conference

The China's national super-way conference titled Super-way Construction and Development Conference was held on 26-29 November 1998. The conference was organized by China Highway Engineering Society. The vetiver grass formed an important component of

the conference. During the conference the China Vetiver Network introduced the characteristics of the grass and the technology of applying the grass for highway embankment protection and erosion controlling along the highway slopes. Multiple vetiver publications were distributed. Typical examples of using vetiver for highway stabilization in Guangdong, Yunnan, Fujian Provinces were introduced. Grass samples and a set of photos were exhibited. The representative of CVN suggested that the environment should be one of the main parameters before the new road was checked and accepted, and mentioned that a proposed workshop on highway embankment protection and slope stabilization in 1999. More than 90 participants attended the conference coming from highway engineering institutions, universities, and construction companies through out China. Some detailed descriptions on the grass behavior and application in Yunnan Province was presented. During the conference, some participants went to AnNing to visit the demonstration site.

In the past, the highway institutions were used to protect the highway embankment with rocks or sometimes with short grass which usually could not stand long time. The grass generated great interests in the participants. The Highway Science Institute of Communications Ministry planned to establish a large demonstration for several dozens of kilometers. Many participants from northern China were also expressed to test vetiver.

The conference decided that the activities of China Highway Engineering Society will include three subjects: road surface, road embankment, and environment, in which the latter two subjects involving vetiver technology. Some participants said that the most impression issue from the conference was that they knew the miracle grass vetiver.

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Vetiver Research and Development -- Published

Vetiver Research and Development, a proceedings of the International Vetiver Workshop held in Fuzhou of China in October 1997 was published by Agricultural Science Tech Press of China in Beijing. It included 4 parts: General description, Growth behavior and utilization, Vetiver for soil conservation, Reproduction and perspective. There are altogether 37 articles, most of which were written by Chinese scientists and extensionists. It contain 200 pages with 86 tables, 39 figures, and 28 photos. The Proceedings was published in Chinese, and its English version is to be published when funds available. ***Liyu Xu, Coordinator China Vetiver Network Email: lyxu@ns.issas.ac.cn***

Vetiver in Agriworld

The miracle grass vetiver was distributed into Agriworld as one of the most important component of modern agriculture and forestry technology this spring in Suzhou of Jiansu Province of China. Over 10,000 tillers of vetiver planting materials were transported to and planted in the Agriworld in March 1998. After 5 months' the grass grew pretty well without any management. It could stand both dry and water logging. Now, the Agriworld is going to propagate the grass and as a modern technology to disseminate vetiver technology to the whole country.

The Agriworld is an abbreviation for Suzhou Future Agriculture and Forestry World supported by Singapore WBL Co., Ltd., which was situated on the east bank of Taihu Lake. With 3,000 Mu (200 hectares), the Agriworld is to demonstrate the most modern agricultural technology in the world to Chinese farmers and to analyze and introduce development tendency of agriculture into China. The Agriworld will help upgrade China's agriculture by collecting and providing scientific information and personnel, explore and design the direction of China's agricultural development, promote the exchange of international scientific and economic issues. ***Liyu Xu, Coordinator China Vetiver Network Email: lyxu@ns.issas.ac.cn***

Insects on Vetiver Hedges

Chen Shangwen (Guangxi University, Nanning, China 530001)

Summary. *Vetiveria zizanioides* (L.) Nash is a perennial plant. In order to conserve and also effect better usage of the natural resources of insects, the author carried out an investigation of insects on vetiver hedges, from March to November 1998 in Guangxi Province of China. The results showed as follows:

In 211 days of investigation, 1225 common species of insects were found in Nanning suburb of Guangxi Province, of these there were 79 species on vetiver hedges. These insects were came from 53 families of 13 orders. There were 14 species from Hymenoptera, 11 species from orthoptera, 10 from Diptera, 9 from Homoptera, 9 species from Lepidoptera, 9 from Coleoptera, 5 from Odonata, 4 from Hemiptera, 3 from Mantodea, 2 from Blattaria, 1 from Isoptera, 1 from Dermaptera, and 1 from Collembola.

Under the environmental conditions of Nanning of Guangxi Province of China vegetables and flowers are widely cultivated. Of 79 species of insects on Vetiver hedges, insects eating vetiver leaf in test tube are locust, snoutmoth, tussockmoth and leaf beetle. Owing to a tiny population density and limited amount eaten these insects did not cause negative effect on vetiver growth. On the contrary, beneficial predators

(total 30 species) were attracted to the vetiver hedges, such as mantids, dragonfly, ladybug etc. — all are important predator insects of garden, agriculture, and forestry pests. Therefore, the author suggests that when vetiver is introduced to a new environment it would be appropriate to practice integrated pest management (IPM). Due to the short time of survey, the above conclusion needs verification by further research. (Full paper on web site at **www.vetiver.org**)

The First Highway Vetiver Contract Implemented In China

The first contract on the highway embankment protection with vetiver was signed and implemented in Nanping of Fujian Province of China. During the International Vetiver Workshop held in Fuzhou of China in October 1997 Mr. Diti Hengchaovanich introduced the successful experience of using vetiver for engineering purpose. After that the China Vetiver Network (CVN) disseminated his experience to numerous institutions involving in highway, railway, mining, quarry, etc. through out the country. In August 1998, the directors of the highway bureaus in 10 counties or cities in Nanping Prefecture of Fujian Province held a meeting to discuss the possibility of using vetiver for highway protection. In the meeting the director of Jianyang City Highway Bureau introduced the results and experience of using vetiver for highway embankment stabilization and rice field protection in Jianyang, which was conducted in 1997/1998 by Mingbei Agricultural HighTech Institute. A mid-meeting tour was organized to visit the protection site. Then a decision was made to establish a large demonstration on the National highway of No.316 in the most critical section where the soil was extremely poor and re-vegetation failed. The directors and engineers considered that if this demonstration could be successful, there were no problem in other places and more highways will be protected by vetiver grass.

A contract was signed after the meeting on 26 August 1998 between Nanping Highway Bureau (Party A) and Mingbei Agricultural HighTech Institute (Party B). The followings are some main contents:

1) Party A and Party B realized that it was an excellent thing to use biological methods to protect highway and nearby farm fields, while vetiver would be the first consideration of the plant to be used.

2) The demonstration section would be on the national highway of No.316: k109 + 800, and K120 - k121, with total area for 10,000 sq. meter (the sloping area). Party A would provide Party B 5 Yuan RMB x 10,000 sq. meter = 50,000 Yuan RMB. Party B would be responsible for the planting of vetiver grass, which would be completed within the period from mid-September to early October 1998. Vetiver would be planted honey combed, spacing 2 x 0.2 m. Each hole (clump) would include 3 tillers or more. Other spices of short grasses would be planted in between. The survival rate of the planted grass would be 80% in the first year of 1998, and 95% in 1999 after replanting. The roots of vetiver would be at least 25 cm deep at the end of half year since planted and 50 cm one year since planted.

3) Payment: the 50 % of the total payment would paid when the grass was planted; 30% would be paid half year later; and 20% would be paid one year later since first planting.

4) Party B would not be responsible for the possible collapse or landslides. If it happened Party B would replant grass on the additional charges from Party A. Party A was responsible to keep animals and human away from possible damaging. ***Liyu Xu, Coordinator China Vetiver Network Email: lyxu@ns.issas.ac.cn***

Vetiver: An Authorized Grass For Highway Stabilization

An official document was prepared and released by Highway Bureau of Fujian Province of China on 8 July, 1998. The document fully approved the function of vetiver for highway embankment stabilization and asked all highway institutions, offices, and departments at county and prefecture level throughout the province to study vetiver technology and to use vetiver for highway stabilization and erosion control. The document requested all institutions to strengthen the exchange of ideas and experience in order to extend the grass throughout the province more rapidly.

There are 3 prefectures, 16 cities, and 54 counties in Fujian Province with a total area for over 120,000 sq. km. The Province is northeast of Taiwan with many mountains and hills accounting for more than 90% of total land area. There has been a rapid development of highway construction. For example, in Fujian Province 4,000 km of highways were built during the period of 1992 - 1996. The highways were usually constructed on the deeply weathered granite, from few meters to several dozens of meters deep, and were subject to soil erosion and collapse, leading to damaged highways and new soil erosion area along the highways. To protect highway engineers had to use rock and concrete for the critical sections of the road embankment. There are 2.6 million sq. meters of road embankment slopes that need to be protected in Fujian Province. However due to financial constraints, there was only a very small percentage of the slopes protected. Following the International Vetiver Workshop held in Fuzhou, the capital of Fujian Province, in October 1997, the vetiver technology was intro-

duced to the highway authority of the province. They realized that the Vetiver Grass Technology was a cheap and effective way for highway embankment stabilization. As an attachment, the document also included the article titled Vetiver Technology Application in Engineering Aspects which was translated from the paper written by Diti Hengchaovanich of Thailand. ***Liyu Xu, Coordinator China Vetiver Network***

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Study On Ecological Characteristics Of *Vetiveria Zizanioides*

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Abstract

Vetiver (*Vetiveria zizanioides*), a miracle grass, has been widely disseminated and applied around the globe due to the facts: 1) it has very high tolerance to adverse conditions; 2) it has an wide adaptation to climate and soil; 3) it has significant effects on: erosion control, polluted-environment mitigation, soil amelioration and so on. Over the past 14 years, scientists and researchers have carried out many studies on this unique plant and gained substantial achievements. On the basis of the past research, the author conducted further research on the species, and obtained the following results:

The experiment on leaf electrical conductivity showed that the resistance of three species of plants to adverse conditions, including drought, and high and low temperatures, was *V. zizanioides* > *Paspalum notatum* > *Alternanthera philoxeroides*. Especially when the period of stress was longer or the stress factors are stronger, the high resistance of *V. zizanioides* showed more prominently. As compared to *P. notatum* and *A. philoxeroides*, *V. zizanioides* had the characteristics of high-intensity and sustainability in respects of tolerance to extreme environments.

The three species had few or no distinct differences in their tolerance to salt when experimenting with in vitro leaf, whereas they presented an evident sequence of *V. zizanioides* > *A. philoxeroides* > *P. notatum* in this aspect when experimenting with seawater irrigation. Soil ECse values for 90% biomass yield of *V. zizanioides P. notatum* and *A. philoxeroides* were 6.40, 4.32, and 5.12 dS m^{-1} respectively, and those for half yield were 20.94, 11.45 and 16.17 dS m^{-1} respectively. *V. zizanioides* and *A. philoxeroides* were the tolerant group, and *P. notatum* was moderately tolerant, to salt. In sum, the three species were all relatively strong-resistant plants.

Effects of salinity on the growth of *V. zizanioides*, *A. philoxeroides* and *P. notatum* were quite conspicuous, and both Na^+ and Cl^- were probably the direct factors influencing their growth and development. Contents of Na^+ and Cl^- in plants, especially in shoots, increased with increasing level of salinity, and had negative correlation with leaf area, plant height, biomass. However, Na^+ and Cl^- did not substantially influence leaf photosynthetic pigments. Photosynthetic pigments increased as contents of plant Na^+ and Cl^- rose when the latter was relatively low, and reduced as contents of plant Na^+ and Cl^- rose when the latter in plants were relatively high, but their decreased scopes were much less than those of biomass. It is suggested that a reduction in photosynthesis could be due to feedback inhibition by high sugar concentrations in mesophyll cells resulted from high salt concentrations, but could not be limited directly by Na^+ or Cl.

Different plants have different salt-resistant mechanisms. *V. zizanioides* was characteristic of avoidance to salt, and kept a great part of salt, particularly Na^+, absorbed in the roots. The mechanism of salinity resistance in *A. philoxeroides* was increasing water content and diluting salt in tissues, and moreover it leaves seemed to become thicker, so it was characteristic of tolerance to salt. *P. notatum* had a huge capacity to salt, and probably it could exclude extra salt, through salt glands and through accelerating the death of old leaves, to resist salt harm and there was characteristic of secretion to salt in *P. notatum*.

The pollution caused from urban garbage and its leachate on the environment is becoming an increasingly prominent problem in the process of development of Guangzhou City. Wastewater leached from Likeng Life Garbage Landfill of Guangzhou contained high concentrations of pollutants, and did not reach the effluent standard, and therefore could be harmful to plants and surroundings. Of four plant species investigated in this study, *Eichhornia crassipes* was poisoned to death in two types of wastewater tested; *Paspalum notatum* could not survive in the high-concentrated leachate (HCL) and was severely damaged in the low-concentrated leachate (LCL); *Alternanthera philoxeroides* was impaired in HCL, too, but it formed a considerably large biomass in LCL, which was possibly due to the result that LCL may have efficiency of eutrophication; *Vetiveria zizanioides* was also damaged by the leachates, but was the least of the four species. The tolerance of the four species to garbage leachate was ranked as *V. zizanioides* > *A. philoxeroides* > *P. notatum* > *E. crassipes.*

Of the two species growing relatively better in wastewater, *A.*

philoxeroides on the whole was superior over *V. zizanioides* in purifying LCL, especially in purifying total N and nitrate N; but the effect of *V. zizanioides* in purifying seven kinds of "pollutants" of HCL were all better than that of *A. philoxeroides*, and furthermore the purification of P and COD in LCL by *V. zizanioides* was, too, better than by *A. philoxeroides*. Of all seven items measured in the study, ammoniac N was the best cleansed, and its purification rate was between 77%_89%. *V. zizanioides* showed a quite high purification rate for P, more than 74%. From the research, we suggest that *V. zizanioides* and *A. philoxeroides* could be used as purifying plants to assist in purifying the high and low concentrated garbage leachates respectively.

However, the amounts of purification by plants were absolutely unequal to the amounts of uptake by them; as a matter of fact, the latter accounted for only one limited part of the former, some 26%_73% for N, 88%_94% for P, and 33%_96% for Cl^-. Moreover, the ratio of the amount of uptake to the amount of original leachate was lower. This indicates that the main approach to remove wastes, with exception of uptake of roots, contains adsorption of roots, and subsidence, conglomeration, volatilization of elements, and influence of micro-animals and microorganisms in water, etc. In a word, the plant purification of waste water is in fact a comprehensive influence of the rhizospheric micro-ecosystem on pollutants.

Three plant growth retardants, B9, PP333, and CCC, all had influences on the growth, development, tiller formation and inflorescence of vetiver grass; but different kinds or concentrations of retardants produced distinctly different effects on the respects. The three medicaments all promoted tiller formation, up to 11% _52% or so in a growing season. 8 g L^{-1} B9 also retarded the growth of vetiver by 6%, delayed flowering for nearly 10 days, and reduced the number of inflorescence significantly by 80% at the same time, as compared to the control; but 4 g L^{-1} B9 hardly retarded the growth and flowering except that it, too, reduced the number of inflorescence, up to 50%. However, PP333 with concentrations of 0.6 and 1.2 g L^{-1}, and CCC with 1.0 and 2.5 ml L^{-1} all promoted the growth of vetiver, up to 5%_22% or so; and furthermore, the treatment of 1.2 g L^{-1} PP333 also enhanced inflorescence by 31%, and 0.6 g L^{-1} PP333 promoted flowering 4 days earlier than CK did. The results above-mentioned indicate that B9, as the retardant of vetiver, had better effects than PP333 and CCC. The reason why B9 had relatively better effects resulted probably from its relatively higher applying concentrations, which not only increased the cost, but produced environment pollution as well.

This field trial showed that impacts of the plant growth retardants on vetiver were obviously different from on most crops, which is most likely that vetiver has strong resistance and accordingly the retardants do not produce clear influence on it. In sum the plant growth retardants can efficiently promote the tiller production of *V. zizanioides*, but cannot dwarf it effectively. Therefore it is necessary, also meaningful, to seek new vetiver dwarfing mechanisms or methods, such as gene mutation.

Highway slippage not only blocks the traffic, but also endangers the safety of lives. The general way for inhibiting slippage is to take stone-based projects, which not only is expensive, but also has quite limited eco-benefits. The Vetiver Eco-engineering was applied in South China for the first time to control landslides and protect highways. Vetiver planted in slopes of highways, under some cultivation and management measures, grew rapidly and luxuriantly and formed dense hedgerows. These appropriate cultivation and management measures include planting along the contour, reasonable spacing, applying fertilizer, especially basal manure, etc.; irrigation is not necessary if the Eco-engineering is conducted in rainy season. The Vetiver Eco-engineering is quite effective for stabilization of slopes and embankments, and furthermore it costs no more 18% than the stone-based technique does. Other species in the Vetiver Eco-engineering, including trees, shrubs, herbs and vines also aided vetiver to mitigate runoff, inhibit erosion, stabilize slope as well as afforest and beautify highways. In a word, the application of the Vetiver Eco-engineering in roadcut and embankment protection produced quite good ecological, social and economic benefits, which indicates that the Eco-engineering will have a broad application perspective.

Plantings of vetiver plus local species of trees, shrubs, herbs and lianas with strong resistance and adaptability, and supported by simple engineering structures where necessary, form "The Vetiver Eco-engineering". All experiments and applications conducted in highways, including the Conghua section of China National Highway No. 105, Tianluhu section of Guangzhou First-Ring Highway and Huadu section of CNH No. 106 have indicated that the Vetiver Eco-engineering provides better ecological effectiveness in respects of slope stabilization, environment mitigation, beautification and the like than just vetiver planted alone. Therefore, it is suggested that the term Vetiver Hedgerow Technique should be substituted with the Vetiver Eco-engineering.

It is generally believed that vetiver grass is native to India and the cultigen domesticated in China was introduced from India and Indonesia in the middle 1950's. However, there have been natural distributions of wild vetiver all long in Guangdong

and Hainan of China. Particularly in the 1950's, a total area of up to 6670 hm^2 natural vetiver community was found in Wuchuan County, Guangdong. This tropical grassland, however, has been severely destroyed due to the effects of human activities and the excessive utilization, which has been rapidly dwindled over the last 40 years. Therefore, it is very meaningful, and also urgent, to protect the vetiver wetland through demarcating a reserve *in situ*. This would not only efficiently protect bio-resources and biodiversity, but would also offer an ideal basis for conducting research on vetiver and tropical wetland in South China.

Vetiver from the Wuchuan Wetland had been regarded as *V. nigritana* during the past 40 years. The specimen study in the paper, however, indicates that it is *V. zizanioides*, not *V.* nig*ritana* or other species. But then it has already prominent differences with the cultigen in aspects of growing habit and genetic feature, so it has become another completely different ecotype or genotype.

There have been poorly documented about the origin and genealogy of vetiver, and the taxonomic system the genus *Vetiveria*, currently, is far from consummate, so the basic research in this area should continue. In addition, there is also lots of work to do in aspects of vetiver's biodiversity and the preservation and utilization of its germplasm.

On the whole, *V. zizanioides* is an indeed excellent species with reference to its resistance to adverse circumstances, and its ability to alleviate polluted-environments and inhibit soil erosion and runoff.

China Vetiver Network (CVN) Annual Report (1998)

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The year 1998 is an unusual year for vetiver technology development and dissemination through out China. In 1998, the CVN's work focused on the following points: the continuation of vetiver technology dissemination to most of the provinces in southern China. Many new applications were tested, such as the uses of vetiver for vegetation recover on sandy dune in Poyang Lake area, recovery of copper mines, and vetiver for river bank stabilization. More and more institutions were involved in vetiver tests and application. However, one of the most inspiring issues is that the grass has given deep impression to engineers who are working in highway and railway institutions, as they realized that the grass could be economically and effectively used for highway and railway embankment stabilization.

Information dissemination. Although many thousands of copies of vetiver publications were released countrywide in the past few years, is still a strong demand for vetiver information dissemination. As a large agricultural country, there are thousands of research institutions at from national to provincial to prefectural level. Besides, there are many thousands of extension stations at county and township level involving agriculture, forestry, soil and fertilizer, soil and water conservation, etc. Besides, there are also thousands of institutions involving in engineering subjects and also ecology and environment. Therefore, information dissemination should be a top item in a long term.

In 1998, we continued to publish and distribute the following publications:

- Vetiver Newsletter in Chinese, 4 issues, totaling 4500 copies were disseminated.
- Vetiver Fact Sheets, 4 issues totaling 8000 copies that introduced substantial technology to extension stations were mainly distributed to county extension stations.
- Agroforestry Today. A quarterly journal in Chinese published for 6 years, in which vetiver grass technology is a major component. The average circulation remained around 1000 copies.

Besides, Vetiver Research and Development, a Proceedings of International Vetiver Workshop (Fuzhou, 1997) with over 200 pages, was published in Chinese by Agricultural Science Tech Press of China.

In 1998, CVN also introduced vetiver through other multiple national or regional communication mediums, such as:

- Chinese Journal of Ecology,
- Soil and Water Conservation,
- Soil Science,
- Soil and Water Conservation in Fujian,
- Science of Jiangxi Province,
- Resources and Environment in the Yangtze Valley,
- Reference Information,
- Huangshan Daily.

To disseminate vetiver technology, multiple meetings and training courses were organized, co-organized, or participated by CVN and its members, such as:

- South China Soil and Water Conservation Meeting (Xiamen),
- Soil Erosion and Conservation Workshop (Jiangxi),
- Vetiver Network Meeting of Fujian Province,
- Yangtze River Flooding and Soil Conservation (Wuhan),
- Sustainable Agriculture in Yangtze River Basin (Nanjing),
- Vetiver for Edible Fungi Cultivation (Fuzhou),
- One-day Training Courses in Fujian and Anhui Provinces, etc.

Vetiver introduced to highway institutions. During the International Vetiver Workshop, organized in Fuzhou, October 1997, Mr. Diti Hengchaovanich of Thailand introduced vetiver application in engineering aspects, which generated high interests in participants. Most of them realized that there is a great potential for vetiver in highway and railway construction and maintenance. Because there has been a rapid development of highway and railway construction in China vetiver could play an important role in the embankment stabilization and controlling the erosion caused by road construction. As a result, since the beginning of this year, we decided to introduce vetiver technology to highway institutions, representing the engineering field, andwas divided the process into three steps:

- disseminatation of vetiver information to highway and railway institutions;
- designing and establishing large demonstrations showing how the grass can stabilize highway embankments and protect farm land from erosion and sediments adjacent to the roads, and the demonstration of methods of proper application of the technology.
- organizing a conference, in cooperation with national highway research institute and highway bureau to show engineers the examples.

To achieve this target, multiple measures were taken by CVN and its friendly members throughout the country:

CVN translated the article on vetiver grass in engineering application written by Diti Hengchaovanich into Chinese and distributed to 1200 highway institutions via our Vetiver Newsletter.

- In cooperation with experts and engineers from Highway Bureau of Jiangsu Province, and Survey and Design Academy of Communications of Jiangsu Province, we prepared articles to introduce vetiver and its application in highway aspects. These articles were published in several highway journals as:

- The Journal of Jiangsu Provincial Highway Society
- The Journal of Guangdong Provincial Highway Society
- The Journal of East China Highways
- Science and Technology of Communications of Zhejiang Province (to be published)
- CVN introduced vetiver at several regional and national highway conferences, such as East China Highway Conference in Xiamen in June 1998, National Superway Conference in Kunming in November 1998.

Following the above information dissemination many engineers started to accept and test the grass. Again, just like the wide application of vetiver for erosion control, riverbank stabilization, sandy dune fixing in Fujian Province, the Fujian Highway Bureau acted as a pioneer to accept the grass for highway embankment stabilization. On 8 July 1998, the Highway Bureau formally issued a document to ask all highway institutions through out the province to use the grass to protect the embankments. So, Fujian Province became the first to authorize vetiver as a grass for highway stabilization in China, and possibly in the world.

Following Fujian Province, the highway bureaus of Jiangxi Province, Zhejiang Province, and Hubei Province are also testing vetiver on different level highways and in different area.

Demonstration of vetiver for highway embankment stabilization and paddy field protection was established in Jianyang County of Fujian Province in 1997 and enlarged in 1998. A large demonstration is to be established in Fujian by Ms. Zhangjing of CVN and Fujian Highway Bureau. During the East China Highway Conference held in Xiamen in June 1998, a special national highway conference titled Vetiver for Highway Embankment Protection and Slope Stabilization was proposed to be held later 1999 in Fuzhou in cooperation with national highway research institute and Fujian Highway Bureau. Looking is better than hearing. The conference participants will watch demonstration, exchange information, and then distribute vetiver technology more widely in highway field though out the country. Although agriculture and engineering were two independent kingdoms here in China, we are very pleased to see that vetiver enabled scientists and engineers to join together for solving a same problem soil erosion control and slope land stabilization, although it is only an initiation.

New applications and new users. The International Vetiver Workshop held last year familiarized more people with the grass. In order to support more person to test and use vetiver we released mini-grants. There were total mini-grants for US$ 10,375 distributed to 17 recipients in 7 provinces in 1998. In addition, CVN organized one million planting materials during the spring of 1998 and transported to 14 institutions in 9 provinces free of charge. All of these encouraged more scientists and technicians to test and use the grass. So far most of the recipients sent us feedback and used the mini-grants and/or planting materials very effectively and successfully. As most of the recipients were those who did not know or did not see the grass before, the first thing they did when they had received planting materials was to establish nursery for reproduction. Also, there were some recipients who arranged and conducted various tests or experiments with limited and valuable planting materials and re-distributed

planting materials to their neighboring institutions. The followings are the short description of new applications:

Fujian Province. Ten hectares of demonstrations were established on saline sandy soils of Pingtan Island aimed at using vetiver to improve soil property and reduce salt contents. Meanwhile, the grass was planted as living fence along home gardens and roads to relieve harmful effect of wind /sandy storm to the village. The prunings were used as fodder.

In addition to a small demonstration for 4 km for highway stabilization and 100 ha for slope tea and fruit tree protection in Jianyang County, in cooperation with Fujian Highway Bureau, three sections of highways with different construction standard were selected as large demonstration sites based on a joint field survey. A 10 ha nursery was established to provide high quality planting materials. The latter is very important for highway embankment stabilization because the condition along most highways is usually bad, particularly where the soil nutrients are poor and moisture retention is limited, and usually contains harmful chemicals. As a result, the planting materials should be of high quality and planted carefully.

Following the International Vetiver Workshop, the Fujian Provincial Vetiver Network was established in November 1997 aiming at information exchanging, allocating planting materials, coordinating different institutions involving in agriculture, forestry, highway construction and maintenance, mining, etc.

Guangdong Province. Several new nurseries were established which can provide millions of planting materials for the year 1999. The grass was planted in coastal islands to fix sandy dune. The tests indicated that grass was much better than the traditional tree belt wood (Casuarina equisetifolia L.). A demonstration of using vetiver for highway stabilization was implemented at the national highway No.106 near Guangzhou where the cut was 26 m high with 50 m of slope. More research was conducted on the effect of salt on vetiver; vetiver nanization with growth regulator; vetiver propagation with tissue cultivation.

Additionally, supported by National Natural Science Foundation, a new project is to be launched, studying the effect of heavy metal elements on vetiver in order to use vetiver to ameliorate metal mine wastes.

Hubei Province. In Hubei Province which is situated in central China and suffered from serious flooding in 1998, the grass was tested in three places: Luotian County, Huanggang City, and Machen City. All of these places belong to Poverty Area of the Dabie Mountain where soil erosion was proved to be serious. In Luotian County, the Huanggang Prefectural Soil and Water Conservation Institute established a nursery on the terrace. The grass grew extremely well. It was over 3 m high after 6 month's growth. Besides, the grass was also planted on the edges of the terraces. Unfortunately most of them were only around 40 cm high caused by repeated grazing of cattle and goat. It seems that these animals were fond of eating vetiver especially when it was young. Even the 6-month old grass cut from the nursery still attracted the goat. Hence, in sub-tropical area where there were less species of grass for animals, vetiver could be a prospective source of fodder.

In Huanggang City, the grass was successfully used to protect the new terrace that was 1 m deep and 4.5 m wide in average. Although it was only 6 months since it had been planted after long distance transportation by train for over 20 days, it is quite evident that the grass experienced a very good example for soil erosion control, especially where soil was deeply disturbed such as newly established terraces.

In Machen City, the Soil and Water Conservation Station of Machen City established a demonstration. The grass was contour-planted on river banks consisting of pure white sands where there was very little water and nutrients. They all grew well and exerted as a pioneer plant for vegetation recovery. Even though cattle repeatedly grazed vetiver it grew much better than local wild weeds. There is a long distance of river bank in the city, i.e., 280 km, most of which consisted of white sands subject to breaching during the flooding season.

All of these tests showed that the grass had high survival rate even after long distances and long time transportation. The only problem is that they had fewer tillers (about 1:10-1:50) than that in Fujian Province (1: 80) as all of the planters did not prune the grass because they worried that pruning might be harmful to vetiver. All of the planters will enlarge their planting area and distribute the grass to their neighboring area in next spring. There were more than a dozen of counties in Hubei Province of Dabie Mountains visited the vetiver plots and asked for planting materials for testing.

Jiangxi Province. In Jiangxi Province, the grass was planted on sandy dunes formed by the river in order to establish an example for desertification control in sub-tropical China. The grass was planted in lines with a space of 5 m between rows. The groundwater table was high but the soil was short of nutrients. Therefore, agricultural production there became impossible. Further more, there was an obvious tendency that the desertification is accelerating. Although the height of most of the grass was around one meter after one growing season, evidently the grass played an impor-

tant role in dune stabilization and the vegetation recovering. Since vetiver planted more grasses were found on the plots than the control. That is vetiver helped other grasses to grow on the barren land.

Another inspiring issue was that there was an excellent demonstration of using the grass for embankment stabilization at the highway of Nanchang-Jiujiang, where the slope was about 10 m high in which the lower 2 m was protected by stone and the remainder protected with honey combed grass.

Chongqing Municipality.
Chongqing Municipality is situated at the upper reaches of the Yangtze River, belonging to the Three Gorges area. Accordingly, soil conservation became a critical issue to reduce the harmful effect of sediments to the dam and to diminish the losses caused by heavy flooding in the lower reaches. Supported by local government vetiver was introduced to the area, to have been used as pioneer plant for afforestation, controlling new soil erosion caused by resettlement of immigration, and retaining sediments on lower land.

Since the establishment of the Municipality highways have been constructed on a large scale in the Three Gorge area. However, most of the highways were along migrating rivers and a lot of soil and rock fall into the river and caused further risk of slope collapse and point erosion. Vetiver was selected as a priority species for vegetation recovery and slope stabilization. The Fuling Forestry Institute has actively involved in the coordination of vetiver technology development in this area.

Shanghai Municipality. In Shanghai, vetiver was introduced and experimented by Shanghai Agricultural Academy starting from the spring 1998. They received planting materials from Jiangxi Province and also from Mr. Diti in Malaysia.

Eleven tillers from Malaysia was planted and grown in green house from 17 February to 9 April. The tillering was 1:1.8 and the height was 15 cm in average at the end of this period. Then the grass was removed outside the greenhouse. Observation on 22 May indicated that survival rate was only 60% with 12 cm high. But later it grew as well as the vetiver from Jiangxi, except that it was shorter. It remains to be known that if they can withstand winters in Shanghai.

The planting materials from Jiangxi were tested at several sites with different living conditions: nursery, river bank, pots, and orchards on slope land of Zhejiang Province. General speaking vetiver grew well at all of these sites, it could compete successfully with local weeds, and could withstand drought and waterlogging. They produced fewer tillers (from 1:8 to 1:20) compared with that in Fujian Province. In the coming year of 1999, the grass will be planted in a larger scale for Shuzhou River management and garbage yard covering, depending on the quantity of planting materials.

Jiangsu Province. The miracle grass vetiver was distributed into Agriworld as one of the most important component of modern agriculture and forestry technology this spring in Suzhou. Over 10,000 tillers of vetiver planting materials were transported to and planted in the Agriworld in March 1998. After 5 months the grass grew pretty well without any management. It could stand both drought and waterlogging. Now, Agriworld is going to propagate the grass and as a modern technology to disseminate vetiver technology to the whole China through its information service system.

The Agriworld is an abbreviation for Suzhou Future Agriculture and Forestry World supported by Singapore WBL Co., Ltd., and is situated on the east bank of Taihu Lake. Comprising 3,000 Mu (200 hectares), Agriworld will demonstrate the most modern agricultural technology in the world to Chinese farmers and will analyze and introduce development tendency of agriculture into China. The Agriworld will help upgrade China's agriculture by collecting and providing scientific information and personnel, explore and design the direction of China's agricultural development, promote the exchange of international scientific and economic issues.

Besides, multiple tests and experiments have been implemented in Jiangsu Province:

- Vetiver was tested for wet land utilization in Wuxi City by the Limnology Institute of Academia Sinica.
- Supported by Director's Foundation of Soil Science Institute of Academia Sinica, vetiver was to be used for eutrophication control in Taihu Lake.
- Pot test was conducted in Nanjing for vegetation recovery of copper mine wastes.

Guangxi Province. In Guangxi Province, vetiver was mainly introduced and tested by Guangxi University and the Science Bureau of Du'an County. The grass was planted in nursery and water reservoir area. The experience from Du'an confirmed that the grass could withstand serious drought and long term waterlogging. The grass was planted on 1 April 1998. There was heavy water logging on three occasions: from 11 to 16 May with water depth for 50 cm above ground surface; from 23 to 30 June for 80 cm; and from 25 July to 5 August for 150 cm deep. Later, since1 September there was a long period of drought for 2 months. Investigations at the end of October showed that vetiver still grew well with 2 m high, while the elephant grass which was planted at the same time died

during the first waterlogging. As a result, the county leader planted to develop a larger nursery in 1999 to produce more planting materials in order that the grass can be planted on a large scale in the year of 2000.

It is worth emphasizing that Du'an is national poverty county and they planted the grass with their own tight budget. Some other poverty counties, such as Bama County, are also searched for planting materials for the application with their own money, because more government leaders realize that soil erosion could threaten their economy and aggravate their poverty, especially after the heavy flooding in the Yangtze River Basin in 1998.

The scientists in Guangxi University studied the effect of various factors on the growth of the grass, that includes: soils with different pH, fertility, organic matter, etc., different treatments before planting, sunshine and shading, temperature and moisture. Their study showed that pruning at a height of 5 cm above ground surface promoted the growth of the grass, while the shoots of unpruned grass began to turn yellow when observed on 9 November.

Moreover, vetiver exhibition was organized by Forestry Department to introduce the grass to students and colleagues during the 70th anniversary celebration of the university.

Anhui Province. In addition to Yuexi County in Dabie Mountain where the grass was introduced and extended in 1996, vetiver was introduced to Xi County, as a reproduction base. The county is situated in Huangshan Mountain area, a famous tourist site, and the grass is to be used for slope stabilization, reservoir protection, and highway stabilization in the region. It was implemented by an NGO called Ever Green Charity Society.

As we did in Fujian Province, one-day training courses were organized in several townships. Participants included master farmers and technicians, government officials and leaders from townships and counties as well. Meanwhile, small group discussions (from village to village and even from family to family), were held by CVN members, local technicians, and also government leaders, with the objective of disseminating vetiver technology and to listen to farmers' comments and suggestions.

Yunnan Province. Directed by Insect Resources Institute of Chinese Academy of Forestry, vetiver was introduced and planted in several cities or counties, such as Chuxiong City, Yuanmo County, Yuanjiang County, and Jingdong County. They established nurseries and implemented some experiments with very valuable planting materials for slope stabilization of waste mountain in the hot and dry valley, riverbank protection, and highway embankment protection. They also cultivated seedlings in paper bags for vegetation recovery in the extremely hot and dry slopes. Again, all of this work was done at their own expense except for the granted planting materials.

Other Provinces. In addition to the provinces described above, institutions in other provinces also showed great enthusiasm in testing and introducing vetiver, such as Hebei Province, Tianjing Municipality in Shangdong Province, the grass became a top subject of research and extension by agricultural institutions.

To sum up, the year 1998 was a great year for vetiver technology dissemination and development throughout China. More institutions, disciplines, and regions were involved in the technology. Many scientists and institutions promoted the development with their own funds.

Jiji sao: a grass for soil conservation in cold and dry areas. In 1998 three field investigations were carried out in Loess Plateau area involving 12 counties in 4 provinces in order to study the possibility of using jiji sao *(Achnatherum splendens*) as a 'cold vetiver' for the extremely dry and cold area. Mr. Grimshaw led the first investigation in May. Through field investigations and discussion with villagers we realized that jiji sao was similar to vetiver but tolerant to extreme drought and cold:

- Its natural habitat is the saline soils in northwest China such as Inner Mongolia, Ningxia, Xinjiang Provinces. When planted on upland soils (such as the Loess soils) it grows extremely well.
- Like vetiver it also belongs to Gramineae, some farmers in northern Shanxi use it to stabilize the vertical cuts made in the hill slopes above their houses to prevent slippage and damage to the house.
- The grass has strong, deep (at least 3 meters), and profuse roots.
- It is completely drought proof, and withstands extreme cold.
- It has good longevity and is usually propagated vegetatively by plant division and is not invasive.
- The grass was used also to feed animals with young leaves, to make basket, broom, mattress, rope, curtain, shed roof cover, and medicine. And also, it was used for pulp purpose and for highway stabilization as we saw in Inner Mongolia.

The jiji sao appears to have many similarities to vetiver grass, although there are some very distinct differences, including a less dense and weaker leaf system. However there are enough similarities, as well as farmer experience and knowledge, to suggest that jiji sao could be key to long term embankment stabilization (terrace, dams, and roads) in north China and other similar areas in the world if planted as a closely spaced in line hedgerows across the slope of embankments, just as has

been widely proven for vetiver. It also may well be possible to use it as an effective contour hedgerow on unterraced sloping land. The China Vetiver Network's newsletters included information on jiji sao. Some experiments were arranged in Ningxia Province on Loess Plateau. Demonstration was established in cooperation with county or township extension stations in Shanxi Province.

Improvement and promotion in 1999. All of the tests implemented in 1998 showed that the grass had high survival rate even after long distance transportation. It can tolerant various conditions. We have not got any report on insects or disease induced from vetiver so far. The grass in most of the planting provinces could flower but could not produce ripe seeds. Generally, the grass had fewer tillers in northern provinces than that in Fujian Province possibly caused by less rainfall and lower temperature. Almost all of the new planters did not prune the grass during the growing season because they worried that pruning might be harmful to the newly planted vetiver. Due to the lack of planting materials, in some places the grass was planted with too much space between clumps, which resulted in an ineffective hedge and subsequent erosion.

The experience showed that more institutions were involved in vetiver technology extension. Especially, we were very pleased to see engineers are being interested in the grass. Many new users applied the grass on their own expenses, including the institutions from poverty counties. As a result, in the year 1999, we are planning to distribute more planting materials free of charge to new users and then to establish awards for successful users, in stead of distribution of minigrants.

In China, the construction of highway forms the major component of economic development and was deemed as a key channel for poverty alleviation. The total length of highway increased from 1,118,000 km in 1994 to1,186,000 km in 1996. The annual increase reached 34,000 km. However, caused by financial limitation many highway embankments were not properly protected and subject to destruction, resulting in frequent re-construction and burdensome maintenance.

Furthermore, unprotected highways not only caused big problems in transportation but also influenced agricultural production and environment. The construction of highway often leads to accelerated run-off, new soil erosion, increasing sediments and land collapse in a considerable area outside road, dozens of meters wide as usual on both sides of highway. Friable road embankments formed serious point sources of erosion, that created major problems further down in the catchment area. Sediments from eroding highway embankments bury each year farmlands and crops.

A workshop on vetiver for highway embankment protection and slope stabilization is proposed to be held in October 1999 in order to show engineers the demonstrations, and to disseminate the technology more widely to highway, railway, and other engineering institutions.
In 1999, a comprehensive research will be started on the Loess Plateau to investigate the "COLD VETIVER" — jiji sao:

- effect of jiji sao hedges on run off and sediments (amount and nutrients)
- effect of jiji sao hedges on the intercropped crops
- ecological change of surface soil layer and micro climate
- growth behavior of jiji sao under different water, pH, soil, fertility, and landform

Demonstrations, training, and small workshops will be organized. However, as we did in the past years, the top task will still be information dissemination at a national level to let more people be familiar with and to encourage the use of the grass.

EUROPE AND THE MEDITERRANEAN

Status Report - European And Mediterranean Region, The Vetiver Network (EMVN) - April-November 1998

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Overview Since the last EMVN Status Report the majority of activity in the region has occurred in Portugal. It is very much hoped that on the next occasion there will be more to report from other countries within the region where interest and positive responses have been expressed, but not yet brought to fruition through research or field application activities.

Visit of Dr. Paul Truong Paul and Julie Truong visited Portugal and Spain between September 9-18, which gave a considerable boost to our activities. Paul spoke at two well attended seminars/field days in the Algarve and also visited a number of locations where vetiver was established in March 1998. These included those of a non-government organization concerned with the protection of a sensitive mountain region (Serra de Monchique) which has suffered considerable erosion in recent years. He also visited Antonio Vasco de Mello's property in Central Portugal (39ºN) where vetiver is thriving, having been established in April 1996. Paul was also able to appreciate some of Portugal's soil erosion problems particularly in regard to the need to stabilize cliff-tops and protect disturbed soils along engineered structures, notably highways and dams. His visit, which was reported in the

press, stimulated interest in the potential of Vetiver Grass Technology to address critical aspects of soil erosion and soil stabilization in this part of Europe. As a result we are now initiating action towards making a further importation of 1 cu. meter planting material in March 1999 to meet the increased demand. In Spain, Paul met with Dr. Tíscar Espigares of the Universidade de Alcalá de Henares, near Madrid who accompanied us to view vetiver planting activities in the harsh climatic and pedologic conditions near Lorca, Murcia region where vetiver was established some 4 years ago. Engº Diego Frutos, the responsible agricultural technician, was an enthusiastic and excellent host who sees considerable potential for VGT as a stabilizer of engineered structures in this part of Spain. Drip irrigation ceased for the hedges at Lorca in about March 1997 but they are nevertheless performing well in a 250mm environment, protecting the steep banks of an access road leading to a reservoir. Control blocks on either side of these plantings show severe erosion and gullying.

Conclusions arising from Dr. Truong's Visit My personal conclusions or lessons learnt out of Paul's visit were as follows:

- In Southern Europe it is likely that we should give primary focus to agro-engineering uses of VGT ahead of agro and forestry uses. Findings in China and Australia, for example, indicate that VGT when applied to such structures as highway embankments and cuttings are some ten times cheaper than classical engineered approaches. Thus, in drier parts of Europe drip irrigation of vetiver hedges established along highway embankments would still be considerably cheaper, more permanent and more environmentally friendly than an engineered alternative. Under such circumstances, irrigation would be critical and justified in the drier areas (say 300-700mm p.a.) to ensure rapid and effective establishment and long-term continuity.
- Paul places considerable emphasis on periodic application of inorganic fertilizer—diammonium phosphate) to ensure vigorous and continued field hedge growth and we would follow this practice.
- Hitherto, for the Region, I have recommended maintenance trimming of field plants (to say 40cm) at least once per year to stimulate tillering and root growth. Paul advises that whilst desirable, this is not strictly necessary. This can be important for doubters of the technology who would otherwise be concerned regarding annual maintenance costs.
- In Southern Europe our climatic conditions provide us with tighter margins of planting times than in the tropics. I feel, therefore, that stimulating early establishment could be of particular importance in EMVN where the emphasis will be primarily on agro-engineering uses of VGT. During Paul's visit we put together a paper summarizing four techniques for aiding early establishment with contributions from Paul, Dick Grimshaw and Criss Juliard. These are described elsewhere and include: manure-tea; sand pots; strip production and individual pots.

March '98 Plantings Reports and observations of the plants that were imported from Zimbabwe in March, and which were established in 14 locations ranging from the Açores to Southern Spain, indicate that the majority of plants are now well established and subdivisions have been successfully carried out. By Spring of 1999 there should be a good plant resource base in Southern Portugal and a steadily increasing knowledge as to vetiver's performance or limitations in Southern Europe.

DNA Analysis Program Under the overall coordination of Dr. Paul Adams of Baylor University, Texas, the following accessions were obtained from Spain (ex Dr. Juan Tasias and Engº Diego Frutos) and are being multiplied in the Coordinators nursery: Malaysian, Sabak Bantar, Parit Buntar, Sabah and Karnataka. The program will be expanded considerably with the receipt of some 13 further accessions from Bob Adams that will be established under professional management in a commercial nursery located in the Eastern Algarve.

Northerly Limits of Vetiver Establishment Contact has only recently been established with growers of vetiver in the Piedmont Region of Northern Italy. Vetiver was apparently established in 1997 and some 3,000 plants are doing well at 45º 20' N at Vercelli which is about equidistant between Torino and Milano. This may be the most northerly latitude at which vetiver has been established and we will monitor its future performance with considerable interest. It is early days yet and 1997/98 was a warmer than usual winter in Northern Italy. Encouragingly, reports from Albania indicate that the vetiver that was established at about 40º N some two years ago is doing fine.

***Achnatherum splendens* (jiji sao)** The above comments on latitudinal/climatic limitations to the establishment of vetiver are particularly pertinent to our European conditions. We are therefore taking considerable interest in the possible application of jiji sao within EMVN at latitudes and climates where basic temperatures are too cold for vetiver's survival. We are liaising closely on this matter with Professor Liyu Xu and wish to identify research bodies in Europe that might be interested in examining the potential of this relatively unknown plant as a vegetative means of soil conservation and soil stabilization under European conditions. There is also the possibility of a joint Sino-European

exercise to examine the potential or limitations of this grass in much greater detail.

Use of VGT in Cyprus and Gibraltar EMVN has provided advice to an engineering consultancy firm, Allot & Lomax of Sale, Manchester on the use of VGT relative to a large, steep and complex hillside that surrounds a proposed power station project in Cyprus. This may be typical of the agro-engineering projects which could employ VGT effectively in the EMVN region. In similar vein, EMVN has drawn the attention of the Ministry of Defence UK to the possibility of using VGT in stabilizing the Eastern face of the Rock of Gibraltar which is currently being decommissioned as a water catchment area and which the Government of Gibraltar in association with the MOD proposes to be vegetatively rehabilitated.

Registration of EMVN The Deed registering EMVN as an official body in Portugal was signed in November by six founding members coming from Albania (2), Germany (1), Portugal (1), Spain (1) and United Kingdom (1). TVN funded this formality which formalizes EMVN as an European-based body. Whilst the informational and reporting links to TVN remain as before there is now financial and organizational responsibility within Europe. It is hoped that this action will strengthen the position of EMVN in its upcoming application to the EC for finance covering the period 1999-2001 or to other European-based funding bodies.

Lectures During the review period lectures supported with slides were given to Universities in Spain and England.

The Vetiver Network needs your funding support in order to continue producing newsletters like this one. Please send your donations to The Vetiver Network, 15 Wirt Street NW, Leesburg Virginia.

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INDONESIA

Cultural Practices for Soil ErosionControl on Cassava based Cropping Systems in Indonesia

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ABSTRACT
About 1.3 million hectares of cassava harvested area in Indonesia are located in sloping marginal - upland, where soil erosion is a serious problem. Alfisol is the dominant soil for cassava cultivation. Cassava cultivated in sloping land could resulted a severe erosion if it is not properly managed. Study on the effect of different cultural practices on erosion and yield of cassava was conducted on Alfisol with about 15% slope in East Java during the rainy season 1996/1997. Twelve cultural practices were tested, using 12 m long and 3 m wide plot for each treatment. A channel was made below each plot and covered by plastic sheet to collect eroded soil. The eroded soil was weighed every month and the crop yield was recorded at harvest time. Trial on the effect of potassium fertilizer on cassava yield was also carried out closed to the above trial. Five fertilizer treatments were studied to determine the role of potassium in increasing yield of cassava. Results showed that farmers' practice with "up and down ridging" gave the highest cassava yield (18.6 t/ha), but produced high level of erosion (11.8 t/ha) compared to other treatments. Staggered mounds for cassava cultivation that is mostly practiced by other farmers also produced high level of erosion (8.3 t/ha). When contour ridging was prepared before planting, the soil losses due to erosion were similar to the above system (9.0 t/ha). Combination of contour ridging with elephant grass (Pennisetum purpureum) hedgerows or vetiver (Vetiveria zizanioides (Linn) (Nash) hedgerows in every 4 meters produced the lowest level of soil erosion> (7.3 t/ha) and good cassava yield (13.4 t/ha). Lemon grass (Cymbapogon sp.) could be used as an alternative of hedgerows, however, vetiver was the most tolerant to drought compared to the other grasses. On the other side, gliricidia (Gliricidea maculata), Flemingia (Flemingia sp.), Leucaena (Leucaena leucocephala), or Caliandra (Calyandra callothyrsus) hedgerows produced higher level of soil erosion (9 -10 t/ha) compared to elephant and vetiver hedgerows. It can be concluded that contour ridging combined with elephant or vetiver grass hedgerows could be recommended for planting cassava since this practice reduced soil erosion as well as gave a good cassava yield. Potassium application for up to 200 kg KCl/ha linearly increased cassava yield, and indi-

rectly would reduced soil loss due toerosion. Alternative materials which are cheaper than KCl and available locally should be identified, since this fertilizer now is too expensive for farmer.

MEXICO

Program for Erosion Control and Restoration of the Soils of Oaxaca (PCERS) on behalf of SASO.

Nick Dolphin

Background SASO is a small Oaxacan NGO which provides direct services to communities and small farmers to conserve and restore their soils and natural resources, as well as to improve their food self-sufficiency. The core program of SASO is the dissemination of vetiver grass technology and in this regard SASO started, and continues to take a lead role in, a statewide program for erosion control (PCERS) spearheaded by vetiver grass technology, in collaboration with communities, local authorities, government agencies, NGOs, and research centers.

Mexico is the 10th largest country in the world in area and Oaxaca State in southern Mexico is the 4th largest state in Mexico. The State of Oaxaca is the size of Portugal and almost twice the size of Costa Rica. It contains 80% of the vegetation types in Mexico, from desert to tropical rain forest, and has the highest concentration of ethnic and biological diversity in the country. Oaxaca has been identified by the World Resources Institute as being one of the places on the Earth of grave concern for its soil erosion and rate of desertification. It is therefore an excellent place to demonstrate the exceptional properties of vetiver grass which is one of there few plants which can unite the whole State around the common theme of erosion control and soil conservation because it grows in all the climatic and vegetation zones.

There are two equally important challenges to getting vetiver grass used on a significant scale throughout Oaxaca and to creating the awareness of the seriousness of the problem of soil loss: firstly, production and demonstration of the grass (when well demonstrated the grass speaks for itself), and, secondly, the development of organizational and diffusion mechanisms which will enable this to happen in a relatively short time. The problem is so serious and the social, inter-organizational and political divisions so deep that new approaches are needed. SASO and The Program for Erosion Control and Restoration of the Soils of Oaxaca (PCERS) are attempts to find new forms of organization to disseminate the vetiver grass (and other) technologies.

SASO provides a legal and support structure for individuals wishing to develop their projects on soil, water and seed conservation. SASO focuses on communities and small farmers - 75% of the territory of Oaxaca is the collective property of communities, mostly indigenous.

The PCERS provides a legal and support structure for organizations to work together pursuing their soil conservation projects in their own ways integrating vetiver. The Program, which started in 1995, has 50 participants from communities, NGOs, research and education organizations, state and federal government agencies, and the private commercial sector - small farmers and householders also participate.

This report focuses more on organizational mechanisms for diffusion than on the technical aspects and outputs of the vetiver grass because this year has been a year with few funds and has been used to prepare strategies and to make appropriate changes in the organizational mechanisms for the second phase beginning next year.

SASO para los Suelos Agua y Semillas de Oaxaca. SASO is focussing on 3 regions - the Sierra Norte, the Sierra Sur and the Costa - with its own propagation nursery in the center of the State in the Valles Centrales, and work in the City of Oaxaca.

In the Sierra Norte, we continued with the two communities which established nurseries in 1996 and 1997 - Tlahuitoltepec and Amatepec. The new Tlahuitoltepec authorities (which change every two years), being unaware of the value of the grass, were persuaded to exchanged it for tree seedlings by an entrepreneur from out of the State. Whilst slowing dissemination of the grass in Tlahui (it retains a basic nursery), this shows that the grass is taking off in other states and that the market is developing. (Tlahui is way up in the mountains, very poor roads and hundreds of miles from where the entrepreneur set up his nursery). About 15 campesinos in Amatepec have distributed the grass amongst themselves for individual nurseries. A new campesino member of SASO, Carlos Sanchez, established a nursery and two demonstration barriers with the farmers group in his community of Chichicaxtepec. The site will provide a source of grass for over 20 communities in this ecozone. These areas range from 1000 to 2500 meters above sea level.

In the Sierra Sur, we continued follow-up in the three communities in Sola de Vega District identifying hedgerow demonstration sites with farmers in each area. In the event, not more than 300 meters of new barriers were planted. We discovered that in this area farmers are used to being paid by government projects to improve their land (fertilizer subsidies) and to introduce new crops (vote catching). In this case - and the problem is not unique to this area - a slow process of demonstra-

tion will be required. One of the members of SASO, Paul Hebb, is setting up a nursery in Sola de Vega and will be on hand next year to work directly with the local farmers to demonstrate the use of the barriers. A new nursery was set up with a group of 120 mezcal producers - mescal, the local alcohol, is produced from the maguey cactus and is the major export of the area. The leader of this group is the technician who originally requested the grass for Sola de Vega. There are now four nurseries in Sola de Vega area.

In the Coast, a new campesino member of SASO who worked with Kevin O´Sullivan in the early 1990s set up a nursery. Heriberto Ricardez is working directly with 6 communities in the area which will receive the grass next year and has good contacts with the Pochutla Municipal Authority. We participated in the first University ecology event in Puerto Escondido and will be planting a nursery in this important tourist resort over the Christmas period.

In addition to field activities, Ana Maria Le Moing included a significant vetiver component in her proposals for rural development in the Huaxteca region of Veracruz; Government/World Bank funding is expected next year for protecting 10 hectares of steeply sloping farmland. I wrote an article on the PCERS for publication in the Autonomous University of Mexico anthropology journal. The SASO team participated in a degree program on natural resource management for Portland State University/Technology Institute of Oaxaca taking the group of 25 US and Mexican students to our sites in Sola de Vega and talking on erosion and vetiver in Oaxaca. In March, a team from the BBC filmed the SASO mother nursery which has resulted in a BBC/ITDG Hands-on Program on vetiver (also with inputs from TVN); we will also be editing the raw footage into a vetiver promotional video for Oaxaca. The trial vetiver clothes sachets have been selling consistently (150 to date). Vetiver is being tested in a household black water recycling system and another friend intends to bale it up and build houses.

The new Mayor elect of Oaxaca planted vetiver at the Nexacubi site in Oaxaca City and we will give his team a talk on vetiver when he takes over early next year. We also have contacts with the new State Governor who takes office this month for a six year term; his support is essential to getting vetiver into official projects and programs. Finally, I have been helping the 3 local entrepreneurs develop the market for vetiver.

Program for Erosion Control and Restoration of the Soils of Oaxaca (PCERS). The first phase of the Program culminated in 1997 (results were reported in previous reports). The objectives of the first phase were to prove that vetiver grass grows in all the climates and vegetation zones of Oaxaca and does not become a weed, and to establish sources of grass throughout the State by including all relevant sectors of government and civil society. By the end of 1997 there were 35 nurseries directly participating in the Program, plus at least 15 others, in 6 of the 7 regions of Oaxaca, and all sectors are participating - community and other local authorities, farmers and women's groups, NGOs, research and education centers, state and federal government agencies, and the commercial sector. See the annexed map.

The main objectives of the second phase, which starts next year, are to: 1. widely demonstrate the vetiver grass in use (farm land conservation, restoration of eroded lands, gulley stabilization, and road maintenance): 2. influence public policy in favor of soil conservation; and, 3. start disseminating local plants and techniques for erosion control alongside vetiver.

Between July 1997 and December 1998, the Program continued with only a small grant of US$7,000 from the Fondo Mexicano para la Conservación de la Naturaleza, A.C. for the 18 month period - $390 per month (we have still not received the final payment). The fact that it has continued indicates the commitment of key members working voluntarily and the fact that the dissemination of the vetiver grass no longer depends on the Program.

Nursery and hedgerow outputs for the year will be surveyed when funds become available early next year. Casual contacts indicate that the grass is spreading well through all participants. For example, in one area in the arid zone of the Mixteca, 70 small demonstration hedgerows have been set up, and a member in the Valles Centrales has started work with 4 new communities.

The vetiver is now taking off in 7 other states and, as reported previously, an important demonstration, including several kilometers of hedgerow, is flourishing in the State of Mexico and the Federal District with plant material and technical assistance from members of the PCERS. The site is very heavily eroded, has very poor soils with little organic material, and receives 3-400 mm of rainfall per year - a good challenge. The vetiver is being used in conjunction with reforestation. In addition, there are at least 5 commercial vetiver nurseries, 3 of which are in Oaxaca and the others in Morelos and Hidalgo States.

The report on the first vetiver training workshop held in 1997, in which Jim Smyle and Joan Miller of the Latin America Vetiver Network participated, was completed. This report contains an excellent summary of the experience with vetiver in Oaxaca to date. A manual on vetiver nursery establishment and management was also produced.

Protracted negociations with the

Fondo Mexicano para la Conservación de la Naturaleza, A.C. resulted in obtaining a grant of 500,000 pesos for the next 3 years. The main sponsors of the FMCN are the US and Mexican Governments. We also managed to persuade the FMCN to be flexible in their requirements for working with organizations. The Program is not a legal entity - to date one of the members has provided a channel for funds. This arrangement has enabled a wide variety of organizations to participate who would otherwise have found it very difficult to do so. For example, government agencies have been able to participated and get familiar with the grass without requiring official, political endorsement. The FMCN will accept a simple notarized contract between the members of the Technical Committee giving us time to bring new members into the organizational bodies of the Program and to decide what kind of formal identity we want and when. We are also designing a management structure that does not have a single coordinator - competition for power and control is a major cause of conflict and failed initiatives. We are also exploring various ways of ensuring transparency, such as publishing the accounts in a web page - expropriation of funds is a major cause of suspicion and lack of cooperation.

Experience. In places where local technical assistance organizations, usually NGOs, have established good, long term working relationships with local communities and farmers groups, the vetiver takes root fast. In other areas, it has proved relatively easy to establish nurseries with communities, however dissemination in hedgerows is much more complex. The reasons, which vary from place to place, include dependence on government programs for payment to adopt innovations; the communal land tenure system; lack of awareness of soil loss; small farmers suffering depression under the onslaught of the global cultural and market changes taking place which are undermining local traditions and cohesion; realistic and natural caution over new fixes; soil conservation is a long term investment with no immediate returns (which also puts off many funders). Local farmers groups participating have said that it will take 4 to 5 years to convince their neighbors to adopt vetiver. In addition, we have not designed an effective demonstration package to go with nursery establishment. We are working on this now.

The first phase of the Program concentrated on small farmers and a major effort has not been made to influence government, formal institutions and the commercial sector. The research and government sectors tend to be reluctant to adopt vetiver because initially there is no money to be made and because of the “not-invented-here” syndrome. However, individual researchers in all the major agricultural research organizations in Oaxaca have been some of the most ardent supporters. Ecologists and environmentalists tend not to like the grass because it is introduced (not native) - like wheat, cows and cars.

The PCERS has been set up in such a way that anyone can participate. There is no central control or party line - each organization can use and develop their own ways of disseminating the grass. The members of the Program provide technical advice and collaborate to provide training and production of technical information. The coordination provides exactly this function - coordination of technical advice and assistance between the participants as they want it. It also has the role of promotion.

The dissemination system which has evolved can best be described as a flat pyramid: flat because each member and participant is autonomous, and pyramidal because each year the base broadens as each participant spreads the grass to their neighbors and collaborators. The basic design principles have proved to provide the basis of an effective organizational structure: autonomy of participants (so each can work in the way they know best and no central control or ownership), independence of the Program (it is not the property of one organization), minimum of bureaucracy (it can survive with a minimum of money), and dissemination by *enlaces* (liaisons), the only obligation being to pass the grass on to others and tell us what you are doing.

Contrary to the good advice of many, initially the vetiver grass was given free to every organization and individual who wanted it. In three years there are over 50 nurseries in all but one of the 7 regions of Oaxaca and I am beginning to meet people on the street who ask me if I know about vetiver grass. The vetiver grass is now disseminating on its own, however, the Program has an important role to play in speeding up the process and demonstrating the many alternative uses of the grass.

SOUTH AFRICA

Vetiver as an Effective Mulch

Tony Abbot

A Mauritian farmer who came to our district introduced vetiver as a tool in the conservation of natural agricultural resources to me. He told me that in Mauritius it could be seen all around the small farms protecting the soil and was also used by the cane farmers for soil movement control.

The need for better control of soil movement becomes clear when the research carried out by the Agricultural Research Council at Cedara is considered. From this work in soil

loss, it has become clear that, as farmers, we are not maintaining a sustainable soil profile. In real terms, we are losing our soil faster than it is being created. This research targeted commercial farming operations where techniques for soil control and resources for their implementation can be expected to be available.

The first step in controlling soil movement lies in controlling water run-off. Water carries 32 times the amount of silt and particles 64 times larger when its speed of flow doubles.

Clearly, this is where we must concentrate our attention to conserve our capital stocks of soil. Biological contour banks of Vetiver grass make good sense, preferably planted on a slope sufficient to carry away the excess water but at a speed not fast enough to cause erosion.

Vetiver as a mulch works extremely well and can last for up three years, depending of course on how thick the application is. It easily outlasts veld grass due to its stem thickness and texture. Mulch must be one of the most useful farming techniques available to farmers. As a mulch it:

- retains moisture;
- assists rainfall penetration;
- controls surface water movement;
- suppresses weed growth; and
- improves soil texture.

The only disadvantage that I can think of being its tendency to reduce ground temperature.

Turning specifically to how we carry out the mulching on my farm. We cut Vetiver by hand and bind it into bundles for transport; the grass itself makes suitable ties. It makes very compact bundles as it is more stem than leaf and is more economical to move than veld grass. The bundles are moved by tractor and trailer and are convenient for carrying into plantation crops where vehicles can not go. As it does not shoot or sprout, it makes a most convenient mulch as compared to Napier Grass which repeatedly regrows in the field.
Vetiver grass may well provide the only techniques available to us which can be used without machinery and expensive planting methods to control water run-off, to maximize its availability in the soil and to conserve our rapidly disappearing soil stocks.

Editor's note. I have seen numerous photographs of mulch applications in South-East Asia. One of the techniques that is employed in orchards is that vetiver is planted between the rows of trees as a conventional soil conservation mechanism (care needs to be taken that the trees do not shade out the vetiver). The hedge is then cut annually and the cuttings are placed directly around the base of adjacent trees. This saves on transporting cuttings into the orchard and provides a two-pronged approached to moisture conservation.

I understand also that in South Africa vetiver has been used very successfully as a mulch in coffee plantations. In addition to its moisture conservation activities it has resulted in reduced applications of both herbicides and insecticides

Mpumalanga Vetiver Program - an update

David Jobson (The most useful point ***of contact for David is through his cell-phone: 082 708 6820)***

A Visit to Palabora and Foskor Mines. The main aims of the Mpumalanga Vetiver Program (MVP) are to raise awareness of the value of vetiver for bank stabilization and soil erosion control in particular, and to help to create economic opportunities in the process. As many of you will know, several mining companies have been using vetiver as a pioneer grass for some years in order to stabilize slime dams, reduce wind and soil erosion, and to provide an environment in which indigenous vegetation can thrive.

As my knowledge of South African mines is extremely limited, I was keen to team up with an Ecolink colleague who was exploring some work with the Palabora Foundation, a local NGO set up and substantially funded by the Palabora Mining Company (PMC). Knowing that Tony Tantum of Specialized Soil Stabilization had been planting at Foskor for over a year, it seemed opportune to have a look at the progress that was being made. I was particularly interested to see how vetiver coped with the poor substrate conditions and extreme heat associated with the mine dumps.

At PMC I made a short presentation to the Environmental Unit. Some of the staff from this unit then took me across to Foskor where Patrick Tantum (*son of Tony - also bigger than Tony if you can imagine that, but not quite as good looking. Ed.)* showed us some of the vetiver sites. We were enormously impressed with the impact vetiver had made in a relatively short space of time. Correct planting methods together with the heat and ample summer rainfall had clearly done wonders. Vetiver had established in weeks rather than months which is the usual situation in normal growing conditions in non-toxic soils. It was fascinating to see vast swathes of vetiver lines marshaled across an alien landscape. Contours had been created and a light covering of topsoil had been deposited in which indigenous grasses were already growing vigorously.

This visit appears to have stimulated the PMC environmentalists to trial some vetiver stabilization themselves and to seriously consider it for other purposes such as channeling water.

Another purpose of my visit was to check out the potential for creating economic opportunities for people from disadvantaged communities. I found that the Tantums together with the mining companies and an organization called Business Linkage were already well down the road of developing a business plan for setting up community operated nurseries at the mines. This has great possibilities. Correctly implemented, such initiatives can contribute to addressing the multiple issues of unemployment, retrenchment, skills training, and rehabilitation and conservation.

While in Phalaborwa I made inquiries about loans and start-up grants for SMMEs. As per usual there was not much information available. (Who actually gets all this help that is supposed to be available and accessible?) Khula Enterprises and the Industrial Development Corporation (IDC) were suggested. Also the Great North Credit Company, Pietersburg, for those living in the Northern Province. I understand that the Palabora Foundation has a scheme to assist micro-enterprises which is basically a very low interest loan scheme for capital items. I appeal to readers of this article who know more about obtaining low interest loans for small enterprises requiring less than R 50 000 to contact me. I am mainly trying to assist people in Mpumalanga and surrounding provinces.

Help me be More Effective

As a foreigner (this English accent does me no favors), promoting the value of vetiver to an often skeptical audience can be a lonely and discouraging task. Civil engineers and farmers, for example, are not renowned for seizing on new ideas - or more particularly those that work elsewhere and were not invented here! Not that I am blaming them. Farmers, for example, have often been led up the garden path to bankruptcy by bold new methods and supposed miracle crops. However, as we know, vetiver is for the cautious as well as the brave.
Rather than waste time up dead-end garden paths myself, I appeal to readers in Mpumalanga, Gauteng, Northern Province and Swaziland in particular to give me contacts where doors don't have to be levered open. My focus for workshops this year is on
forestry, roads, dams and mines. I will follow up on the most promising leads and then link up to try and find local supplies of vetiver. For example, it would make a lot of sense for forestry companies to supply vetiver from their own nurseries for the public and their own use as Mondi does in White River. The same could apply to the Department of Environment and Tourism, and the Mpumalanga Parks Board.

I also find that forestry and agricultural shows are the type of arena in which vetiver gets very useful exposure. Do you know of any appropriate shows and venues coming up this year?

Finally, I am preparing a simple manual comprising mainly photographs of vetiver doing its job in a variety of Southern African situations. If you have or can take such pictures I would be delighted to consider them for inclusion. Any photographs would be credited.

Comment by Duncan Hay:

David Jobson is a British Volunteer from Voluntary Service Overseas (VSO). VSO is the largest volunteer-sending agency in Europe and the third largest worldwide. It provides skilled and experienced men and women to work alongside local colleagues in response to requests from governments and NGOs. David has been in South Africa for three years during which time he achieved the dubious distinction of being mugged on three occasions. Despite that we don't seem to be able to get rid of him! He is currently attached to the Institute of Natural Resources and his costs are covered through a variety of donations and grants.

Vetiver in Aromatherapy

By Angela Stubbings

The term aromatherapy was coined in 1920 to describe the usage of essential oils for therapeutic purposes. The aromas and oils come from the plant kingdom: flowers, herbs, trees, bushes and roots. The relevant part of the plant is distilled and the volatile aromatic substances are captured. These substances are called "essential" oils. They are highly concentrated and should be diluted before use.
The oils are rich in teipines, phenols, alcohols and aldehydes. These natural essences have antiseptic properties and their anti-bacterial action has been used in practice for thousands of years.

The roots (rhizomes) of vetiver grass are extremely rich in volatile oil. It has a heavy earthy aroma and is strongly repellant to flies, cockroaches and fish moths for example. It is used as an ingredient in oriental "woody" perfumes, soaps and cosmetics, and also as a powerful fragrance fixative.

Vetiver oil has the ability to combine with other scents, thereby enhancing blends of oils.

TANZANIA

Terminal Report On Vetiver Technology And Development In Tanzania - Rukwa Region

Vetiver Grass is now a talk shop in Kaengesa Ward and Sumbawanga township. The impact of Vetiver grass is now felt by the grassroot people, almost every farmer wants the grass as a soil erosion control plant.

The climax of Vetiver Technology promotion was at the time of the Presidential visit to Rukwa Region in which the President participated in planting the grass and trees. A handshake by his Excellence Benjamin W.Mkapa to the Chairman of KAESO Mr. Ozem Chapita commending him for his NGO and himself in particular added flavor in the crusade to promote the grass. The President in his remarks to the Chairman of KAESO said, *"I have visited several parts of Tanzania and a lot more people are talking about the environment, but much of it is theory only, but you - KAESO, are talking, about environment by doing practical things I thank you very much. Please I request you to continue doing what you are doing".*
The Vetiver Technology has been given to the villager by way of Video shows, Seminars, and mobilizing drama groups. However, Vetiver knowledge dissemination by video shows has proven to be very effective followed by the drama group.

To our advantage, heeding to the presidential call on environmental conservation and soil erosion control, the regional district authorities could get vetiver splits from KAESO only. This has resulted in a big demand for vetiver grass splits to be distributed in all the three Districts of Mpanda, Nkansi, Sumbawanga rural and urban. KAESO's next move is to identify interested farmers in each district who could run vetiver nurseries in each district for future distribution in their district as opposed to the present situation where all vetiver splits are collected from KAESO's central nursery at Lula Village in Kaengesa Ward.

On the other hand, GTZ, a German development agency which has been involved in Nutrition Programs in Rukwa Region, became the major distribution agent of the grass to all farmers under their project, given their transport facilities to reach as far as possible all villages all over the Region.

Despite all the success achieved, the project faced a lot of problems, namely,

- Lack of transport to distribute the grass and the movement of personnel to supervise planting in the field.

- Cost of having a pickup vehicle for video shows and drama group is a limiting factor.

- Lack of a photo-copier for producing leaflets, newsletter for distribution to villagers.

- The El Nino rains have destroyed most of the access roads making it very difficult to reach as many villages as possible.However, for all the success achieved, all has been possible through the financial support from VETIVER NETWORK and more sincerely all thanks are directed Mr. Richard Grimshaw for his tireless efforts to encourage us to promote this unique grass.

Vetiver Grass in a Soil and Water Conservation Trial - Tanzania

By Holger Nehmdahl (Holger is a Ph.D. candidate at the Royal Veterinary and Agricultural University, Denmark. Ed.)

Introduction
This article contains a presentation of a soil erosion and water management trial site located in the Iringa Region of Tanzania. Special emphasis is given to the performance of Vetiver grass. The aim of the experiments is to evaluate the effectiveness of different low input soil erosion control measures and impact of these measures on the plant nutrient - and water balance. The experiments are fully financed by the Danish International Development Agency (DANIDA) and carried out by the Chemistry Department and Department of Agricultural Science at the Royal Veterinary and Agricultural University, Denmark. Locally, there is close co-operation between the research project, the HIMA/DANIDA-Iringa project (presented in Vetiver Newsletter No. 16) and the Soil Science Dept. at the Sokoine University of Agriculture in Tanzania.

The three soil erosion control measures tested in this study are either recommended by the HIMA-Iringa project and/or practiced by some local farmers. Although Vetiver grass in numerous experiments has proven to have almost ideal properties when used to combat water caused soil erosion, no controlled experiments on the effectiveness of Vetiver grass and magnitude of soil erosion in the Iringa Region have been carried out. Data from 3 growing seasons has been collected so far starting with the 1995/96 season. Since this is an ongoing research project and selected data will be published in technical/scientific journals, only few figures are presented here.

The experiments

Location, climate and soil
The trial site is located in Kilolo Division, Iringa District, Iringa Region on a 29% slope with a SSW aspect. The climate is moderately cool tropical and subhumid. The unimodal rainfall pattern is often broken by a short dry spell in January/February. The start of the rain season is marked by thunderstorms yielding high intensity downpours with a high degree of spatial variability. The highest temperatures occur in November/December and the lowest in June/July, when temperatures can drop below 0º C.

Average annual rainfall in the area is1100 mm and the annual average potential evapotranspiration about 970 mm.

In the area, characterized by steeply dissected convex slopes, maize sometimes intercropped with beans

is the dominant crop on well-drained soils. The parent material, climate and the extent of weathering determine the nature of soils in the area. Located in the subhumid and cool tropical climate of the Iringa Highlands and developed on a mosaic of acidic pre-Cambrian metamorphic and plutonic rocks, most soils are deeply weathered and leached. Kaolinitic clay minerals and aluminum - iron-oxyhydroxides dominate the red and yellow soils. Another important feature of the soil is a high infiltration capacity approaching values for sandy soils despite its high clay content. The soil is classified as a "Humic Acrisol" according to the FAO Soil Classification System.

The Site

Three soil erosion control measures are tested in 12 classic runoff plots separated into 3 blocks. Each plot with dimensions of 4 times 20 m is fenced on 3 sides by metal plates buried to a depth of 0.5 m. At the downslope end of each plot a collection gutter guides water/soil lost due to surface runoff into a system of 2 concrete tanks. One fourth of an eventual overflow from the first tank is collected in the second tank. The total tank capacity is close to 3000 l. The volume of water and soil lost from the runoff plots is recorded after each single runoff event. Samples are taken for laboratory analyses.

At the site rainfall is recorded by means of an automatic rain gauge monitoring amount and intensity of the incoming rain. A nearby meteorological station supplies the other climatic data. Soil water content at different soil depths is monitored the Time Domain Reflectometry (TDR) - method. Soil water samples are collected from 1 m depth in all plots and analyzed.

Soil conservation measures applied

In each of the 3 blocks 3 soil conservation measures are tested against a control plot. The 3 measures are:

- Vetiver grass lines on the contour
- Calliandra hedgerows on the contour
- Tied contour ridges

The vegetative control measures used are *Vetiveria zizanioides* and *Calliandra calothyrsus* provided by the HIMA-Iringa project. Grass lines and hedgerows are repeated every 2 m of vertical interval. Vetiver grass was planted with a spacing of 10 cm between slips, Calliandra with 20 cm between seedlings. Both Vetiver and Calliandra was planted in 1992 and fully effective with regard to soil erosion control in the first trial season 1995/96.

Tied ridges have a spacing of 80 cm. The control treatment is flat cultivation as practiced by nearly all farmers in the area.

In all plots (including the control plots) maize intercropped with beans was used as test crop for all 3 seasons. All plots received N - and P - fertilizer and pesticides were used when needed.

Rainfall and runoff statistics

The first 2 seasons were characterized by a late start of the rain season, rainfall below average, prolonged dry spells and few high intensity rain events. Widely blamed on the "El Nino" phenomenon, rainfall above average with often destructive downpours were recorded in the third season.

In each of the first 2 seasons only one major runoff event was recorded. In total 14 runoff events were recorded in the 1995/96 and 1996/97 seasons and 22 events in the 1997/98 season.

Only 1 - 2% of the incoming rain was lost as surface runoff from control plots in the first 2 season but about 10 % was lost in the last. In single events up to 20 % of incoming rain was lost by surface runoff from control plots during the first 2 seasons and up to 70 % during the last season.

The highest recorded rain intensity was 192 mm/h (5-min. max.) i.e. receiving 16 mm within a period of 5 minutes. No rain storm with an intensity lower than 24 mm/h (5-min. max.) triggered losses of measurable amounts of soil/water. During the first 2 seasons 5-min.-max. intensities had to exceed 40-60 mm/h to cause any runoff since the top soil usually dried up between major rain storms and regained it's porosity. As the top soil largely was saturated throughout the first months of the last growing season, large amounts of soil and water was lost in rain storms at much lower intensities.

Surface loss of soil and water

All applied soil erosion control measures greatly reduced soil and water loss by surface runoff. Vetiver grass lines virtually stopped the loss of soil and reduced the amount of water lost by surface runoff by 85% on average. In total - 110 tons soil/ha was lost on average from control plots during 3 growing seasons compared to less than 2 tons/ha from Vetiver plots (preliminary data).

Within the 3-year trial period a 50 cm terrace developed along Vetiver grass lines. This is partly due to sediment trapped behind the lines but also due to a downslope cultivation of the plots. The contribution of the latter to a terrace build-up becomes obvious in the "Calliandra plots". Here terraces reached almost the same height although the amount of soil trapped behind the hedges during runoff events is much less.

The efficient filtering effect by Vetiver grass lines is easily observed when comparing soil/water loss in plots with Vetiver lines and Calliandra hedges. Whereas the decreased slope angle/length between the Calliandra hedges sharply reduced surface runoff in the first 2 seasons, an additional filtering effect was needed in the extreme 1997/98 season. During this season average soil

loss from Calliandra plots was above 20 tons/ha.

Soil loss from plots with tied ridges was less than 10 tons/ha during 3 growing seasons. When evaluating the effectiveness of tied ridging it has to be mentioned, that ridges were re-established in connection with major agronomic activities in the plots (weeding).

On this soil even a moderate loss of plant nutrients will exceed quantities provided by continuing weathering. Obviously, losses of topsoil from the control treatment, i.e. the commonly practiced cultivation of farmland in the area, and its constituents do reach unacceptable values. Although not readily available for plant growth both total N and total P lost from these plots equals the amounts of N and P removed by 6 - 7 tons of harvested maize grain i.e. about 2 years produce for this site (tons/ha) and the applied fertilizer/pesticide strategy. Plant nutrients lost in this way from Vetiver plots are negligible.

Assuming that most of the water retained in Vetiver plots during runoff events compared to control plots will have to be added to water leaching through the system (rooting zone), then this "surplus percolation" in Vetiver plots will remove more plant nutrients like Ca, Mg, K than are lost by surface erosion. This assumption is based on analyses of soil water samples collected at the bottom of the rooting zone.

Possible implications on water balance

As mentioned above the soil water content at different depth in the rooting zone (0-100 cm) is monitored by means of the TDR-technique. Analyses of 3 years of data is still incomplete but with regard to the Vetiver treatment observations do indicate:

- a lower soil water content in all layers of the rooting zone inside and close to the Vetiver lines at the end of the dry season as compared to measurements made between the lines and inside the control plots. This may be due to the continuous transpiration byVetiver grass throughout the dry season.

- a higher soil water content along the Vetiver lines in the upper soil layer in very wet periods of the rainy season (e.g. in Figure 1) as compared to measurements in the control plots. The higher water content may be due to increased infiltration around Vetiver lines during runoff events. A comparable higher water content in the upper horizon is also observed in periods without any surface runoff. This could be explained by a higher water retention capacity of soil accumulated here.

- Accumulated within a certain period an increase in soil water content along Vetiver grass lines often exceeds the amount of rain received. This can be due to subsurface flow accumulating at a hydraulic barrier. As seen from Figure 1, this excess water is rapidly lost to drainage/ evapotranspiration in dry spells during the rain season (day 85 - 105).

- a lower soil water content in deeper parts of the rooting zone between Vetiver grass lines i.e. inside the maize/bean crop. A possible explanation to this finding could be a diversion of lateral soil water movement into deeper soil layers along Vetiver grass lines.

Crop yield

Amounts of harvested maize and beans are recorded for each plot. A direct comparison between treatments proved to be difficult since crop yield is affected by changing soil physical/chemical properties within the experimental site. Data on crop yield will have to be collected for some more years before significant differences in crop performance due to soil conservation measures should be considered.

Other findings with focus on Vetiver grass lines.

Cultivation at a 29 % slope will leave areas close to the downslope side of Vetiver grass line stripped for humus rich top soil. Crop performance of the first line of maize below Vetiver grass lines therefore was very poor. Along with the area occupied by Vetiver grass this fact was often pointed out by visiting farmers. For farmers with access to farmyard manure and/or compost this problem could be addressed by localized application of these inputs. On the other hand this drastic removal of topsoil accompanied with a poor crop performance can be seen at as a forecast on crop production in unprotected fields.

Rats and mice do find shelter and hiding places in Vetiver grass lines. Although no immediate problems arose from this, a large percentage of maize seed close to the lines was eaten and re-planting had to be done.

VIET NAM

The Vieät Nam Vetiver Initiation Visit of January-February 1999

Ken Crismier, Interim Coordinator, The Vetiver Network Viet Nam, 4850 156th Ave NE #395, Redmond Washington 98052, USA. kencris@gte.net

This trip was the culmination of a process that began in the latter half of 1997, when I first "discovered" vetiver on the Web. Soon thereafter, my 2-month trip of December 1997-February 1998 did not have vetiver as a nominal purpose, but many initial contacts for vetiver were made at that time, including the single contact which appears to be

continuing to develop into the most important one.

The period of February-October 1998 was a time of intense effort in learning more about vetiver and looking into how most effectively to spread the word about vetiver in Vieät Nam. Following up on and developing a suggestion from a friend of many years in Vieät Nam, the effort came to focus principally on working with the Department of International Cooperation of the Ministry of Agriculture and Rural Development (MARD), as being appropriate for the way this kind of thing would normally happen in the Vieät Nam context.

The 1-month trip of October-November 1998 was an intense round of meeting prearranged appointments with mostly governmental agencies, including among others the Departments of International Cooperation in the Ministry of Transport and Communication and the Ministry of Science, Technology, and Environment, as well as (within MARD) the Department of Flood and Storm Prevention and Control and Dikes Management. At each stop I spent the time provided me in telling and retelling the story of vetiver.

At MARD, in particular, we spent much time at first organizing a first significant meeting – a "buoåi trao ñoåi", an "exchange of views", the designation reflecting the modest scale and goals of that meeting. On November 7 about 23 people from 17 different government and quasi-private agencies met for 3 hours for a presentation by me and questions and discussion with the other participants. Subsequently, and by consensus of the participants, meetings focused on preparing for the larger objectives of the next trip.
The trip now just past lasted from 9 January to 7 February 1999. Since I have always made it clear that I am not a professional in the field – as a self-defensive measure if nothing else! – this time, the culmination of the vetiver education process, two international experts accompanied me, Paul Truong from Australia and Diti Hengchaovanich from Thailand. (This was Paul's first visit "home" since 1975 – he found it very rewarding to be reunited with, and feted by, colleagues and students from the University of Can Thô! – and the first visit ever to Vieät Nam for Diti and his wife Arunee.)

The main organized events were

- 19 January: seminar in Haø Noäi, the capital, with about 100 participants
- 20 January: field trip to vetiver site in the uplands of Phuù Thoï province for about 10 of the seminar participants
- 25 January: seminar in Vinh, the main city of Ngheä An province, with about 20 participants
- 26 January: guided tour for Ken and Paul of various representative erosion sites in Ngheä An province
- 29 January: seminar in Hoà Chí Minh City (Saøigoøn), with about 80 participants.

The seminars featured presentations by Paul (Haø Noäi and Saøigoøn), Diti (Haø Noäi only – Diti and Arunee had to return to Bangkok early), and Ken (Saøigoøn), as well as shorter presentations by local people experienced with vetiver, including Mr. Thaùi Phieân (Haø Noäi) and Mr Ñaëng Thoï Loäc (Saøigoøn), both from the National Institute of Soils and Fertilizers. (The Phuù Thoï vetiver site is a project of NISF.)

The province Gardeners Association, also known as Vacvina sponsored activities in Ngheä An province. Vacvina is a very major grassroots organization in Vieät Nam, which is (so I am told) present in every district of every province. Vacvina Ngheä An – and in particular its chairman, Mr Nguyeãn Hoàng Sôn – was that "most important" contact referred to earlier. (This was just one of several contacts made back on 27 December 1997, the day after the most recent 5-year national congress of Vacvina ended, when representatives of a number of provinces had not yet left for home.) The seminar included basically all the agriculture leadership at the province level, and the morning of 27 January four of us (Paul, Son, Vieät the Vacvina general secretary, and myself) were also able to meet with Mr Hoà Xuaân Huøng, chairman of the People's Committee of Ngheä An and the highest-ranking official in the provincial government, and separately with more ag. leaders.

The Haø Noäi and Hoà Chí Minh seminars each concluded with very enjoyable, very late lunches – noteworthy in that almost all participants chose to remain at least to enjoy the lunch at the beginning, when typically lunch would have been nearly 2 hours earlier!

What did we accomplish? As I have said quite a number of times, "All that hard work paid off – now the really hard work begins!" To this point we have "merely" laid a foundation of vetiver awareness – I would guess the number of people in Vieät Nam who are now well aware of vetiver and its role against erosion might well be 10 times what it was in mid-1997. (I am referring here to people in the scientific/technical community, policy makers, and planners – the kinds of people who participated in the seminars.) Discussion has been voluble and animated, and of course we hope it reflects how vetiver will progress in the near term!

We distributed a good quantity of assorted vetiver literature, including 200 copies of the "blue book" (the BOSTID/NRC report of 1993), dozens of copies of recent reports by Paul (vetiver in environmental protection and mitigation) and Diti (engineering aspects of vetiver), information about the vetiver movement

in Thailand, and – especially – the World Bank "green book" of vetiver, recently published in Vietnamese by the Agriculture Publishing House (also of MARD) – of the 5,000 copies printed, about half have been placed in the hands of people to whom it is of interest! Along with that we created a poster based on the green book cover – and of the several hundred that have been distributed, some have started showing up on inside office walls here and there!

Where do we go from here? At the moment that is somewhat hard to say with any certainty... In any society, inertia tends to militate against significant mobilization of efforts in a "cause" such as vetiver. In Vieät Nam, that tendency is perhaps exaggerated both by the way elements of the society interact traditionally, and over the past 50 years by the form of organization and control imprinted on the society by the Democratic Republic of Vieät Nam, earlier, and later by the Socialist Republic of Vieät Nam, and by its "vanguard" element the Communist Party. The "renovation" (ñoåi môùi, change for the new) since 1986 has certainly greatly modified the social climate, but it remains true that individual initiative is the exception, not the norm – in Vieät Nam it would be difficult – it is difficult – for a "champion" of vetiver to rise up as has occurred in a number of other countries.

Secondly, Vieät Nam despite "renovation" is still a poor country – although perhaps a more significant observation is that what wealth exists may not be directed to the most important aspects of its future. (My motivational speech for the seminars – as opposed to my vetiver presentation! – opened with the opening lines from the Land Law and the Law of Water Resources of Vieät Nam, which go so far as to say that these are matters of "survival" for the country...) In any case, resources – funds – are not necessarily readily available for as mundane a purpose as vetiver against erosion, when the existing funds can be applied to major construction projects, major reforestation projects, major "investment" and "development" schemes of all sorts, which are far more visible, more dramatic, more bespeaking "progress". The nascent vetiver movement in Vieät Nam could benefit hugely from an amount of money that would be insignificant in some of these other areas – such money has not yet been found.

The best we can do until a can of gasoline comes along is to carefully tend and encourage the bright sparks that do exist – most noteworthy being that of Sôn and Vacvina Ngheä An, with whom I have personally cast my lot, vetiver-wise, and Paul I believe shares that approach in his involvement with vetiver in Vieät Nam. Working with Sôn, Paul, and Diti, and members of the vetiver community in Thailand, along with Thaùi Phieân and Loäc from Vieät Nam, we are urgently trying to prepare for the coming rainy season by getting planting material in hand at Vinh, at least for a decent nursery. Email exchanges even of the past 24 hours are cause for concern, but we plunge forward, exploring all avenues, rejecting none out of hand. It is of utmost importance to move vetiver along this very rainy season!

The immediate goal is to procure planting material in significant quantity to establish as much as 1 hectare of nursery in which to multiply vetiver as a first step. Beyond that – just beyond! – are 40 hectares of sloping cultivated land on which Sôn wants to apply vetiver, along with pilot projects urgently desired by folks in the Ministry of Transport (a badly eroded site along Highway 1, also in Ngheä An) and the Dikes Management department (test sections on the banks of the fabled Red River right on the edge of Haø Noäi proper).

I myself have repeatedly emphasized that which I think is paramount – even more than planting material in the ground – and that is communication among all interested parties. In theory this does not absolutely need to be embodied in a formal organization, but in practice it is probably the best way. To that end we are trying to get together a nucleus of committed people who can "take the ball and run with it", who will "take the bull by the horns", to start the work of realizing the Vetiver Network Viet Nam (Maïng Lööùi Vetiver Vieät Nam).

In the manner of the successful model of many other regional and national "vetiver networks" around the world, VNVN (MLVVN) would coordinate and promote ongoing efforts in the cause of vetiver against erosion in Vieät Nam.This is definitely a critical moment for vetiver in Vieät Nam: It would have done no good to delay the propaganda effort until the future after it was already assured, since there could be no assurance that happy state would ever be achieved – but having accomplished the missionary work to date, without that immediate future assured, there is a risk the work might be wasted, its energy squandered, if that energy is not soon harnessed to visible, satisfying action. Many are very supportive in this – and as for myself, I am committed to not allowing that to happen...

Vì nööùc soâng Lam trong, vì ñaát nööùc Vieät Nam! – for the sake of clear water in the Lam river, for the sake of the "land and water" [the country] of Vieät Nam!

SAVE CHILDREN'S LIVES. READ ALL ABOUT

POWER FLOUR

See page 56

Report on the Visit to Vietnam 17 to 30 January 1999

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BRIEF BACKGROUND

Through the initiative of Ken Crismier of the VietNam Vetiver Network (VNVN), a visit was organized by Ken and the Vietnamese Ministry of Agriculture and Rural Development (MARD) to promote the application of Vetiver Grass Technology (VGT). The Vetiver Network, Ken Crismier and MARD supported this visit.

A series of four seminars were held during this visit, one at the MARD auditorium in Hanoi, one at MARD Training Center in Saigon, one at VACVINA (Gardeners Association) at Vinh, Nghe An province and one at the Institute of Agriculture Science, South Vietnam (IAS) in Saigon.

Due to unexpected health problem, Diti was only able to give the seminar and associated field trip in Hanoi.

NORTH VIETNAM

MARD Seminar in Hanoi

About 100 participants attended this seminars, in addition to representatives from various MARD departments, research institutes, provincial chiefs and agencies, there was a good number of representatives from other Ministries (Transport and Communication, Animal Production), Universities, Agro Forestry agencies and Agribusiness.

In addition to the traditional application of VGT in agriculture and forestry lands, the main attraction here is in infrastructure protection particularly in highways, dams, river banks and dykes. Some interests also in environmental protection such as landfill and mining rehabilitation.

Of particular interest was that Dr.Tung, Vice Director of the Department of Science and Technology, Ministry of Transport and Communication, approached Diti personally after his presentation for more details of VGT and expressed keen interest in using VGT to stabilize steep slopes on National Highways 7 and 8, connecting central Vietnam to Laos.

Field Trip to Upland Region of Phu Tho Province

This is the demonstration site of the Canadian-Vietnamese project on Sloping Land Management Practice. This site is 2 or 3 years old, it was established by the National Institute for Soils and Fertilizers to demonstrate to farmers the effectiveness of a number of vegetative hedges system in soil erosion control (details in Vetiver Project section). In addition to the main demonstration site, the farmer also uses vetiver for terrace stabilization and soil and water conservation purpose in his cropping land.

To date he is very happy with the effectiveness of vetiver in terrace stabilization and thinks vetiver is much better than pineapple, the species commonly used for this purpose locally, as vetiver is easier to manage and it does not spread into his cultivation. He prefers vetiver for this purpose despite the fact that he can get a small income from the pineapple crop. However he is not happy with the vetiver contour hedges planted amongst his crops as these hedges take a lot of land and he is in the process of digging them out even after we demonstrated to him on site that only after one year about 20cm of soil was trapped by the vetiver hedge.

Field Trip to the Red River Bank and Dyke in Hanoi

Following a brief discussion with the Director of the Department of Dyke Management and flood Control, MARD, the senior engineer in charge of bank maintenance took us to a site on the bank of the Red River where work was being carried out to repair a section that collapsed last year. Massive rock works were being taken at the site and this officer literally 'jumped with joy' on learning the effectiveness of VGT in bank stabilization. He admitted that rock baskets (mattress/gabions), which he called "Chinese technology", do not work as they were always washed away when the earthen bank collapsed under them. He added that the Red River is now full of rocks from previous attempts over the years but they have no choice as they do not know any other techniques. He also told us that the Red River delta has 5 000km of banks and 20% of which is damaged every year after the rainy season, this translates to 1 000km of banks which need repair every year. After we explained to him the roles of the deep root system and the tops of vetiver under flood flow conditions and also the design layout of the hedges, he was so convinced that VGT would provide effective protection that he is willing to keep a 100m long section, which was being prepared for gabion work, for an immediate trial this year if we could provide planting materials.

CENTRAL VIETNAM

VACVINA Seminar at Vinh

Vacvina is a very active NGO in Vietnam with branches throughout the country. It promotes good and modern agricultural practices not only to gardeners but also to farmers in the province. Nguyen Hong Son, the Chairman of Vacvina in Nghe An province is very active and a keen supporter of VGT. He has experience in working with farmers in central as well as south Vietnam, he is also politically well connected so he

would make a good candidate for the position on of VNVN coordinator or Chairman.

About 25 people attended the seminar from various local government agencies, MARD and NGO. Again the main interest is in infrastructure stabilization particularly highway batter, dam wall and river bank stabilization, in addition to agriculture and forestry applications in soil and water conservation.

Field Trip to Upland Region of Nghe An Province

Field trip to visit several problem sites in various districts including Thanh Chuong and along the Lam River valley of the province. One site of particular interest was a section of National Highway 1, just north of Vinh, the capital of Nghe An, where a massive and expensive rock retaining wall at least 300m long was built to stop the eroded sediment from its steep batter blocking the Highway. Although the batter now looks well stabilized with various Acacia species from the distance, on closer examination bad gullying still occurs between Acacia trees. As a result the retaining wall is now almost full after only 3 years and further protection is needed as other sections of the badly eroded batter threaten to block the Highway again. This is the location that Vacvina hopes to establish the demonstration site as it is highly visible and of significant importance to the local authority. On another section of the Highway where new road was being built, no attempt was made to stabilize its batter which form the bank of a 700 year old historical canal.

Two sites along the Lam river were visited, one to demonstrate the seriousness of the erosion problem on dykes and its annual costly maintenance program, and the other to show the devastation of severe bank erosion which is threatening the stability of a dyke system protecting a thin strip of fertile and precious farm land. According to the deputy chief of the district, if the erosion went unchecked this whole strip of alluvial land, which currently supports the livelihood of several thousand people, would be washed away.

I strongly believe that these dykes could be simply and effectively protected against flooded water with VGT, as for the river banks, major reshaping of the slope is needed before planting can be carried out.

SOUTH VIETNAM

MARD Seminar in Saigon

Approximately 80 people attended the seminar including representatives from MARD provincial offices, Vacvina, University, Research Institutes and Agro-forestry business. The main interests are in erosion and sediment control on agricultural land on the foothill region north of Saigon, river bank erosion control in the Mekong Delta, rehabilitation of eroded acid sulfate soil in the Plain of Reeds and also in coastal lowlands.

Strong interest was also expressed in the use of VGT in the rehabilitation of landfill and industrial and contaminated lands

Seminar at the Institute of Agricultural Science

This seminar was, basically a training session on the principles of Soil Conservation, erosion and sediment control on sloping lands, given to the Institute staff, with special emphasis on the advantages of VGT over traditional soil conservation practices such as contour terraces, farm waterways and diversion banks etc.

About 60 staff members from Saigon and surrounding provinces attended, the majority were P.Truong's old students from the Faculty of Agriculture, Cantho University. The main interests were on the application of VGT for erosion control of the foothill region north of Saigon where the major crops are maize, sorghum, fruit trees and industrial crop; such as mulberry are grown on sloping lands, severe canal bank erosion in the Mekong delta and acid sulfate soil rehabilitation.

NEEDS AND POTENTIAL APPLICATIONS OF VGT

From the above it is obvious that there is a tremendous need for VGT in Vietnam due to its low cost, simplicity and effectiveness. Although its importance in erosion and sediment control in agricultural, forestry and grazing lands can not be overemphasized, we feel that the most urgent need of VGT is for the stabilization of the banks and dykes of the major rivers throughout the country, particularly the Red River and its tributary in north Vietnam.

The next urgent need and of equal importance is the use of VGT for the stabilization of infrastructure such as highways, roads, railways and dams.

Although we did not have the opportunity to visit the upland region, the very steep slopes of Truong Son mountain range where extreme erosion occurs due to massive deforestation in recent years, the rehabilitation of these highly erodible slopes is also urgently needed. However, we think the application of VGT in the present form, that is hedgerow planting, is very difficult to achieve and slow due to the harsh environment and remoteness, a more innovative approach is needed. The use of native and seeded varieties of vetiver as proposed by Dr. Hong of Reading University may offer an opportunity to tackle this very difficult problem.

VETIVER PROJECTS IN PROGRESS

Presently there are two major research/demonstration projects in Vietnam involving vetiver grass — one in the north conducted by the

National Institute for Soils and Fertilizers in Hanoi, Prof. Thai Phien is the leader of this project. The second project is being conducted by the Institute of Agricultural Science in Saigon, this project is led by Dr. Cong Doan Sat. Highlights and results to date of these projects are presented below:

1- The use of vetiver grass as green vegetative hedges in the protection of sloping lands in Vietnam by Thai Phien and Tran thi Tam.

Vetiver contour hedges is one to the several green vegetative hedges used in this series of trial on four different soil types and land uses in North Vietnam. The effectiveness of vetiver hedge in terms of soil erosion control and casava and peanut yields was compared against other hedges such as pineapple, and two legumes *Tephrosia candida* and *Flemingia congesta*. In addition to pure stands of vetiver, the combination of vetiver and *Tephrosia candida*, vetiver and tea plant and vetiver and *leucaena* were also tried at some of the sites. These sites were also intended to be used as demonstration sites for local farmers to judge the effectiveness and economic return of the different systems.

Results obtained at some of the sites are shown in the two tables above

One of the reasons farmers favor vetiver hedges was that it provides a long term protection whereas *P.candida* has to be replanted ev-

Site 1: Phuong Linh Village, Thanb Ba District, Phu Tho Province (average of 4 years 1995 – 1998).

Treatment (hedges)	Soil loss (*t/ha*)	Profit (Mdong)	Farmers' choice (%)
No hedge	43.0	8.2	25
T. candida	32.2	8.6	82
Pineapple	23.1	9.1	96
Vetiver	28.7	10.0	100

Crop: Cassava intercropped with peanut.
Fertilizer: NPK
Landslope: 18°

Site 2: Pho Yeu district, Thai Nguyen Province (1996 results)

Treatment (hedges)	Soil loss (*t/ha*)	Profit (Mdong)	Farmers' choice (%)
No hedge	8.3	4.6	-
T. candida	4.9	6.8	59
Vetiver	6.3	6.8	40
Vetiver & *T. candida*	4.2	5.8	3

Crop: Cassava intercropped with peanut
Fertilizer: Manure 15 *t/ha*

Site 3: Luong Son District, Hoa Binh Province (1997 and 1998)

Treatment (hedges)	Soil loss (*t/ha*)	Profit (Mdong)	Farmers' choice (%)
No hedge	1.8	4.6	10
T. candida	0.3	3.6	55
Pineapple	0.1	8.5	47
Vetiver	0.0	4.3	58

Crop: Cassava intercropped with peanut
Fertiliser: NPK
Landslope: 15 – 18°

Summary of annual soil loss on sloping lands.

Hedges	Soil loss (*t/ha*/year)
Cassava only	32.2
Cassava & *T.candida* hedges	14.2
Cassava & *F.congesta* hedges	13.2
Cassava & vetiver hedges	9.7

ery 3 years.

Conclusion:
Vetiver hedges provide the best soil erosion control measures, reducing soil loss by 50 – 90% as compared to control. It also has good effect on the crops grown between the hedges and it is recommended for application in sloping land in Vietnam. The combination of vetiver and other legume is probably better than pure vetiver stand. However to promote the application of vetiver hedges further, the following limitations have to be overcome:

- Shortage of planting materials
- Technical specifications for different soil types, slope gradients etc. (spacing)
- Limited contribution to soil fertility level
- Financial assistance to establish demonstration sites, training and extension programs
- Financial assistance to farmers to establish hedges

2- Soil erosion control practices for sloping lands in the Lam Dong province by Nguyen quang Chon.

The aim of this trial is to determine the effect of soil erosion on maize and soya yields in terms of nutrient and soil losses. Vetiver hedge was introduced as a soil control measure to reduce nutrient losses.

Vetiver hedge is a very effective soil erosion control measure on sloping lands of this province. In comparison to other methods such as contour planting of tree crops, contour ridges & contour banks etc. (Average soil loss reduction of between 35 – 52%). Vetiver contour hedge is the most effective and the best soil erosion control measure tested.

Summary of results: **Soil loss (*t/ha*) (1995 – 1997).**

Year (age)	Control	Vetiver hedges	% reduction
First year (1995)	31 .143	23 .156	26
Second year (1996)	52 .996	11 .057	79
Third year (1997)	79 .362	10 .243	87

Land slope: 12 – 15°
Nutrient loss in 79 .362 *t/ha* of soil in 1997 was 140 kg of N, 218 kg P_2O_5, 466 kg of N_2O and 1968 kg of organic carbon.

RECOMMENDATIONS

- Establishment of nurseries is the first most important step for the introduction of VGT to Vietnam. A nursery in Nghe An province can supply planting materials to both northern and central regions, but a nursery in the south is needed for southern region. Vacvina should have enough experience to establish and propagate vetiver plants for both agricultural and industrial applications.

2- For greatest impact two demonstration trials should be established as soon as enough planting materials become available. One on the Red River bank in Hanoi and one on the National Highway No.1 north of Vinh.

PLAN OF ACTION
As proposed by Mr Chuong, representing MARD at the end of the seminar in Saigon.

MARD (Mr.Bam):
- Summary and proposal to establish VNVN through out VN in the next 2 years
- Present to the Prime Minister and all four Deputy Prime Ministers the effectiveness and benefit of VGT applications in VNVN.
- Establishment of demonstration sites in 3 regions

VNVN
- Appointment of Chairperson
- Continuation of the extension effort.

Paul Truong
- Contact and request supply of vetiver planting material from the Director General, Land Development Department, Bangkok.
- Provide technical input in nursery establishment and any demonstration sites in the future.

Do you want to support Ken Crismier's efforts in Vietnam. If you do please contact him directly at:
Vietnam Vetiver Network,
4850 156th Avenue NE #359,
Redmond, WA 98052, USA.
Email: kencris@gte.net

POWER FLOUR ACTION NETWORK

The Vetiver Network is helping to promote Flour Power through people and organizations associated with the Vetiver Networ. Flour Power has great potential in reducing malnutrition in young children, and like vetiver the technology is effective, simple and very cheap.

If you want further information and some samples contact:
Thomas H. Hartzell
Power Flour Action Network
1717 Pheasant Lane
Sheboygan
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(920) 458 0244
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Every year, malnutrition claims somewhere between 10 and 14 million children. These innocents mainly reside in Africa, Asia and Latin America. At present they suffer and die with only the remotest hope of rescue. The Power Flour Action Network is being established in an effort to change all that. With its new and novel approach, the Network hopes to remove an underlying cause of this tragedy: the lack of appropriate babyfoods.

In this project, we are bringing to world attention a technique that is potentially effective for feeding those children at highest risk: the ones born to the poorest of the poor, the ones whose mothers are themselves badly malnourished, and the weanling orphans with no mothers at all. The new technique is notably promising for use in remote locations, in times of want, and in the aftermath of natural or manmade disasters. In can thus reach the populations where mortality from malnutrition is greatest. It complements breast feeding and makes the weaning process more successful for the most threatened individuals in locations where milk and baby formula are unavailable.

The prime "tool" in this new technique is food-grade malted barley. This white powder is nothing more than ground-up sprouted barley grains. It is a flavoring ingredient in malted milk, corn flakes, Grape Nuts, Wonder bread, English muffins, pizza crusts, Milky Way bars and many more foods. The United States, alone, produces thousands of tons of it annually, but none is now used to help starving babies survive.

Nonetheless, food-grade malted barley flour could save lives. It is rich in the enzymes that digest starch. Indeed, it digests starch so well that it turns any hot boiled staple into a fluid. We call it "Power Flour" because it causes such a spectacular transformation.

The approach we envision involves no change in diet, no complex routines to learn, and barely any change in lifestyle. Power Flour would be employed solely to turn a portion of the family staple into a form babies can fill up on. Children have difficulty swallowing corn mush, rice, potato, sorghum, and dozens of other "solids." Power Flour converts those boiled staples into liquids to be drunk. In other words, solids that infants struggle to ingest become suddenly easy to handle with a baby's natural born instincts.

Using Power Flour is simple. The mother merely adds the powder to the hot pablum, porridge, mash, mush or gruel that constitute the basic diet of the poorest of the poor families. The conversion occurs almost instantaneously. The quantity used is very small: a teaspoon of Power Flour easily liquefies a gallon of corn porridge, mashed potatoes, or other boiled staple. The cost is negligible; the price of a teaspoon of Power Flour, for instance, is not even 1/10 of a cent.

Taste is no limitation. Power Flour gives malted milkshakes their flavor. Moreover, its enzymes release sugars from the starch, so the liquefied product becomes doubly palatable. Despite some studies of weaning foods made with starch-digesting enzymes, nothing like this instant, barley-based, food-liquefying catalyst has been employed before.

In everyday practice in the Third World village, the mother merely scoops a sample from the family cooking pot, stirs in a little Power Flour, and passes the resulting fluid to her weanling child. No more fighting to get pablum down; no more diluting pasty foods with potentially contaminated water; no more digestive difficulties from a wad of starch balled up in a tiny tender stomach. The baby feeds itself by sucking a sweetish liquid from a cup.

Power Flour samples could be supplied by the local health service, rural clinics, relief agencies, or other organizations. The raw ingredient could be provided in bulk or in pre-packaged form by United States, Denmark, The Netherlands, South Africa, Japan, or other country that makes food-grade malted barley. The cost would be about 1 cent per child. One cent buys enough Power Flour to catalyze the liquefication of 100 cup-sized servings of the local staple. Ingesting that much food will ensure an infant a full stomach at least once a day. That in turn will remove the threat from inadequate food intake during the early weaning period.

The process is safe. The food has been boiled and thereby rendered free of infection. More than 99 percent of it is the local staple, eaten since time immemorial. The added Power Flour (less than 1 percent) is itself wholesome. The only real changes are the liquid consistency

and the disappearance of starch. In most cases this latter will cause no problem, but the released sugars may perhaps prolong any diarrhea outbreak.

The Power Flour Action Network is being established to get this process employed with dispatch and with appropriate cautions and guidance. Through the Network, information will be communicated to audiences ranging from national leaders to field workers. Trial Power-Flour samples will be provided to interested parties. Research results and field responses will be compiled and disseminated. The Network's written documentation will include a technical overview, a field-guide in different languages, and a newsletter published several times a year. Electronic dissemination will include a website and an e-mail service to answer questions and take orders for Power Flour. A videotape demonstrating the process will also be created. Although the ultimate outcome can only be speculated on, we are confident that the results will be profound. Already, a program directed by former president Jimmy Carter and Nobel Prizewinner Norman Borlaug has found that malnourished children in Ghana's villages ingest three times more food using the Power Flour process. Observers consider that the method makes the difference between life and death for those children. Similar results are reported from Haiti and other spots where fatal malnutrition is prevalent.

The Power Flour Action Network is being established as an IRS-approved nonprofit organization under code 501(3)(c). The activities proposed will help garner the worldwide attention this innovation deserves. In this way, the Power Flour Action Network might well accomplish in a few short years, and at modest cost, a result that multinational, multi-million-dollar organizations could take pride in accomplishing over decades. At present, Power Flour is hardly known to such organizations. By stimulating them and also others outside the mainstream we can swing open a new window of opportunity for reducing the death rate among the world's littlest and least deserving sufferers.

Noel Vietmeyer
President
The Power Flour Action Network
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ROTARY DISTRICT 6270
NEWSLETTER, MARCH 1998
POWER FLOUR UPDATE

The Power Flour project, now in its fifth year, is directed by our District's World Community Service Committee. During the past year, Power Flour(P.F.) has nourished children m HAITI, MALAWI, GHANA, and PERU. A brief description of its role in these third world countries follows. Presently a new Rotary Club in Port-de-Paix is distributing P.F. to drought-stricken families in northwest Haiti. This club has requested an additional 200 pounds of four, as the need continues to help these isolated families.

Three separate feeding programs have been initiated in Malawi, a poor east- central African country, where communication is sadly lacking and infant mortality is alarmingly high. A St Louis Fulbright scholar and pediatrician is monitoring the benefits to Malawian children. Last week, additional P.F. was flown by the Global 2000 project of Jimmy Carter and Nobel laureate Norman Borlaug to supplement Dr. Borlaug's maize introduction in Ghana, which is made into cooked porridge for weanling babies.

The latest success for P.F. has been documented by a botanist who routinely visits Amazonia, Peru. Native Indians who inhabit the area along the Amazon River depend an a beverage they produce from locally grown cassava and plantain. This drink, known as "masato," is the major nutritious food for young children and the elderly. Unfortunately, in recent years, the outbreak of both hepatitis and tuberculosis has been traced through the traditional spittle method of digesting the starch for this fermented beverage. Last year, officials persuaded the Indians to substitute P.F. in preparing the masato, rather than chewing the starch to ferment the beverage. This innovation not only eliminated the disease transmittance, but resulted in a sweeter beverage that was easier to prepare! Additional P.F. will be needed this spring to continue this successful venture.

This month, ten-pound samples of P.F. have been airmailed to caregiving organizations in ETHIOPIA and KENYA. As the benefit of P.F.'s use spreads, more and more countries will need a dependable source.

Our District's Zone A Rotary Clubs have elected to pool their resources to help defray future shipping costs of P.F. If your Rotary Club would like to join in contributing, please contact Ken Schumann, W.C.S. Treasurer at 140 North Ave., Hartland, WI 53029 (Office Phone is 414-367-3322)

An exhibit of this project is planned for the Indianapolis R.I. convention in June. Please stop by to visit and offer suggestions for the future benefit of the P.F. Action Network As R.I. President G. Kinross wrote in the December ROTARIAN MAGAZINE, "This year Rotarians are working to combat poverty and hunger. Children are the major victims of these two evils. Some 18 million people, the majority of them children, die each year from poverty-related causes - most often chronic hunger. And, all of those children who are malnourished between birth

and age three, will live their entire lives with mental deficiencies. In 1998, let us 'SHOW ROTARY CARES' by protecting the children of the world.

Thomas H. Hartzell, 1717 Pheasant Lane, Sheboygan, WI 53081-7724, (920) 458 0244,

Briess Malting Company, PO Box 226, Chilton, WI 53014-0226, Phone 920 849 7711, FAX 920 849 4277

DIRECTIONS FOR USING POWER FLOUR (MALTED BARLEY FLOUR) TO FEED ONE BABY

Prepare a normal porridge-like consistency of the starchy food to be used. This starch source may be maize, rice, cassava, potato, wheat, oats, millet or any other carbohydrate starch source. Remove 1 cup portion (1cup=227 grams) of porridge that is to be

used to feed the baby. When it is "warm to the touch" add 1/4 teaspoon (= 1.3 ml) of Power Flour and stir for several minutes. This will liquify the porridge so that it can be given to the baby By spoon or bottle. The baby will benefit greatly by this method of feeding.

DIRECCIONES PARA USAR POWER FLOUR (HARINA DECEBADA) PARA ALIMENTA A UN BEBÉ

Se prepara normalmente el atol de maiz, arroz.,mandioca, tapioca, papa. harina. avena, mijo u otra comida de fecula.

1 taza = 8 onza = 250 ml
1\4 cucharita = 1.3 ml

Se quita una porcion (una taza) del atol que se va a usar para dar de comer al bébé. Cuando estécaliente, se anade 1\4 cucharita de Power Flour y sc remueve por varios minutos. De esta manera el atol se hace líquido y se puede darselo al bebe por cuchara o por botella. El bebé sacará mucho provecho de esta manera de alimentarlo.

DIRECTIONS: COMMENT SE SERVIR DE POWER FLOUR (FARINE PUISSANTE)
(ferine d'orge malt) pour donner à manger à un bébé

Préparez une bouillie (porridge) normale d'une source de fécule, puet-etre mais, riz, cassava, pmme de terre, blé, millet ou aucun autre aliment qui consiste de carbohydrate.

Enlavez une portions d'une tamme (227 grams) de cette bouillie (porridge) qui est preparée pour donner à manager au bébé. Commencez à la chauffer. Quand à d'est chaude au point de toucher, ajoutez 1/4 cuiller à thé (1.3 ml) de cette farine puissant Power Flour) et agitez pour quelques minutes. Ceci liquéfiera la bouilie pour qu'elle puisse etre donnée à manger au bébé per cuiller ou bouteille.

Le bébé benéficiera grandement de cette méthode d'alimentation.

TYPICAL SPECIFICATIONS OF A NATURAL MALTED BARLEY FLOUR

MALTOFERM* MDF F-17
DESCRIPTION:
A white to creamy, NATURAL MALTED BARLEY FLOUR with a pleasant accented malt aroma and flavour. Diastatic
ADVANTAGES:
1) Uniform and improved fermentation. Enzymatic digestion of starch increases production of fermentable sugars aiding in browning and oven kick.
2) Helps reduce dough mix time, improves machinability, extensibility, and gas retention (increased volume).
3) Natural dough conditioner. Improves crumb quality and grain, softer texture and helps extend product shelf life.
4) Provides a clean barley flavour and aroma.

APPLICATIONS:
Bagels, Beverages, Crackers, Flavour enhancer, Ice cream cones, Pita bread, Sauces/gravies, baked Goods, Breakfast cereals, Fermentations, Health Foods, Pancake/waffle mix

SPECIFICATIONS:
Moisture 7.0%
Color (extracted color) 2.0%
Diastase, Lintner minimum...200
Protein (Nx6.25) 12.0%
Fibre (total dietary 7.5%
Fat 2.6%
Ash 1.4%
Carbohydrates 77.0%
Calories 380
Sulfite .....less than 10ppm

LABEL INGREDIENT LISTING:
Barley Malt, Barley Malt Flour, Ground Barley Meal.

SHELF LIFE:
Suggested Storage: 6 months maximum
Storage Temperature: 40º - 75º F
Storage Conditions: Clean dry warehouse

PACKAGING:
50# net weight, multiwall paper bags with polyliner. Heat sealed. 20003 (40 bags) per pallet, stretch wrapped

*DGR LOVIBOND, SERIES 52, 1/2" CELL
The data listed under specifications are subject to the standard analytical deviations. They represent average values, not to be considered as guarantees expressed or implied nor as a condition of sale.

The product information contained herein is correct, to the best of our knowledge. As the statements are intended only as a source of information, no statement is to be

construed as violating any patent or copyright

RECENT VETIVER PUBLICATIONS

Proceedings of the First International Conference: Vetiver: A Miracle Grass, Chiang Rai, Thailand, 4-8 February *1996,* Edited by Narong Chomchalow and Hans V. Henle. Published by The Office of the Royal Development Projects Board, Bangkok, Thailand.

Capim Vetiver – a Barreira Vegetal contra Erosão, Perguntas & Respostas E Proximos Passos. Ciers – Es -Brasil Rede Mundial E Latino-Americano Do Capim Vetiver~Edwin A. Balbarino Rotaclo S. Gravoso

Vetiver Grass: The Hedge Against Erosion. Modfied, printed and distributed by the Kwekwe Environmental Education Programme (KEEP), Zimbabwe.

Bio-Engineering For Effective Road Maintenance In The Caribbean, by J. Clark And J. Hellin. Published by FRP, ODA, NRI

Proceedings of Conference 30, February 22—26, 1999, Nashville, Tennessee. USA International Erosion Control Association Steam Boat Springs, Colorado. USA

Boletín Vetiver Volume 1: Abril 1996 - Junio 1998. La Red Latinoamericana Del Vetiver Enero 1999. Published by La Red de Vetiver Latinoamericana, Apdo. 173-2020, Centro Postal Zapote, San Jose 92332, Costa Rica

Vetiver Grass — A Hedge Against Erosion. Vietnamese translation. Translated and published by Ken Crismier, Vietnam Vetiver Network, 4850 156th Avenue NE #359, Redmond, WA 98052, USA

Vetiver: For Soil Erosion Control. By Edwin A. Balbarino and Rotacio S. Gravoso. Published by Vetiver Network–Philippines (VETINETPHIL) and Farm Resources Management Institute (FARMI)

Pacific Rim Vetiver Network Technical Bulletin No. 1998/2 Vetiver Grass for Slope Stabilization and Erosion Control By Diti Hengchaovanich. Published by the Pacific Rim Vetiver Networ, the Office of the Royal Development Project Board, Bangkok, Thailand.

Pacific Rim Vetiver Network Technical Bulletin No. 1998/1 Vetiver Grass System for Environmental Protection by P Truong and D Baker. Published the Pacific Rim Vetiver Network, Office of the Royal Development Project Board, Bangkok, Thailand.

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Vetiver Grass Technology. Research and Development in Australia

Vetiver Grass Technology for Flood Erosion Control on the Flood Plain in Australia

Vetiver Grass Technology for Infrastructure Protection (Globa)

Vetiver Grass Technology for Environmental Protection (In preparation for the IVC2 January 1999)

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The Vetiver Network is a registered on profit organization under IRS code 509(a) (1). Donations to the Network are welcome and are tax deductable.

The Network produces a biannual newsletter edited and published by Dick Grimshaw. We encourage those interested in vetiver technology to participate by contributing articles to the network.

The Network also manages ahomepage on the Internet at http://www.vetiver.org. Most articles are published on the homepage and the associated ftp site at ftp://www,vetiver.org. The small green handbook, including diagrams, "Vetiver a Hedge against Erosion" can be downloaded from the ftp site

FIRST ANNOUNCEMENT

Vetiver and the Environment

The Second International Conference on Vetiver To Commemorate the Sixth Cycle Birthday Anniversary of His Majesty the King of Thailand

Phetchaburi, Thailand, 17-21 January 2000

It is undeniable that man is a main source of changes in the world geography and environment. Explicit examples of such act include the explosion of mountains to build roads, drilling of mountains to operate a mineral mine, construction of dykes along rivers which creates large bowl of water storage comparable to a lake, or the destruction of forest resources. Besides those, other causes include chemical changes in the atmosphere as a result of emission of gas or certain types of chemical substances, earthquakes, landslide and land subsidence, extinction of wild animal and plant species, as well as waves of extreme heat or drought which have occurred in several parts of the world. Undesirable and critical changes to the environment caused by man are now having impacts on human lives beyond control. Worst of all, one cannot anticipate the possible disastrous outcomes of this ongoing situation.

In response to this, different countries are earnestly trying to resolve or mitigate the problems by using several measures. Different methods including reliance of heavy machinery and cultivation of various crops have been attempted to resolve and prevent the problem. However, some of the methods incurred high costs and the technologies applied are too complicated for farmers to implement.

It has been proven worldwide that vetiver grass grown as contour barriers across sloping lands provides a low cost and sustainable system with numerous advantages for environmental conservation e.g. preventing and controlling soil erosion, maintaining soil moisture, trapping heavy metals and other toxic materials before they reach valuable natural resources etc. Moreover, the grass's ability to grow in areas containing high levels of toxic substances proves significant in removing heavy metals and other toxic materials by increasing the organic content and allowing the translocation of plant nutrients in the soil. All these help improve the conditions of the area, in terms of soil nurturing and atmospheric moisture.

Thailand is a country which faces the problem of soil erosion and has been utilizing vetiver grass in many areas throughout the country. In 1992, His Majesty King Bhumibol Adulyadej of Thailand graciously granted initiatives to relevant agencies to use vetiver grass for conserving soil and water as well as for other purposes on a continual basis. Consequently, study, experiment, research, together with actual cultivation of the grass in different areas, have been carried out. The fruitful results of the experiments have been extended to farmers who applied the cultivation on their own land and successfully improved the soil, allowing the benefits from farming to be realized.

On 4-8 February 1996, Thailand received the honor from The Vetiver Network to host the First International Conference on Vetiver in Chiang Rai province under the name *"Vetiver: A Miracle Grass".* The seminar ended with overwhelming success in widely disseminating vetiver uses and benefits. On the auspicious occasion to commemorate His Majesty King Bhumibol Adulyadej's Sixth Cycle Birthday Anniversary on 5 December 1999, Thailand is once again given the privilege by the Interim Committee for the Second International Conference on Vetiver to host this second seminar. The main objective of this seminar (ICV-2) is to show that vetiver grass is one of the simple and low cost solutions to deal with a broad and ever increasing range of environmental problems.

Conference Theme

Towards the new millennium : an era of practical and economical methods of vetiver utilization for environmental conservation and protection.

Objectives

1. To commemorate the Sixth Cycle Birthday Anniversary of His Majesty King Bhumibol Adulyadej of Thailand;
2. To provide an international forum for experts to exchange views, knowledge and new techniques on the utilization of vetiver, especially on its attributes in environmental conservation and protection;
3. To educate the public and disseminate the knowledge on vetiver, its usage and application.
4. To be a venue for different vetiver networks and dissemination units all over the world to share their work experiences and achievements.

Organizing Agency

The Chaipattana Foundation and the Office of the Royal Development Projects Board, Thailand.

Conference Technical Program

The conference technical program will be divided into 4 main sessions: plenary sessions, concurrent sessions, poster sessions, and technical tours. Research works and experiences on the following topics will be presented:

1. Soil and Water Conservation Attribute
   - erosion control in agricultural areas
   - land rehabilitation- watershed management
   - improvement of extreme soil
   - sedimentation control - irrigation
   - soil fertility improvement and associated impacts on farming practices
   - waterway stabilization

2. Pollution Control and Treatment / Restoration and Rehabilitation of Disturbed and Contaminated Areas
   - wastewater treatment
   - wasteland
   - mine spoils
   - highway and other constructions
   - non-point source pollution
   - bioengineering applications
   - pollution from construction

3. Disaster Prevention
   - flood control
   - fires
   - hurricanes
   - structural failure
   - droughts
   - mudslides

4. Training and Technology Dissemination
   - vetiver network experiences
   - best practices of vetiver promotion
   - available sources of vetiver for dissemination

- economic way for vetiver application and for improving planting practices

5. Basic Research and General Studies
   - environmental tolerances and responses
   - taxonomy
   - pest and plaque resistance
   - genetic research
   - heavy metal accumulation
   - association with other species
   - CO_2 absorption - etc.

6. Alternative Uses of Vetiver
   - construction materials
   - supplementary feed
   - handicraft
   - weed prevention
   - energy source
   - essential oils & traditional medicine

7. Other Topics
   - vetiver on national policies
   - hydrologic regime regulation
   - use of vetiver grass and its role in the certification of sustainable agriculture

Technical Tours
With particular reference to the environment, four sites for technical tours on vetiver researches, applications, and technology dissemination to farmers have been selected. Huai Sai Royal Development Study Center and Chaipattana-Mae Fah Luang Reforestation Project in Phetchaburi Province will provide activities concerning researches and applications of vetiver while visiting to a farmer's farm will enable the participants to see the practical use of vetiver and the successful application of vetiver.

Participants
A total of 300 participants are expected to attend ICV-2. These include about 120 international vetiver experts from countries of all regions, international organizations and development agencies.
Additionally, about 180 local experts from Thai government agencies as well as non-governmental organizations involved in the utilization of vetiver are also anticipated to join the conference.

Venue and Date
Cha-am Regent Beach Resort Hotel, Phetchaburi, Thailand, on 17-21 January 2000.

Official Language
The official language as well as all documents during the conference is English.

Registration Fee
As this Conference is organized to commemorate His Majesty the King's Sixth Cycle Birthday Anniversary, all participants will be treated as our special guests. Thus, there will be no fee for registration. This includes the attendance of all sessions, the provision of all documents, and transportation while attending the ICV-2 (includes pick-up service from and to Bangkok Airport and study tours) However, due to the prevailing economic crisis, all participants are required to pay their own accommodations and all meals during the conference period.

Sponsorships
There will be a limited number of sponsorships for qualified participants from the least developed countries. Those interested should send, along with the pre-registration form, their curriculum vitae indicating work experience related to the topics in the technical programs.

King of Thailand Vetiver Award
King of Thailand Vetiver Award has been announced since June 1997. According to the announcement, His

Majesty the King of Thailand has agreed to award two US $5,000 from the Chaipattana Foundation funds. One award will be granted to the best vetiver research work while the other for the best dissemination of vetiver technology. Nominees for these awards have already been selected by a committee of The Vetiver Network who sent them to the Thai Committee for the selection of the winners. The awards have not been judged, however, since it was considered that as Thailand is about to host ICV-2, these awards should be extended to provide opportunity to other qualified persons whose papers will be presented at the concurrent sessions and the poster session at the ICV-2. Winners of the award will be announced in December 1999 and will be invited to attend conference with full sponsorship.

Spouse Program

During the conference period, a spouse program will be provided for participants' spouses or followers to visit interesting places which are abundant in the area such as the near-by Cha-am and Hua Hin beaches, world famous's Dammoen Saduak Floating Market, Khao Wong Heritage Park, and Khao Luang Cave. The program will be arranged by Tourism Authority of Thailand (TAT), the detailed information of which will be found in the Second Announcement.

Post Conference Tour

The post conference tour will be organized in collaboration with TAT for the participants and their spouses to visit vetiver growing and applications in areas other than those specified in the technical tour program. The proposed areas will either be: (i) Chiang Mai and Chiang Rai in the North, or (ii) Pattaya in the East, or (iii) Phuket and Hat Yai in the South. Participants will have a chance to visit vetiver application fields as well as world famous tourist attractions of Thailand. More details will be provided in the Second Announcement.

Second Announcement

The Second Announcement which will include detailed programs, instructions for submitting abstracts and papers, registration form and accommodation will be available in August 1999. It will be sent only to those who pre-register with the attached form (may be photocopied if more copies are needed).

Pre–registration Procedure

Pre–registration for the conference can be made through 3 different channels :

1. Fill out the form below and fax or mail it to the Secretariat of the Conference at the address specified at the end of the announcement.
2. Fill out the form attached in the First Announcement sent by the Secretariat , then send the filled form for pre–registration. In case you have not received one please request for the announcement from the Secretariat at the address below.
3. On-line registration through PRVN web site at 'http://prvn.rdpb.go.th'.

PRE-REGISTRATION FORM

First Name …….....

Last Name :.....

Position .....

Organization :.....

Country :.....

PostalAddress :.....

.....

.....

.....

Tel : (.....) (.....) Fax : (.....) (.....)

E-mail .....

Please check (X) in the box below.

( ) I want to receive the Second Announcement.

( ) I plan to present a paper.

( ) I plan to attend the Conference.

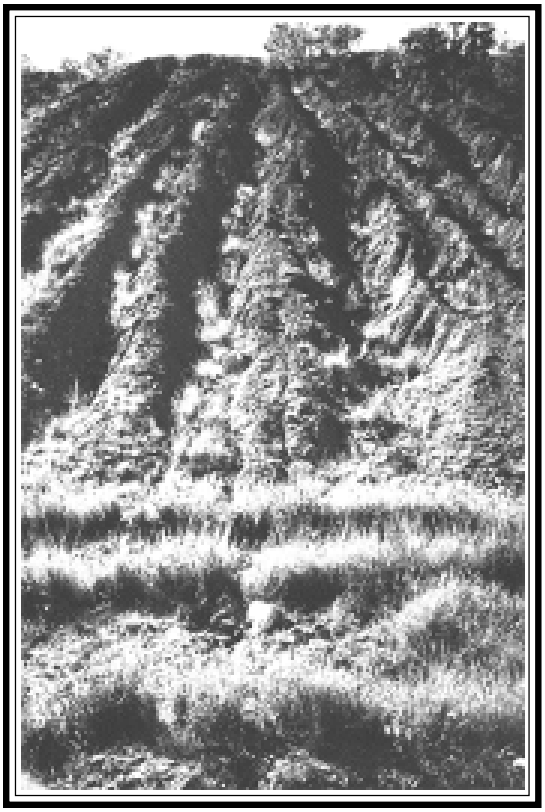
( ) Please mail the First Announcement to:

Name .....

Address .....

.....
Country .....
Tel : (.....) (.....).....
Fax : (.....) (.....).....
E-mail :.....

Australia, Queensland: A Severely eroded gully rehabilitated with vetiver grass hedgerows. Photo Credit: **Paul Truong.**



Left: Australia, Queensland: Coal mine tailings stabilized with vetiver. Note vetiver has been planted up and down in the deep rills and in hedgerows across the bottom of the tip. Once vetiver is established natural grasses and shrubs can colonize the area. Photo Credit: **Paul Truong.**

Below: Australia, Queensland: Vetiver Grass Hedgerows planted along housing area to stabilize the embankment and prevent pollution and trash “invading” the road. Photo Credit: **Paul Truong.**

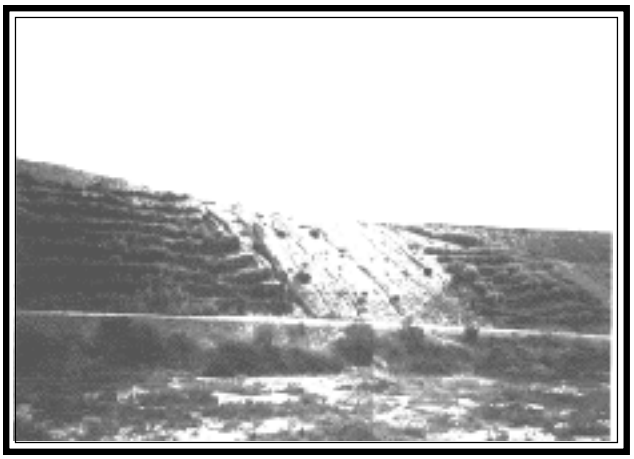
Australia, Queenslan:. Highway drain stabilized with vetiver grass hedgerow. Note the trapped silt behind the hedge. Photo Credit: **Paul Truong.**

Australia: Queensland: The bitumen edge of a highway stabilized with vetiver grass hedgerow. Photo Credit: **Paul Truong.**

China, Guangdong Province: A coastal area subjected to highwinds. Here vetiver has been planted between casurina trees on sand dunes close to the sea to help reduce wind erosion. Photo at right is a close up of well grown vetiver on beach sand. Photo Credit**: Xia Hanping.**

China, Hubei Province: Vetiver planted in 1998 as hedgerows to protect terraced land. Photo Credit: **Liyu Xu.**

Haiti: Vetiver Grass Hedgerows planted to protect vegetable gardens on degraded lands. Photo Credit: **Calvin Bey**.



Spain, Lorca: These vetiver hedgerows were planted four years ago to protect a fill sesction of a highway. Note the control section in the center where major and deep rilling has occured. Once the vetiver is properly established (right) natural vegetation colonizes the inter hedge areas. The climate here is Mediterranean with a rainfall of only 250 mm per year. Photo Credit: **Mike Pease**

Philippines: Vetiver hedgerows under partial shade protecting a fruit orchard. Rainfall over 2000 mm annually. Photo Credit: **Noah Manarang.**

Philippines: Containerized vetiver plants being readed for planting on a steep highway cut. Photo Credit: **Noah Manarang.**

Sri Lanka: Vetiver hedgerows used to protect tea gardens and to reduce silt from filling the old silt traps in the tea gardens. Photo Credit: **Andrew Taylor.**

Sri Lanka: Vetiver hedgerows used to protect the side of a black top road and adjacent tea gardens. Photo Credit: **Ananda Fernando.**

Table of Contents

UP FRONT
Vetiver and Disaster Mitigation 1
TVN Research and Development Awards -- 1998 2
Vetiver Network Appoints Representatives for Europe and The Far East and Pacific Areas 3
A Tribute to Kevin O'Sullivan 3
Vetiver Grass Hedgerows Key Solution For Stabilization Of Central American Watersheds 3
Letters, Feedback, and Vetiver Chat 5

AUSTRALIA
Report from Australia 19
Resistance Of Vetiver Grass To Infection By Root-Knot Nematodes (Meloidogyne Spp) 20
Soil Moisture Competition Between Vetiver Hedges and Sorghum Under Irrigated and Dryland Conditions. 22
VGT Applications in Queensland 27

CHINA
Recent Trials with Vetiver in Hong Kong 27
Vetiver For Water Eutrophication Control in Taihu Lake of China 28
Vetiver Grass For Water Eutrophication Control 29
Vetiver at China Super-way Conference 29
Vetiver Research and Development -- Published 30
Vetiver in Agriworld 30
Insects on Vetiver Hedges 30
The First Highway Vetiver Contract Implemented In China 31
Vetiver: An Authorized Grass For Highway Stabilization 31
Study On EcologicalCharacteristics Of Vetiveria Zizanioides 32
China Vetiver Network (CVN) Annual Report (1998) 34

EUROPE AND THE MEDITERRANEAN
Status Report - European And Mediterranean Region, The Vetiver Network (EMVN) 1998 39

INDONESIA
Cultural Practices for Soil ErosionControl on Cassava based Cropping Systems in Indonesia 41

MEXICO
Program for Erosion Control and Restoration of the Soils of Oaxaca (PCERS) on behalf of SASO. 42

SOUTH AFRICA 44
Vetiver as an Effective Mulch 44
Mpumalanga Vetiver Program - an update 45
Vetiver in Aromatherapy 46

TANZANIA 46
Terminal Report On Vetiver Technology And Development In Tanzania - Rukwa Region 46
Vetiver Grass in a Soil and Water Conservation Trial - Tanzania 47

VIET NAM 49
The Vieät Nam Vetiver Initiation Visit of January-February 1999 49
Report on the Visit to Vietnam 17 to 30 January 1999 52

POWER FLOUR ACTION NETWORK 56

RECENT VETIVER PUBLICATIONS 59
THE VETIVERNETWORKDIRECTORS AND OFFICERS 59
COORDINATES OF REGIONAL AND NATIONAL VETIVER NETWORKS 60

The Second International Conference on Vetiver 61

Photo Gallery 64

A NETWORK AND NEWSLETTER PROMOTING THE VETIVER SYSTEM

THE VETIVER NETWORK

VETIVER NEWSLETTER NUMBER 21
MILLINENNIUM EDITION FEBRUARY 2000

The Second International Conference on Vetiver. Vetiver and the Environment.

To Commemorate the Sixth Cycle Birthday Anniversary of His Majesty the King of Thailand 18 - 22 January 2000, Phetchaburi Province Thailand

Some 340 engineers, researchers, practitioners, development experts, donors and businesses from 5 continents and 31 countries attended the conference which was organized by the Office of the Royal Development Projects Board with support of the Chaipattana Foundation.

The Executive Chairperson of the Foundation, Her Royal Highness Princess Maha Chakri Sirindhoorn attended the Conference which was Chaired by Dr. Sumet Tantivejkul, the Foundation's Secretary General.

The conference must be regarded as a great success bringing together vetiver users and researchers from all over the World. Over the past four years since the first conference in Thailand the Vetiver Grass system has moved from just being an agricultural technology to one that can be applied over a wide range of environmental needs. The technology has taken hold in more than 100 countries and it attracts new users daily.

At this conference the quality of presentations were good, as were the wide range of R&D topics. There were excellent demonstrations set up at the Conference and in nearby areas. Additionally the Conference was enriched by the feedback from regional and national networks, and by the presentations from users around the world.

The King of Thailand Vetiver Award winners received their awards at the Chitralada Palace from Her Royal Highness Princess Maha Chakri Sirindhoorn. The winners were:

Paul Truong - Australia
W.S. Shu et al. - China
Department of Land Development - Thailand
Oscar S. Rodiquez - Venezuela
Liyu Xu - China
Yadana Gas Pipe Line Project - Thailand

Table of Contents See Back Page 82

The conference organizers produced some excellent documents that are available from the PRVN Secretariat, (Attn. Suwanna Pasiri), Office of the Royal Projects Development Board, 78 Rajdamnern Nok Avenue, Dusit, Bangkok 10300, Thailand. Fax: 662 280 6202. Email: pasiri@mail.rdpb.go.th. A list of publications is available, the latest include:

- **Vetiver Handicrafts in Thailand** by the Department of Industrial Promotion.
- **The Use of Vetiver Grass System for Erosion Control and Slope Stabilization along the Yadana Gas Pipeline Right-of-Way by The Yadana Gas Pipeline** Project - Petroleum Authority of Thailand.
- **Vetiver Grass Technology for Mine Rehabilitation** by Paul Truong.
- **Techniques of Vetiver Propagation in Thailand** by Narong Chomchalow.
- **Factual Tips About Vetiver Grass** (A Manual with photos). Office of the Royal Projects Development Board.

Also the Royal Projects Development Board stands good on its offer to train bonefide vetiver users in various applications of

vetiver. Training in handicraft and propagation would be of special value. Trainees have to get to Thai at their own cost.

For a more detailed account of the Conference read Criss Juliard's article found on page 12 of this newsletter.

Dick Grimshaw

Third International Conference on Vetiver CHINA --- 2004

The Continuing Committee of the Second International Conference on Vetiver recommended that the **Third International Conference on Vetiver**should be in China in 2004. The focus of the Conference would be **Vetiver and Water.**

For further information please contact Liyu Xu at China Vetiver Network. Email: vetiver

VETIVER AND WATER AN ENHANCED PERSPECTIVE

At the start of this new millennium many of the world's governments and institutions are focussing on the pending water crisis that will effect most parts of the world during this century. Fittingly the Conference endorsed the proposal that the 3rd International Conference on Vetiver, to be held in China in 2004, should focus on Vetiver and Water. The Vetiver Network endorses this proposal and asks its members and affiliates to give special focus to the water related aspects of vetiver. This should not be difficult because each time vetiver is used it interacts with some aspect of water; thus for many vetiver users and researchers it will be mainly a matter of highlighting the water related aspects of vetiver. However we need to give special emphasis to those vetiver application that will have a direct water focus.

The World is faced with fast growing problems of reduced availability of water and declining water quality. With regard to quantity there is a need to improve ground water recharge to offset the lack surface water storage and increasing losses through violent rainfall occurrences. With respect to quality water is increasingly polluted by chemicals and by sediments from the increasing areas of eroded lands. These polluted waters not only effect humans but also effect fisheries, coastal coral reefs etc.

Vetiver grass should be an essential tool in mitigating this pending water crisis. The following areas are of special interest:

Quantity:

- Vetiver should be used to protect the fountain of rivers i.e. the spring heads.
- Vetiver hedgerows play a vital role in watershed protection. Hedgerows slow down flood runoff, spreads the water out, and recharges groundwater (it does this better than most plants because of its deep penetrating roots). Later in this newsletter you can read about substantial recharge of aquifers in Orissa, India. Vetiver increases soil moisture thus reducing the need for supplementary irrigation.
- Vetiver hedgerows can be used to stabilize dam walls, canal banks, and drains thus reducing maintenance costs and assuring the integrity of the systems.

Quality:

- Vetiver hedgerows when used for watershed protection will significantly reduce soil loss and sediment flows into the drainage systems.
- Vetiver rehabilitated degraded lands and those lands effected by landslides (mass sediment flow sources) will have significantly reduced sediment out flows, and hence improved water quality.
- Highways and other engineered structures when stabilized with vetiver will result in less polluted runoff from highway sites.
- Vetiver used for the stabilization of mines, landfills, and other polluted sites will cause a reduction in leachates and better quality water.
- Vetiver used across out flows from high intensity agricultural enterprises that use large amounts of fertilizers and pesticides can reduce the discharge of chemicals significantly, thus improving water quality.
- Vetiver can be used to block animal and human waste effluents.
- Vetiver can be used to stabilize river banks, levees and canal banks reducing the risk of breaching and the resultant water loss, and devastation to human life and property.

These are just some of the many benefits that vetiver can bring to the water sector. We know that vetiver will be effective, but in many cases we need more quantitative data and application architecture to present to potential clients. These needs should provide an in-

teresting challenge to researchers and developers.
Dick Grimshaw

WHERE DO WE GO NEXT?

At the start of the Second International Vetiver Conference I presented a paper, part of which is in this newsletter, that set out the following agenda for accelerating the dissemination of the technology:

- The spontaneous establishment of new national and local vetiver networks and the expansion of existing networks without financial assistance of TVN. Hopefully governments and donor agencies, including international agencies and trade organizations such as Rotary and Lions' Clubs or such local equivalents, will provide assistance.
- As government and other agencies, become more appreciative of the value of VGT, they will include it in their technical strategies, and be more active in its promotion application. Agencies need to better appreciate the cross sector linkages that VGT impacts on;
- The expanding involvement of private sector enterprises that are realizing the importance of the technology and the fact that it can be applied profitably. The private sector will actively market the technology, and thus will impact a whole string of enterprises from small plant material producers to landscapers and construction companies.

By the time the conference completed I considered that views were generally supported by the description of current activities reported by conference attendees.

There are no lack of ideas as to how the technology can be applied now and in the future -- there are plenty of innovative users and researchers around the world who will create new vetiver architecture and its quantification. However our ideas are far in advance of improvements in dissemination of the technology. Over the next few years we must find better ways of getting more vetiver out to more users.

The single biggest constraint is the availability of plant material. Most users or planners just do not appreciate the hundreds of hectares of vetiver nurseries that are required. At its best 1 ha of nursery will supply enough plant material for 100 - 150 linear kilometers of hedgerow. On very steep slopes one needs 1 km of vetiver hedgerow per protected hectare of farm land. Adoption rates will be slow, and opportunities for large applications will be lost unless large multiplication programs are established. Therefore we must find ways of increasing supply significantly. This can be best done by small farmer nurseries and or by large commercial nurseries.

Market development can either be as now -- slow -- or can be accelerated by better marketing in user countries. The experience of the private sector in Madagascar, Philippines, and El Salvador is interesting because all the companies involved were able to convince government policy makers and planners of the effectiveness of the technology, to the extent that in Madagascar and the Philippines the technology is now formally incorporated as government policy. As a result markets will grow and nurseries, whether large or small, can develop and produce larger quantities of plant material that have a good chance of being sold.

Many countries are dependent on bilateral and multilateral agencies for financing of development projects. We must get these agencies to pay greater attention to vetiver. Some such as USAID, DANIDA, and GTZ know about the technology and are increasingly using it. Most vetiver developers and users are part of the agricultural sector -- we are not good at marketing to the non agricultural sectors, and yet it is in many of these sectors where a large potential market exists. As this non agricultural market develops the supply of plant material will increase to the benefit of the agricultural sector

With few exceptions governments have a bad record in promoting vetiver grass for erosion control amongst farming communities. The reasons are complex -- split departmental responsibilities, alternative agendas, poor extension approaches, failure to communicate, and a host of other reasons. Without exception we find that when NGOs introduce the technology to farmers by and large the adoption rate is high. A review of an NGO vetiver project in India, described later in this newsletter, gives a good example of the problems and successes of a vetiver initiative with some of the poorest rural people in the world -- the tribals of Orissa. Interestingly we also find that where government vetiver initiatives have worked it is nearly always because the lower level government workers are committed to the technology, even though their superiors may not be. Most government extension services look to research services for guidance and support, many of these services seem disinterested in vetiver grass -- maybe a "not invented here" syndrome. Some others have researched with the object of proving that the technology is not what it is advocated to be, but have ended up finding the contrary, often leading to strong support for the technology! Vetiver initiatives from Malawi, Mexico and Papua New Guinea suggest that community programs that link NGOs, researchers, government extension services, and the private sector may be the best way to go. The NGO can play an important part in leadership and working with and building the trust of the communities; research services support the program in resolv-

ing technical problems as they occur (and they do!); the extension services can supplement the work of NGOs by providing special farmer training services, and providing other technologies that are needed to complete the technical package in its broadest sense, and the private sector acts as a bridge to sophisticated engineering projects that need to use the technology.

The vetiver networks established at regional and national levels have on the whole been very successful. The best have not only networked information but have been very active in promotion and development of vetiver initiatives. They have done this with minimal funds. Some have been supported by TVN, some have established themselves independently. Some developed from local vetiver initiatives as did the Amhara (Ethiopia) and Cameroon Vetiver Networks, other started before field vetiver initiatives were developed. It doesn't matter which way, the key is committed persons who want to do something for erosion control and their people, and who are convinced that vetiver is an effective and low cost technology. Over the next four years we need to establish many more national networks in all the regions of the tropics and semi tropics. Even within countries local networks can be usefully developed. Networking with or without the Internet is very effective -- with the Internet it is even more effective. People who want to start networks in their countries need to find local funding sources -- preferably from the private sector or by bilateral donors such as DANIDA, NEDA, DIFID, USAID and GTZ. All these agencies know about vetiver and use it on their projects.

What of The Vetiver Network? It is not going to last forever. TVN continues to have a "knowledge transfer" role, something that we have been successful at in the past and can continue to do in the future. We can link users together, we can help put funders and networks in touch, and we can help find specialized consultants to help get special programs initiated or problems solved. It looks as though we will NOT be able to fund networks or field vetiver programs directly. We will do our best, we will be flexible in our approach and we willingly hand over responsibilities to others as and when the time arises. TVN's own staff resources are less than minimal, so we need help from others to do some of the work. Recently we found the funds for Paul Truong to put out a new CD-ROM, and Suwanna Pasiri of PRVN was able to get them "printed" at a much lower cost than elsewhere. This is just one example of how we can share the work load. If there are any volunteers who would like to involve themselves with our work please get in touch with me at vetiver@vetiver.org.

Dick Grimshaw

A TECHNICAL DESCRIPTION OF VETIVER GRASS TECHNOLOGY (VGT)

At TVN's Board meeting held during the Conference we discussed the need for establishing standards for VGT in order to try and assure that application quality was maintained, particularly in the commercial sector. Our Board will give this some thought and we hope to come up with something that should be helpful for the maintenance of standards. In relation to standards we discussed "Trade Marking" the technology as a means of preventing the technology from being corrupted and used in inappropriate ways i.e. outside the conformity of standards and general description of the technology. We decided to leave "Trademarking" for further discussion. Again in relation to Trade Marking we discussed the name "Vetiver Grass Technology" and "Bio-engineering". There was a consensus that both names were not fully appropriate. The word "technology" makes vetiver sound too complicated and high tech which it isn't. Bio-engineering gives some people the feeling that we are marketing "terminator genes", "modified crops", and other activities that some see as distinctly "non green".

We agreed that we would use the phrase "VETIVER SYSTEM". It is simple and descriptive. All VETIVER SYSTEMS (VS) use vetiver grass. VS is a system of conservation and stabilization of natural resources using vetiver grass, generally in the form of a narrow hedge on the contour or across the slope of the land. Within this there are variations, e.g. Vetiver System for soil and water conservation - VSSW - (i.e. on farm conservation); Vetiver System for embankment stabilization - VSES - (i.e. for construction site stabilization); Vetiver System for polluted site stabilization - VSPS - (i.e. mine reclamation, land fill stabilization); and so on.

We would like to try this nomenclature over the next year and see how it works out. We would appreciate that you cooperate (you don't have too!). If it works and it helps clarify the use of the technology we might then go ahead and Trade Mark "VETIVER SYSTEM".

If anyone has any thoughts on this topic please get in touch with me.

Dick Grimshaw

THE GLOBAL IMPACT OF VETIVER SYSTEMS

How does one measure the global impact of Vetiver Systems (VS)? International donor agencies go to great lengths and cost to evaluate the impact of their development programs. TVN does not have this luxury; thus it is difficult for TVN to monitor its impact. However we are able to make an assessment of progress since 1986, the starting year for the revival of the technology:

- In 1986 the technology was introduced to India, in the year 2000 some 138 countries know about the technology and more than 100 are using it in one form or other;
- In 1986 there were no vetiver networks, in 2000 there are at least 14 known networks;
- Since 1989 TVN has produced 17 formal newsletters with an issue of about 3,000 per newsletters;
- The first newsletter had about five pages; the last one, # 20, had 70 pages -– mostly technical information coming from the field. Other networks have produced newsletters on a biannual basis – LAVN, MVN, SAVN, PRVN, WAVN, VETINETPHIL and CVN have all produced newsletters regularly;
- Over 100,000 vetiver handbooks have been distributed since 1987;
- TVN's homepage that was established in 1996 has received about 17,000 hits;
- Over 800 NGO's are using the technology;
- Some 800 government agents are using the technology;
- About 1000 research stations/ agencies receive the vetiver newsletter, many of them carry out vetiver research;
- In Ethiopia we are told that half a million farmers know about the technology;
- In Malawi it is government policy to promote VS;
- In 1986 VS was solely applied as an erosion control measure, in 2000 it was used for highway stabilization, mine land rehabilitation, river, canal and drainage bank stabilization, sea shore stabilization, wind breaks, pollution control mitigation associated with municipal trash dumps, and for housing construction site stabilization;
- In 1986 few engineers knew anything about vetiver grass, today many do, and for example in 1999 the Madagascar Society of Engineers formally recognized VS as an important technology for road stabilization purposes;
- In 1986 VS was associated only with government projects today more than 800 commercial and private individuals receive the Vetiver Newsletter. There is an increasing involvement of the private sector in the establishment of VS enterprises that serve the engineering sector, good examples of this can be found in Malaysia, Thailand, El Salvador, South Africa, Philippines, and China;
- VS has become a frequent component in bilateral funded projects in Ethiopia, Ghana, Madagascar, Malawi, Tanzania, Zimbabwe, China, India, Sri Lanka, Papua New Guinea Philippines, Indonesia, Honduras, Panama, Costa Rica to name but a few;
- Apart from numerous site oriented workshops there have been a number of international conferences devoted to VS, and most other conferences that to soil erosion control and biological engineering include papers on VS.

The Vetiver network is continually receiving letters and other communications from persons in most countries in the tropics and semi tropics requesting information about the technology. We receive feedback from unlikely places which suggests that the technology is now becoming quite well known and that there is a lot more going on with VS than we really know. When the vetiver initiative was started most scientists had either had never heard of the technology or thought that it could only be confined to the low altitude wet tropics — the technology has indeed come a long way.

NETWORKING – A MEANS FOR THE DISSEMINATION OF TECHNOLOGY

The Vetiver Network (TVN) was one of the early organizations to network a single technology. Subsequently other vetiver networks were formed in association with TVN. Together the networking process has been successful, and it is worthwhile setting out some of the reasons for this success:

- the networks focus on VS and not on other comparable technologies (although it acknowledges that other technologies may be effectively used in conjunction with VS or as stand alone technologies). One of the failures of many technology initiatives and development programs is that sometimes too many options are introduced that often prove over complicated both as a message and for the messenger. Lower level extension workers often feel that the delivery of one or two good messages will produce better results than multiple messages. Further more VS is an exceptionally good technology that is superior to most other comparable ones – feedback from users confirm this fact. Some bilateral donors feel that beneficiaries

need to have many options to choose from. This view is only acceptable if the intended beneficiary knows what the options are. Fifteen years ago hardly any one knew about VS, thus there was a need for a single technology approach in order to disseminate the VS technical message.

- The message is technically simple, low cost and effective, when applied correctly. VS is really a very simple technology to apply and good demonstrations quickly convince potential users. "Seeing is believing" is an important aspect of passing the message on to new users. One user wrote to TVN "we read, we did, and it worked" — what better accolade than this!-
- The technology requires a much lower labor input than traditionally engineered systems, and once established needs little maintenance. On average a person can construct 15 meters of traditional terrace a day, compared to 200 m of VS hedgerows. This means that a ha of land can be protected in two or three days, compared to 40 days for terracing, and therefore it is an attractive technology to resource poor farmers;
- VS is gender positive. For example, Ethiopian women like the technology as it is not as hard work as terracing, and they see plenty of useful social bi-products from the grass including thatch, weaving materials, medicinal supplies, mattress stuffing material, snake excluder, privacy hedges, and a host of other uses. Women in the Philippines like the technology as they can develop mini nurseries to produce containerized vetiver plants to sell to the commercial sector for highway stabilization purposes. They call it "cash grass".
- VS is unique in that vetiver grass can be applied over a wide range of ecological conditions (hence a basis for wide adoption), and many environmental and economic uses — the two often combined. It is difficult for most people to believe that the grass will grow over a wide range of extreme conditions. Thus one species will do the job of many. Once planners and users are convinced of this, and promote it as such, the technology adoption accelerates rapidly;
- The end user comes first. This is a basic principle of TVN. Users are more important than government officials and scientists. TVN recognizes that the latter are useful, but we do not forget that it was, in the first place, the users who developed the technology; and it is the user who comes up with many of its refinements;
- The majority of information received is immediately fed back to users, and is published in the newsletter and on TVN's website. There are no delays;
- There are no formal peer reviewers — the end user is the peer reviewer — he/she either uses the information or rejects it. . So long as material received by TVN is readable and relevant we will publish it. There are no peer reviewers to reject the material as unworthy of publication, or to reject the material because it conflicts with their own agendas. There are no supervisors who want authorship in return for publication;
- Incentives (awards) are provided to encourage active participation. The awards program has been very successful, not only does it encourage research but it also acknowledges many "small" persons in the vetiver system that work hard with little recognition. A vetiver award is often a coveted prize, even if it is just a certificate (in the future if TVN has limited funds, certificates may be the only way we can recognize worthy contributions to the furthering VS.);
- Most vetiver researchers and users have been generous in sharing their information; because of the open approach taken by TVN, those involved with vetiver have been keen to provide feedback. This doesn't mean that we get all the feedback that we would like, we would like a lot more from those that receive but do not give!
- In most countries there are committed individuals who make great efforts to disseminate information on VS, organize training etc. There are perhaps three dozen individuals around the world who have really made a difference to "moving the technology". Amongst them and foremost is His Majesty the King of Thailand. Others include: Ed Balbarino and Noah Manarang of the Philippines, Liyu Xu and Xia Hanping of China, Govind Bharad of India, P.K.Yoon of Malaysia, Tony Tantum and Duncan Hay of South Africa, Paul Truong of Australia, Diti Hengchanovich and Narong Chomchalow of Thailand, Joan Miller and Jim Smyle of Costa Rica, Linus Folly of Ghana, John Greenfield and Don Miller of New Zealand, Criss Juliard, Mark Dafforn, Ken Crismier and Noel Vietmeyer of the US, Alemu Mekonnen of Ethiopia, Ngwainmbi Simon of Cameroon, Glenn Allison and Paul Zuckerman of UK, Mike Pease of Portugal, Cornelis des Bouvries of the Netherlands, Stephen Carr of

Malawi, and Jano Labat of Zimbabwe. These are but a few of the many active participants of TVN – they and others have all created change.

- 99% of the information that is networked is delivered at no cost to the recipient; and is delivered fast. Early in its operations TVN found that people either don't like paying for new information, or don't have the money, or can't get the foreign exchange even if they have the money. So we have a policy that it is better to get the information out at our cost rather than not at all, or in limited amounts. Occasionally we ask people to pay or make a donation. But I am convinced that our success is partly because we have delivered good information quickly and at no cost.
- TVN has deliberately set a policy that encourages affiliated networks to take the lead at regional and national levels. Although TVN led in the beginning we have made great efforts to devolve responsibility and fund raising to local networks. We have provided up to US$ 30,000 – US$ 50,000 per network to assist networks get off to a reasonable start. Mostly the response has been good and the networks have done far more than we originally anticipated. TVN remains in the back ground as a feeder of information, and a linker of information and persons;
- Networking vetiver technology appears to be self-sustaining. If TVN closed down we can be assured that VS's adoption would continue at an increased rate, particularly in those areas that are using it widely. This says much for the technology and for the way the technology has been disseminated. However there are still many countries and sectors that do not know much about vetiver. Thus we think it is important to keep TVN operating in some form or other.
- The Internet homepage, CD-ROMs etc. are powerful tools in the dissemination effort. A picture can tell a thousand words. TVN has made a point of sending out videos and slides relating to the technology and its uses. Now that CD-ROMs are so cheap (US$ 1,500 per thousand CDs) it is possible to send out all we know about vetiver at a very low cost. The current CD that we give away includes all 20 newsletters, important vetiver papers and articles, the vetiver data base, five pictorial presentations, and the "Green" books in English, French and Spanish. The Internet also provides a very good information source about VS. TVN's home page, http://www.vetiver.org, with links to other vetiver network sites, contains all we know about VS (some 15 megabytes). More people are using it, and if only 20% actually do something with what they have learned then the return to the annual cost (about US$ 1000 per year) of running the homepage and the associated ftp site will indeed be high. As other web sites with similar interests are established and inter links are made between sites we can expect an acceleration of hits on our site;
- Hard copy newsletters are an essential component in disseminating information to the majority of recipients. Unfortunately we cannot do without hard copy newsletters. Most of our participants do not have computers, and if they do, accessing the Internet can be expensive. TVN and local network newsletters are therefore essential. We find vetiver newsletters for sale, often in tattered condition, in remote book fairs in the heart of India! We find one newsletter is often circulated to 50 other readers – so hard copy is still a powerful tool;
- Internet dissemination is a powerful information tool for NGOs and other agencies that are plugged in to the World Wide Web. Once these agencies have access to the information they disseminate to a wide audience of users. TVN's homepage has played a vital role in information dissemination, and will in the future become even more important as more users and potential users come "online". Other NGO's that, like TVN, have limited financial resources should find the Internet hugely useful for information transfer. Along with our homepage the use of email has greatly enhanced communications between the networks and between users. Network coordinators can become real communication facilitators if the system is used to its full capability; and
- TVN itself is unencumbered by bureaucratic processes. TVN was fortunate to raise over half a million dollars, most of which was quickly disbursed, under simple agreements, to recipients (other vetiver networks and NGO's). Most grants were processed from start to delivery within six weeks. Much was done on trust, and most times the trust paid off in successful programs, the few times when it failed was so small that it made little difference to the overall outcome. The really successful grant support was to those organizations whose leader(s) were already fully committed to the technology and who had a real sense of

commitment to their own people and to the environment. All were volunteers in the sense that they already had personal incomes (a salaried job, pension etc.). They took on VS because they believed in it.

CONCLUSIONS

What of the future? I see the future expansion of the technology coming from three directions:

- The spontaneous establishment of new national and local vetiver networks and the expansion of existing networks without financial assistance of TVN. Hopefully governments and donor agencies, that might include international agencies and trade organizations such as Rotary and Lions' Clubs or such local equivalents, will provide assistance.
- As government and other agencies, become more appreciative of the value of VS, they will include it in their technical strategies, and be more active in its promotion application. Agencies need to better appreciate the cross sector linkages that VS impacts on;
- The expansion of private sector enterprises that are realizing the importance of the technology and the fact that it can be applied profitably. The private sector will actively market the technology, and thus will impact a whole string of enterprises from small plant material producers to landscapers and construction companies.

The dissemination of VS has undoubtedly been a successful initiative, and the original objectives have been exceeded by far. Rather than just being a carrier of words, the initiative has been a creator of actions. This process will continue, probably not with TVN in the prime spot, but rather through the actions of users and scientists working in better communications and harmony in the field. TVN's own future is, and has always been, rather fluid, we change course depending on the availability of funds and the need of users. If TVN does not receive any significant funding in the near future it will downsize its work to an information exchange based on the Internet. The latter is almost a costless exercise.

VS has proven a very successful technology because it is simple, low cost, and effective. It is also a very exciting technology because its use seems to be boundless, and it is therefore an exciting technology to use and experiment with. It is also a technology that is available to everybody without being tied up in bureaucratic practices. It is not a technology that is controlled by large consulting engineering firms, in fact it is quite the opposite -- we can mainly be free of costly consultants, protracted studies, and complex procurement and financing programs. In fact today its use would be more widely applied if other technologies, particularly "hard" engineering technologies, were less financially attractive to corrupt officials and profit optimizing entrepreneurs.

Richard Grimshaw

NEW BOARD DIRECTORS APPOINTED TO VETIVER NETWORK

At a Board meeting held at Phetchaburi, Thailand on 22 January 2000, four new Board members were elected:

Cornelis des Bouvrie (Netherlands)
Mark Dafforn (USA)
Criss Juliard (USA)
Paul Truong (Australia)
Shawki Barghouti (Jordan)

These directors are in addition to:

Richard Grimshaw (USA)
John Greenfield (New Zealand)
Noel Vietmeyer (USA)
James Smyle (USA)
P.K.Yoon (Malaysia)
Monty Yudelman (USA)
Paul Zuckerman (UK)

MISCELLANEOUS NEWS

Don Heumann of Louisiana tells me that in collaboration with Louisiana State University a compound in vetiver oil has been identified, synthesized, and patented that will kill termites. Termites cause colossal economic damage in the southern parts of the United States.

Also published at this time are new papers that confirm VS application for mine stabilization, wetlands, infrastructure, and the removal of surplus pesticides from cotton and sugar cane fields in Australia. (available at our web site: www.vetiver.org)

Paul Truong is compiling some new CD-ROMS about VS, including P.K.Yoon's reports "Look See at Vetiver I and II". P.K's research work in the early 1990's remains some of the best explorative research on vetiver agronomics and application. His reports are well documented and are full of excellent photographs.

We hope that the Proceedings of the Second International Conference on Vetiver will be published on CD-ROM and made readily available.

New vetiver networks have been established for the Amhara Region of Ethiopia and Cameroon. We understand that new networks are under consideration in California, Bangladesh, Brazil and Nepal. If this is the case we would invite the network coordinators to bet in touch with TVN at vetiver@vetiver.org

DEVELOPMENT MARKETPLACE A WORLD BANK INITIATIVE

In early February I attended Development MarketPlace at the World Bank's Headquarters in Washington DC. This was a really good and useful initiative by the Bank. The end product was $3 million awarded to 44 innovators (amounts from $30,000 to $360,000) who put together innovative start up proposals that would impact positively on poverty. I won't go into the details of the award winners' innovations, but of 1200 entries, 300 were selected as finalists (including a proposal by TVN and CVN) and these 300 were given a booth at the MarketPlace to market their "project." More information and the details of all the 1200 projects can be found on the Internet at: http://www.DevelopmentMarketplace.org.

This event will be held again next year and I am sure that it will be even more competitive. So if you want to enter I suggest that you start thinking about it now. For those of you who want to start up new vetiver networks, or special projects here is an opportunity of getting some funds. There are a few rules. Keep it simple and too the point. Emphasize the end objective -- that objective should be poverty/community/sustainably/ orientated. For example: AIDS prevention, land (asset) protection, rural water quality improvement, handicraft improvement, disaster aftermath clean up and so on. Of course vetiver systems will be used in all of these programs -- however the focus should be on the result and not the means!!

I will publish the rules and the forms for the next MarketPlace later on this year when they are available.

Apart from meeting a lot of good people and introducing them to the Vetiver Grass System I learned some very useful lessons.

First: Policy makers, planners and others (the judges) are basically not that interested in the means of achieving an objective but rather on the objective itself. Thus when we are trying to raise funds for our vetiver networks and projects, take a hard look at what the major issues are in your area and then see if the Vetiver System will provide the means of solving all or part of the problem. Our new theme of Vetiver and Water provides plenty of opportunity for innovative vetiver orientated programs. For example in most developing countries ground water levels are reducing significantly so that rural people have far less water in their wells. The Vetiver System for Ground Water (VSGW) improvement would require reducing rain water runoff on farm land and wastelands -- we all know how good vetiver grass hedges are for reducing runoff. We thus put a different focus on the objective - in this case groundwater improvement, but at the same time we achieve a whole bunch of other secondary benefits that we are interested in such as erosion control, better water quality, improved soil moisture, etc. The point is don't talk to rural water supplies people about vetiver grass for soil conservation, but talk about what they want to fix -- improved quantities of rural water in village wells!!

Secondly: We tend to get too bogged down in detail. As agriculturists and engineers we need details (and we are trained to produce details, but the people who make decisions don't have time for them, and often don't understand them -- they rely us on us for quality and effectiveness guarantees. So when looking for funds keep your proposal short and to the point, illustrate it with a few key pictures or diagrams and focus on RESULTS and IMPACT. For example if we want funds to reduce "slash and burn" practices in the Philippines a few farmer quotes on how "mora" grass (vetiver) has resulted in continuous and profitable farming practices will say a lot more than detailed technical explanations and cost estimates.

Thirdly: Development planners and funding agencies love innovations that give good results and are LOW COST, SIMPLE, AND WORK. Vetiver Systems meet all these criteria.

STABILIZING HOMES ON STEEP HILLSIDES IN SOUTHERN CALIFORNIA

In January I was the guest of Wolfram Alderson and Leslie Baer, and their son Oscar, at Panoma, southern California. All great people. Wolfram until recently was the head of Casa Colina's horticultural operations, he has now set up an NGO called Global Gardens. He has been growing vetiver for the past eight years and has proven quite conclusively that once established the Vetiver System does well in this dry Mediterranean type climate. He has found that during the establishment year drip irrigation using RainBird's "T" tape has been a simple and cost effective method. He has been collaborating with some landscapers in the area. Two in particular should be mentioned -- Doug Richardson (tel: 805 565 9453 and John Greenlee (tel: 909 629 9045) -- These landscapers using Vetiver System for Steep Slope Stabilization (VSSS) have successfully stabilized high value residential land on steep fragile hillsides that are subject to slippage and mud slides. These sites have even more valuable houses built on them, so the cost is fully justified. Both containerized and bare rooted plants have been used successfully , obviously bare rooted plants are preferable if irrigation is available. I think what has been done thus far has attracted a lot of attention. I also gave a presentation to the local Clairmont Water District - it is interested in low cost solutions for watershed stabili-

zation particularly around their reservoirs -- a good fit for Vetiver Systems for Watershed Protection and Vetiver Systems for Water Quality (VSWQ).

I was surprised at the tremendous waste of water in this part of California. CALTRANS -- California's highway authority -- uses millions of gallons annually to irrigate and keep alive various plants and weeds on highway cut and fills. Water use could be greatly reduced if Vetiver System for Highway Stabilization (VSHS) was introduced. The same applies to some enormous landfills that are being stabilized. These landfills are hundreds of feet high and cover many acres of land. Vetiver System for Landfill Stabilization (VSLS) would stabilize these artificial mountains, would reduce or even eliminate leachate outflows, and would save tens of thousands of dollars every year of irrigation and maintenance costs.

Wolfram is now thinking of establishing a Vetiver Network for California. People interested in supporting his effort should contact him at: <wolframald@earthlink.net>
Dick Grimshaw

PROMOTION OF VETIVER GRASS SYSTEMS

You will notice that I have written a lot about Vetiver Systems dissemination in this newsletter. This is because I believe we must give much more attention to promotion, than we have thus far. Many, many people -- potential users, planners, policy makers, and funding agencies know nothing about the Vetiver Systems. We have to change this rapidly, and it is mainly up to the members of The Vetiver Network to do this promotion. In other words **YOU!!**

Promotion will be a lot easier if we focus on the end of objective. Most of us are connected to the agricultural sector and have tended to confine the technology to the agricultural sector. We need to get out and sell VS to other sectors. As I mentioned earlier consider all the problems in your area and then list them out and see if VS will be part of the solution. If it is go and find the people who are concerned -- politicians, administrators, community groups and tell them how VS can solve the problem. Find local journalists to write articles in the local papers or for broadcasting on radio or television. Search out traders and companies who are selling and advertising products in your area -- it might be soap, special foods, condoms (anti AIDS), and see if it would be beneficial for them to link their advertizing with VS. For instance it would be easy for local soap manufacturers to perfume their soap with vetiver oil. That "vetiver soap" would make a nice link with Vetiver Systems and Improved Water Yield in Village wells. Another might be "Use Condoms - - A Barrier Against AIDS - - Use Vetiver A Barrier Against Erosion". I am sure you can all think of slogans (potential advertisements) like these or better.

Improvement in Vetiver Systems technology dissemination is very important, and you will find most of the articles in this newsletter deliberately focuses on dissemination and networking. It is quite evident that the establishment of vetiver networks in countries and regions have done much to promote and activate the use of vetiver grass in many countries. We need to see many more networks established. Regretfully TVN can't help fund new networks as we did with those first established, but we can give you technical and professional support. I am sure you will get good funding support if you can clearly articulate the end objectives of the your new network. Funding agencies are looking for sustainable objectives, poverty alleviation, gender, natural resources improvement, better water, less pollution and better quality of life for all. The Vetiver System has a role in all of these objectives if properly crafted.

VETIVER SYSTEM FOR ENGINEERING

Two years ago Liyu Xu, the Coordinator of the China Vetiver Network (CVN) organized a conference in Fujian Province to introduce VGT to a wide audience of users in south China. In October 1999 he did the same again in Jiangxi Province, but with a focus on engineering for highways.

I attended the conference. It was a great experience working with him, Paul Truong (Australia) and Diti Hengchanovich (Thailand). More than half the time was spent visiting sites in Jiangxi, Fujian and Guangdong Provinces that had been stabilized with VGT.

During the past few years China has added over 30,000 km of major roads to her inventory. Many of these are in the south of the country. It is estimated that over 80% of the point source erosion comes from these and other infrastructure developments in China's south eastern provinces. Apart from their great length these highways often pass through rugged terrain involving massive fill and cut engineering. As a result there are huge stabilization and re-greening problems to deal with. The normal Chinese approach is to stabilize with local grasses (that are not deep rooted) and or use stone masonary to face the cut and fill. Linked to this construction are large and unrehabilitated stone quarries that add to sediments flows and remain environmental eyesores.

Over the past three years the highway departments of the provinces have been testing VS and the results are convincing and impressive.

In Guangdong a cut and fill slope on a highway near Guangzhou planted by Xia Hanping in 1996 is now fully stable. Vetiver was interplanted with *Acacia mangium* seedlings. These trees

are now over 6 m high and the area has been turned into a dense woodland. It is an excellent example of how vetiver can be used to stabilize nearly impossible sites with slopes over 100% and extreme "soils"

Most of the vetiver has been shaded out. But it did its job in providing initial stabilization and a better environment for the trees to grow.

It appears that there are a lot of opportunities to expand the use of VS to highways throughout south China, and to use it for the reclamation and re-greening of the many quarries that have been opened to supply materials for the huge construction program that has taken place in China since the market reforms were initiated.

A major limitation to the expansion of VS is the lack of trained and experienced landscapers. This can be rectified through technical training workshops for existing and new landscaping companies. We see a big increase in demand for VS, which means that small farmers will get involved as suppliers of quality plant material (training needed here too).

What we are seeing in south China is an emerging pattern of increased use of VS for engineering purposes. Companies have been established in Central America, Philippines, Malaysia, Australia, and South Africa to produce large quantities of plant material and to apply the technology to construction sites. The rate of demand is likely to go up as more companies are established and they market the technology to highway designers and owners. A new paper shows that in Australia (a high priced labor market) financial savings are estimated at over 60% when VS is used over conventional methods. In China the savings are 90%+!!

Other areas of potential for VS in China and other tropical countries is VS's ability to stabilize acid sulphate soils in coastal areas, rehabilitation of mines, and stabilizing of river banks, dikes and levees. In China, Bangladesh, and Vietnamfor example, millions of dollars are spent annually on maintaining the levees and banks of major rivers. VS could be used to reduce these costs.

VS is on the move; and those of you whose main focus is to use VS for on farm soil and water conservation should look at some of these other engineering related applications, because as the demand for them grow, so will the demand for vetiver planting stock, the majority of which will be produced by small farmers.

Some New Homepage Papers http://www.vetiver.org

Application of Vetiver Grass Technology in Off-Site Pollution Control. I. Trapping Agrochemicals and Nutrients in Agricultural Lands.

Tolerance to herbicides under selected wetland conditions inAustralia.

Soil Temperature and Insect Damage Impacts on Vetiver Grass New Zealand.

Vegetative Barriers - A New Upland Buffer Tool - USA.

Water Bioengineering Conference, Manila, Philippines April 1999.

Southern California Vetiver Grass Tales: "Moondust & Shale".

Growth of Vetiveria zizanioides and other three grasses on Lechang (China) lead/zinc mine tailings: A field experiment.

THE VETIVER NETWORK HOMEPAGE.

http://www.vetiver.org

The home page continues to expand. We are receiving as many as 400 hits a week -- so there must be something useful on it!! On page 71 of this newsletter there is a complete list of all the files currently on the home page. Some are duplicaates and cross referenced, but most are not. There is so much information coming in now from various sources that it is no longer possible to publish them in the Newslette. However what ever we receive normally goes on our web site or our FTP site at ftp://www.vetiver.org. To make it easier to follow what is newl have dated the files. Those of you who have access to the internet should go to "What's New" on our site and then navigate to "Recent Developments". These two sites have everything that has been put on the homepage during the past three months.

The Vetiver Network is a registered on profit organization under IRS code 509(a) (1). Donations to the Network are welcome and are tax deductible.

The Network produces a biannual newsletter edited and published by Dick Grimshaw. We encourage those interested in vetiver technology to participate by contributing articles to the network.

The Network also manages a homepage on the Internet at http://www.vetiver.org. Most articles are published on the homepage and the associated ftp site at ftp://www,vetiver.org. The small green handbook, including diagrams, "Vetiver a Hedge against Erosion" can be downloaded from the ftp site

The Second International Vetiver Conference --Thailand Summary 18 - 22, 2000.

Report by Criss Juliard

WHAT: The Vetiver Grass Network's 2nd International Conference on Vetiver was held January 18–22. The King of Thailand through his development foundation sponsored and helped organize the conference, held in a coastal region of Thailand with the theme "Vetiver and the Environment."

WHO: We were some 340 engineers, researchers, practitioners, development experts, donors and businesses from 5 continents and 31 countries. Vetiver Grass Technology, first introduced in India in 1986 under a World Bank agricultural/environment project, is now used in over 100 countries for soil/water conservation, erosion control, and environmental protection.

THE SUBJECT: Vetiver Grass Technology uses vegetation (bioengineering) to mitigate environmental degradation, improve soil fertility and crop production, reduce water contaminants and ameliorate reforestation and wetland practices. The plant's numerous and strong root system holds soil when planted in hedgerows. Its deep roots grow to 2-3 meters in a year, and because of their depth, bring nutrients back up to the surface like a biological pump. The King of Thailand is a fervent promoter of Vetiver Grass Engineering, and has personally seen that it is integrated into Thailand's rural development strategy. The King is a respected engineer committed since the 1960s to improve Thailand's land, forestry and water resources. He has some 20 patents to his name, most related to soil and water conservation processes. Through Royal Demonstration Centers, universities, research institutions, ministries and NGOs, vetiver grass engineering has been promoted on a national level with impressive success. The King requested that Thailand host the second conference to show the significant results obtained through broad promotion and research of vetiver technology.

THE CONFERENCE: Upon arrival at Phetchaburi, the conference site we were given some 15 publications covering recent research and application of vetiver; one was a 480 - page bound document containing all the papers to be presented over the succeeding 3 days. The documents allowed us to follow each presentation since most presenters where not native English speakers. In addition, CD-ROMs were distributed of all slides and pictures presented at the conference. Two prizes valued each at $5,000 were offered by the King of Thailand for the best papers on the conference subjects.

DAY ONE: The conference opened with an impressive reception, dinner and cultural show organized by the Palace (dances, songs, fireworks, light shows). Next morning key papers were presented discussing basic improvements in the technology since the last international conference 4 years ago.

Key among these was a paper on the impact of The Vetiver Network, a well-managed information dissemination and exchange system linking some 15 national, regional vetiver networks, and Internet sites, newsletters, and institutions. The Network's web site www.vetiver.org receives about 1,000 hits per month. Over 800 NGOs, 800 government agencies, 1,000 research stations and about 800 private individuals and commercial entities are part of and access The Vetiver Network.

The Vetiver Grass Network records research and field experience in the area of:

- soil and water conservation (recorded reduced soil loses between 70% and 90%)
- crop yields (increased by up to 20%)
- forestry development (soil stabilization to reestablish eco-systems)
- stabilizing engineering structure (extends life of roads, bridges, embankments)
- pollution control (reduces dangers of pollution and waste site thru absorption of heavy metals and toxins)
- improving groundwater (improves ground water recharge due to long roots)
- flood control (dynamic reduction of damages to croplands, river banks, hillsides)
- land rehabilitation (used for extremely degraded soils)
- disaster mitigation (after Hurricane Mitch, where vetiver had been planted in Honduras, very little damage observed on hillsides)
- other application (handicraft industry using the leaf and root and thatching stimulating rural income)

Field experiences in El Salvador, Tanzania, and the Philippines show that when provided several options to different conservation practices, over 80% of farmers applied and preferred vetiver. The technology is simple, inexpensive, gender positive and it works.

Other papers included the results of DNA studies on vetiver varieties, and its adaptive resistance to diseases. This was delivered by Dr. Robert Adams of Baylor University's Plant Biotechnical Center.

A paper by Dr. Paul Truong, provided the result of his research in the heavy metal tolerance of the plant, and the global impact it is hav-

ing on reducing landfill pollution and purifying polluted waters. A paper presented by Chinese researchers from the School of Life Science in Guangzhou Province and the Chinese Academy of Science gave results of experiments with four different types of grasses to reduce pollution levels of a lake damaged through chemical run-offs and improve surrounding infertile lands. Vetiver was found to have significantly improved the re-vegetating of abandoned area. Other papers the first day covered experiences in establishing countrywide dissemination programs which included our paper from Madagascar. Other countries included Venezuela (winners of the King's Vetiver prize), Ethiopia, Cameroon, Malawi, Thailand (the State Oil company adopted a complete vetiver remediation program to protect a gas pipeline recently established to supply the country's gas imports), Philippines.

DAY TWO: Day Two was the opening of a large exhibition fair set up on the resort grounds which included some 20 pavilions, all demonstrating a ministry, agency, university or NGO's work and research in vetiver. The extent and detail of this exhibition was daunting. Pavilions included the Ministry of Public work in protecting roads and structures using vetiver, the Ministry of Land Management work in rehabilitating desolate lands, models of the State's Oil company's use of vetiver, the Ministry of Industry and Commerce's work in developing marketed handicraft products including charcoal briquets from compacted vetiver leaves; insulation panels, construction bricks of mixed cement/clay/vetiver leaves, tiles, nursery pots, household products of all types including mats, lamps, picture frames, hats, paper, screens all made from the vetiver leaf or root. Various universities displayed research results of work conducted over the past several years, the Ministry of Education showed the books it had developed to teach school children the value of vetiver. The exhibition took about two hours to visit.

Papers continued to be presented the entire day. They focused on field-testing techniques and field experience where vetiver provided sustainable farming and agro-forestry practices. Three panel discussion groups and four concurrent presentations in which some 40 papers were presented and discussed highlighted the day. Topics of interest included the positive effect of vetiver on crop yield and soil moisture (studies conducted by Kaen University and the Thai Bureau of Land Management), the ability of sloping land farmers in Fiji and Vietnam to obtain sustainable farming and controlling cash crop through use of vetiver hedges, improving efficiency of vetiver propagation, rehabilitating degraded watershed in Ethiopia using vetiver, disseminating technology at the village level worker in India and at the decision level in South Africa.

It was clear from day two that Thailand, which had initiated vetiver research and application since 1991 was far ahead of other countries in knowledge and widespread usage of vetiver. Thailand was propagating biomass using tissue culture, and went from producing about 6.5 million plants in 1993 to a production and utilization level of about 99 million plants per year (1999 figures). Agricultural development difficulties in Thailand had been exacerbated by land degradation, especially in ecologically fragile areas, and rainfalls had carried away precious topsoil and plant nutrients. It was estimated that Thailand was losing between 12.5 to 62.5 tons per hectare per year. Applying vetiver in hedgerows was able to reduce that loss by about approximately 85%. The Thais were proud of this achievement, and reserved Day 3 to "show and tell" what they had accomplished.

DAY THREE: Technical tour. Participants to the conference spent Day 3 visiting four project sites where vetiver had been planted either for public demonstration purposes or by individual farmers for their own use. The visual impact of these visits was impressive. The first site was the Huai Sai Royal Development Study Center, one of 14 throughout the country. This one had been chosen because vetiver was used to rehabilitate the harsh environment and specific ecosystem. The site had been selected in 1993. It was an inhospitable, rock-covered region with little or no vegetation. Dr. Paul Truong from Australia had visited the site at the time of selection, and had advised the Center to chose another area since the sub-strata was basically hard rock. However, upon the insistence of the King, the site was maintained. Holes 15 cm in diameter were chiseled in the rock landscape to permit young vetiver to be planted with potting soil. Dr. Truong informed us that over the 7 years since he had seen the site the transformation was impressive. Vetiver was planted in both large circles and semi circles; slow growing trees and fruit trees (mangos, citrus, tamarind) had been planted in various arrangements for demonstration purposes. We were shown how the long vetiver roots helped maintain humidity and brought nutrients up to the surface. The fruit trees were growing well, the hardpan soil and rock had turned into productive land.

The second site demonstrated vetiver usage in an integrated farming system. The grass was planted in hedgerows, and in a semicircle and circle around the base of fruit trees that had been planted in poor sandy and dry land conditions. Vetiver leaves were cut periodically and used for mulch, as the leaves become a good source of organic matter helping improve the soil's potential in retaining water and plant nutrients. This was done next to trees where no mulch had been used. We were able to witness the difference in fruit size and taste, as well as see the difference in vegetation between areas where vetiver was planted and

where it was not. Vetiver was planted around pond edges to prevent soil erosion. The diversity of plants serve as supplement to the paddy as well as poultry and fish farming practiced in the area.

The third site was 770 ha area that had been an uninterrupted pineapple growing plantation for 20 years, and without proper soil and water conservation measures, the land was no longer suitable for cultivation by individual farmers. The Department of Land Development decided in 1994 to use the land as a study area and incorporate the use of vetiver to restore soil, water and forest or forest ecological system. Vetiver was planted along the contours across the slopes, and along check dams along gullies. By 1999, the vetiver system had helped maintain topsoil and moisture, which led to an improved ecological system. Natural vegetation grew to cover the soil and fostered growth of the trees. Again, Dr. Paul Truong had been at the site at the outset of the project and indicated now that the reforestation and revegetation were "unbelievable."

The last site included the farm of Mr. Songsak a small citrus grower. He first planted vetiver as a nursery in a field adjacent to lime trees. He saw that the lime trees that rimed the vetiver nursery did not have yellow leaves like the others further away, and in fact produced larger quantities of limes. He consulted with vetiver extension agents who suggested he rim all his trees with vetiver as the grass, through its long root system maintains ground humidity during the flowering season, extending the time flowers remain on the tree, and thus increase the pollination period. The farmer has become a "Dr. farmer" who provides farmer-to-farmer extension services to neighbors. We were able to see where he had stabilized the bank of a river that runs along part of his farm, which had eroded during recent floods, using vetiver.

In the evening, we had another outstanding dinner and Thai show, complete with singers, dancers, marionettes and demonstration. We also had a business meeting to help discuss the venue and topic of the next vetiver conference planned for 2004. It was agreed that the Chinese will host the next vetiver conference, and the topic would be "Vetiver and Water." This was chosen to help stimulate research on vetiver usage to improve water quality, prevent coral degradation in coastal regions, mitigate flood damage and to reduce water wastage in agriculture.

DAY FOUR: This was a half day with some 15 concurrent presentations on such topics as soil and water attributes of vetiver, research and general studies in China, Bangladesh, Zimbabwe, the US Army and India, and evaluation of vetiver application in road construction, in perfume, and cotton yields. Most interesting were the closing sessions that included summary comments from organizers of the conference and Richard Grimshaw, Founder of the Vetiver Network, on the future outlook for vetiver.

There was an additional field visit to a model farmer as we drove back to Bangkok. The farmer had applied vetiver on hillsides, but had not seen spectacular result, this in part because he had been among early users, and had used a variety of vetiver that is no longer recommended.

SUMMARY

Vetiver has made significant inroads in the minds of professionals who several years back scoffed at the idea that a grass indigenous to India could be used to replace mechanical engineering works, could have multiple environmental applications, and could offer inexpensive and reliable solutions to soil degradation and loss of soil fertility.

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EROSION CONTROL IN AGRICULTURAL AREAS: AN ETHIOPIAN PERSPECTIVE

by Alemu Mekonnen, Ethiopia presented at the Second International Vetiver Conference, Thailand, January 2000

Introduction

Ethiopia, with an estimated area 1.12 million km^2 and close to 60 million inhabitants, is one of the largest and most populous countries in Africa. Agriculture is the mainstay of the economy as it contributes 57% of the GDP and 85% of the employment (UNCTAD 1997). With GDP $150 per capita in 1995, Ethiopia is among the poorest country in the world (World Bank 1997). Most of the agricultural land is located in the highlands and is operated by Peasant Households. Smallholders cultivating fragmented micro holding (0.075 -1 ha) produce more than 90% of the annual agricultural output. Despite its pivotal role, the performance of the sector has remained largely unsatisfactory. Food self-sufficiency remains an unattained objectives, and per capital food, production has been falling over the decades. In 1993/94 production grew by 0.05% per year while population grew by 3% implying a per capita food production declined by 2.5%.

This is constrained by the country's deteriorating natural resource base and environment. Degradation of the resource base mainly due to soil erosion and nutrient depletion has continued at alarming rate. The national soil erosion hazard assessment which is based on soil erosivity and erodibility and land cover land use data of 1994 indicates that over the whole country, up to 3.5 billion tons of top soil is eroded every year mainly from farm lands through the process of sheet erosion. Because of this,

annually it is estimated that 20,000 - 30,000 ha of cropland is abandoned because the land could no longer assist cropping. Consequently, by the year 2010 it is expected that about 2.8 million highlanders would be affected.

Soil erosion is greatest on arable land where the average annual loss is estimated to be 42 t/ha, but may even reach to 300 t/ha/year on some fields. This is six times the rate of soil formation and probably causes an average annual reduction in soil depth of 4 mm. FAO (1986) estimated 50% of the highlands are significantly eroded, of which are seriously eroded and have reached a point of no return.

Various approaches, mainly based on mandatory policies, have been unsuccessfully tried in the past to encourage adoption of erosion control practices by the peasant sector. Soil and water conservation (SWC) program, mainly engineering based, was implemented with large investment input from the government, generous international organizations and the local people. Around $ 20 million was disbursed annually during 1980s and 1990s in the form of FFW. Farmers' labor involvement amounted 30 million person days per year. With available resources 25% of the targeted areas were rehabilitated and most of the physical measures constructed. Recent study in Food For Work (FFW) areas indicate that structures were dismantled from 53% of the plots and partly removed from 31% once the coercion to keep them is lifted. Faster than the degraded land recover, more land became exhausted. The success of the effort, as witness in recent years, has however been limited. One wonders what prompts peasants to destroy vital resource - improving investments of high value to the society. Several factors may be mentioned for failure of the past conservation program. The most significant are:

- Lack of participation / top down approaches.
- In appropriate technology / blanket recommendation: No attempt was made to involve the end users in adoption the technologies to the local conditions. Soil or stone bunds are not equally effective in high and low-rainfall areas. The productivity impacts of the structural measures were not considered, as the focus was only to curb the loss of soil.
- Takes scarce productive lands out of production thus yield falls at least in the short-term.
- Structures also created a breeding ground for noxious weeds and rodents.
- Focus on quantity rather than quality: Apart from failure to involve land users in the design, implementation and management of conservation works, the FFW approach of remunerating the workers according to the quantity of work accomplished led workers constrained to meet their subsistence needs, to emphasis quantity rather than quality.

Today, many development based organizations have brought the new approach into the main steam of thinking, and have highlighted particularly the potential use of biological soil conservation in general, and the use of vetiver grass in particular, and a need to move away from pure engineering approaches for SWC.

Introduction of Vetiver Grass

In 1970, for the first time, the grass was introduced to the country by the State Coffee sector. It was imported from India. The purpose of its introduction was mainly to demarcate the different coffee estates and to control the expansion of noxious grass called *Cynodon dactylon. A* few years later, some NGOs also reputedly introduced the grass to the peasant sector. It is probably after the commencement of the Vetiver Newsletter in 1989, and the First National Workshop in 1991, most people become aware of the wonder grass as the cheapest means of erosion control in croplands.

Barriers to the Technology

Like any other introduced technology, the vetiver grass faced a considerable resistance from the professionals and farmers side. The major reasons were:

- Farmers were reluctant to use because they considered the grass as a noxious, invasive grass that occupies and abandons their croplands.
- Farmers also doubted about its different uses advocated by the extension agents.
- Professional, starting from the top policy makers down to the development worker, who were geared to physical SWC measures and used to work under FFW program were not convinced at all and did not even allowed the introduction of the grass to FFW areas. They said "It is the grass of the World Bank and the Bank may have its own hidden mission".
- Another reason they raised was that the grass has not been researched under our condition in any of the SWC research centers. That at least needs 6 -10 years before the research result officially comes out.

Because of the above stated obstacles and until end 1989, the usage of grass was limited and localized only in the State Coffee sector and in non-FFW areas. It was in 1991 that an Ethiopian based NGO called Menschen fur Menschen (MfM) for the first time broke the barrier and introduced the grass to the peasant sector particularly to its project areas.

This NGO promoted the grass mainly for its SWC using the following approaches:

- *Creating Awareness.* The first and the most important entry point was creating awareness for its own development agents.
- *Establish Vetiver Nursery.* Establish the first vetiver nursery in the country for SWC purposes. In addition, very strictly follow the management at nursery level.
- *Demonstrate the Application.* In the same year, demonstrate the application of the grass for farmland SWC. For the first time in the country, 1991, the grass was planted on ten-ha cropland owned by five farmers. One of them won the 1993 Farmers Award arranged by The Vetiver Network in Washington
- *Organize Training.* After two years of progress, the Project organized training. This training was the first of its kind in the region that brought together all organizations (NGOs, GOs) working in the SWC projects to discuss the potential of the grass for SWC and its promotion in the region.
- *Handing Over the Award.* Invite local level officials and influential farmers during the handing over the award to the farmer, Mr. Walelege, the winner of Farmers Award. This was the occasion for most people to become enthusiastic about the grass.
- *Environmental Clubs:* The majority of the schoolboys and girls in Ethiopia come from rural areas. They spent their time after school hours and school vacations assisting their families in their day today farming activities. Taking this as an advantage, the NGO has assisted the establishment of environmental clubs at five school grounds in order to disseminate the technology at faster rate through students to parents. Vetiver was one of major components included for SWC purposes. This principle played an essential role in the expansion of the technology to the majority of the beneficiaries with out any additional cost and labor (extension staff).
- *Media and Press:* Since the introduction of the grass to the area, there were five press releases about the grass in the major news letters and more than ten radio interviews made by the staff of project and government and the beneficiaries. On top of this, the progress of the project was on air in Ethiopian Television every year during the main rainy season. This approach contributed much to introduce the technology through out the country.
- *Training Supports:* Translation the Green Book into local languages and making available to extension workers and farmers was one means of technology transfer used by the NGO. Beside, video and slide show contributed a lot to programme. Flyers on the technology is prepared and distributed during Subject Matter Specialist and farmers training.
- *Farmers Self-Help Groups:* In 1995, when all concerned bodies accepted and started applying the grass for their SWC program, the project handed over partially the production centers to interested farmers groups. This created confidence among the groups about the technology because it helps to generate income to the owners of the nurseries.
- *Assisting the Establishment of Nurseries:* Besides assisting farmers groups in establishing their nurseries, the Project also technically and materially assisted almost all GOs and NGOs in the region during the initial establishment of nurseries.
- *Farmers to Farmers Networks:* Farmers groups are the main targets for the enabling roles of the development support services. A principle of ennoblement is minimum input for maximum out put. This implies that the support services have to promote self-help, local level initiative, and farmer to farmer interaction. The network, though not officially established helps farmers to share resources and skills. It helps in marketing the grass to needy organizations.
- *Paper Presentation:* Whenever there is possibility of participating in workshops, conferences and seminars, papers on vetiver were presented in particular for officials and policy makers at federal or national level This has contributed very much in changing the attitude to officially accept the grass as one of potential plants for on going SWC programs in the country.
- *Awards:* Every year in the month of December, the project organizes an award ceremony for outstanding farmers and field workers. On the occasion, invited people from GOs, NGOs and influential people such as farmers, religious organization and youth groups.

Vetiver Today

Beneficiaries and Organizations Involved

Unlike those initial years, the vetiver grass is being used by a majority of the farmers, rural road experts, urban dwellers, small-scale cottage industries and Wet Lands Development Project. There are 250 NGOs in the country working in different program. Of these, 110 are working in the field of natural conservation. 80% of them are now

using the grass for their SWC program. This has brought the number of NGOs involved from one in 1991 to 88 in 1999.

The country is administratively divided into 12 regions. According to the latest survey made by the Ministry of Agriculture in 1998, the majority of the, regions now are using vetiver grass for their different program.

Other than these, the bilateral organizations like GTZ, SIDA, CIDA; and multilateral organizations such as FAO, UNCDF, IJNDP, World Bank, etc. have fully accepted and willing to finance projects that are interested to promote the technology. Consequently, today one the biggest vetiver promotion projects has been launched by financial assistance of two bilateral organizations, GTZ and SIDA, in the northern part of the country.

Number of Nurseries, Production, Total Area Treated

As stated above, the first nursery was established in 1991 by MfM in southwest part of the country. In the same year, more than 50,000 clumps were produced and about 10 ha of farmland was planted for SWC purpose. Since 1991, great progress has been observed in the development of nurseries in the country. Table 1 shows the nurseries established by government agencies and non-government organization until end of 1999.

Table 1.Vetiver nurseries established by government agencies and non-government organizations until end of 1999

[Table excluded]

Application

Agro-Ecology:

Slope: The grass is practiced on different slope classes. The upper slope limit ranges between 40-45%. Still at this slope class, it effectively holds the sediments. The planting procedures should strictly be applied otherwise, the cause of the damage will be enormous. For very steep slope, containerized plants are used for better and quick effect.

Vertical Intervals (VI): The applied VI in the country varies from one slope class to other. The VI recommended in the country for slopes classes between 3-15%, 16-25%, and 25% is 1, 1.5 and 2 m, respectively. For very steep slopes, it is advisable to plant splits closer and just after the first shower. In our case, we also use containerized plant for better survival and effect.

Altitude: Most of the high lands in Ethiopia are situated above 1800 m a.s.l. These are highly populated and experiencing sever land degradation. The upper altitudinal limit where the grass is tested is 3100 m. a.s.l. Even when it freezes the plant has survived with out big shock. However, the optimal and effective limit is below 2,800 m. a.s.l.

Area of Application: Apart from farmland conservation the grass is used for the following areas:

Plantation. The main use of the grass is to replace stone-made micro basins by vetiver made micro basin. This is now becoming a famous undertaking in coffee growing areas.

Gully. Together with physical measures the grass is widely applied to control the gully sides and heads.

Waterways: Mainly used to stabilize the sides of the channels from sliding and falling. It is used mainly to protect the drains along the roadside.

Irrigation canals and riverbank control: The walls of irrigation canals that have low angle of repose are better protected by planting vetiver along both sides of the canals. In the same way riverbanks that have undercut / scouring effect were protected by planting bigger size plants without splitting into smaller tillers.

Dam catchment protection: It is the only grass family that has proven to be effective in controlling the sediment from silting the dam. Today, domestic water supply and hydroelectric authority involved in dam construction area are convinced to use the grass to treat the catchment before any dam is built. Good examples and experiences are the dam built by one NGO called the Amahara Relief and Development Organization in the northern part of the country and the Fincha Hydro electric power plant in the south that used vetiver to treat the whole catchment.

Benefits other than the above: Beside the different uses stated above, the grass has other economic and social advantages that are as follows:

- *Thatching.* 83% of the population in the country lives in the rural areas, of this 2-4% can only afford to roof their hut with iron sheets while the majority use grass for roof making. Those farmers who established the vetiver grass hedgerows not only use it for their own hut building, but also sell it to neighboring farmers.
- *Feed value:* Though international literature declares Vetiver as unpalatable for livestock - probably on the account of its feed value - it is readily eaten by livestock here. Occasional cutting is practiced that stimulate the growth and as livestock fodder by-product. The year 1999 can be remembered for its long dry season (Oct-July). This has caused considerable damages to human and animal life. The presence of this drought resistance grass has saved the lives of many heads of cattle in the project area.
- *Rodent.* Field rodents reduce crop yield by 10 -12%. They damage standing crop while they are in the field. Their main nesting areas are structures built for soil and water conservation and road purposes. Thanks to the introduc-

tion of vetiver for SWC, the damage caused by rodents has considerably reduced by 85%.

- *Obstacle for farming:* One of the complaints of farmers about physical SWC measures is the obstacle to freely move farm implements and farm animals. The continued length and of course the height of the structures limit the movement of animals from one terrace to other. In many cases, this problem has been overcome by replacing vetiver for structures.
- *Mulch:* Nowadays vetiver is the main source of mulching material to cover pre-germination seedbeds and as mulch to conserve moisture for young seedlings.
- *Mattress.* Mattress made from vetiver grass is most liked by rural people. Farmers say it is completely free of any bed bugs and fleas. Good information and findings.
- *Income:* Schools who have well-established hedgerows are getting income from the sale of the grass mainly during Ethiopian holy days and weeding ceremonies. On top of this, additional income is also obtained by selling the grass for multiplication purposes. They sell tillers by dividing the hedgerows into two leaving major portions to remain on the ground. The income is mainly used to assist students who quit their education because of financial problems.
- *Wetlands rehabilitation:* Wet lands are our main source of ground water. They are natural reservoir of streams and rivers. If disturbed they cause considerable damages to habitat and bio-diversity. One major cause of this particular ecosystem is the unlimited exploitation of the grass that grows only in this habitat. Farmers in the area usually live in the hut where the roof is made from grass. The main source of the grass comes from the wet lands. Every year in the month of November and December it is a common practice to replace the old roof with new once. Farmers have to walk a distance to cut and carry the grass. This continuous exploitation of the grass has resulted to drying of wet lands there by affecting the continuous flow of stream and rivers that have their water source from this ecosystem. After expansion of the vetiver grass into the region, mainly for SWC, farmers now use vetiver grass for thatching. First, it is available near their villages and secondly it lasts long compared to the grass from wetlands. More over, the downstream people can confidently develop their irrigated agriculture and animal husbandry without any danger.
- *Cost of the system:* The over all labor cost of establishing a nursery and planting in the field is far less than that of using structural measures for SWC. A hectare of nursery can produce about 2.5 - 3 million splits in five months. Labor requirement to mange this nursery until planting out is five PD/day. The daily wage of a laborer in the area is $0.55. Plants produced in one hectare of nursery can treat 166.5 ha cropland on 3% slope or 40 ha on 20% slope. Total establishment cost of vetiver hedgerows/ha on 3% slope including production is estimated to be $ 3.02 and $ 13 for 20% slope. With structural measures the same slope and area may cost $ 119 for 3% and $ 186 for 20% slope.
- *Spacing:* Farmland occupied by hedgerows is about 1/10th of the equivalent physical structures.
- *Gender sensitive:* In the country, 25 - 30% of the farming households are women. The typical households that exercise poor SWC are these disadvantage group. The main reason for this condition is all SWC measures in practice were mainly engineering by nature and they usually require more labor and time that can not be afforded by women. With vetiver introduction in the country, we see more and more women participating in SWC. On top of their appreciation for its easiness of application and time saving job, they use it for spreading on the floor during coffee ceremony. Traditionally, the coffee ceremony with out green grass spread on the floor is not attractive.
- *Organic fertilizer:* In several villages, particularly in the south, it is a common practice to use the grass as bedding for their animals in order to collect manure.
- *Local based development:* To day, where MfM is active, farmers' overall level of continuing innovation is remarkable. Dividing and selling tillers from existing hedges can be cited as the best innovation for sustainability of the technology.
- *Leadership capacity:* Seventy-six well-trained farmer extensionists are presently active for vetiver grass promotion in the whole MfM program areas. Farmer to farmer extensions trips and inter village visits are organized and arranged by these extensionists. They also participate during the selection the best farmers for annual award this created healthy competition and trust among farmers.

Replication to Non-Program Ar-

eas

Replication by other organizations within and outside Ethiopia has been significant. The program methodologies, as well as technologies, have now spread to all part of the country. In 1996, the presenter of this report has been selected as a resource person by The Vetiver Network, Washington, to share his experiences for Cameroon people. Today the federal government has accepted the grass to be included in its conservation policy and forest action plan. This by itself will assist the wide spread of the technology mainly in the peasant sector.

Discussion

Sustainability of the Technology It is quite clear that a very close inverse correlation exists between the sustainability of SWC technologies and the amount of labor they require. In Ethiopian context, the most long lasting technology is one that:

- requires the least amount of labor.
- leads to significant increase in the villagers' well-being, economic as well as social, and
- can be carried out by villagers themselves. Besides, it should contribute to decrease cost and risk.

Vetiver Grass Technology meets these criteria.

How to Achieve Sustainability

These days governments of developing countries are constrained by financial problems. The chance of financing projects with big inputs no longer exists. Beneficiaries should be responsible for the continuation of projects that have been earlier assisted by the governments or others. One of these programs includes the promotion of vetiver grass technology. Experiences from similar projects reveal that by encouraging farmers to produce and sell the grass on their own can also support farmer's own multiplication schemes, and buy from them to distribute to other needy farmers. It can be foreseen that such an approach may increase the participation of farmers even more and more in addition generating income.

Training and visits at all level should be one tool to sustaining the technology in the future. Moreover, proper care during propagation will also contribute to the better success of the program.

Selecting the proper time for planting will increase survival and easily convince and attract the beneficiaries. Always the expert in charge should practically demonstrate how to plant in the farmers' fields. He/ she should invite all stakeholders like the development agents, the contact farmers and the owners of the farm.

Giving lectures in the agricultural and forestry colleges will be of an advantage to the programme as they are the factories producing young and energetic people that go directly to the field after graduation.

Beside the technical feasibility, which ideally should be further tested for another 2 or 3 seasons, the social dimension should not be overlooked. This is mainly true for countries experiencing free livestock grazing. If farmers are unable or unwilling to curb uncontrolled grazing, the technology most probably may not be as attractive and effective. This will automatically affect the sustainability of the technology. This has been very clear to the farmers and has to be repeated at every possible opportunity.

Recommendations and Policy Implications

- Combine vetiver grass with other compatible leguminous fodder crops. Parallel to planting the grass for SWC purposes, compatible and supplementary fodder crops should be sown or planted along the hedgerows to increase the feed value of the grass. This is advantageous particularly in places where trimmed vetiver is usually wasted during maintenance of the hedgerows. However, this approach has also been found effective for better growth of vetiver in northern high lands. Good grass growth has been observed in places where leguminous fodder crops are grown along with the vetiver hedgerows. This is because leguminous fodder crop can fix nitrogen, which is required by the grass deficient in the area.
- Use simple and cheap means of propagation the grass. It is important not to loose momentum. Soil erosion in most part of the world is so rampant that very little time only is left to halt this trend of degradation. The present need of getting the grass from limited nurseries may not be sufficient to tackle the problem. Another very effective way of propagation the grass should be researched and made available to people at large. The available technique like that of tissue culture should be further promoted.
- Maintain flexibility in application of the technology: Giving exact and scientific specifications and making only one recommendation as to how to solve each problem reduces the space the farmers own trials and make the technology theirs. When we recommend, for instance, we should give the farmer a range option for spacing, plant population to experiment with and should encourage him or her to try other grasses for comparison he or she may have seen elsewhere.
- Develop closer relationship between the governmental and non-governmental organizations: The mutual learning and sharing resources and experiences between govern-

ment and non-government organizations, as well as among the non-government agencies, has definitely helped the promotion do more effective and spread quickly in the country.

- Watershed Approach: Another important fact is to apply the Watershed Management Approach. Only if a whole watershed area is treated simultaneously the required impact and effect of the technology can be effected.
- Better support to The Vetiver Networks at all level: International organizations and donor agencies should better support both financially and materially the Vetiver Network. It is because of these networks and the initiatives of few devoted individuals that helped us to be here at this gathering.
- Even poor countries like Ethiopia should direct some of their funds to assist the international networks in their own countries.
- Push now and get our respective governments to include the grass in their conservation policy frame works. Never give up until they do so!

Conclusion

It can be seen from the report that vetiver grass has the potential to improve in the medium and long term the natural resource base in fragile and heavily abused environment such as the Ethiopian highlands. In this case, it may well pay off to have trodden the path of the last two decades where priority had been given to physical SWC measures. The Vetiver approach is six to eight years old in some places and in others is just at its initial stage. Future problems and setbacks should not be excluded or minimized. Yet, there can not be progress without taking (calculated) risk. Therefore, we should not give up if we are confronted with technical and social problems. We have to try repeatedly. Hopefully, we will be successful.

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THE PILOT PROGRAMME FOR PROMOTING VETIVER GRASS IMPLEMENTED BY THE PEOPLES RURAL EDUCATION MOVEMENT (PREM), ORISSA, INDIA.

A Review By Rajan Ghandi.

(Editors comments on this review are at end notes on page 27)

P.R.E.M (Peoples Rural Education Movement) in mid 1998 implemented a Pilot Project to promote the planting of Vetiver in 10 villages in 10 Community Development Blocks in Orissa, India.

The objective of that Pilot Programme was: "*To promote the cause of vetiver as widely as possible in the tribal areas under the influence of PREM".*

The underlying reason for promoting vetiver in these areas was to mitigate the problems due to depletion of forest cover and the related decline in traditional forest products. Dependency on shifting cultivation had increased. Optimum intervals between shifting cultivation cycles were no longer possible. "Slash and burn" techniques had resulted in serious problems of soil erosion and it was felt that there was an "*urgent need to begin the process of restoration ….*"

THE REVIEW

The review was initiated by Mr. James Campbell in early October '99. The objective was to learn from PREM's experience so as to assess whether and how similar programmes could be replicated elsewhere, for instance in Gujarat.

A secondary objective was to evaluate the need for and the type of a central training and coordination organisation that might function as an arm of a future India Vetiver Network. Such an organisation would act as a repository of the expertise and experience of Vetiver existing in different parts of India and the world, provide training in the technology to any persons interested in Vetiver and promote Vetiver throughout the country.

The review involved visiting as many sites/villages as possible where PREM had planted Vetiver, to interview those involved in the Pilot Programme (whether beneficiaries, village leaders or trainers) and to assess the degree of success.

The review was held from January 3 - 12, 2000. Since this author was not familiar with Vetiver, it was suggested that the very first visit be to the World Bank-financed Integrated Watershed Development Programme (IWDP) at Phulbani. The IWDP had extensive plantings of Vetiver as a major component of its Soil Conservation efforts and the Programme had resulted in widespread use of Vetiver for this purpose as well as for reinforcement of the banks of canals and waterways.

Berhampur-Phulbani

There were no officials of the IWDP available. Fortunately, an employee of Fr. Paul Raj's orphanage, had been working with Vetiver at the IWDP was able to take us to a few

sites, including the dirt airstrip where Vetiver had been planted to stabilize embankments. It was very clear that Vetiver had done an excellent job in preventing landslips on the embankments all along the runway. Photograph 1 illustrates the Vetiver row along the dirt strip.

A fruit plantation behind the airstrip had been planted with Vetiver amidst the rows of trees, but the entire plantation had been abandoned and there were huge gaps in the hedgerows. It was learned that villagers had cut down the barbed wire fencing, allowed free grazing and generally ravaged the plantation. Photograph 2 illustrates the present condition of the Vetiver originally planted. There were wide gaps between the Vetiver clumps and indications vetiver had been subject to grazing. The plantation was on relatively flat land which facilitated grazing, whereas the runway embankments would have made it difficult for animals to graze.

En route to and from Phulbani, there were some instances of Vetiver being used along the banks of waterways; the neat rows were evidence of human intervention and it was learned that the IWDP had extensively used the technology for soil conservation. It was, however, disappointing that the technology had not spread to individual farmers in the area. Only isolated instances were seen of farmland with Vetiver planted on earth bunds. We were advised that it was a local practice to demarcate plots belonging to the same family using Vetiver[1]. This practice was considered more socially acceptable, for instance amongst brothers, than building a wall or a fence. It is thus possible that the isolated instances noticed were thus for purposes of demarcation than soil conservation.

We were able to meet Mr. R C Panda, District Soil Conservation Officer, who was part of the IWDP team. He stated that the IWDP had reclaimed 7000-8000 hectares of land in Daspalla, Saranpur, Nayagadh, Bhanjanagar, Jagganath Prasad, Belaguntha etc. Success in reclaiming gulleys and ravines had been outstanding. The water level in open wells had risen by 5 m over a 4 year period.

Mr. Panda felt that Vetiver is best used as a part of a "total" and integrated approach[2]. Water harvesting was an equally important factor and he went out of his way to illustrate the methodologies adopted.

Berhampur – Daringabadi Photographs 3 and 4 illustrate the countryside and the terraced farmland around Daringabadi. PREM had sponsored the plantation of approx. 6000 running metres of Vetiver in mid-'98. 6000 running meters of Vetiver had been planted by about 10 workers at the commencement of the Monsoons; they covered between 400-500 metres per day or around 50 metres per worker per day.

The community had been paid @ Rs.1.00 per running metre for the labour, which translates to Rs.50.00 (about US$ 1.50) per capita per day. In contrast, the Government-approved rates for manual farm labour are said to be Rs.40 per day for males and Rs.35 per day for females. It must be noted that tribals rarely, if ever, receive the full Government approved rates.

Two truck (actually LCVs or Light Commercial Vehicle) loads of Vetiver had been sent by PREM but these arrived just at the commencement of the rains when farmers were anxious to begin sowing of their own crops. Thus there had been a delay of 3-4 days between arrival of the Vetiver slips and planting.

Vetiver slips had been planted with a spacing of 15 cm (about the span of 1 hand) and a horizontal interval of approx 20 feet between rows, with the vertical interval largely ignored (this was relatively flat land). No chemical fertilisers had been used and no-one seemed sure about whether FYM had been used at the time of plantation. By and large, the farmer had ploughed and cultivated along the contour.

The farmer had allowed cattle and goats to graze on the land immediately after harvest. Vetiver shoots would have been tender and palatable to grazing animals at that stage and according to him, the gaps occurred due to this reason rather than the delay in planting.[4]

The farmer himself did not appear particularly concerned at the ravaging of the Vetiver rows. In fact he had himself ploughed the land right across a Vetiver row and appeared mildly surprised at all the fuss. Photographs 5 and 6 illustrate the present condition of the Vetiver plantation rows[5]. An estimated 15% of the Vetiver originally planted survives to this day and were visible, the leaves were just 3-4'' above the ground.

A Vetiver "nursery" covering 1 hectare on Government land was in even worse shape, as was a field in a nearby village. It is doubtful whether this could ever be used as a nursery, but considering the apparent lack of interest, it will not be greatly missed.

Berhampur – Gunpur – Koraput: Deepti, an associate of PREM was the agency which promoted the plantation of Vetiver in Gunpur on a hillside (Photograph 7) where there was a mixed plantation of fruit-bearing trees, yams etc. They had planted approx. 6000 running metres across the slope of the hill and had in fact sought more slips which were not available.[6] The slips had arrived (1 truck load) a bit late in the Monsoons, but nevertheless had "taken" well with more than 70% survival rate evident.

Although the prescribed spacing between Vetiver slips had been followed, there were a number of gaps and one could not really see a hedgerow, as such. Unfortunately, there did not seem to be any attempt to plug the gaps during the '99 Monsoon season. The villagers interviewed at Gunpur stated that they practiced a controlled form of grazing and did not allow animals

on the hillside, which probably accounted for the high survival rate.

The fact that animal grazing was prevented was also evidenced by the tall grass (Photograph 8)

The hedgerows had been planted about 10 feet apart and followed the contour of the hillside. The reason for the 10-foot interval could not be explained by anyone, but all those interviewed seemed convinced that even after one Monsoon, the benefit – prevention of soil erosion – was already apparent. In fact Mr. Maheshwar Rao of Deepti had set up a separate Society solely for promoting Vetiver grass.

There is ample scope for this in the terraced fields in the area where the traditional crops of bajra and dal would benefit. A village approx 20 km away where Vetiver grows in the wild and is being harvested and sold by locals could provide the necessary planting stock. The sheer enthusiasm displayed by Deepti and the local villagers is commendable, as is the tremendous effort it must have taken to undertake the planting of Vetiver in what is a remote and steep hillside.

Koraput: The agency responsible for the Vetiver Pilot Programme in this area was SOVA (South Orissa Voluntary Action), an associate of PREM.

The area comprises largely denuded hills and gently undulating rocky land. Photograph 8 shows the general environment. Gullies and ravines can be noticed in the background. On the path leading to the village of Lankaput, where the Vetiver Pilot Programme had been implemented, clumps of Vetiver could be seen growing wild. SOVA representatives stated that these had possibly been planted by villagers 10 years ago but for some unknown reason, the practice had been abandoned.

Using locally available planting stock, they had planted 13 rows of 400 running metres length along the contour of a hillside (community land), with rigorous observance of a vertical interval of between 1 – 1.50 metres. The gap between hedgerows was observed to be between 15-20 feet. Slips had been planted with a spacing of 6". However, the gap between clumps of Vetiver was somewhat high, about 9"-12" and these gaps had not been "plugged" during the most recent Monsoons.

SOVA representatives stated that it took 25 farm workers approx 20 days to plant the Vetiver, i.e. approx 500 man-days for 5200 running metres or 5.2 running metres per man-day[7]. This contrasts with the speed of plantation of 50 metres per man per day in Daringabadi, which was on relatively flat land. Planting of Vetiver had been undertaken in June '98 at the commencement of the Monsoons.

Excellent "take" of the Vetiver had been observed, unsurpassed by anything seen elsewhere. The Vetiver had grown high enough for it to be pruned to about 6" height, the cut leaves being harvested for use as roof thatching, for making ropes, handicrafts etc. (Photograph 11). Villagers were asked specifically about whether Vetiver seeds spread onto their crops and proliferated as a weed. They said that by and large, this did not happen but if it did, they ploughed right over it. Certainly they did not see it as a potentially hazardous weed[8].

The red soil was pretty rocky but villagers were planting hill paddy and dal and all those present, including the head of the village panchayat and the block leader, commented that the run off of soil had been significantly less in '99 than in the previous years. There was unbounded enthusiasm for the Vetiver Programme amongst the villagers who appeared proud of their effort and glad of its appreciation. Villagers from surrounding areas had made special trips to see the benefits themselves, and it was reported that several local farmers had started planting Vetiver on their own land and of their own accord during the Monsoons of '99.[9]

In contrast to other sites, the hill with the Vetiver plantation had been fenced off (Photograph 9). SOVA had financed the fencing, paying for it over and above the Re.1.00 per running meter paid to the community chest for the Vetiver plantation. This possibly accounted for the high degree of success achieved at Lankaput although the villagers stated that grazing animals found the sharp, serrated leaves of Vetiver unpalatable. They said that in some areas, there was no fencing but animals still stayed away from Vetiver.[10]

Photographs 11 – 13 all illustrate the Vetiver plantation at Lankaput. Truly, this was an example of outstanding communal effort and success. The enthusiasm and confidence was plain to see; in contrast to other areas, villagers were keen to volunteer information and proudly posed for a group photograph with this author. Whether enthusiasm breeds success or whether it is the other way around, the example of Lankaput should be recorded on the Vetiver map.

The local Soil Conservation Officer, Mr. Patro, paid a visit to SOVA and discussions were held with him about Vetiver. He was unstinting in its praise, particularly in arresting the menace of gully and ravine formation. In contrast to the villagers here and elsewhere, he said however that Vetiver attracted snakes, particularly cobras, and that one had to be very careful to avoid them in Vetiver nurseries[11].

He also suggested growing Sisal in wastelands. It did not require more than one Monsoon to take roots and the fibres yielded an income when the leaves were harvested in approx 5 years from planting. The waste after the fibres were

extracted was excellent green manure and the fibres themselves fetched a market price of Rs.20 per kg.

We paid a visit to the Orissa University of Agricultural. Although they recognised the importance of Vetiver in soil conservation and stated that it would help in water harvesting, they had not planted Vetiver themselves nor was it their responsibility to promote the planting of Vetiver[12] !! They had, however, developed some very interesting techniques, particularly of growing bamboo.

Koraput – Kharikua – Chandragiri – Berhampur: The local coordinator at Kharikua (Mohana) village was away at a meeting and thus detailed information was not available. Nevertheless, a local villager served as an escort to the hillside where Vetiver had been planted during the Pilot Programme in mid-'98 on a mixed plantation, similar to the one at Gunpur.

The results were nowhere near as impressive as observed in Gunpur. There was a fair degree of tree cover and only sparse and occasional clumps of Vetiver grass could be observed. Possibly due to excessive shade, the plants seemed stunted and weak (Photograph 14) and it appeared doubtful whether the surviving Vetiver would be able to play any significant role in soil conservation.

Our escort was directly asked what he saw as the chief benefit of Vetiver. He was unable to provide a satisfactory answer without much prodding. Possibly he was not involved too deeply with that particular plot of land, which was community property.[13]

PREM's excellent establishment at Chandragiri was the next halt. This was where PREM had, amongst other projects, set up a Vetiver nursery with feedstock from Konarak. Four beds were seen, each with thick and high Vetiver growth (Photograph 15) which had not been harvested or trimmed.

Vetiver planting is one of the vital components of PREM's new Social Forestry plan, aided by the DFID, and PREM could draw stocks from the nursery at Chandragiri if needs be. At the moment, the nursery is not being used.

En route, we observed Vetiver growing wild on the banks of the Bansadhara River at Gumuda. The legendary (in this area) James Campbell[14] is reported to have repaired to a bus shelter and proffered drinks all around when he saw the expanse of wild Vetiver growing in abundance, free for the taking ! (See Photograph 16)

Berhampur – Baraikudi – Berhampur: Visited the Secretary of PREM, Father Chacko, in the morning. He very kindly showed us the illustrations prepared for training villagers and trainers when the Vetiver Pilot Programme was launched. Also discussed community-size Solar Cookers for possible installation at Chandragiri, for which this author has promised some help, and the offer by Wilfried Riehle to finance a tribal house which he had designed.

In the afternoon, visited Baraikudi, a short distance from Berhampur. There are entire fields of Vetiver growing wild here and PREM had drawn their stocks from this source for the Pilot Programme, it being much closer than Konarak. A flat rate of Rs.850 per LCV-load was paid to the villagers for the Vetiver slips. One LCV load took approximately 10 man-days and was sufficient for approx 3000 running metres of planting.

Discussions with the local farmers yielded the following additional information:

Local farmers stated that Vetiver did not necessarily attract snakes. However, rats definitely burrowed under thick clumps of Vetiver They endorsed the view that cattle and goats grazed on Vetiver only when the shoots were young and tender. Mature leaves were left alone, since the sharp serrations would cut the tongues of grazing animals.

It was interesting to observe that although the paddy fields all around were destroyed by the recent cyclone, Vetiver was still flourishing[15] . Locals stated that the fields had been inundated for 10 days continuously with water levels as much as 20 feet high on occasion, but Vetiver was unharmed.

Berhampur – Konarak – Bhubaneshwar: The purpose of visiting Konarak was to see the type and enormous quantity of Vetiver growing wild en route, as well as to meet Mr Lakshman Naik of CPDA, a PREM associate. CPDA that day were completely pre-occupied in Cyclone Relief measures owing to the unexpected arrival of 2 truckloads of relief supplies which needed urgent distribution. They had themselves not much experience of Vetiver planting, but were glad to point out the several areas where Vetiver was growing and could be harvested as needed.

Konarak had been savagely mauled by the Cyclone. Damage to the standing crops, said to have been the best in the last 30 years, can be assessed from the condition of the trees (Photographs 17 and 18) and even electricity poles (Photograph 19). Wild Vetiver grass had, however, successfully withstood the storm and subsequent inundation even by saline water from the sea[16] . (Photograph 20).

A canal along the road had been planted with a single row of Vetiver along the embankment, probably by the IWDP (Plains Division). The canals had overflowed for days and yet at the time of the visit, Vetiver had regenerated and was thriving (Photograph 20).

Dept. of Silviculture, Govt. of Orissa, Bhubaneshwar: Although the Dept. of Silviculture has nothing to do with Vetiver, the purpose of the visit was to meet Mr H S Kumar who had been the Project Director of the IWDP Project at Phulbani. Several people met during this visit, including the President of PREM, had suggested that this author meet him since he was considered the "guru"

of Vetiver in Orissa.

Mr. Kumar kindly granted an appointment and the question of possible replication of his results in different States/areas was discussed, with particular reference to Gujarat. He felt that if the topsoil was clay, chances of survival by the 3rd year were poor.[17] If, however, the clay layer/black cotton soil was found beneath a 1 metre layer of good soil, Vetiver would thrive and its roots could penetrate the clay layer, permitting recharging of ground water resources. His experience was that open wells which had dried up showed 2-3 feet of water within the first year of starting with Vetiver along with other methods of water harvesting. In Phulbani, they had found that roots went down to 4.2 metres.

He said that the seeds were, by and large, sterile – especially the stock drawn from Konarak which had been used for the nursery in Phulbani.[18] A spreading variety did exist and whilst this was inadvisable where crops were being planted, he had found it useful in preventing splash erosion on hillsides.

To establish a nursery, he suggested planting in a continuous shallow ditch with Vetiver slips having 10 cm of leaves and an equal length of roots, with 5g per plant of Di-Ammonium Phosphate (DAP). In the event of mortality, the next clump could be used to fill in the gaps. Termites were a definite problem and he strongly advised dusting with any anti-termite powder if they were in evidence (Daringabadi had plenty of termite hills in evidence – could this have been a reason for the high mortality rate ?) [19]

Mr Kumar also suggested the following rules of thumb:

> Agriculture: plant Vetiver at horizontal intervals of 40 metres, at bunds
> Horticulture: plant Vetiver hedgerows at every 5 rows of trees
> Forestry: plant Vetiver hedgerows at every second row of trees.

His experience had been that in Horticulture, Vetiver had not worked too well since farmers rarely bothered to look after the hedgerows.

He was asked whether there was a need for a Central resource-base on Vetiver, such as a branch or offshoot of The Vetiver Network. He felt that it was a good idea because the huge benefits of Vetiver technology were indisputable; all it needed was a push in the right direction. Mr Kumar offered to assist in any way he could if such a central resource-base was set up.

Discussions with the PREM were a critical component of this visit since only they could provide necessary guidance and advice on replication of their experience elsewhere. Discussions with PREM personnel were held before and during the field visits, but regrettably, a "wrap-up" session was not possible.

PREM had trained some 100 people from the 10 selected blocks both in "classroom" type situations and by organising field visits to the IWDP project at Phulbani. The trainees were the farmers themselves and Mr James Campbell had played a crucial role in the training process. Ten hand-painted posters had been produced to assist in the training and the 2000 copies of the "Green Book" in Oriya had been printed (specimen collected). Although the farmers were mostly illiterate, these copies were distributed to NGOs, Government officials, PWD (Public Works Dept) officials etc. They had also held 2 Workshops for NGOs and Govt officials.

PREM had established 2 Vetiver nurseries of their own but did not consider the establishment of nurseries too good an idea. For a start, wild Vetiver was plentifully available and secondly, the roots of Vetiver plants in nurseries went down so deep that gathering of slips became a problem.[20]

The methodology adopted was that PREM would arrange for the Vetiver slips to be delivered to the selected sites, at its own cost. Villagers contributed by way of labour and the village community – never an individual – was paid a sum of Rp.1.00 per running metre for planting of Vetiver. There was only partial financial support for fencing off. Since a farmer from that particular village had been trained in Vetiver technology, the care and maintenance of the slips to maturity was the responsibility of the trained farmer and the community.

One problem faced by PREM and its associate organizations was that the planting of Vetiver corresponded with the onset of the Monsoons, when the farmers were understandably preoccupied with sowing of their own crops. This had on occasion caused a delay between the physical arrival of the slips at site and the actual planting.[21]

Informal discussions with PREM personnel also revealed a concern about the levels of motivation of the villagers. They felt that farmers would more readily care for the Vetiver hedgerows if the technology was introduced as part and parcel of an income-generating project, e.g. the plantation of cash crops such as fruit trees which could yield an immediate/near-term income.[22]

Notwithstanding the problems which PREM and its associates had faced, and further not withstanding the erratic results obtained, PREM is sufficiently convinced to make Vetiver a key component of its DFID-aided Social Forestry Project in Gajapthy District[23].

PREM's Pilot Programme provides a unique learning experience. The lessons learnt are invaluable not only for PREM's Social Forestry Project, but for others interested in replicating PREM's experience elsewhere[24].

Whilst the foregoing parts of this Report merely record the observations, the following section attempts an analysis. The observa-

tions, and therefore the analysis, are based on the villages actually visited and to that extent are limited. However, the visit schedule had been carefully planned by PREM to be as representative of the whole Programme as possible and thus (subject to PREM's concurrence), this analysis should be valid.

OBSERVATIONS AND ISSUES

TRAINING: Great effort had been made in training the associated NGOs, village/community leaders and project co-ordinators and it was clear that the training had paid off in most respects. Vetiver slips had been planted along the contour and at the prescribed intervals. However, the vertical interval seemed to have been ignored (or at least, the significance had been forgotten). Also, in several instances, "success" seems to have been measured by the height that the Vetiver achieved rather than by the density of the hedgerows.[25]

MOTIVATION: This strikes one as being a key element of any similar Programme. It must be acknowledged that the true benefits of Vetiver to farmers will arise in the medium to long term. In contrast, the population in the areas surveyed had more immediate needs, those of survival. This factor is compounded by the fact that the tribals do not own the land they are cultivating, and quite naturally are not particularly concerned about the long term.[26]

The statements of Mr Mitrabhanu Panigrahi and Mr Ratan Mishra of PREM therefore assume great significance: that when encouraging Vetiver technology in an area as poor as this and when the land is not owned by the cultivator, it is best to promote the technology as part and parcel of something which will yield an income in the near future[27].

But even fruit trees take time to yield income. In the interim, the farmer must care for the Vetiver hedgerows as much as he cares for his crop. In Daringabadi, there was a marked absence of enthusiasm on the part of all concerned and the pitiful condition of the Vetiver hedgerows was plain to see. Conversely, in Lankaput, there was abounding enthusiasm and tremendous success. The enthusiasm could not have been caused solely by the direct benefits of Vetiver, since only one Monsoon had passed and it would have been somewhat premature to assess the full impact.

What led to this enthusiasm? The answer is not clear, but perhaps the keen interest shown by SOVA played an important role.

What is abundantly clear from the Lankaput experience is that success breeds enthusiasm, and the fact that villagers of their own accord have started to plant Vetiver hedgerows is an indication of true success. In the absence of committed organisations such as SOVA, perhaps a Video recording showing "before and after" scenes would serve to motivate villagers and to keep them motivated.[28]

MANAGEMENT: This has several facets:

1. Planting: It was learnt from the visit to Baraikudi that it took 10 man-days to put together an LCV-load of Vetiver slips, and that an LCV load covered approx 3000 running metres.

If the objective is to plant Vetiver as soon as possible after the slips are gathered, and if the slips are to be transported over a distance, this obviously means that a work-force of 10 persons has to be engaged each day for every 3000 running metres of Vetiver hedgerow. However, the rate of planting ranges from 50 metres per person per day (Daringabadi) to a low of 5 metres per person per day (Lankaput).

Admittedly, the terrain in Daringabadi and Lankaput was different, and factors such as supervision, levels of skill etc. may have varied. However the 10-fold difference needs to be investigated further and some kind of norm evolved, so that the rate of harvesting of slips is matched as closely as possible with the rate of planting. Otherwise delays can occur which lead to a loss of continuity in work. Such delays, experience shows, can be further compounded by other factors such as farmers' preoccupation with sowing their own crops and the net result could be an unacceptable mortality rate. This could in turn result in formation of noncontinuous hedgerows which could actually *accelerate* the formation of rills and gullies unless corrective action is taken.

Since Vetiver planting in unirrigated areas is done only at the onset of the Monsoons, the time lag for corrective action is by definition 1 year, during which a fair amount of soil erosion can take place. Equally importantly, farmers could easily be discouraged by the apparent lack of "results" with disastrous consequences.

Site selection is also of critical importance. For example, the Kharikua plantation had a high amount of tree overgrowth and the Vetiver hedges looked relatively weak and fragile. Evidently, they need a reasonably high amount of sunlight to thrive.[29]

2. Follow-up: PREM's Pilot Programme was scheduled to last 6 months. Mortality of Vetiver slips can occur because of faulty planting, poor quality slips, grazing, trampling etc. In none of the areas visited was there evidence of corrective action taken to replant in spots where the Vetiver slips had not survived. As mentioned above, large gaps in the hedgerows can actually accelerate the formation of rills and gullies and it is essential to include a formal mechanism to follow-up the initial planting and to replant as necessary.

This effectively means that a 6-month programme is inadequate. It would seem logical to have a programme that last about 15 months, i.e. from the commencement of a Monsoon to the end of the next Monsoon. Whatever be the format or duration, repeat visits to inspect the hedgerow formation and

to take corrective action must be built into the design of future programmes of this nature.[30]

3. Fencing Off: No separate budgetary provision had been made for fencing off and PREM were only able to partially finance fences to keep away grazing animals. As long as there was a standing crop, villagers kept animals away but in Daringabadi, for example, animals were freely allowed to graze soon after harvest.

In Gunpur, villagers practiced a strictly controlled grazing regime and survival rates were at least 5 times higher than in Daringabadi. In Lankaput, the hill had been fenced off and the results were even more impressive.

Unless it can be assured that grazing animals will be kept away, some form of fencing with naturally available material (e.g. cacti or thorny plants) seems to be essential. In the initial stages, when farmers cannot see the benefits from Vetiver, they cannot be expected to be as scrupulous as necessary and if fodder is scarce, animals will surely graze on Vetiver. The ravage seen at the IWDP fruit plantation at Phulbani, where the Vetiver was at least 4 years old, is adequate proof that animals will graze on even mature Vetiver when other feed is scarce.[31]

4. Conflict with Crop Sowing: In at least 2 cases, the Vetiver slips were not planted immediately on arrival since the concerned farmers were preoccupied with sowing operations. There was a time lag of about 4 days which could have contributed to the mortality rates.[32]

This situation arose because the onset of the Monsoons is the best time for planting Vetiver as well as the best time for sowing operations, resulting in a conflict of priorities where sowing will invariably win out. Such a conflict is inevitable in areas without year-round irrigation.

There is no immediate solution that can be thought of. Perhaps poly-potting, which appears to raise the "shelf-life" of Vetiver slips, provides an answer but this is practical only where there is a Vetiver nursery, unless a mechanism can be devised where poly-pots are transported to the area from which wild Vetiver is to be harvested.[33]

5. Nurseries: PREM did not find the establishment of nurseries a very practical proposition. Wild Vetiver was frequently found growing near the target area and it was simpler and more economical to harvest slips from there. Also, PREM had found that the roots of Vetiver form such a deep and complex structure that they were difficult to remove. Unless Vetiver was regularly harvested from the nursery beds (before the roots went too deep), the land became difficult to cultivate. This fact must be borne in mind whenever a nursery is contemplated.

There is much to be said in favour of Vetiver nurseries but the numbers planted and the time of planting must be carefully coordinated with the potential usage pattern.[34]

6. Spreading the Message: If Vetiver technology is to be spread far and wide, demonstration units are not enough. There should in addition be meticulous recording of yields, fertiliser usage, soil moisture content etc. before and after Vetiver was adopted. This data, along with a video recording before and after, (possibly with actual video shots of water flow being retarded down a hillside) as well as video/stills of reclamation of land in gullies and ravines, would be excellent material for showing to villagers.

Such efforts would be time-consuming and expensive, but would be a sure way of motivating farmers to try out Vetiver technology on their own. Sceptics could be directed to the closest demonstration plot: this also means that the audiovisuals should at the first instance be screened in villages proximate to the demonstration unit.

Finally there is the question of commitment. Deepti and SOVA, both NGO associates of PREM, were deeply committed to Vetiver and were able to pass on their commitment and enthusiasm to the beneficiaries. Both these organisations have done such a good job that they deserve recognition and further financial aid in spreading the message and technology.

Deepti and SOVA, in turn were fortunate in having PREM to back them. Indeed their own commitment originated from PREM without whose drive, management and support they would not have been able to achieve any results[35].

THE NEED FOR A CENTRAL COORDINATING ORGANISATION

It had been hoped that after the successful implementation of the Vetiver Pilot Programme, PREM would take on the role of a Central Coordinator for India, imparting training and motivating other NGOs throughout the country to adopt Vetiver technology. Certainly PREM, with its vast organisation and managerial skills, was very well placed to do so. However, PREM is heavily committed to several other Projects and appears reluctant to take on this burden.

Perhaps this is just as well. Any such endeavour requires an organization dedicated to Vetiver and to very little else; the magnitude of the task is too great otherwise. Is there a need for a central organisation in the first place ? Available evidence seems to indicate that there is not just a need but a crying, desperate need.

Within a short span of time, this author was referred numerous people who had done "excellent work" on Vetiver. Inevitably, such people were found to be academicians or Government officials. Pockets of expertise indisputably exist but there is no central repository of data, experience and skills.

Secondly, the "lab to land" experience seems to have been abysmal. Indeed at Phulbani itself, the site of the massive and now-abandoned IWDP Project, there is

very little evidence of farmers nearby adopting Vetiver technology for their own benefit. Whether this due to absence of information or lack of motivation is not clear, but certainly academics and Government officials have not done very much to spread the message. Perhaps they do not see it as their role, even though all of them without exception stressed the enormous impact that Vetiver could make.

Other organisations which should in theory be involved seem blissfully unaware of Vetiver. Surprisingly, even the Centre for Environment Planning in Ahmedabad (contacted well before the start of the Orissa visits) knew only vaguely about Vetiver. The Gujarat Ecology Commission – which has an entire cell devoted to wasteland reclamation – was equally ignorant.

NGOs have been identified as the vehicle through which the technology could spread. However, as with PREM, NGOs often have a number of diverse Projects many of which are of a more immediate nature. NGOs, too, operate in a restricted geographical area. Constraints of funds, management skills, communications, location and numerous other factors prevent them from playing a countrywide role.

NGOs can at best be expected to implement Vetiver projects and to assist in the education and motivation role. It is unrealistic to expect them to take on Vetiver technology as their sole raison d'etre. Optimally, a coordinating body should be formed whose initial role would be to gather and store in easily accessible format all relevant material relating to the technology. It would then set about disseminating this information not passively, but by actively seeking out individuals and organisations working in the area of soil conservation and convincing them of the advantages of Vetiver technology, encouraging the application of the technology, providing technical, training and promotional inputs for the application of the technology, monitoring recording and analysing the effects of such application, according recognition to good work in an effort to promote emulation, publicising the benefits and facilitating exchange of data and opinion.

Despite the fact that Vetiver grass is native to India, that Vetiver hedgerows have been used in parts of India for 200 years or more, that it provides a simple, inexpensive and durable method of soil conservation, India continues to lose megatons of topsoil every year to erosion. Surely this situation needs urgent correction by whatever means. The suggested central Co-ordinating body, properly manned and financed, could make an enormous contribution in this direction[36]

COMMENTS BY YOUR EDITOR!

[1] This is a good idea , on very small plots at least two of the boundary hedges will be across the slope and therefore will be effective.

[2] Agreed.

[3] Agreed.

[4] Grazing of vetiver in first year can be a big problem, not because the plant is eaten , but rather because it is pulled right out of the ground during the act of eating. Sheep and goats are a particular nuisance.

[5] This together with subsequent comments would seem to indicate that farmers have not been adequately trained. This is a real problem in India.

[6] A good sign.

[7] I think that this is a mistake it should be 10 meters. Even this figure is ridiculously low. In Karnataka farmers are said to plant 200 meters/manday. I suspect because these farmers are being paid there is little incentive to work very hard.

[8] Note the vetiver being used in Orissa is probably a north Indian seedy cultivar. It is not the best, but it will do.

[9] Good sign.

[10] This probably reflected an alternative forage supply, if there had been none the goats and sheep woulf have had a crack at the vetiver.

[11] Who do we believe Mr. Patro or the villagers, I would go with the latter. Nearly always it's the officials who find fault, and not the users. I wonder why?

[12] Typical "not invented here" syndrome

[13] sounds as though this was a bad site with minimum farmer and communal participation.

[14] Jamie did a great job — I salute him!

[15] Was this vetiver used to stabilize paddy field bunds, if yes, did it protect the bund from destruction.

[16] Same in China after a cyclone on Pintang Island.

[17] Questionable.

[18] Konrak stock is OK.

[19] Agreed.

[20] generally it is better to have nurseries as over time you can select better quality plant material. I suspect that a lot of the "wild" vetiver slips may have been poor quality and would have died at planting. Vetiver from nurseries is not difficult to dig up. You only need a few inches of root It might be better not to devide into slips at the nursery but rather transport large clumps. These if left lying about have much greater survival time prior to planting.

[21] More reason to transport clumps.

[22] Agreed. I believe the approach should be to get the whole community involved with the plan and an overall explanation of the many benefits of vetiver — not just soil conservation. After that some individuals in the community - the innovators need special training in the technology so that it is correctly applied. In addition fruit trees and other long term crops need to be introduced.

[23] You have to expect erratic results in the beginning. Greater conformity can be obtained by following note 22. Incidentally if a community is not interested and committed, don't include them in the initial stages.

[24] Also for other countries.

[25] I sometimes feel that for most

farmers horizontal interval is the important factor. They just don't want the hedges too close together. Its probably better that way. Once the farmer sees the effect of vetiver he is more likely to add additional hedgerows if he thinks it is necessary.

[26]Correct.

[27] Correct.

[28] Sounds plausible and most likely. A video would be a good idea

[29] All the observations in this section are valid. I suspect the incentive factor is the most important factor that determines the rate of output. In my view the digging up and preparation of plant material should be done "commercially" - i.e. pay for the job. As for on farm planting, once the community is convinced of the value of vetiver there should be no need to pay the farmers for protecting there own land, so long as the plant material is provided at no cost.

[30] Agreed. It was six months because that was all the funds that were available - hopefully DIFID or some other agency might fund the next phase.

[31] Fencing is an expensive option. Back to initial community involvement training etc.

[32] Consider the option of delivering clumps rather than slips of vetiver. Clumps will survive a long time, and thus delays in field planting should not result in high mortality.

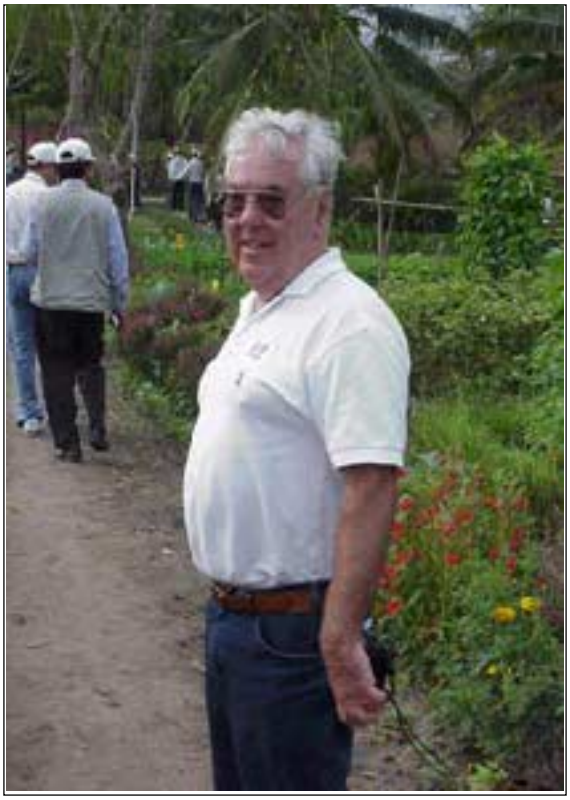
[33] No - too expensive and non sustainable

[34] Vetiver nurseries are better - they produce better planting material. Harvesting from nurseries need not be any more difficult than harvesting from the wild. One only needs about 10 cm of root. In Malaysia the best tool for digging vetiver clumps is an oil palm harvesting tool. This comprises of a long single handle (1.5m long) with a chisel like knife attached at the end.

[35] I agree with this section

[36] Good and valid observations. I have always wanted an Indian Vetiver Network, but have been discouraged from establishing one because it has been nearly impossible to identify individuals and or agencies who are committed enough to do a good job. I believe it is impossible to do this within currently operating research, academic or government agencies. There are too many conflicting agendas. Some people just don't want to know about vetiver. Others say that there are 40 other grasses that are just as good (*incorrect*) thus no need to promote a single species. There is the "not invented here" syndrome. and so on. Probably the best way is for an independent such as Rajan Ghandi to set up a network with financial backing from a some big corporations like Tata. There are also some people at high level in Government who are interested and who know the value of vetiver. I know one thing that the Network should not be in the hands of government, academia or research. They can all help, but they seem unable to lead and motivate.

Sandy Robertson of Portugal pruning his very well grown vetiver with his mechanical scythe on his avocado farm located in the Algave. Sandy is also a source of planting material. Photo credit: Mike Pease.



John Greenfield, the "Father" of the renaissance of Vetiver Systems and author of "Vetiver Grass - A Hedge against Erosion". Photographed during the Conference in Thailand in January 2000. Photo Credit: Dick Grimshaw

Best Practices -- Establishing a National Vetiver Diffusion Program: Example of Madagascar, A Country Eroding into the Sea.

Criss L. Juliard, Ph.D., CHEMONICS INTERNATIONAL, presented at the Second International Vetiver Conference,Thailand, January 2000

OVERVIEW OF THE MADAGASCAR PROGRAM

The author headed a USAID-funded technical assistance project to stimulate the agribusiness sector and to rehabilitate rural infrastructure in two of Madagascar's six regions. The infrastructure component improved farm-to-market transport. It spent $13 million over five years to rehabilitate rural roads and partially rehabilitate a railroad. Rehabilitating the roads proved to be an easier task than assuring their maintenance at reasonable cost. The hypothesis was that maintenance could best succeed by using a participative approach with the local population, who had a vested interest in protecting the investment. Management of the roads was formally turned over to road user associations comprised of villages living alongside the roads and agricultural enterprises with an interest in the area. (see Picture Gallery, #* ARABIC 1A and #1B). The associations and project staff witnessed serious problems when some of the new and costly engineered works washed out during a cyclone, and erosion and massive landslides threatened other areas under rehabilitation. (see Picture Gallery, # 2). We searched for solutions together, which led us to vetiver. We initially contacted the Vetiver Grass Network through the Internet. They subsequently provided the project with information, guidance, experience and visuals aids to tackle the problems that had already occurred and develop a capacity to avoid new ones. This led to a sensitivity and awareness campaign in the two regions where roadwork and agricultural intensification were being implemented. Subsequently, we expanded the initiative on a national level. This was done both in response to requests for assistance in setting up vetiver in other regions of the country and as a way to ensure long-term support from businesses, donors, professional associations, and government at the national level.

The overall cost for diffusing vetiver, first in the project area and later on a national scale, was roughly $750,000 over three years. This amount included about $464,000 for the purchase, transportation, and planting of the plants, $40,000 for the communications campaign, and $196,000 for project-based technical assistance. We also benefited from about $50,000 of in-kind contributions from other organizations. The result was the planting and caring of approximately 160 linear kilometers of vetiver hedges (1.6 million plants), which protected over 400 km. of roads and associated masonry works and 20 km. of vetiver hedges along a railroad line, watershed basins and agricultural lands. Approximately 200,000 of the 1.6 million plants were used in agricultural plots to improve soil quality. Cost per planted meter averaged about $2.90. The cost of protecting rural roads and masonry works with vetiver varied from 1.2% to 4.6% of the rehabilitation investment. On average vetiver cost was 3.1% of rural road cost. We estimate that vetiver will extend the life of the road by 30 to 100%, thus greatly increasing the rate of return on the rehabilitation investment.

Over the course of the project, the vetiver activity assumed greater importance than what was anticipated at the outset. Through our participation with new partners who operated on a national scale (the National Environment Office, Ministry of Public Works, World Bank, UNDP, Peace Corps, World-wide Fund for Nature, and CARE), the technology became better known, and demand for assistance outpaced our ability to respond. After three years of intensive vetiver outreach activity, vetiver dissemination in Madagascar reached a significant scale. We had established a core of people skilled in the technology and a critical mass committed to its use. The adoption rate is high and the demand remains strong.

How did the country get to this point? What specific actions led to achieving this critical mass state? Looking back we concluded that the dissemination strategy developed as much by chance as by design. However, we believe that a good part of our success can be traced to the manner in which three questions were addressed: who will do the dissemination, with what material, and by what means?

Two or three previous attempts at vetiver dissemination in Madagascar did not succeed. We believe our efforts have been rewarded because they:

- Got the right people involved and committed.
- supply of the plant material
- Provided technical support to assure the technology was applied correctly.

This paper discusses the manner by which these three concepts were addressed and given priority.

1. GET THE RIGHT PEOPLE INVOLVED

At the heart of a vetiver dissemination program is getting the

right people and organizations involved and committed to promoting the technology. A program needs a locomotive, and it is preferable that this engine be an independent body that has:

- A mandate to achieve results in a field such as agriculture, environment or infrastructure;
- Recognized leadership skills;
- Access to financial resources;
- The drive to establish partnership relations with other organizations; and
- Create a catalyzing event.

To get people and organizations to address a common problem, organize an event such as a disaster preparedness seminar, a soil conservation workshop or engineers' conference on road maintenance. In Madagascar, an early catalyst to get people thinking about solutions to the massive erosion problem was the organization of a conference called: "Effective technologies used to preserve agricultural soil and to reduce erosion." Vetiver was one of the field-tested technologies presented by practitioners to a diverse audience of agronomists, engineers, NGOs, researchers, ministries and donors.

Such an event becomes the catalyst to help conceptualize the scope and breadth of a vetiver program. It allows individuals and implementing bodies with the drive, ideas and nurturing skills to emerge as actors who will take the idea from conception to reality. It is useful to have an eye-catching presentation by a vetiver practitioner who has slides, reports, and scientific evidence and background information on vetiver in other regions or countries. Richard Grimshaw was the main advocate of vetiver technology at the conference, and he helped to establish vetiver's credibility. The conference also discovered that other organizations that had used vetiver in the past had applied inappropriate technology. The Vetiver Grass Network and its WEB site (www.vetiver.org) provide excellent material and contacts to ensure good application of the technology.

The event can also serve as a preliminary planning platform to discuss target beneficiaries, resource requirements, sources of planting material, participating organizations, short and medium term goals, and a schedule of follow-on planning exercises.

Involve both big picture people and the details folks. In the early stages of program development, involve professionals representing the engineering, agricultural, environmental, financial, forestry, business and NGO sectors. Look for those who have a sense of the big picture and policy issues. People who are busy, who already carry many responsibilities, who have a wide network of contacts, and who work under a private umbrella are the most likely to help the initiative succeed. These people will have know-how to access key documents, pictures, reports, slides and videos on vetiver usage.

When considering partnership organizations, look for ones that have the best records working closely with village associations, farmer cooperatives and producer groups. These are the resources that deal best with the smaller details such as how best to get the message to targeted beneficiaries, problems of local logistics and ground-truthing proposed practices. They are critical to a national campaign as they complement the vision, big picture folks and help resolve practical problems at the village and local level. Remember that it is often the details that ruin a well-planned national vetiver program.

Create an information network among key people and lead organizations. Critical to a national vetiver program is networking information about the plant, its uses and virtues to the beneficiaries, including those who plant, finance, become stakeholders, researchers, businesses and those who hold local and national offices. These groups must understand the plant, the technology, and what vetiver has done elsewhere under similar conditions.

Basic information about vetiver exists in abundant supply. In addition to the vetiver web site, important documents that help get started are the World Bank Technical Paper #273; the National Research Council's 1993 *Vetiver Grass, A Thin Green Line Against Erosion,* P.K. Yoon's 1991 *A Look-See at Vetiver Grass in Malaysia;* and VGT newsletters. In addition, see the reference section of Richard Grimshaw's V*etiver Grass Technology Network and Its Impact on the Environment*, presented at this conference

To create the information network, the lead organization must establish a communications plan and a strategy to transmit information about the plant and the technology to target groups. Regardless of the target group, the program requires large quantities of visual-aids and written documents, organizing workshops, participating in seminars, involving schools in "vetiver planting days," assuring press reporting, and using resource and experienced personnel, even if at the outset they must be brought in from the outside. Estimate an active communications budget to be about $6,000 to $12,000 per year. Elicit help from journalists and the media only after there are success stories to report, and have them visit demonstration sites and put them on a mailing list to receive all the documents you generate on vetiver and its use in the country.

The communications plan or awareness campaign should be adapted to each type of beneficiary group. The challenge is to conduct your communications plan simultaneously with each. Aim at four segments of the active population discussed below:

- Vetiver users and direct beneficiaries
- Private businesses
- Local officials
- Ministries, donors and profes-

sional associations.

Vetiver users and direct beneficiaries. The first group, by far the largest and the most important, is the rural farmer and village associations. These are the most strategic groups to reach along with adjacent schools, extension agents and model farmers. (see Picture Gallery, #3). To reach them, use a community-based, participatory approach. Hold meetings. Find out their major environmental, agricultural, and disaster mitigation issues, and how they seek to resolve them. Be prepared to introduce several techniques, including vetiver. Use individuals who are good at village level mobilization to conduct these early meetings.

It is best to have a catalyst to introduce vetiver at this level such as a village level project, a major event such as "earth day," or a road rehabilitation activity. The village has to have a felt need for a vetiver project. Be prepared to show pictures, give a slide or portable computer presentation of how vetiver is used, and provide simple handouts in the local language of how vetiver has benefited others in the same situation.

Private businesses. The awareness campaign for the second group centers on private businesses, nurseries, seed producers, essential oil processors, transporters, people with land looking for an investment idea, and business associations. It focuses on ways to develop and help create the market for vetiver. Use illustrative costs estimates and reports on testing experiences. Provide on-site training visits, conferences and technical presentations.

Local officials. The third group includes local officials in the regions where vetiver has the best chances of assisting soil erosion campaigns or addressing other particular problems. Visits, discussions, slide shows, demonstration sites, and presentations on how vetiver can give their locality a competitive edge are very useful. Local officials have to see the political advantage to their region before they commit to supporting a vetiver program. This legitimate concern is to be addressed in the communications strategy.

Ministries, donors, professional associations. Technicians and decision makers at the level of ministries (agriculture, forestry, environment, land planning, public works, transport), professional associations (order of engineers, agronomist associations), and donors are the fourth target audience of a communications strategy. This is the hardest group to reach; many have set ideas, are not risk takers, and are comfortable with what their group has done before. One way to reach this group is by participation in technology seminars, conferences, and workshops. You can issue press releases, set up demonstration booths, and distribute books and brochures. Repeated visits to ministries and donor offices are a must.

Partnerships. Get partnerships established with NGOs (i.e. Peace Corps, UN Volunteers), extension services, environment projects, students and teachers at local schools, professional associations of engineers, agronomists, and rural development specialists. Most important is the support and understanding of people in the private sector. It has been the experience in several countries that giving the lead to government ministries or research institutions have not produced the best results.

Newsletters/mailing lists. Establish a network among all partner organizations, individuals, and ministries. Use electronic newsletters as a way to maintain communications among all these interested parties. Appoint one person to gather and to edit a newsletter that is Internet-based. Keep the text short and crisp, and send it regularly. For those who cannot be reached by email, fax the newsletters and as a last resort, mail them through the post. The newsletter mailing list should be expanded continuously.

Reporting. Finally, to expand the information network, it is good practice to prepare a report of the year's activity, lessons learned, and above all to record the program with cameras for the first couple of years. The vetiver network would like to receive reports and pictures. The reports can be used for further extension and sensitizing groups in other areas. Using a digital camera facilitates transmitting progress and success pictures to people in the network. Put a digital camera into your planning budget.

ASSURE A READILY AVAILABLE SUPPLY OF PLANT MATERIAL

A sound vetiver strategy requires planning for a surplus of plant material. The need for plants during every planting cycle almost always exceeds supply. We recommend promoting at least three types of plant material sources:

Private nursery and growing fields of vetiver to supply the plant in clumps or plastic bags;
Roving nurseries to supply on-the-spot replanting material;

Small plots in the gardens of people committed to the technology – for multiplication, gifts, starters, experimenting, practice, and testing.

Nurseries are established in well-watered, sandy soils, and run by professionals. Where the cultivation of vetiver for essential oil exists, the producers can be enticed to provide cut clumps as starting material. Nurseries are encouraged to prepare plants in three forms: clumps, bags, or individual tillers. As a basic multiplication technique, the nursery multiplies from its primary source by in-ground planting, not potted planting. Original tillers are to be planted 30 cm on a square in rich loose soil. A warm, wet climate generally allows a multiplication rate of about 30-60 tillers per clump over a six-month period. The nursery will use part of the multiplication stock to put

plants in poly bags and part to be sold as tillers (2-3 shoots per tiller) for direct planting. Generally, the aim is to have several hectares in continual production so that every month as plants are taken from the nurseries, five to six times the amount can be replanted for multiplication and expansion.

"Roving" nurseries, or temporary multiplication centers, are recommended for rural roads, hard-to-get watersheds and other isolated spots, where established nurseries are far away, and the cost of transport is high. Transporting plant material is one of the costliest links in the vetiver technology chain, which is why the on-site nursery is so important. The roving nursery was an extremely useful implementation tool in Madagascar. It allowed for rapid deployment of resources to isolated areas for short periods of time, and reduced overall cost of material by about 20%. A "roving" nursery is one that is established close to the planting area by a professional nursery person near for a particular planting season. It is a temporary multiplication center that has easy access to soil, water, labor and land. The plants multiplied in this nursery will equal the approximate number of plants needed for the site. Tillers or clumps are brought to the sites, and then a speedy production cycle is used. We recommend that all soil erosion applications of vetiver be planted from poly-bagged plants rather than newly separated tillers. While this may increase overall costs, it ensures immediate protection of hillsides and roads for each forthcoming rainy season since the plant no longer goes through its dormancy phase.

The following steps are recommended for the roving nurseries:

Soaking. To accelerate rooting, place tillers that have just been separated from clumps into a cow-tea bath for a period of 7-10 days (*pralinage* in French). The cow manure juice should cover the root and crown section of the plant. New white roots will emerge. Transplant these directly into poly bags, or plant directly in hedgerow. Cow manure bathing eliminates the browning phase that vetiver goes through when multiplied. (see Picture Gallery, #4)

Use cow rather than bull manure. Female manure has a greater concentrate of the hormone needed to stimulate new root growth. Don't let plants soak more than 10 days unless you add soil or dirt to the bath.

Quick rooting. Dig a trench approximately 40 cm wide and 30 cm deep, insert a plastic sheet the length and up the sides to form a water tight reservoir. Fill the trench with 10 cm of the cow tea and soak the tillers upright. Make several of these so there is a continuous amount of available tillers for transplanting. (see Picture Gallery, #5)

Transport. For access to hard-to-reach mountainous planting areas, transport the tillers (which have already rooted from the soaking cycle) in baskets lined with plastic, allowing the roots to remain soaking in small amounts of cow tea. The baskets are head carried to sites, and can remain unplanted for up to two weeks while in the basket. (see Picture Gallery #6)

Garden plots. People responsible and involved in the vetiver diffusion program need to be users, practitioners and experimenters. The best way to do this is to have small production plots right at home that can become the source of gifts of vetiver to anyone who comes by for questions, information or hints. Prepare vetiver plants in nice pots to give away at every occasion, dinner parties, Christmas, birthdays. With every give-away, encourage the recipient to multiply the plant and the technology. Provide them with little written documents explaining its uses and benefits.

T**ransporting and unloading vetiver.** Plants are transported either as clumps, tillers or in bags. Easiest to transport are clumps. Clumps and poly-bagged plants last the longest in transport. Clumps should be uprooted and transported so they can be watered daily. In a loaded truck, transporter must agree to water clumps so the bottom plants get soaked during transport. We suggest clumps be packed in jute bags. Leaves and roots should be trimmed (leaves 25 cm; roots 5 cm.) (see Picture Gallery, #7)

Poly-bagged plants should be packed in crates if possible or laid horizontally. This method is OK if the packing and transport time does not exceed 2 days.

Tillers should be bunched together in clumps of 10 or 12, and should be trimmed the same as clumps. They can be transported bare (which makes them easier to water), and stacked neatly. Cover with wet burlap to protect from sun and evaporation.

Timing. Minimize the time between transport and replanting. Clumps can last up to two weeks, but every day left unplanted decreases the survival rate. Don't store the bagged plants in a shaded area. They need sun and water.

Moisture. Don't transport bagged plants when the soil in the bag is wet. Bagged plants transport best when dry for three days. If possible don't water the nursery for three days prior to loading and transporting.

Unloading. Unload plants in clumps or bunches as near to planting site as possible. Handle plants as little as possible. Arrange for watering plants if they sit more than one day.

APPLY THE TECHNOLOGY CORRECTLY

For a vetiver diffusion program to succeed, the technology has to be applied correctly, and for this to happen, the program needs a core of five or six well-trained professionals (engineers, agronomists, foresters, nurserymen), and a larger group of on-the-ground extension agents. The first group provides training, field support and network-

ing at the implementing organization level, the second works directly with groups who grow, plant, and care for vetiver at the base. The second group is best recruited from a pool of recent graduates of agronomy, engineering or forestry schools, NGOs and rural development projects. The younger, more dynamic and eager-to-learn individuals tend to be the best kinds. As individuals or members of an organization, they must be ready to live on-site, particularly during planting season and immediately after it. In Madagascar we used an apprentice (*expert junior*) program that placed recent graduates in villages to work on agribusiness efforts. Some were assigned to work promoting vetiver full-time, others filled in when needed.

The majority of implementing organizations should be companies that do road construction, associated agro-forestry contracting services or NGOs. The most effective way to assure that these organizations will implement the technology correctly is by providing them with detailed instructions of what is expected at every step of growing, planting and caring for vetiver. This is done through detailed, and carefully written contracts. Attached to this document are sample pages from the three types of construction company contracts that were developed in Madagascar. (Annex) These guidelines have been adopted by the central government (Ministry of Public Works) and have become required construction clauses for civil engineering work financed by many donors and the government. Regular supervision is important to be sure planters understand and apply the technology correctly.

Selecting plant sites. Experience in Madagascar proved that furrows or trenches should be dug 25 cm deep and about 20 wide in all areas where the vetiver is to be planted in hedgerows. Add approximately 1 kg of animal fertilizer or compost per linear meter. Mix the soil well. Have watering cans handy. The best time to plant is during the wet season. Prepare the soil and trenches for each day's planting.

When planting along masonry works (along culvert exits, bridges, causeways, gabions), cut the furrows 4-5 cm from the masonry and along where the fill dirt meets the concrete. In this way, the vetiver can bond the two mediums as it grows. (see Picture Gallery, #8) Where an embankment, hillside, or cut is very steep, dig individual holes rather than furrows for each plant 10 cm apart, horizontally at about a 45-degree angle. This way the vetiver (preferably from a potted source) can fit in as a plug. The roots growing downward will protect the cut from erosion. On river embankments where flood waters moves at high speeds and there is a curve, dig cross furrows in a quadrant pattern, so that the vertical hedge can slow the flow and reduce the currents. Vetiver can survive for several months underwater as long as leaves protrude.

Plant vetiver perpendicular to the flow of water. Hedges should be planted on the up-stream and down-stream side of a cement crossing or bridge pillars to stabilize the footings and gabions. This prevents water swirls that loosen the soil under the cement structures. Space the lines one to two meters apart, depending on the slope.

Always start from the low end of a hillside, and move upwards as plant material and time permit. Avoid putting plants under bridges or shady areas since vetiver likes sun.

Along masonry drains, plant a row of vetiver just uphill from the lip of the drain to prevent silting. (see Picture Gallery, #9)

Where large erosion gullies have been formed, dig the furrow at the base of the gully, and work your way up with successive rows several meters apart. To stabilize the plant during rainy season, drive a wooden stake through the "crown" of the plant.

On downhill curves, dig short furrows to plant vetiver in a herringbone style so that the water is directed from the road surface to the inside drain ditch, and so as to reduce the speed of rushing water. The hedge can grow slightly into the road surface so as to increase the catchments of the herringbone pattern.

On sites where fill dirt has been excavated, begin long rows of vetiver hedges from the base of the excavation site, upwards to prevent further erosion. Ensure that the contour is respected. Place double or triple rows of vetiver along the lowest drainage points of the zone. Constantly check the selection and digging of the furrows as they are being dug. Have a supervisor outline the exact path the planting furrows are to follow along the slope's contour to facilitate the work of those who dig the furrows.

It is important to remember that vetiver technology allows one to experiment. You might not get it right the first time, but at least you can modify and change the application points as the water run-off changes course.

Estimating number of plants required. For the first season, make broad estimates of plant needs. Use the rough number of 10 to 12 plants per linear meter (plants can be either as tillers or in poly bags) or approximately 11,000 plants for every km of hedgerow planted.

After the first year, estimates have to be more precise. For each site where vetiver contour hedging is proposed, establish an on-site planting matrix or *schema d'itineraire.* For a road site, the planning/planting matrix table will include for each kilometer (on the column side of the matrix) a breakdown of the road by 50-meter lots, and (down the row side of the matrix), a list of all road-side items (e.g.: road bed L & R, bridge, access ramp to bridge, culvert, embankment L & R, ridge, gully, drain ditch, retaining wall, gabion, masonry ditch, cement crossing, downward curve, raised road-bed etc.). For each section of

the road that needs to be protected, the engineer, vetiver specialist, or program manager estimates the number of linear meters of vetiver hedge needed to protect the engineered work, embankment or fill site. Once recorded and reviewed by the potential planting entity, the planting matrix is finalized and inserted as part of a planting agreement or contract. The matrix is used to plan the budget, estimate the number of plants, people and time required to complete the planting cycle. But most importantly, it helps people review the work to be completed and establishes the base for agreement on the priority zones and areas where efforts will be concentrated. When working on the planting matrix, don't forget to look far uphill beyond the road site to check if run-off from heavy rains might not eventually come from areas far from the road, and which may need to be deflected using vetiver hedges. Count on planting time, transporting plants and watering to be greater in these areas than those adjacent to the road.

Replacement requirements over the course of a year vary from 10% to 30% due to the loss of plants that dry out, are eaten, or washed away. Calculate this requirement in the plant estimates.

An adapted matrix is used to plan a watershed protection activity, an agricultural terracing project or reforestation. Estimating the number of vetiver plants needed is derived from the number of walked-through linear meters identified for each project.

Planting and supervising planting. After losing a high percentage of plants due to drying conditions, we recommend planting vetiver from rooted stock in poly bags over planting directly from tillers. There are exceptions, but generally the survival rate of rooted plants is higher (98% versus 75% for tillers). They add good soil to the planting area, require less water, and are more easily fixed (by putting a stake through the root system), thus reducing the chances of wash-outs during periods of heavy rain. Based on recent experiences in Madagascar, we recommend:

- Spacing between plants should not exceed 10 cm (the space of a closed fist).
- Animal or organic compost should be mixed at the bottom of the planting trench.
- The crown of plant should be covered with soil, but not to plant too deeply.
- The earth around each plant must be compacted ("healed" with feet) and slightly lower than the ground level so as to create a small depression or gully that will retain water. It is compacted hard to reduce erosion caused when heavy rains fall before the vetiver hedge has had time to develop. Avoid mounting of earth around plant leaves. (see Picture Gallery, #10)
- Plants should be watered daily for three to four weeks if there is no rain.
- Mulch, cut vetiver leaves or cut grass should be put along planted trenches to reduce evaporation, maintain moisture and begin trapping eroding soils.
- On very steep embankments, putting a stake through the root system will stabilize plants. If the area is riddled with run-offs, plant vetiver with the poly bag, but cut out the bottom to allow roots to spread. Push a wooden pole or bamboo stake through the bag after it has been planted in the trenches.

Contractors must have large bags on hand at construction site to collect and dispose used poly bags. The controlling engineer could count used nursery poly bags as a way to control number of plants planted, and ensure no used poly bags are left to the wind.

Site or supervisory engineer must establish the planting schedule with the contractor. Planting vetiver should not begin until road construction and engineered works are completed.

Five days after contract award, the planting contractor needs submit to the supervisory engineer the plan of where, how, with whom, equipment and tools to be used for the work.

Once the schedule and plan are set, and work commences, the controlling engineer keeps a daily log of all activities of the day (the number of plants planted, number of meters dug, number of meters planted, number of people on site, and observations). The contractor and controller must agree on plant and meter counts to ensure proper payment papers are processed.
The controller assures that 100% of planted material is alive, free of disease, watered and in good vigorous shape.

The controller assures respect of the detailed operational plan indicating the number of location of plants to be planted. Jointly with the contractor, he determines deletions or additions to the original planning.

Motivating workers. We recommend talking to workers about vetiver and giving each worker a handout to keep on the virtues of the plant and how to plant it correctly. This effort increases their interest, quality of work and commitment to the program.

Follow-up work: watering, replacing plants, weeding and trimming. While this important phase is straightforward, it must be included in the contract of the implementing entity. Payments under the contract for planting vetiver should be spaced out over several phases (i.e., first payment when establishing the work site, second payment when completing of 40% of work, then 80% of work, then 90%). Don't make the final payment (10% of total contract) until 3 weeks after all planting is completed and the engineer or controlling entity has conducted a follow-up visit. The contractor must replace all plants that have

not re-sprouted and those that washed away. Replacing dead or damaged plants is a must in order for the vetiver hedge to be effective and for the technology to have credibility. Implementing groups must aim and insist on a 100% success rate as well. The contractor or village groups or another entity must be contacted to assure that watering is provided to the vetiver hedge for three weeks after planting if there has been no rain.

Avoid making the mistake of not planning or providing for weeding, trimming and watering after the planting cycle. Weeding should be planned for about 1 or 2 months after planting, and preferably six months thereafter. When weeds grow near or along the crown of the plant, vetiver growth is seriously delayed. Shade prevents vetiver from growing. Weeds (if the furrows have been well fertilized) will grow more quickly than the vetiver.

Vetiver hedges should be trimmed to about 50 cm (knee high) within 8 to 10 months of planting if the plant has reached more than a meter in height. After that, hedges should be trimmed once or twice a year. The leaves can be used as mulch, thatch and in handicrafts.

CONCLUSION

While Madagascar's vetiver program began within a small project that addressed a specific problem in two regions of the country, it expanded nationally because demands for its services came from other parts of the country and a network was established to meet that demand. The dynamics that ensued, in which demand for the plant and accompanying support services challenged the suppliers of plant material, technical support and researchers, have produced a process to expand the use of vetiver throughout the country. There is an inertia that keeps the process going where organizations, NGOs, and implementing agencies respond to demands expressed by end users. The experienced learned is that we cannot go into an area or a country and initiate a vetiver program because it is good and works elsewhere. The starting point is the demand rather than the supply. In Madagascar, we believe the critical mass point has been attained because demand and supply are now both growing and reinforcing each other.

On the demand side, the Ministry of Public Works has indicated that all road contracts will require a vetiver clause, and that the plant is to be used to protect engineered works and roadbeds throughout the country. The Order of Engineers has included vetiver in its norms to protect roads, dikes, and watercourses. According to the Order of Engineers, use of vetiver will be required in all terms of references where soil erosion is an issue. The European Union and the Japanese Development Agency require that road and irrigation projects funded by them must use vetiver where soil is threatened. Two World Bank projects (the livestock project and a rural infrastructure project) are using vetiver. CARE, Catholic Relief Services, and the Worldwide Fund for Nature are using vetiver in the infrastructure projects they finance.

On the supply side, seven private nurseries are now producing vetiver, some in large quantities (capacity up to a million plants a month). Eleven construction companies have experience in planting vetiver and using the technology successfully. Approximately a dozen NGOs produce vetiver for their members and for sale in the agricultural sector, and approximately 30 village level associations have small nurseries to produce plant material for road maintenance and agricultural intensification. Training in vetiver technology has been provided to engineer associations, officials from the forestry ministry, and staff of the extension service at the Ministry of Agriculture. Development organizations such the Peace Corps have been provided vetiver training and they now incorporate vetiver in the training of all volunteers.

The keys to reaching the point of critical mass are getting the right people involved, assuring a reliable source of supply, and applying the technology correctly.

Wolfram Alderson of Pamona, southern California, with vetiver growing without irrigation on "moon dust" at the CALPOLY campus. Wolfram hopes to set up a Vetiver Network for California. Photo Credit: Dick Grimshaw.

Experiences of the Latin American Vetiver network - Dissemination and Promotion

Joan H. Miller(Coordinator - Latin American Vetiver Network,San José - Costa Rica), presented at the Second International Vetiver Conference,Thailand, January 2000

Background

The Latin American Vetiver Network (LAVN) was started in October 1995 to serve the Spanish speaking countries in order to expand the dissemination of Vetiver Grass Technology (VGT). Previously the only document available in Spanish about VGT was the green book (*Vetiver, The Hedge Against Erosion*).

The LAVN has no institutional or organizational affiliation. There are a coordinator and a director who work on a volunteer basis out of a home office. The director, Jim Smyle, seconded from The World Bank to The Regional Unit for Technical Assistance (RUTA) has been able to devote some of his professional time to the LAVN within the realm of his job identifying and preparing natural resources projects for funding by the World Bank. Most funding has come directly from The Vetiver Network (TVN) which covers costs for office supplies, copying, mailing of correspondence, information packages and newsletters, and printing of newsletters and other materials.

To kick off the LAVN, the first newsletter in Spanish, *Boletín Vetiver*, was published in May 1996 and sent out to all members of TVN in Latin America. This first mailing reached approximately 400 members in 20 countries of North, Central and South America (Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Venezuela, Bolivia, Ecuador, Peru, Brazil, Chile, Argentina, Uruguay, Paraguay, Cuba, Dominican Republic and Puerto Rico). The most recent *Boletín Vetiver* (#7 - September 1999) was distributed to approximately 723 members. The majority of our members are affiliated with NGOs and the second largest group is formed from university researchers and students and individuals who are interested in VGT. The smallest group of network members are private companies and government and research organization.

Goals of the LAVN

The stated objective of the LAVN is dissemination of information in Spanish about VGT, its applications and potential uses. The aim is to provide members access to the existing knowledge about VGT for soil and water conservation, bioengineering and bio-remediation, its application, potential uses and assist in the exchange of information. The *Boletín Vetiver* permits users and researchers to share their knowledge and experiences with not only Latin America, but also the world through our link with The Vetiver Network. Additionally we have worked to increase network membership. The Vetiver Homepage and word of mouth have been the most effective means of increasing membership.

Activities to date have included the following:

- seven newsletters published in Spanish (the *Boletín Vetiver*);
- Volume I of *Boletín Vetiver* published which contains newsletters Nos. 1-5 and a reference index;
- distributed vetiver videos (*Vetiver, la barrera contra la erosión*) in Spanish;
- sent out additional technical information on specific topics such as use of vetiver in coffee, mining rehabilitation, and bioengineering;
- sent out questionnaire regarding use and experience with VGT, in order to better understand members' needs;
- assembled a directory of the most active VGT users and network members;
- assembled a growing list of vetiver grass suppliers which is printed in each *Boletín* and posted on the LAVN web page;
- provided networking assistance in the interaction of network members;
- started electronic discussion group via Internet;
- provided materials to the Vetiver Network Homepage;
- maintained contact and information exchange with other regional vetiver networks;
- obtained financing and provided technical assistance for development of a CD-ROM and video on the use of vetiver in bioengineering;
- visited the state of Oaxaca, Mexico twice to participate in training and information workshops and provide technical assistance;
- toured through southern Costa Rica to locate planting materials for a project in western Panama;
- co-sponsored and participated in a workshop on use of vetiver for bioengineering;
- provided small grant for initiation of vetiver nursery at an organic coffee farm;
- supported a local university student to research and author articles on VGT in Costa Rica;
- answered hundreds of letter and queries.

Financial Support of Network

To date we have receive $8,000 from The Vetiver Network for network activities. Additional funds

were collected which include the 1998 Vetiver Prize for Soil Conservation ($1083) and a small donation of a lottery prize (approximately $663). A Knowledge Management grant of $42,000 from the World Bank was made to RUTA and the LAVN for a regional workshop in El Salvador in May 1999 (see below for further details). There is no NGO status for the LAVN due to the bureaucracy involved in the process. Knowledge that the LAVN office would not likely remain in Costa Rica after our return to the United States (there exists no obvious candidates in Costa Rica to take over the network) have contributed to this decision.

Effectiveness of the LAVN

The LAVN has been very effective in the dissemination of the VGT throughout the Latin American region. Our membership has grown by no less than 81% from original 400 members to more than 720 members currently (the growth is actually closer to 90% due to removal of members from the network who have moved and left no forwarding addresses). All new members receive at least each of the newsletters published to date in addition to a Spanish copy of the "green book" (*Vetiver, The Hedge Against Erosion*). Requests for information and membership currently comes primarily via the Internet and often current members request membership for colleagues, associates, and organizations.

Recently more specific requests have come in for information on the use of vetiver for land reclamation, infrastructure stabilization and rehabilitation, etc. In such areas we have been able to utilize the expertise of other TVN members outside the region (for example, Paul Truong for land reclamation and use of vetiver in highly saline environments and Criss Juliard for details of their program for road rehabilitation in Madagascar).

Furthermore the development of the electronic discussion group, although not as active as we might have hoped, gives an opportunity for individuals to ask questions and receive answers (usually from the LAVN coordinator and director) that are shared with the group of subscribers. Archives of the discussion group are available on the TVN Homepage and also are printed in the newsletter. The discussion group was initiated at the El Salvador workshop amongst the participants having e-mail accounts and then opened up to the remaining LAVN membership with e-mail accounts who responded to a subscription form.

Generally the effectiveness of the LAVN has been positive, based on the growing membership and the obvious increase in sources of vetiver grass available to potential users. This means that there is more grass being grown and more people are interested in obtaining it. This is a priority function of the LAVN.

Where the LAVN lacks effectiveness is possibly in getting information to users on specifically requested topics. The reason for this is the inability to translate large volumes of information into Spanish on short notice. Correspondence is normally answered within a day and information packages sent out within days of request (on average), but providing information on specific and technical issues generally takes a great effort that is sometimes difficult to reply to in a rapid manner.

Also we feel that our effectiveness in getting feedback from our members and in "locating" vetiver activities of non-members has been limited. We know that there is a lot going on of which we have no knowledge. We constantly "stumble" on references (written, oral, second-hand) to activities, projects, people, etc. But we cannot seem to effectively inspire people to generally keep us informed. Only about 15 members provide information/feedback on any type of regular basis (more than once or twice a year). For those "active" members and champions of vetiver we are grateful. For the rest, we are frustrated.

Promotion of VGT

Promotional activities are defined as organization and participation in workshops, providing demonstrations and technical assistence, establishing nurseries, etc. During the past 4 years we have traveled to Oaxaca, Mexico twice to participate in vetiver promotion at workshops at the request of an active NGO network there which was also able to convince a financing agency to pay our way. In May 1999 the LAVN co-sponsored a 2 1/2 day workshop in El Salvador on use of VGT in bioengineering. The workshop in El Salvador (*Bioengineering Workshop for Post- [Hurricane] Mitch Reconstruction - Experiences with Utilization of Vetiver Grass for Infrastructure Protection and Stabilization*) was financed through the Knowledge Management Fund of The World Bank and co-sponsored by RUTA, NOBS Antierosion, and the LAVN. Forty-two people from 9 countries attended the 2-day workshop, which included panel discussions, technical presentations, and a full-day field trip to observe vetiver used in both bioengineering and watershed rehabilitation projects.

Knowledge Management Funds from the workshop were also used to develop an 8-minute video (*Vetiver: The Hedge for Bioengineering in Protection and Stabilization of Infrastructure*) as a tool to promote the use of vetiver for infrastructure protection and bioengineering. This and a CD-ROM focussing on bioengineering are distributed to those who request it for the cost of mailing. We then request that they make at least 2 copies of the video and give those copies to others for further dissemination. The Spanish version of the video "Vetiver, the hedge against erosion"

is sent, free of charge, to LAVN members who specifically ask for it.

In spite of the above activities the LAVN feels that it has not been extremely active or successful in this area. Our lack of promotional activities is the result of several factors.

- Our area of coverage is very large - a total of 20 countries spread between approximately 30º N and 55ºS latitude and 35º and 117ºW longitudes, thus it is difficult to organize or attened to promotional activities with a small staff and lack of institutional association or support.
- Financially all travel is paid for personally. Where VGT is in use in watershed management and natural resources projects, the LAVN can only provide information, whreas direct technical assistance or training would be much more effective. With only two people involved with the administration of the network, personnel resources are spread quite thin for any further activities. There are currently no other Spanish-speaking "vetiver consultants" within region aside from NOBS in El Salvador, but technical assistance is not their core business; though some are developing in Mexico, Venezuela, Costa Rica, Honduras, Chile and Ecuador.
- Finally language has been a barrier. The coordinator spoke no Spanish prior to living in Costa Rica and although currently fluent, the ability to make presentations and making all information of interest available in Spanish has been difficult. Volunteers within the LAVN have been used for translation and editing services, but there are limitations to the efficiency of this.

The LAVN's one large promotional activity, the workshop in El Salvador, has shown its effectiveness through the resulting activities carried out by many conference attendees and the references which have come about since then. Following are some of the activities of conference attendees since May:

- Workshop organized by CARE Honduras on vetiver for watershed management and roads construction;
- Development of mother nurseries and micro-nurseries and planting of hedges by CARE - Honduras;
- Coordination between CARE Honduras and Chiquita Brands/Tela Railroad Company for locating and planting vetiver for joint nurseries;
- Protection of drainage canals with vetiver in banana plantations in Honduras;
- Development of additional nurseries and plantings in Costa Rica by Chiquita Brands;
- Week-long workshop on organic agriculture in Costa Rica given by a workshop participant which included a vetiver component;
- Development of a proposal for the "Establishment of a Vetiver Nursery as a Source of Planting Material for Environmental Conservation and Stabilization of Infrastructure Projects" in Honduras;
- In Panama the "Rural Poverty and Natural Resources" Project have been giving talks and practical seminars about VGT and disseminating copies of the video and plan on establishing 8 nurseries.
- The US Army Corps of Engineers, the World Bank and the Interamerican Development Bank are both calling for use of VGT in landslide and road stabilization;
- A small, but tangibly growing interest is being felt in VGT for infrastructure and roads in Costa Rica, Nicaragua, and the Honduran Minstries of Transport.

Also as a result of the workshop we have seen increased correspondence between many of the workshop participants and the LAVN. A follow-up assessment of workshop participants' vetiver-related activities and promotion is planned for May - one year after the event.

We have seen success in the promotion of VGT in the region through a number of dedicated individuals and groups. Included here were the three projects that received grants from TVN Support to NGOs Program. These projects were PCERS (Oaxaca, Mexico), Fundación Golondrinas (Ecuador) and Sociedad Conservación Aragua (Venezuela). Promotional activities in these projects included workshops, technical demonstrations, and nursery establishment, etc.

Aside from the effectiveness of their promotional activities another benefit which came out of these projects was that we were able to confidently refer other interested vetiver grass users to these groups for technical advice and potentially as a source of planting material. And even more importantly to us now, is that these groups will likely be tapped to officially take over networking responsibilities for either their region or country.

DECENTRALIZATION OF THE LAVN

Because of our departure from Costa Rica scheduled for July 2000 we intend not only to transfer the LAVN to another coordinator, but also request the participation of individuals in other countries to act as local coordinators to disseminate technical information, improve promotional activities and further gather information on the use of vetiver in their regions/countries.

Ideally the LAVN will be transferred to an organization or individual which has both the interest in running the network and, equally as important, an association with an organization which would support their activities both on the time re-

quired and some of the basic overhead costs. Such an organization might include a university, technical school, NGO, or a private company. Responsibilities would include at least maintaining a database of members and user profiles, publication of LAVN newsletter, and directing inquiries to the appropriate regional coordinators.

Smaller regional coordinators would be identified based on their participation, interest, motivation and desire to carry out the responsibilities of the coordination for their region. Optimally there would be coordinators for each of the 20 countries in the region. If a country at that time doesn't have the in-country expertise or interest then a coordinator from an adjacent country could take on the responsibilities. The responsibilities foreseen for these local coordinators would include dissemination of vetiver information packages (newsletters, green book, etc.), maintaining and expanding a database of vetiver users, nurseries and other sources for planting material, providing country/regional updates and articles to the LAVN for inclusion in the *Boletín Vetiver*, etc.

Actual promotional activities would be determined by the individual regional coordinators based on their abilities (i.e. financial and personnel) and commitment to carry this out. This would include organization and participation in workshops and demonstrations when possible. Many of individuals being considered for coordination positions already are promoting VGT within their own organizations, regions and projects. There is great need in all countries for the participation of knowledgeable and experienced vetiver users for giving presentations and demonstrations of VGT. It is hoped that these more local coordinators will be able to help fill this need and also help train others to do the same.

What Have We Learned ?

The LAVN uses a single office to network, gather and disseminate information to its members in the Latin American Region. The years of experience have revealed the following:

- work and should be encouraged as much as possible… they would also be the easily identifiable prime candidates for funding should such an opportunity ever become available.
- Efforts to increase membership such as mass mailings are generally not worth it. On several occasions we sent either letters of invitation to join the network (with a green book enclosed) with little or no response. A worthwhile task would be to follow-up on activities and progress of existing members who have written for information or updated the network in the past and invite them to contribute to the newsletter in the form of articles.
- No matter what is written in newsletters, people will write and ask for the same information. This may be an indication that much of the same information, variously presented should be recycled and summarized in future newsletters!
- We would recommend further translating into Spanish as much technical information as is possible and made available to members. Although there are is a significant number of members who speak and are able to correspond in English, the LAVN needs to be able to provide all existing information and data in Spanish. This can be done by having the LAVN reside with a native Spanish-speaking coordinator and also by increasing the pool of technical assistance experts to both help answer inquiries and provide personal technical assistance.

Conclusions

The role of the LAVN is simply stated as the gathering of information for further dissemination. This is currently accomplished through a single LAVN office which carries out correspondence with a growing membership, provides contacts and technical information when requested, and publishes of a newsletter. As the LAVN is transferred to another office and coordinator, it is anticipated that the role of the LAVN might be expanded to increase effectiveness and influence of networking in the region through further promotion and increased participation. This can hopefully be accomplished though the expansion of the LAVN through the development of locally situated network respresentatives and offices. Such a change will likely require additional financing through fund-raising activities, project support, corporate/industrial sponsorship or the selling of technical assistance services. This is a challenge that we hope to overcome as we transfer the network in the year 2000.

Vetiver -- the sediment trapper!! 1 meter of trapped sediment in a South African drainageway after 300 mm storm

PACIFIC RIM VETIVER NETWORK OPERATIONAL OVERVIEW

Narong Chomchalow, Acting Regional Coordinator, Pacific Rim Vetiver Network , Office of the Royal Development Projects Board Bangkok, Thailand

Introduction

The creation of the Pacific Rim Vetiver Network (PRVN) was the result of a proposal made by Mr. Richard G. Grimshaw, Coordinator, TVN at the First International Conference on Vetiver (ICV-1) held in Chiang Rai, Thailand, 4-8 February 1966. Mr. Grimshaw suggested that Thailand acts as the core of the PRVN since Thailand is considered most suitable because it is the site of the world's largest vetiver project known as the Doi Tung Development Project implemented under the supervision of the Office of the Royal Development Projects Board (RDPB), the Organizer of ICV-1.

Subsequently, RDPB submitted the proposal to His Majesty the King, a keen supporter of the use of vetiver grass, in order to obtain his comments and approval. His Majesty agreed with the proposal and commissioned the setting up of the PRVN under the supervision of the Committee on the Development and Promotion for the Utilization of Vetiver Grass (CODPUV) according to His Majesty's Initiative, to be administered by RDPB.

In order to facilitate the effective implementation of the network with a common view and flexibility, CODPUV established a Task Force to take care of the PRVN on 6 May 1997. The Task Force consists of Mr. Manoon Mookpradit, then Deputy Secretary-General of RDPB, as the Chairman of the Team, together with a number of experienced officials from concerned agencies and renowned institutions. RDPB itself functions as the Secretariat of the Task Force.

Objectives

The main objective of PRVN is to serve the countries of the Pacific Rim as the center to collect, compile and disseminate information on vetiver grass technology (VGT) in the forms of newsletter, occasional publications and homepage of the internet. A secondary objective is to assist the member countries in training, study tours, and obtaining plant materials, as requested and when necessary.

Members

Country Members

The following 22 countries, geographically situated in the Pacific Rim, are automatically entitled to become members of the PRVN. These are, in alphabetical order, Australia, Brunei, Cambodia, Cook Islands, China, Fiji, Indonesia, Japan, Korea (Republic of), Lao PDR, Malaysia, New Zealand, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Taiwan, Thailand, Tonga, Vanuatu, and Vietnam. They are grouped under the following three categories:

Countries (4) with National Network and National Coordinator:

- *China:* China Vetiver Network (CVN), with Prof. Liyu Xu as National Coordinator (NC)
- *Philippines:* Vetiver Network Philippines (VENETPHIL), Mr. Edwin Balbarino as NC
- *Thailand:* Thailand Vetiver Network (THVN), Dr. Apichai Theerathorn as NC
- *V ietnam:* Vetiver Network Vietnam (VNV), Mr. Ken Crismier as acting NC

Countries (9) with no National Network but with Country Representative in PRVN:

- ***Australia:* Dr. Paul N.V. Truong as Country Representative (CR)**
- *Brunei:* Mr. Jonathan Davies as CR
- *Fiji:* Mr. Jai Gawander as CR
- *Indonesia:* Mr. Kucahyo B. Prayogo as CR
- *Lao PDR:* Mr. Boonkong Sengthavon as CR
- *Malaysia:* Dr. P.K. Yoon as CR
- *New Zealand:* Mr. Don Miller as CR
- *Papua New Guinea:* Mr. Rob Shelton as CR
- *Taiwan:* Mr. Yue-Wen Wang as CR
- *Vanuatu:* Mr. Henry Kathecau as CR

* ***Cambodia:* Contact person: Mr. Numa Shams (1998)**

Countries (9) with no National Network nor Country Representative in PRVN:

Cook Islands:
Japan:
Korea (Republic of):
Samoa:
Singapore:
Solomon Islands:
Tonga:

Scientist Members

Scientists of the member countries of PRVN who had made prior contact with the Secretariat of PRVN are automatically registered as Scientist Members, which at present amount to about 1000. Others who want to join PRVN can apply directly to the Secretariat (by giving name, current position, place of work, mailing address, e-mail address, and other information which deem necessary.

Activities

The following activities have been carried out under PRVN since it was established in early 1997:

Newsletter An English language quarterly newsletter (8-pages A-4 size), VETIVERIM, has been issued since July 1997. Its circulation is 2,000 copies per each number. It has been sent in bulk to National Coordinators or Country

Representatives of the member countries for further distribution to scientists and institutes within each country in order to save postage and other difficulties in international mailing. A bound volume of 11 numbers, with subject index as well as other relevant information, is presented to every participant as a gift from the Secretariat of PRVN. A four-page index has been attached to VETIVERIM-11 for use in binding by those who do not attend ICV-2 and wish to bind those 11 numbers.

The author, who has been the Editor of VETIVERIM from the beginning, has tried his best to include news and articles from as many countries of the Pacific Rim Region as possible. However, due to the lack of responses, not many news/articles from these countries have been published. It is hoped that with better communication, more news and articles from member countries should be published in future issues of VETIVERIM. Comments and suggestions for the improvement of VETIVERIM are most welcome. Other regional vetiver networks wishing to receive VETIVERIM should contact the Secretariat.

Homepage From the very beginning, an Internet homepage for PRVN has been prepared by the Secretariat through the website: http://www.prvn.rdpb.go.th. Information has been revised from time to time, especially when worthwhile events are happening, e.g. conferences, study tours, visits, exchange of planting material, announcement of awards, research results, etc. It also includes eight pages of the present issue of the VETIVERIM.

Scientists of the member countries are invited to submit information on research and technologies on vetiver, especially those that are appropriate to the Pacific Rim countries. Information and photographs are most welcome. These can be sent to the Secretariat by mail, fax, or e-mail.

Publications The following technical bulletins (1000 copies each), have been prepared and distributed:

1. Technical Bulletin No. 1998/1 – "Vetiver Grass Technology for Environmental Protection" by Paul Truong and Dennis Baker, August 1998. (Second printing of 1000 copies had been made to distribute to scientists of Vetiver Networks of other regions.)
2. Technical Bulletin No. 1998/2 – "Vetiver Grass for Slope Stabilization and Erosion Control" by Diti Hengchaovanich, November 1998. (Second printing of 1000 copies had been made.)
3. Technical Bulletin No.1999/1 – "Vetiver Handicrafts in Thailand" by the (Thai) Department of Industrial Promotion, October 1999.
4. Technical Bulletin No. 1999/2 – "Vetiver Grass Technology for Mine Rehabilitation" by Paul Truong, November 1999.
5. Technical Bulletin No. 1999/3 – "The Use of Vetiver Grass System for Erosion Control and Slope Stabilization Along the Yadana Gas Pipeline Right-of-Way" by the Petroleum Authority of Thailand, December 1999.

National Activities Since the system of operation of each national program is independent of the PRVN, no formal reports of such activities have been received by the Secretariat of PRVN. In order to make this report complete, the author has searched for such activities from the VETIVERIM. They are presented in the Annex.

The Secretariat

The Office PRVN Secretariat Office is located at the Office of the Royal Development Projects Board, 78 Rajdamnern Nok Avenue, Bangkok 10300, Thailand; Tel. (662) 280 6193 to 280 6200; Fax: (662) 280 6206, 280 6209, 280 8915; E-mail address: pasiri@mail.rdpb.go.th; Homepage: <http://prvn.rdpb.go.th>

The Staff There is no full time staff working for PRVN. Responsible person is Mrs. Suwanna Pasiri, Head of Information Section of RDPB. Other staff of RDPB, especially in the Divisions of Compilation and Foreign Relations, also assist in the operation of PRVN. The author himself is working voluntarily as the Acting Coordinator of PRVN, the Editor of VETIVERIM as well as of PRVN Technical Bulletins.

Budget There is no regular budget for PRVN. All expenses incurred under PRVN are obtained either from RDPB or from the Chaipattana Foundation, His Majesty's own development foundation.

Problems and Prospects

Problems It is understandable that with no budget and staff of its own, PRVN has not been fully functioning. However, since the objectives of PRVN are mainly to disseminate information through publication and homepage, there seems to be no problem of both the budget and staff. The only problem is to obtain information and feedback from the scientists of the member countries.

Prospects In spite of certain existing problems, PRVN is probably one of the most active regional vetiver networks, thanks to the support of RDPB, TVN, member countries, and a few dedicated persons. With more useful information being accumulated from the member countries, it is anticipated that PRVN will be more active in the future in the dissemination of information to the member countries.

Brief Activities on Vetiver of Member Countries under PRVN

Australia: Although no official network has been set up, activities on vetiver in Australia has been one of the most active in the region. Dr. Pual Truong of the

Queensland Department of Natural Resources who voluntarily acts as the Country Representative, together with his colleagues and a group of researchers at the Central Queensland University, have conducted various researches on vetiver (e.g. Ashwath 1998; Tomar 1998). Dr. Truong has been a regular supplier for news and articles in the VETIVERIM (e.g. Troung 1998b, 1999a, c) as well as the Technical Bulletin (Nos.1998/1, 1999/2). His group has done a lot of work on the role of VGT on environmental protection such as mine rehabilitation, treatment of toxic wastes, heavy metals, etc. (Truong 1998b). He also produced CD ROMs on various topics related to the application of VGT (viz. R&D and Applications of VGT (Truong 1998a) and VGT for Infrastructure Protection (Truong 1999b)).

Brunei: Country Representative has been nominated, but no activity on vetiver has been released from Brunei.

Cambodia: Mr. Numa Shams, Manager of "Sustainable Agriculture and Integrating Farming' project, is testing the feasibility of planting vetiver hedgerow to control erosion and as a source of animal feed during the dry season. He is requesting for planting material and information from PRVN (Shams 1998).

China: A very active national network (China Vetiver Network-CVN) has been set up, with the head office in Nanjing under the leadership of Prof. Liyu Xu. He has been a regular supplier for news and articles in the VETIVERIM (e.g. Xu 1999a, and b). CVN organized two international meetings on vetiver. One held in Fuzhou, Fujian Province on 20-26 Oct 97, the other in Nanchang, Jiangxi Province on 19-21 Oct. 99. A few national meetings were also held. Other activities include large-scale demonstration of growing vetiver for soil stabilization on barren land, riverbed, embankment, as well as on the farmlands. A quarterly newsletter (in Chinese) and other occasional publications have been produced. Small grants for scientists have been provided with support from TVN. See details in Liyu Xu's paper (PD-4/2).

Fiji: Country Representative has been nominated, but no activity on vetiver has been released from Fiji.

Indonesia: Country Representative has been nominated, but no activity on vetiver has been received from Indonesia.

Lao PDR: Country Representative has been nominated, but no activity on vetiver has been released from Lao PDR. However, an EU-funded provincial irrigation project is now working on introducing vetiver into Luang Prabang Province. Two nurseries have been established, one at a local agricultural college and the other at a farmer's field. The main objective is to use vetiver for road erosion control or irrigation scheme erosion control, but no effort of using vetiver on the farmland at this early stage. The aim is to have the farmers learn of the benefits to be gained from VGS without first using on their farmland. Meanwhile, there is now a greater awareness of VGS among Lao Government officials and donor representatives (Gillespie 1998).

Malaysia: Country Representative has been nominated, but no activity on vetiver has been received from Malaysia, a country that used to be very active in R&D of vetiver. This is probably because Dr. P.K.Yoon has already retired from office.

New Zealand: Country Representative has been nominated, but no activity on vetiver has been received from New Zealand in spite of the fact that Mr. John Greenfield, one of the founders of VGT is still residing in the country. Perhaps, he is quite busy in traveling, and the name of Don Miller of the Land Use Consultant in Gisborne, New Zealand, is suggested to replace John Greenfield.

Papua New Guinea: Vetiver was introduced in 1997 in Simbu province and farmers quickly realized the potential of VGT. Only few months after planting, vetiver survived the severe drought in 1997. A booklet on VGT in Melanesian Pidgin was prepared and widely distributed, even to community schools (Shelton 1998).

Philippines: A national network, called Vetiver Network Philippines - VENETPHIL, has been established in December 1996, with Dr. Edwin Balbarino of the Farm Resource Management Institute, ViSCA, Baybay, Leyte as the National Coordinator. VENETPHIL publishes a quarterly English language newsletter (*Vetiveria)*, organized a few national workshops, and hosted an international meeting on "Ground and Water Bioengineering" in Manila, 19-21 Apr. 99. During this meeting, a short course on "VGT for Erosion and Sediment Control, Slop Stabilization and Environmental Protection" was offered to the participants. A field trip to observe VGT along the Famy-Infanta road, and to visit Vetiver Farm Inc, the main supplier of plant material to the Department of Highways and Public Works for this project. This is probably the world's first commercial farm for supplying vetiver planting material (see article "Commercial Propagation of Vetiver" in VETIVERIM 3:5-6, Jan. 98). See details in Dr. Balbarino's paper (PD-4/3).

Taiwan: Study on the application and research of vetiver grass has been made in Taiwan by Mr. Mr. Yue-Wen Wang, Department of Agronomy, National University of Taiwan who volunteers to act as the Country Representative for Taiwan. Presently he is working on germplasm collection and obtained 15 accessions from the US Germplasm Bank (Wang 1998).

Thailand: With full support from the Office of the Royal Development Projects Board (RDPB), Thailand is one of the most active national programs on vetiver. His

Majesty King Bhumibol Adulyadej has realized the urgency of the problem of land degradation caused by erosion. After careful consideration of the potential of vetiver grass, His Majesty adopted the idea of using vetiver for soil and water conservation and introduced a simple technology, first for the hilltribes on the highland of Northern Thailand, and later on all others who suffer from the same problem of soil erosion. His Majesty started to implement his concept in June 1991. The RDPB has been assigned to coordinate the R&D activities on vetiver in Thailand. Forty government and non-government agencies which are involved in vetiver activities are partially supported by budgets from the RDPB. A committee (named the Committee on the Development and Promotion for the Utilization of Vetiver – CODPUV) has been established under the administration of RDPB to coordinate all R&D activities of all agencies in Thailand working on vetiver in order to follow the policy set forth in the master plan and to evaluate the results obtained. Among the activities include organizing three national workshops and two international conferences, publishing a quarterly newsletter "Bhumivarin Anurak" (Soil/Water Conservation) and a number of documents, providing training and plant materials to scientists of neighboring countries (including Vietnam, Lao PDR, Myanmar, Philippines, etc.) (Chomchalow 1998). See details in Dr. Apichai Thirathorn's paper (PD-4/1).

Vanuatu: Jonathan Tomately (1999) is interested in using vetiver to deal with a broad and ever increasing range of environmental problems in a small island in Vanuatu. He has built a nursery to propagate vetiver and about to plant them in the field. He is asking for information and other helps from PRVN. Of late, Mr. Don Miller of the Land Use Consultant in New Zealand has suggested the name of Mr. Henry Kathecau, who is knowledgeable about vetiver in Vanuatu, to be the Country Representative of Vanuatu.

Vietnam: With a back up from an American, Ken Crismier, who volunteers to be the acting Country Representative, an active farmers' group has been set up to take care of the vetiver activities in Vietnam. Among these activities are: (i) Formal seminars organized in Hanoi, Vinh, and Saigon in January 1999, under the aegis of the Ministry of Agriculture (with Paul Truong and Diti Hengchaovanich as invited experts); (ii) Informal presentations wherever and whenever an opportunity has presented itself during Ken Crismier's three trips and four months in Vietnam in the past two years; (iii) Production of the documents: the "Green Book" in Vietnamese (5000 copies in first printing), and distributed to all seminar participants, along with a nice poster based on the green book cover, but localized for Viet Nam; 2000 copies of the "Green Book" and poster also distributed in Nghe An province; blue book (100 copies), TVN and PRVN newsletters, and PRVN research reports (all in English) distributed in small quantities to "likely prospects" (iv) A team of two persons from Nghe An province (province town is Vinh) visited Thailand for a week in late May and early June 1999 to see what is going on there (hosted by Thai vetiver people); they returned with a truckload of 12 varieties of vetiver, which have been planted at Vinh and are developing; recent brief report indicates most varieties are developing well; goal of these efforts at this location is for it to become a focal point for vetiver interest throughout Vietnam (Crismier 1999a and b). See details in Mr. Nguyen

Pacific Islands - Vanuatu - are exposed to intensified erosion due to increasing populations, over worked land and tourism. As a result major problems are emerging that effect land, water quantity and quality and the coral reefs. Low cost erosion control systems are needed for most of the South Pacific Islands. In this photo Don Miller from New Zealand has successfully established vetiver in a completely eroded gully. Resulting improved moisture conditions will enable local plants to establish. Phot credit: Don Miller.

EUROPEAN AND MEDITERRANEAN VETIVER NETWORK UNDER A MEDITERRANEAN CLIMATE

By Michael Pease. EMVN Coordinator, presented at the Second International Vetiver Conference, Thailand, January 2000

Coordination Background

The first introduction of a field application of Vetiver Grass Technology (VGT) to Europe probably occurred in 1994 through an EC-funded project that sought to determine its applicability under Mediterranean conditions. The project's managing agency was an Italian firm, Tecnagrind, and the General Manager, Ing. Marco Troglia, was appointed as The Vetiver Network's (TVN) Regional Coordinator. However, focus was limited to that area covered by the EC-funded project in Southern Spain and, with the close of the project, vetiver coordination diminished.

I am resident in Southern Portugal and have followed closely the development of VGT from its first introduction in India, some 15-20 years ago, through my close personal relationships with Dick Grimshaw. I am also a retiree agriculturalist from the World Bank and took over the role of Regional Coordinator in May 1997.

Regional Background

EMVN is one of the most recently formed regions within TVN. All the countries in the region lie to the north of the tropics and subtropics where VGT is most assured of successful application. The introduction of the technology to the region remains therefore somewhat exploratory for the time being. Those European countries within the region where VGT may have application range from Portugal's Açores in the Atlantic Ocean to Albania in the East and include, for instance, Cyprus and the Greek Islands. Potential for the use of VGT may lie in West Asia and the Middle East, particularly Turkey, Iran and Iraq. Along the Southern Mediterranean VGT may well have application in the countries of the Magreb, particularly Morocco and Tunisia. Vetiver has been grown for some time in Israel and Egypt but for its production of aromatic oil, not for soil stabilization.

Registration of EMVN

EMVN was established as a non-profit making Association, registered in Portugal, in November 1998. This was done with the intention of making EMVN more eligible for external financing as a European entity. However, to date, no financing other than that provided by TVN has been obtained though a financing proposal in EC funding format has been prepared.

Technology Dissemination and Communications

For a period in 1998 EMVN operated its own HomePage which was, in fact, little more than a mirror of the TVN WebSite. After one year this was discontinued in favour of a section within the centralised TVN WebSite. This is more cost-effective.

EMVN produced its first Newsletter in April 1999 and will produce a second in November. Newsletters are expected to be produced on a biannual basis thereafter.

National Coordinators within EMVN have been appointed for: Spain (Dr. Maria José Sanchez); Italy (Ing. Claudio Zarotti); Albania (Dr. Vangjo Kovaci) and; Morocco (Dr. Dale Rachmeler). It is hoped that National Coordinators will be able to disseminate the technology more effectively in the national language.

Strong e-mail communication links have been established in most countries within the region with much interest being expressed in the technology. Mainly this comes from private individuals rather than public bodies.

Country-by-Country Activity

Portugal a)Vetiver was first introduced into Portugal by Dr. Antonio Vasco de Mello in 1996 onto his property in north-central Portugal at a latitude of 39º 14' North. Dr. de Mello obtained his plants from Tony Tantum in South Africa and they are thriving despite the fact that his property experiences many days of frost during the winter and, probably, maximum cold of about -8º C. Dr. de Mello is using his vetiver to protect dam walls and to stabilise the banks of a heavily eroded water course that flows down a cultivated valley.

b)The Coordinator arranged additional importations, firstly a small demonstrational consignment donated by EcoGroup, Florida in November 1997 and then approximately 2,500 slips in March 1998 from Jano Labat of Vetiver Grass Stabilization, Chiredzi, Zimbabwe. Demand for plants was stimulated during seminars arranged by the Coordinator during Dr. Paul Truong's visit to Portugal and Spain in September 1998. As a result a further importation of some 3,500 slips was made, also from Jano Labat, in March 1999. Plants from these three importations went to: private individuals, commercial bodies, NGOs, government bodies such as the Department of Agriculture, Departments of the Environment in Municipal bodies and the University of the Açores.

c) In 1997 the Coordinator established a Multiplication Nursery on his property in Southern Portugal, 37º 7' N where, under intensive management the plants have performed well. Maximum low temperatures are about -5º C and mild frosts may occur on some 5-20 days in the year. Total precipitation is about 450 mm per annum with

some 5 months dry. With adequate water plants behave normally, reaching a height of some 2 meters and with active root growth. Multiplication rates are about 30:1 per annum.

Spain In 1994 an EC-funded project sought to determine the application of vetiver under Mediterranean conditions. The selected site was a steep slope of some 60% on an access road leading to a reservoir near Lorca (37º 42' N) in Murcia Region of Spain. The area has a harsh climate with precipitation of only some 300 mm per annum, 5-6 months dry and poor soils. Vetiver hedgerows were established at distances of approximately 1 meter vertical interval in two blocks of land with control blocks either side. Drip irrigation was provided for all plants during the first two years of establishment. Thereafter, within each block, three sections were defined receiving a) continued irrigation; b) reduced irrigation; and c) no irrigation. Since 1998, i.e. for the past two years, no maintenance or irrigation has been provided whatsoever. Nevertheless, the plants have survived well and the hedges are proving effective not only in controlling erosion but in providing a micro climate under which native species of plants have become established. Control blocks on either side show severe erosion with deep gullying and rilling.

Italy In Italy research work has been conducted on biomass production and salt tolerance by Dr. Vito Sardo at Catania University, Sicily. In 1998 a privately owned nursery located near Milano (45º, 25'N) established a holding of vetiver plants originating from the EC-funded project in Spain. Some plants have been distributed to a number of growers elsewhere in the country. Long-term performance under conditions of prolonged cold as experienced in more northerly regions has yet to be determined but initial results are not unexpectedly negative. The nursery is now being moved to near Pisa where climatic conditions will be much more favourable to vetiver production. Generally, within Italy, considerable interest has been expressed in VGT. The technology is likely to have considerable application particularly in the South.

Albania In 1997 the internationally financed Albanian Private Forestry Development Project imported plants produced by tissue culture from EcoGroup, Florida. The Coordinator visited the project in July 1999 and inspected all plantings. There is no doubt that vetiver has a role in certain localities where climatic conditions are suitable. However, in many locations winters are severe and vetiver would either not survive at all or, at best, would perform unsatisfactorily. The prime focus is to address problems of erosion on smallholdings. However, much could also be done within the bio-engineering context of stabilising steep slopes of roads, dams etc.

Other Countries VGT undoubtedly has potential application in such countries as Greece, Syria, Turkey, Morocco and the Spanish off-shore islands such as the Canaries. Expressions of interest have been received from the above mentioned but, to date, interest has not yet been translated into the introduction of plants.

Overview

General There is adequate indication from results of field applications, some of which were established nearly five years ago, that VGT has potential in many countries within EMVN, particularly in Southern Europe, Western Asia and countries bordering the Southern Mediterranean. This is reinforced by the climatic and pedologic parameters for effective vetiver hedgerow establishment under tropical and sub-tropical conditions which indicate that VGT would also be appropriate in many locations within EMVN. In Southern Europe it is probable that the most important immediate applications will be within a bio-engineering context, stabilising road and rail cuttings and embankments, protecting dams and reservoirs, controlling leachate on industrial and municipal landfills and protecting against erosion the landward side of erodable cliff-tops.

Climatic Factors Because of the less favourable growing conditions (cold winters and long hot summers) in many parts of EMVN, relative to tropical and sub-tropical regions, much emphasis needs to be placed on the known techniques for promoting early establishment. Also there is need for a better awareness that vetiver is no different from most other plants in that it requires management attention in the early years of its establishment following planting. For instance, regular watering, some fertiliser application and gap filling is important to early establishment of an effective vegetative barrier. Since it has been shown in Australia and China for example, that vetiver grass hedgerow barriers can be established on engineered slopes at about one tenth the cost of engineered means, e.g. gabions, gunite etc. it is still economic to provide water for the vetiver in its first two years of establishment even if this has to be transported.

Achnatherum splendens (jiji sao) Many countries or regions within EMVN have geographic and climatic limitations to the potential for establishment of vetiver grass due to prolonged and intense cold in winter. Jiji sao may well have application in some of these localities since, in China, it has been shown to have a much a higher tolerance to cold than vetiver. It would, therefore, be desirable to test Jiji sao in a number of locations within EMVN to determine its application where vetiver would be unsuitable.

Limitations on Expansion Availability of plants was a limitation on expansion but supplies are now available from within the region in Portugal, Spain and Italy. The

major problem to overcome is expansion of an understanding of the technology and potential of VGT. This requires finance which is currently limited to that provided by TVN. Some opposition, mainly from within academia, has arisen to the concept of introducing a 'new plant' that is seen as having potential risks of invasiveness and disease-spread. If the financial limitation was removed expansion of VGT usage within the region could be expected to result from the impact of seminars, demonstrations and personal visits.

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THE VETIVER NETWORK PHILIPPINES

Network Development December 1996 - 1999

By Dr. Edwin A. Balbarino
National Coordinator-VETINETPHIL, presented at the Second International Vetiver Conference, Thailand, January 2000

Introduction

The Vetiver Network-Philippines was officially established in the third quarter of 1997. I accepted the task to lead the network because I was confident that the movement could move forward based on the positive feedback of the Vetiver Grass Technology from VGT users. I had little doubts of the acceptability of the technology because I myself had personally used and evaluated the technology and is convince about its effectiveness in controlling erosion with minimal cost.

The idea of establishing a vetiver network for the Philippines was commendable. The network spearheaded an undertaking that successfully created awareness among individuals and organizations about a simple and cost-effective solution to soil resource problems. It assembled people with common interest of protecting the environment, save the government millions of pesos in infrastructure projects, provided income sources of the people, and mobilized various sectors in combating a common foe—soil erosion. Today, the network has more than 500 members composed of farmers, researchers, extension workers, students, engineers, teachers, etc. and a number of agency collaborators who helped spread the technology nationwide.

This report covers the three years (December 1996 to December 1999) operation of the network. The funding was actually programmed for two years but the actual operation that generated substantial results lasted for 3 years.

The Network's Background

My first encounter with Vetiver grass was in early 1991 when I was assigned as Field Coordinator of an International Development Research Center (IDRC)-funded project entitled Upland Agriculture-Philippines. The main objective of the project, which started in 1990, was to test, adapt and promote technologies that would address the problem of soil erosion and soil nutrient depletion in the uplands which is the most extensive and most threatened ecosystem in the Philippines.

The Farm and Resource Management Institute (FARMI) — the implementing agency selected a pilot research site covering five upland villages in the municipality of Matalom, province of Leyte, Philippines. A study of the farming systems in these villages conducted by Tung Ly and Fatima Baliña (1990), revealed that farmers have developed their own technique to fight soil erosion called "kahon-kahon" or natural grass strips. However, the dominant grass species in the strips are not strong enough to hold the soil especially during heavy rains. The project in collaboration with farmers tried to improve the indigenous technology by searching for alternative grass species that is potentially superior than cogon (Imperata cylindrica) and other dominant native species in the grass strips.

Few months earlier, the project staff observed a grass species in another town planted by lowland rice farmers to stabilize the dikes. The farmers called the grass Mora which was confirmed later as vetiver. Farmers thought that Mora was not adaptable to the uplands. In January 1990, the first trial planting of Mora was done in Matalom to test its adaptability to acid infertile soil. A dry spell struck the area from February through May of the same year. When Mora survived this drought, its adaptability to the uplands and its drought-tolerance were confirmed.

The project invited 12 farmers from 3 villages to view a slide show on the vetiver grass technology. The slide set was obtained by FARMI from the vetiver network (TVN). The farmers were also brought to the testing field to observe the grass. The farmers signified their interest to try Mora as hedgerow species in their farms. The project provided some planting materials to interested farmers in one village. In the other two villages, the farmers secured the planting materials by themselves from nearby lowland areas. In June 1991 the farmers who have tried planting Mora numbered to 17. The farmers were requested by the project to monitor and give their evaluation of the grass.

Farmers' first VGT evaluation:

1. As hedgerows in the upland,

Mora seems to be stronger than cogon because it is deep-rooted.

2. Mora does not grow tall compared to legumenous shrubs and trees such as Glericidia, thus pruning may not be needed.
3. Less water can pass through the Mura hedgerows during heavy rains once they are already established.
4. Mora is better than cogon because its root growth is vertical while cogon has lateral roots which produce new shoots, hence more maintenance for cogon is needed.
5. Crops such as corn and upland rice planted near Mora hedgerow show better performance.
6. Mora has an expanded/dense crown which can serve as a physical barrier preventing soil and water to pass through.
7. Mora is favored over Gliricidia because the latter has laterally growing roots which interfere land preparation.
8. Mora contributes much to the control of topsoil erosion. The transported soil is accumulated along Mora hedges where it is trapped.
9. Mora can tolerate partial shading caused by ipil-ipil.

Farmers' evaluation after five years:

1. Mora is easy to plant with minimal maintenance.
2. Herbage deposited along the upper portion of the hedgerows help in trapping the soil during the rainy season. The herbage is also a good mulch for sweet potato.
3. Contour plots have leveled 3 years after planting Mora.
4. Mora grows in any type of soil. Mora planted in Anapogon (calcareous soil) and s grows very well.
5. Once established, it is not easily killed by cogon grass unlike other contour hedgerow species.
6. It does not grow anywhere except in the contour line where it is planted.
7. Mora is not effective unless A-frame is used in locating the contour line.
8. After 4 years of planting lines of Mora, the gullies are no visible.
9. Mora is a good windbreak of my upland rice and also serve as a nest for my hens.
10. In just few cropping seasons the effect of Mora in controlling soil erosion was already evident. I measured about 2 feet thick of soil trapped at the upper base of the hedges. Gullies were observed in the portion without Mora.
10. Mora survives long droughts. It regrows or produces roots at the nodes making it effective as contour riser stabilizer.
11. Corn planted near the Mora produced bigger ears than those near the Napier.

The Philippine Vetiver Network

The farmers positive feedback on Vetiver grass inspired the project staff to make VGT a major component of FARMI's Sustainable Upland Farming Program. With TVN's financial support, an easy to follow technology guide on VGT based on farmers experiences was published in English and in two local dialects. The technoguide was used as the basic GT instructional material for the institute's Soil and Water Conservation and Agroforestry projects. Perhaps TVN recognized this effort for few months later, Dick Grimshaw invited the coordinator to lead in the establishment of a vetiver network for the Philippines.

The Vetiver Network-Philippines (VETINETPHIL) was officially established on August 5, 1997 during the First Vetiver Conference-Workshop held at ViSCA, Baybay, Leyte. The network has more than 500 members at present and continues to attract students, researchers, farmers, extension workers, private and government organizations and other people who have interest in the Vetiver Grass Technology.

The VETINETPHIL Vision:

Soil erosion controlled, lands rehabilitated, and embankments stabilized in the Philippines through the Vetiver Grass Technology.

The VETINETPHIL Goal:

To promote the adoption of Vetiver Grass Technology (VGT) in the Philippines.

The VETINETPHIL Objectives:

1. To lead in the promotion of VGT in the Philippines.
2. To coordinate the VGT research, promotion and application projects of network members.
3. To assist in the establishment of members' vetiver production farms and nurseries and in marketing planting materials.
4. To support the implementation of environmental programs of the government and non -government organizations.

Strategy and Accomplishment

<u>The Vetiver Network Membership</u>. The Vetiver Network (TVN) provided the list of its members in the Philippines. Using the list, people were invited to attend the first Vetiver National Conference. Aside from the list, people who have known to have already engaged in vetiver works were also invited to the VETINETPHIL launching conference. The network now has more than 500 members who are directly or indirectly engaged in vetiver-related activities.

<u>Area Coordinators</u> To facilitate implementation and monitoring of VETINETPHIL activities, area

coordinators for the country's three main groups of islands were designated. The network has designated Ms. Noah Manarang of the Vetiver Farms Inc. to coordinate network activities for Luzon, Mr. Andy Obusa of FARMI for the Visayas and Mr. Jun Talpis of CARE-Philippines for Mindanao. Recently, Mr. Tanny Mobe was designated coordinator for Central Visayas due to the increased vetiver activities in the area. The area coordinators serve as the direct contact person in the area and will assist the national coordinator in carrying out activities and projects of the network.

Technology Demonstration As part of VETINETPHIL's extension strategy, it has set up 3 VGT technodemo and training centers. For agriculture, they are located in Inopacan, ViSCA campus and Matalom. The centers catered to farmer-to-farmer training on soil and water conservation and agroforestry. The Department of Agriculture also managed a technodemo farms in Kananga and Tacloban, both in Leyte Province.

A dozen farms in Western Leyte also served as demonstration farms and are usual destinations of cross site visits of farmers, extension workers and researchers from other areas. For infrastructure, he Department of Public Works and Highways has a demonstration project in Aklan province (in collaboration with the Vetiver Farms, Inc.), Infanta, Quezon and Baybay, Leyte. The Cebu Uniting for Sustainable Water (an NGO) also has vetiver-coco erosion net demonstration in Cebu, Central Visayas.

Training and Cross-site Visits In collaboration with the Farm and Re-source Management Insti-tute (FARMI) and other organizations, VETINET-PHIL offered farmer-to-farmer training on Soil and Water Conser-vation and Agroforestry. The network conducted a total of 7 trainings (72 technicians and farmer leaders) and cross-site visits of 6 groups of farmers and agricultural technicians from Visayas and Mindanao. Planting materials were distributed in both activities.

Extension Promotion Materials The network produced and distributed nationwide the Vetiver Technoguide in English and local dialects, the Vetiveria Newsletter, inserts to PRVN Vetiverim, Newsletter, the "Save our Soil: Use Vetiver" poster, and the Vetiver Grass Technology in the Philippines colored booklet. It also produced posters for presentation in conferences and symposia, stickers and some advertisement and articles in different print media in the Philippines. It also modified the Vetiver slide story now with audio tape. VETINETPHIL members also produced video on "Vetiver Nursery Establishment" by Noah Manarang of Vetiver Farms Inc. and vetiver brochures/leaflets by the Environmental Research and Development Bureau of the Cordillera Autonomous Region, Baguio City. The network has also produced and aired VGT technology tips at DYAC radio at ViSCA. About 20 members communicated using E-mails/internet.

Conferences, Workshops and Technical Assistance The network has sponsored 3 national conference-workshops and con-ducted a dozen of local meetings. It also presented papers and posters in international, national and local symposia. As part of VGT promotional strategy, the network offered free technical assistance to various government and non-government projects (agriculture, agroforestry, infrastructure, etc.) in different parts of the country. As a result, VGT has been integrated in various government programs like the Hillyland Research and Development Program of the Agriculture and Fishery Modernization Act (AFMA) and in various NGOs' upland development projects. The network also took part in the offering of vetiver short course during the Bioengineering Conference in Manila in April 1999.

Production Farms and Nurseries The network's VGT promotional effort has resulted to the increased in demand of planting materials either bagged or fresh tillers. VETINETPHIL encourages members to produce vetiver planting materials for big time users. Now it has more than 30 farmers engaged in the production of planting materials for the market. Most of these farmers maintained farms with vetiver hedgerows. The Provincial of Agriculture Office in Leyte has also ordered all its municipal agriculturists to establish vetiver propagation plots.

The network has maintained its own production farm and nursery to supply free planting materials to farmers, friends, NGOs, people's organizations, government projects, and members who want to use VGT or start a production project. The network's nursery also serves as the farmer-members collection area of tillers for the market.

There are member - NGOs who have commercialized the production and marketing of vetiver planting materials. Example of these are the Green Gold in Ozamiz, Mindanao; PEOPLE in Ormoc, MAFUD in Leyte, CUSW in Cebu and many more. But the biggest suppliers of planting materials are the private farms/firms which are capable of producing millions of planting materials in one production cycle. The number one producer of vetiver planting materials in the Philippines today is the Vetiver Farm Inc., which was set up entirely on a commercial basis to supply planting materials and promote VGT throughout the country. Another future big supplier is the FF Cruz Corporation in Central Luzon who set up a 10-hectare production farm in Nueva Ecija. The firm propagates vetiver for its Ambuklao Dam and coastal road projects and for other users.

Collaboration and Linkages The following are the agency/organization collaborators of

VETINETPHIL in the Philippines. Collaborators' projects include planting material production and marketing, pro-motion, demonstration, publication, research and application of VGT:

Department of Public Works and Highways (DPWH) - VGT application and demonstration.

Department of Agriculture (DA) - Vetiver production and training.

Philippine Coconut Authority (PCA) - VGT application in special projects.

Local Government Units (LGU) - VGT application in pilot sites and farmer-to-farmer SWC training.

Department of Environment and Natural Resources (DENR) - Vetiver research and application.

Central Luzon State University (CLSU) - Vetiver research, application and demonstration.

Visayas State College of Agriculture (ViSCA)-Vetiver research, training and extension.

Department of Tourism (DOT) - VGT application in hilly ecoparks.

Department of Agrarian Reform (DAR) - VGT application in ARC SWC projects.

National Irrigation Administration (NIA) - VGT Application and demonstration.

Government Special/Bilateral Projects.

Presidential Commission for Tagaytay-Taal- Promotion of VGT.

National Integrated Protected Areas Programme (NIPAP) - VGT application and promotion.

Western Samar Agricultural Resources Development Programme (WESAMAR) - VGT application in upland development projects.

Small Islands Agricultural Support Services Programme (SMISLE)-VGT application in upland farms and irrigation projects.

International Institute for Rural Reconstruction (IIRR) - Training and publication.

Forage for Small Holders Project (CIAT-FSP) - VGT application in hilly forage production farms.

ICRAF-Mindanao - Vetiver research.

SEAMEO Regional Center for Graduate Study and Research in Agriculture (SEARCA) - Vetiver research and application in project sites in Mindanao.

Fallow Management-Philippines (FMP) - Soil management research.

Conservation Farming in the Tropical Uplands (CFTU) - Research and extension.

CARE-Philippines - VGT application.

DOLE-Philippines - VGT application in banana and pineapple plantation.

First Worldwide Marketing Corporation - VGT application in Golf Course.

FF Cruz Corporation Inc. - Vetiver production and application.

Juboken Enterprises - VGT demonstration, research and production.

Woodland Development Corporation - VGT application.

ST Hidalgo Construction - VGT highway application.

MRC ALLIED Industries Inc. - VGT application in EPZA sites and publication.

Mag-uugmad Foundation Incorporated (MFI) - VGT application, promotion and planting material production.

Ramon Aboitiz Foundation, Inc. (RAFI) - VGT application and publication.

PEOPLE Foundation Inc. - VGT planting materials production.

PHILDRAA-Philippines - VGT application and collaborator of SWC-Vetiver training.

WELFARE-Leyte - VGT application and promotion in upland development projects

AWESOME-Mindanao - VGT application, promotion and publication.

Soil and Water Conservation Foundation - VGT application, promotion and publication.

Cebu Uniting for Sustainable Water (CUSW - VGT demonstration/promotion, publication and planting materials production.

Vetiver Research

Besides studies conducted by the network members, VETINETPHIL also supported some studies conducted by university students. The following are the completed studies:

1. Communication Environment and Information Gaps On Vetiver Grass Technology Among Upland Farmers in Bilar, Bohol
2. The Physico-Chemical Properties of the Rhizosphere Soil of Vetiver Grass Growing in Degraded Uplands
3. Effects of Nitrogen Fertilizer Application on the Growth of Vetiver Grass planted in 3 Soil Types

Problems Met

The most important problem met was the failure of the coordinator to visit more members' projects/activities due to time constraints and the location of members. Only very few members have access to the internet so communication is still done the conventional means. Majority of the members are not replying letters and network requests.

Summary and Conclusion

The following could be considered important elements that contributed to the successful promotion of VGT in the Philippines:

1. Multimedia promotion and extension system. The network used various extension methods from conventional training and visit method to high technology using the internet, videos and CD.
2. Active area coordinators. The coordinators contributed much in running the network

particularly in promoting the vetiver grass technology.

3. Commercialization of Vetiver grass. The commercialization of vetiver grass has helped create awareness and interest among the big time VGT users.
4. Participation of the private sector. The private sector played an important role in the promotion and marketing of VGT and in the production of planting materials.
5. Financial support. The availability of funds was very crucial in running the network particularly at the earlier stage of the project. Member organizations have recently started supporting some of the activities of the network.
6. Communication facilities. The communication facilities and computer system provided by TVN were indispensable in the day to day operation of the network.

The conservation and protection of our soil and water resources are very crucial towards sustainable agricultural production and the enhancement of environmental quality The unmitigated soil erosion brought about by agricultural activities, road construction, mining and water resources development among others necessitates immediate remedial action. Carrying out this urgent task requires adoption of the Vetiver Grass Technology in a national scale. The birth of the Vetiver Network-Philippines was very significant in the promotion of the technology in the Philippines.

The spread of the VGT in the Philippines in the past 3 years has been considered remarkable by TVN leaders. There are various factors that contributed to this success, one of which is the participation of the private sector. The VETINETPHIL and its partner organizations will continue its aggressive promotion of the VGT and will exerts all efforts to assure massive adoption of the technology in the early years of the new millennium.

PROMOTION OF VETIVER GRASS TECHNOLOGY IN THE PHILIPPINES: VETFARMS INC. Experience

Mary Noah S.J. Manarang
Vetiver Farms, Inc. Quezon City, Philippines, presented at the SecondInternationalVetiver Conference,Thailand, January 2000

Introduction

In December 1994, the author was among the three Philippine delegates chosen to be part of an observation tour on vetiver grass in Thailand. As Project Development Officer of the Department of Environment and Natural Resources (DENR), the author was sponsored by the Royal Development Projects Board of Thailand to a two-week study tour and training on the grass. She was able to visit sites where vetiver was widely used and propagated. The sites included Huai Hong Khrai Royal Development Study Center in Chiang Mai Province; the Doi Tung Development Project in Chiang Rai Province; Huai Sai Royal Development Study Center in Petchaburi Province; the Chaipattana-Mae Fah Luang Reforestation Project at Nong Phlap, Hua Hin District in Prachuap Khiri Khan Province; the Khao Cha-ngum Rehabilitation Project in Ratchaburi Province; and the vetiver nursery of the Land Development Regional Office 10, Ratchaburi Province. The lessons learned from these project sites were the basis of the author's effort in promoting vetiver.

Initial Research and Trials

Back in the Philippines, the author started researching and sourcing vetiver in the Philippines. Some samples from Rizal and Bulacan province were taken and propagated in the nursery of DENR and the author's experimental nursery in Pampanga. Vetiver was planted in various media in polybags to test its growth properties. From this small stock of mother plants, the author started propagation in 4 x 6" polybags as being done with tree seedlings. Aside from this, tissue cultured vetiver plants were sent to the author. The tissue culture samples came from the laboratory in Chiang Mai Province.

Promotion Through Extension Work

As there was no vetiver program at that time, the author together with her DENR colleague (Ms. Ernestina F. Jose) promoted the grass and did extension work with various sectors on their own.

Dove Foundation

One of the extension work done was a presentation with the Dove Foundation. The foundation is involved with providing livelihood program to the victims of the Mount Pinatubo eruption. Sample seedlings were given out to the communities for planting in their resettlement area.

Palawan Foundation

Vetiver seedlings were given at cost to the Bagong Pag-Asa Foundation for use in their Sloping Agricultural Land Technology (SALT) farming.

Vetiver Network - Philippines

One of the most important extension work done was the author's linkage with Vetiver Network — Philippines (VETINETPHIL). The author was invited to join the network to share her experiences and methodology in propagation of the vetiver seedlings. A propagation guide was included in the different publications of the network. The author was also

appointed as the coordinator for Luzon of the network. The author presented in the First Vetiver Workshop held in Ormoc, Leyte.

Academe

Vetiver Farms, Inc. believes that environmental education should be done at all levels in school. In line with this, the company did extension work with academic institutions and students.

Ateneo De Manila University

In the second quarter of 1998, Vetiver Farms, Inc. initiated talks with Ateneo de Manila University regarding research work to be done on vetiver by students and faculty. Vetiver Farms, Inc introduced the plant and its applications to the faculty of the department. These talks resulted in Vetiver Farms, Inc donating vetiver slips to be planted around the newly constructed Science Education Complex which has slope surrounding the whole building.

The Science Education Center, **Ateneo de Manila University*:*** The slopes around the SEC Building protected by vetiver hedgerows. Vetiver blended well with the carabao grass and the building's landscape. Several students initiated mini-projects studying the biology of vetiver.

Student Projects*:* Some of the student projects included:

- Effects of *Vetiveria zizanoiodes* leaf extracts on the red blood cell counts of *Mus musculus.*
- Assessment of anti-inflanunatory activity of *Vetiveria zizanoiodes* extracts on the paw of Sprague-Dawley rats.
- Effects Comparative effects of *Vetiveria zizanoiodes* extract, adrenalin and nitroglycerin on the diameter of rabbit ear meta-arterioles.
- Insect populations leaving near and around *Vetiveria zizanoiodes* hedges.

Some graduate student, also, did a thesis on the morpho-anatomy of vetiver (histological studies on the root anatomy of *Vetiveria zizanoides)*

Live and Learn Study Center

The Prep 1 class of Live and Learn Study center was brought to the nursery on a field trip. The students were shown the different stages of the vetivers growth in the nursery. They were taught the importance of the vetiver grass to our environment. The students took part in the propagation of the grass with VetFarms farmers.

Vetiver Farms

With the little publicity from its extension work, the experimental nursery soon became a commercial operation. In the course of promoting vetiver, the author saw the major flaw of making the technology accepted and successful and this is the lack of supply. As people are beginning to take notice of what this grass can do, replicating its success in Thailand was difficult simply because there were no available quality seedlings to be used in big projects. It was at this point that the author realized that a key to the technology's success is to make the seedlings available. This can only be achieved through its commercialization.

It was difficult to convince farmers also to plant the grass in their farms because do not see any economical benefits from it. There is also this misconception that vetiver is actually a weed and it would compete with the crops that they are planting. After a period of research and trials, the author's nursery then called L and N Farms was able to come up with an easy and practical propagation method which is ideal for volume production of uniform sized, quality seedlings. The lessons learned in the Thailand study tour was valuable in this propagation trials. With vetiver seeds being sterile, commercial propagation of the grass became a challenging task. After four years of Vetiver Farms, Inc. now boasts six nurseries with the capacity of producing five million seedlings a month. The satellite nurseries are located in different provinces all over the Philippines such as Pampanga, Iloilo, Laguna, and Cavite, and Antipolo.

Promotions and Marketing Strategy

The VGT has a niche market so to speak, thus there is not much need for conventional advertisement. Instead, VetFarms believes in bringing the technology directly to the sector that needs it. Identifying the potential users of this technology, VetFarms provided these groups with information material regarding the use of vetiver to their specific application. This saves the company a lot, which makes our seedlings very affordable. Visual presentation through video and power point were done to show the characteristics of the grass and our successful projects. So, to further the interest of the people, Vetfarms launched its own information campaign, starting with the construction of its own webpage. Designed to make, not only the company but also the technology, known to as many as it can reach, VetFarms' webpage is the first step to its worldwide information campaign (www.vetiver.com.ph). Vetiver Farms, Inc. was also featured in leading newspapers (Annex A). The Business Friday section of the Philippine Daily Inquirer on 16 July and 17 September chronicled the beginnings of the company and its marketing strategies to promote VGT. The accounts presented were testimonies of the author's efforts to promote VGT in the Philippines. In the last issue of the Manila Times on 23 July1999, VetFarms became part of history. In this report, vetiver was given recognition for its applications in preventing soil erosion.

The company has also

been featured in international television broadcast. ABS-CBN featured VetFarms in its program "The Global Filipino" which features successful Filipinos in the field of business. The program was beamed in different countries such as the USA, Australia, Hong Kong and the Middle East (Annex B).

Effects of Promotion

Private Sector: The response to the promotion efforts by the author and VetFarms Inc. are very encouraging. In the last five years, VetFarms has done more than 30 major vetiver application projects all over the country. Most of these projects are for private industries and corporations who risked using the vetiver technology for their different environmental applications. It has elicited response even from remote places (Annex C). Tagaytay Highlands/Midlands Project before (left) and after (right) Government Agencies.

The Department of Environment and Natural Resources: A presentation about the VGT to former Secretary Victor 0. Ramos got very good feedback and results. The DENR has been recommending the use of vetiver grass for soil erosion control and slope stabilization in their Environmental Compliance Certificates (Annex D). Being a regulatory tool, major development projects, which involves earth moving/clearing activities are required to use vetiver in "revegetating" the affected areas. The Secretary was also planning to put up a nationwide vetiver nursery through its provincial offices during his term.

The author and Vetfarms representatives during a presentation with (DENR) Secretary Victor 0. Ramos, the Department of Public Works (DPWH). VetFarms is one of the biggest suppliers of vetiver seedlings to the DPWH. The Department has used vetiver successfully protecting slopes in their road projects mostly in the southern part of the Philippines. Although there was skepticism about the technology in the beginning, the officials and field engineers of the DPWH are now convinced of its effectiveness as compared to the conventional riprap and stone walls. The most notable project is the Kalibo-Caticlan road project in Panay Island. This project being situated on a national highway leading to the world-famous Boracay beach, has attracted a lot of attention from both the locals and foreigners. This actually served as a model of vetivers success in protecting slopes ~ people who got in touch with as after seeing the project. Aside from its effectiveness, vetiver hedgerows are about 60% cheaper than the conventional engineering methods being used before. Kalibo-Caticlan Road (L-Before and RAfter)

Handicrafts Industries: Local exporters of handicrafts have signified their interest to utilize the leaves and the roots for their products. Although most of them know that vetiver leaves and roots make beautiful baskets, mats and ornaments, it did not really prosper as they do not know where to get the raw materials. Through our promotion, they are now willing to experiment and manufacture more products out of vetiver, knowing that the raw materials are available. VetFarms is now linking with manufacturers for possible collaboration on production of different export products, which will create new job opportunities.

Export Products Made from Vetiver Roots Featured at CITEM Fair

Peoples Organization and Cooperatives Inquiries regarding the subcontracting scheme of the company are far too many. The idea of the buyback scheme for our propagation is very attractive to groups and communities. This is because it provides them livelihood without leaving their home and their children behind. This scheme has served as a model to other project undertakings specially those which are agricultural in nature.

Future Plans

VetFarms is currently doing a lot of research, in the use of various parts of the grass for livelihood projects. The company would like to see more farmers benefiting from the grass and its myriad of uses. Further promotions through information, education, and communication campaign to farmers and policy makers is a major thrust of the company. VetFarms plans to publish a book of its experiences, the lessons learned from promoting and using vetiver grass in different projects.

Conclusion

The Philippines is an agricultural country, and the potential for vetiver to be a major agricultural product is very promising. With the frequent typhoons and flooding, its use for soil erosion control and slope protection are the ones being popularly utilized at the moment. But the other application of the grass and its by-products are many and are yet to be explored. Because of its resiliency to different weather and soil conditions, vetiver can be a tool for poverty alleviation for people in the countryside where crops are often destroyed by pest and typhoon. VetFarms nurseries alone provide livelihood to no less than 100 families. During the difficult period of El Nino, vetiver propagation was the only activity in the fields of Pampanga for there were no irrigation for the rice fields. The women are now cutting off the leaves of mature plants for drying for roofing materials and for handicraft manufacturers. Thus, the promotion of the grass and its numerous uses should be done both at the grassroots level and at the policy-making level. The potential is there, and it just needs to be tapped. Information about its use is essential and both the government and private sector should pursue promoting it together.

His Majesty King Bhumibol Adulyadej's project through the Royal Development Projects Board, sponsoring people from other coun-

tries to the vetiver study tour program is an effective tool of promoting the grass to the different parts of the world. If every participant to the study tour embarks on a vetiver promotion program in his/her country, the VGT will benefit a lot of people. The author's and Vetfarms modest accomplishments in promoting vetiver in the Philippines, is the product of this study tour, which is truly educational and inspiring. This benevolent project should be continued, and if possible replicated.

DISASTER MITIGATION AND VULNERABILITY REDUCTION: PERSPECTIVES ON THE PROSPECTS OF VETIVER GRASS TECHNOLOGY

James Smyle, Natural Resources Specialist, Regional Unit For Technical Assistance, World Bank, San José, Costa Rica .
Paper presented at the Second International Vetiver Conference Thailand, January 2000

I. INTRODUCTION

The region of Central America occupies an area comparable in size to Thailand. Its 32 million inhabitants live within the 7 nations of which the region is comprised: Guatemala, Belize, El Salvador, Honduras, Nicaragua, Costa Rica and Panama. In general, the countries have mountainous interiors surrounded by coastal plains. On the path to urbanization, the population is still predominantly rural and poor. Agriculture remains the main source of livelihood, employment and, generally, the dominant economic sector.

In the last days of October 1998 Hurricane Mitch, the most intense storm in the Atlantic Basin in the past 200 years and the most destructive hurricane in the history of the western hemisphere (1), battered the Caribbean coast and parts of Honduras, Nicaragua, El Salvador, and Guatemala. From October 27, 1998, to November 1, 1998, it dumped from 300 to 1900 mm of rain on large areas of the four countries. The storm produced sustained wind speeds of 290+ kilometers hr^{-1} and rainfall intensities of more than 100 mm hr^{-1}. The main destruction resulted from the intense rainfall.

The storm's arrival at the end of the rainy season guaranteed maximum damage. In the weeks prior to its arrival, there had been significant rainfall. Soils tended to be at or near their water-holding capacity. The spring/summer crops were at the point of harvest and the summer/fall cropping cycle was beginning.

Summary Of Hurricane Damage

Severe flooding and landslides were widespread throughout the region More than 9,000 people were killed. Over 2,000,000 people were left homeless. Much of the transportation and communications infrastructure of Honduras and Nicaragua was devastated. Towers and bridges were destroyed and roads were lost to landsliding or washed away by floods. In Nicaragua, the rain-saturated southern slopes of the Volcano Casitas gave way and mudslides reached the town of Posoltega, almost 10 miles away. In nearby communities some 1,900 people were killed due to mudslides. In Tegucigalpa, the mountainous capital city of Honduras, a landslide blocked the main channel of the principle river. When the dammed river finally broke through, the flood peak washed away entire neighborhoods; raging currents undercut city hillsides, bringing other neighborhoods crashing into the flood waters.

The dimension of damage to the region was (and is) huge. The

Thailand. Vetiver and water. A river levee stabilzed with vetiver grass. The stabilization was fully effective, and when over topped by flooding was completely stable. Photo Credit: Dick Grimshaw.

Central American commercial corridor, about 90 percent dependant on road transport, was blocked; intra-regional commerce came almost to a halt. The indirect economic losses ran into the hundreds of millions of US dollars. Of the estimated US$6 billion in direct and indirect losses, about 50 percent were from the agricultural sector. Flooding, landsliding and sediment inundation primarily affected banana, melon, pineapple, coffee, basic grain and other subsistence crops, and sugar cane; shrimp farms in Honduras were particularly hard hit. Literally tens of thousands of hectares of the region's best agricultural lands were damaged or destroyed; washed away, carried away by landslides, or inundated under deep layers of rock or coarse or sandy sediments.

The deposition of massive amounts of sediments within river courses has caused radical changes in fluvial morphology and hydrology of many catchments. The hydraulic capacity of the river systems have been drastically reduced. In a substantial number of areas, it is unclear where the current (and future) channels of major rivers are located. In the steep upper watersheds, slope instabilities were activated due to soil saturation. Risks of future flooding and landsliding have greatly increased. This year's rainy season, wetter than normal, resulted in widespread flooding in the cities of the Caribbean coastal plains and landsliding has continued.

Viewpoint of Disaster Specialists

As the true picture of the impacts began to emerge, an explanation was sought to explain what happened and why the impacts were so severe. In addition to the understanding that the disaster was the result of a natural phenomena of extreme magnitude, much attention was focused on the potential role that deforestation and hillslope farming in upper watersheds had played in "causing" or worsening the impacts of the devastating floods. In a real sense, this became the most high profile issue in the months following. The media focused on how "…*it seems that Hurricane Mitch has been far more deadly than it need to have been, just because the forests were no longer there"* (2). Government and foreign donor agencies publicly agreed that "*the effects of Hurricane Mitch have been increased…in particular [by] the deforestation of forests and wetlands that act as "buffer" systems diminishing the surface run-off in the case of such intense rains as those experienced during Mitch*" and that *"flooding was aggravated by a lack of adequate watershed management"* (3).

In parallel to this more public analysis, international experts in disaster mitigation and vulnerability reduction were assisting to diagnose what had happened and what needed to be done. Radar imagery of flooded areas, overlain on geologic maps, showed that Mitch flooded those areas which are underlain by Quaternary sediments, i.e., those soils formed in areas naturally subject to flooding. Damage assessments increasingly tended to place less emphasis on upper watersheds and deforestation *per* se and more on the broader issues of:

- Human mismanagement - *"The risks posed by natural hazards in Central America are exacerbated by social and environmental trends such as rapid urbanization and unplanned human settlements, poorly engineered construction, lack of adequate infrastructure, poverty, and inadequate environmental practices such as deforestation and land degradation"* (4).
- Human encroachment into vulnerable areas - "*People die, are injured or lose their homes in natural disasters because they continue to build and live in unsafe structures and in vulnerable locations…*" (5).
- Social vulnerability and poverty - "*Those in poverty typically do not have access to arable and safe land. Instead, they live and farm on marginalized areas, such as floodplains and steep slopes, maximizing their exposure to the next disaster, fueling the vicious cycle*" (5).

The conclusions were inescapable, the disaster that occurred was not a 'natural phenomena'. Or, as put by two anonymous disaster professionals: "*Disasters are unresolved problems of development"* and *"Disasters are indications that we have not yet learned to live where we are living".* Final estimates placed between 50% and 75% of the economic losses from Hurricane Mitch as having resulted from inadequate design and siting of housing, roads, bridges, and industry (4).

What Was Potentially Avoidable?

Following these conclusions, flowed a long series of recommendations of how to avoid, mitigate, and reduce impacts from future disasters. To those working in areas related to natural resource management, civil engineering or rural development, not surprisingly, the majority of their recommendations consisted of things which have been recommended on an almost daily basis as being "good practice". Indeed, most were basic elements of watershed management and have been a part of the development agenda for decades. Unfortunately, they are also basic elements that tend to be ignored.

We know that good watershed management requires consideration of the many issues that fundamentally influence how humans use natural resources: political, socio-economic, institutional, scientific, technical, community, legislative, regulatory framework, economic incentives, etc., – and as such, is extremely complex. However, despite the complexity, in each

of these areas one eventually has to come down to: (i) getting the objectives right and, (ii) ensuring that you have appropriate and affordable tools in order to achieve those objectives.

In the specific case of Hurricane Mitch, the lessons learned seemed to point out four main "objectives" that should have been pursued prior to the hurricane in order to have reduced or avoided the much of the human tragedy and economic losses. At the risk of oversimplifying, these were:

® *Minimize encroachment into flood plains and other elements of the natural drainage patterns, and areas subject to mass movements of earth* – Urban, commercial and industrial encroachment into these areas resulted in the greatest losses of human life and of high value infrastructure and environmental contamination (toxic and hazardous substances washed into rivers).

® *Ensure proper design and construction of transport network* – In Honduras, access and transport were returned to pre-1900 conditions. The majority of road and bridge damage and losses were ascribed to poor design, shoddy construction, and inattention to stabilization during the construction phase.

® *Ensure the adequate protection and proper maintenance of key roads and access points* – Lifeline roads and critical access link points were destroyed, leaving large populations isolated and endangered and the country's and affected region's economic activities were brought almost to a halt.

® *Assist rural households to adequately protect their production systems and housing sites* – The main economic losses took place in valley agriculture and were a direct result of massive flooding. In the uplands, the main economic impacts were in coffee; thousands of hectares of coffee plantations were lost to landsliding. Large indirect losses occurred due to loss of market access roads, forcing producers to leave crops in the field. Smallholder subsistence agriculturalists (the majority of farmers) were extremely hard hit by landsliding, flood torrents carrying away their best streamside lands, extreme soil losses from torrential rains, and loss of crops in the field. These latter's losses barely enter into the official loss figures. Even with tens of thousands of poor households losing almost everything (house, land, crops), having very little to lose, their losses figured very little in the macro calculations.

The Aftermath. What Needs To Be Done ?

According to the disaster specialists the issue now is not "*reconstruction*", rather it is "*development in the new context created by the last disaster*". From a watershed management perspective, the main challenges in this *"new context"* seem to involve:

® *Mass wasting* – especially within and near urban or other populated zones where large scale landsliding has left behind slide zones subject to further landsliding (at head of slide zones), shearing and collapse (along sides of slide zones) and unconsolidated and unstable debris slopes.

® *Shallow slips* - similar to, but much more numerous than, the deeper and larger landslides. Their occurrence is highly correlated with roads and deforested hillslopes. In the most vulnerable upper watersheds of Honduras, where the United States Geologic Survey found occurrences of up to 100 landslides per km^2, preliminary estimates associated some 50% or more of landsliding with the road system and roadcuts.

® *Sediment storage in stream system* – massive quantities of sediments were mobilized by Mitch, and in some cases river beds were raised as much as 10 meters. Vast quantities of sediments are now stored within and near stream channels. Over the coming years, these sediments will be "flushed" through the watershed, and eventually, out to sea. This virtually guarantees continued channel aggradation (raising of stream bottoms due to sediment deposition) with associated localized flooding, and resilting of dredged irrigation canals and river sections for many more years.

® "*Where's the stream channel?"* – river channels are now many times wider than previous to Mitch. In some of the principle rivers, where channels were less than 50 meters wide, they are now over a kilometer wide. No one knows where the new river channel might eventually be located. This certainly complicates the siting and construction of bridges, rebuilding of affected urban areas, reestablishment of agriculture, development of water supply systems, and numerous other activities.

® *Sediment inundation* - while some benefitted, as evidenced by the record melon crops in southern Honduras this year, this was not true for all. Substantial areas of the best lowland agricultural lands have been buried under a meter or more of coarse and sandy sediments whose productive potential is extremely low.

® *Not all future risk can be avoided in new construction* - Roads will still have to go

through the mountains, within slide prone and unstable areas. Homes will be built in unsuitable areas because the owner has no other option. Eventually the bridges must cross the rivers and building extra kilometers of road cannot always be justified in order to cross at the best possible bridge sites.

® Danger zones and encroachment - extraordinary efforts are under way to identify areas which are vulnerable and at risk. Land use planning and development of new restrictions and zoning ordinances are underway. At the same time the poor are moving back into the same zones from which they were expelled by flooding and landslides.

II. Where does vetiver grass technology fit in ?

If the challenge is to bring about development in the new context left after Hurricane Mitch while ensuring that the hundreds of millions of dollars of official aid transfers coming into the region are used to best advantage, then certainly VGT has a role to play. This fact is underscored by VGT having been specifically identified as a key technology for post-Mitch construction by the World Bank, the US Army Corps of Engineers, the Interamerican Development Bank, the United States Agency For International Development, CARE International, Chiquita Brands and Tela Railroad Company among others. Also, Mitch finally began to create interest in VGT among the Costa Rican, Nicaraguan, and the Honduran Ministries of Transport. In El Salvador, the work by NOBS Anti-erosion had already ensured that their country's transport and infrastructure ministry was aware of VGT and seeing it applied. In addition, to promote the use of VGT in post-Mitch construction, the World Bank provided the Regional Unit for Technical Assistance and the Latin American Vetiver Network a "knowledge management grant". The grant's purpose was to educate key actors and decision makers in the post-Mitch construction (government, donors, and private sector) as to the potential, the benefits and the means to go about incorporating vetiver grass technology as a low cost, proven, bioengineering approach for infrastructure and watershed stabilization.

All that is good. But there is also very limited experience in Central America with the use of VGT, relative to the size of the job ahead. Also, misuse or overselling of VGT can not only result in discrediting the approach, it can also put at risk human lives and high dollar investments. Recently, in a workshop on watershed management in Honduras, an experienced field man spoke up, saying: "*We need to systematize our approaches…I am tired of being told 'use vetiver grass' when my problem is something like an actively cutting gully which is 5 meter deep and 30 meter wide gully"*. From this perspective, a brief review of for what VGT might be good, and possibly not so good is in order.

For What Might VGT Be Good?

What are the uses and limits for VGT ? A number of aspects are worth noting:

® *Stabilizing soil and slopes* – We know from the work of Diti Hengchaovanich (6) and others (7,8,9) that vetiver's root system is excellent for stabilizing soils. The tensile strength of its roots are high ($^1/_6$ the strength of mild steel) and its massive root system greatly increases soil shear strength. Its roots penetrate deeply, even through restricting layers. Its light weight and low wind profile avoid problems associated with greater stress loading on the slope. In terms of limits, while the roots may penetrate 3 to 5 meters, in fact the greatest mass of the root system tends to occur within the top one meter or so. As a result, if shear faces or potential failure zones are at a depth below the 'effective' depth of the root system, VGT will be ineffective in soil and slope stabilization. If you are going to bet your life or investment on VGT's ability to stabilize a slope, it would probably be best not to bet on it if the potential failures are likely to occur more than one meter below the surface.

® *Trapping sediments* - Quite a bit of work has been done (11) on these aspects, including recent (12) studies in Honduras which showed that traditional slash-and-burn sites average 92 tons/ha/year of soil loss compared to 43 tons/ha/yr with crop residues and a "green mulch" cover crop compared to 0.9 tons/ha/year on sites with vetiver grass barriers and the crop residue/mulch. We know it is efficient. We know less about how well or rapidly vetiver can recover from sediment inundation. In Louisiana in the southern US, for example, vetiver barriers were able to trap more than 50cm of sandy sediments in less than one year and continue to grow up through them and maintain a reasonably dense barrier. But, we also know (personal communication, J. Hellin) that in Honduras "*landslides destroyed a number of control plots AND [vetiver] barrier plots [i.e the barriers were washed away]. However, deep-seated landslides only originated on the steep slopes [65-75%]. On the shallow slopes [35-45%] the damage arose from debris from landslides which originated on steeper slopes above and outside the re-*

search site. In the case of the damage on the shallow slopes, much maize was lost but the vetiver grass, although covered by several inches of debris, survived". On this particular aspect, we have no useful rules of thumb, and any rules would vary based on the growth rate of the plants (a function of climate, substrate fertility, available sunlight, weed competition, etc.). To be safe, under conditions where vetiver could be characterized as "growing well", you probably would not want to rely on hedges to trap more than an average between 40 and 60cm a year or that they would recover from a complete burial of more than a few centimeters (10? 20? 30?). For extreme events (e.g., shallow landslides), the expected role of the hedges would probably not be one of trapping sediments *per se*, rather of stabilizing the slope and reducing the occurrence of shallow slips and hydrostatic blowouts.

® *Reducing runoff velocities* – Flume studies in the USA (13) and flume and field studies in Australia (14) have shown vetiver hedges to be very effective at reducing total head (flow depth and velocity) of water flows. The hedge's effectiveness at doing so increases with hedge thickness (maturity). Little information is available to tell us about vetiver's effect on total head across a range of slope conditions and flow conditions, especially with turbulent flows. However, it appears that mature hedges can be quite effective at reducing runoff velocities of flows less than 20cm in depth, moderately effective with flows up to 35 or 40 cm, and have some impact on flows up to possibly 60 to 80cm. The important points here are, if the objective is to reduce runoff velocities, that: (i) first it is required that a reasonably dense hedge be established in order to be effective, (ii) that the design flows for which effectiveness might be expected are more likely to be on the order of 5 to 20 year events (versus 100 or 500 year events, as in the case of Hurricane Mitch) or where flows are turbulent, perhaps you might want to expect effectiveness up to around 20cm in depth; and where flows are laminar up to around 40 cm; and (iii) given the uncertainty at the moment, it would probably be best to restrict this particular application to non-critical areas (e.g., where failure is not "fatal").

® *Diverting flow* – Neither does there seem to be much information in this aspect, however, one might suspect that a vetiver hedge's effectiveness for redirecting flows would probably show similar impact and limitations as they would for reducing runoff velocities.

® *Enhancing infiltration* – Contour vetiver barriers increase infiltration and decrease runoff. This is a very useful characteristic in agronomic situations, but potentially something of a double-edged sword where slope stabilization is concerned. In the latter case, the objective is generally to reduce the amount of soil water, not increase it. In looking at this particular aspect, Diti Hengchaovanich (5) concluded more research was required. However, his preliminary results lead to the anticipation that vetiver would be able to deplete moisture in the soil thus lowering pore water pressure - a positive outcome for stabilization; i.e., though more runoff would infiltrate, extractive use by the hedges would more than offset the incremental infiltration. He based this preliminary conclusion on the fact that, in civil engineering use: (i) slopes will generally be from 30-60º, ii) thus the distance between vetiver hedges would be very small; and (iii) therefore moisture depletion by the hedges on such a slope would be greater. In terms of expecting VGT to enhance infiltration and thus reduce runoff on a scale to reduce downstream flooding: this would simply not be a reasonable expectation, except possibly on extremely small scales (e.g., a 2 ha micro-catchment).

® *Protecting hard structure/soil interface interfaces* - Experience has shown that vetiver hedges are excellent at protecting the interface between soil and hard structures. This is generally a very vulnerable area. It is here where often runoff is concentrated, causing soil to be scoured away. Oftentimes, this is how structures begin to be undermined, leading to the eventual failure of the structure (e.g., gabions along stream channels, bridge footings and 'wings' of approaches, concrete drainage channels along roads, etc.). This is a truly underexploited use. What the limitations might be are not entirely clear, but as this is a problem for which there are very few alternative solutions, it is worth a try wherever conditions would permit you to establish a mature hedge.

® *Demarcating areas* – Vetiver is a long-lived and, once established, resistant to most things (including being underwater for months at a time) except herbicides, shading, severe weed competition, inundation by sediment, and

being dug out of the ground. It is an ideal plant for demarcating areas; nor does it need to be established as a hedge for this purpose.

For What Might VGT Not Be So Good?

Within the uses and limits described above, for what might VGT not be so good? Three particular aspects appear to merit mention:

® You absolutely cannot save or protect a bad design with VGT. This is basic. If the site is unsuitable, if the road is poorly designed, if the fill slopes are not compacted to design standards, etc. VGT will not rescue the situation. Indeed, it could make it worse by providing a false sense of security.

® You cannot guarantee bad work. VGT has to be applied correctly or it will not work. Others shall be presenting experiences and papers in this conference on this aspect. But if there are any doubts as to what "correctly" means, the Vetiver Networks are there to assist you to get the details.

® You should not expect VGT to extend the feasible range of where an activity can be carried out; i.e, the purpose of incorporating VGT into activities is not to allow increasingly more risky or vulnerable areas to be utilized for roads, buildings, houses, etc., but to protect and support well located infrastructure projects.

Pre-Mitch: Where Might VGT Have Reduced Damage ?

As mentioned above, there appear to have been four main "objectives", which had they been more effectively pursued prior to the hurricane, might have reduced or avoided human tragedy and economic losses. What role might VGT play such that future disasters are less disastrous?

Minimizing encroachment into vulnerable areas. Under Central American conditions it is clear that these areas will continue to be encroached upon for a significant span of time yet to come. The main impacts (loss of human life and economic losses) occur in urban and peri-urban areas. The use of zoning does not seem to be a very effective option as neither enforcement of laws and statutes nor insurance (which most businesses and individuals lack) discourages building in vulnerable areas. Indeed, many of the areas hit hardest by Mitch were identified as "vulnerable" and "high risk" in land use plans and zoning ordinances one or more times, since the 1950s. Such areas need to be put under some economically or socially useful activity which, if wiped out in a flood or landslide, does not cause undue economic loss or human suffering.

In urban areas, these risk zones can be converted by the city or turned over to neighborhood associations for recreation areas, city parks, sports fields, community gardens, etc. The utility of VGT in these areas would be to protect these areas from the "normal" hazards and maintain their useful life between the more extreme events, through: stabilizing river banks and natural drainages, protecting roads and footpaths, redirecting runoff from upper slopes, stabilizing hillslopes and fill areas, etc. In addition, the concept of 'social fencing' acts as a deterrent in most Central American societies, i.e., if one can demarcate land (and maintain the demarcation), thus establishing usufruct, this becomes a mild to moderate deterrent to encroachment. Vetiver barriers make excellent boundary markers and are much less expensive to put up and maintain than real fences. "Regular" maintenance, such as twice yearly pruning, would serve to demonstrate continued interest and "will".

Proper design and construction of transport network and adequate protection and proper maintenance of key roads and access points. These two points are substantially the same, the main difference being one of strategy and intensity. In general, proper design and construction require that stabilization of roadsides, roadcuts, fill banks, drainage, etc. etc. be taken into account. Without going into details (as there is a whole section in the conference on these aspects), we know that vetiver works well and is low cost. The experience in El Salvador shows this – over 300 km of vetiver hedges were established before Mitch hit to protect roads and other high value infrastructure, the only failure was in one location where it was discovered that the building contractor had not compacted a fill slope to design specifications. As did the experience in Puerto Rico with Hurricane George, where, Mr. Eduardo Mas of the US Natural Resource Conservation Service was reported to have remarked: "*The storms were terrible. [Afterward there were] Landslides, roads destroyed, agricultural lands washed away; but, where there were vetiver barriers, everything seemed normal".*

Road maintenance is always a problem as there is generally little or no budget provided for this activity. Under such circumstances, vetiver is a good alternative. As Mr. William Ibarra, a division chief in El Salvador's Ministry of Public Works, explained to the attendees at the World Bank-sponsored Vetiver Bioengineering Workshop: *"We never have budget for road maintenence"* therefore his strategy is *"to lose fingers, not the hand"* by building into the construction phase protection measures which are going to give him long term, very low maintenance protection in critical areas. He counts vetiver as one of those approaches.

In terms of ensuring adequate protection of lifeline roads and critical access link points, this involves expecting disasters to oc-

cur and identifying and taking incremental measures to protect key roads and access points. Simply stated, these would be the points where the greatest attention and intensity should be given to see that VGT is used for stabilization and protection. However, given the criticality of these points, VGT would need to be part of an overall package which included hard as well as soft approaches.

Adequately protecting production systems and housing sites. With the main economic losses having occurred in valley agriculture as a direct result of massive flooding, there is little that VGT could be expected to have done to lessen impacts. In the uplands, where thousands of hectares of coffee plantation were lost to landsliding, VGT might have reduced some small percentage of losses. Many of the landslides were deep, tens of hectares shearing off and dropping into the valleys or plantations being wiped out by fast moving debris and mud flows from upslope.

Smallholder subsistence agriculturalists would be the greatest beneficiary of VGT. Damage surveys noted that virtually all the farms using recommended soil and water conservation techniques (especially, vetiver grass contour barriers, rock terraces, "green mulch"[1] and crop residue management, and an indigenous agroforestry system[2]) survived Mitch with little damage, while neighboring farms using conventional practices suffered devastating landslides that destroyed homes and degraded fields.

Simeon Gomez, a hillside farmer in Los Espabeles, Honduras who went through Hurricane Mitch said it best: *"On my field with vetiver grass contours the hillside remained perfectly in place. The fields without grass contours have had their crops and soil washed away".*

Vetiver hedges could also have be somewhat useful in protecting home sites on sloping lands and near minor drainages, especially from undercutting of walls by runoff, and perhaps diverting flows away from the house and reducing sediment damage to interiors.

Post-Mitch: Where Might VGT Be Applied In The Aftermath?

The incorporation of VGT in development efforts might reasonably be expected to assist in dealing with the conditions left behind in many of the watersheds severely impacted by Hurricane Mitch. At the same time, it would also be reducing future vulnerability and risk. Application of VGT can be utilized for treating the following situations:

Mass wasting. Many of these are deep slides whose continued instabilities derive from zones below the depth at which vetiver's root system could affect stabilization, or from huge masses of material still in movement from gravity, or from unstable materials of texture classes (large stones, boulders, etc.) for which VGT is unsuited. On the other hand, VGT could play an important, low cost role in reducing the risk that these instabilities would trigger. Among the particular applications for VGT here are in: (i) reducing erosion and undercutting of the toe slopes, which generate upslope sliding – establish contour vetiver barriers along the bases of the debris slopes, especially where they contact river channels; (ii) halting and diverting run-on from upslope which would increase soil moisture and increase risk that slides or shears would be triggered due to increased pore water pressures – establish cross-slope and herringbone pattern vetiver hedges upslope; (iii) stabilizing the shallow unconsolidated and unstable shallow debris slopes; and (iv) stabilizing the soil surface of both the newly exposed areas as well as the debris slopes such that revegetation (natural regeneration or planting) might occur.

Shallow slips. VGT could play a larger role in achieving complete stabilization of shallow slips in: (i) stopping further landsliding and shearing by stabilizing the heads and sides of slide zones; (ii) stabilizing unconsolidated and unstable shallow debris slopes; (iii) stabilizing the soil surface of both the newly exposed areas as well as the debris slopes such that revegetation (natural regeneration or planting) might occur; and (iv) halting and diverting run-on from upslope to avoid further cutting, shearing, or soil saturation.

Sediment storage in stream system. The sheer volume of the sediments involved are such that VGT might only play a very localized role in such things as: (i) trapping sediments to reduce siltation of lowland irrigation and drainage canal systems (e.g., in banana plantations); (ii) stabilizing and trapping sediments desposited primarily in ephemeral drainages and first-order streams, and (iii) stabilizing sediments in streamside zones for reclamation as agricultural lands.

"Where's the stream channel?" VGT could play a modest role in attempting to influence where the future channel might eventually develop. River training works with gabions and concrete walls are extremely expensive and often a complete waste of money. Vetiver diversion hedges at key points would be much lower cost and in the smaller stream systems (first and second order streams) could be at least as effective as hard structure in 'suggesting' where the channel might develop. Where hard structures are required, it would be recommendable to protect them from undercutting by establishing vetiver hedges along all of points of contact between the structure and the soil.

Sediment inundation. In these areas the challenge is to stabilize the soil surface so that the sites can either be reclaimed for agricultural use (e.g., through overseeding with leguminous cover crops or pasture grasses) or reveg-

etated. VGT is an ideal system for this use.

Not all future risk can be avoided in new construction. As previously mentioned, bridges must cross the rivers, roads have to go through the mountains, and some homes will be built in unsuitable areas. In these endeavors, VGT should not be perceived as allowing these to be carried out in newer, even riskier or more vulnerable areas. The appropriate role of VGT here is to extend the design life and safety margin where risk is unavoidable.

Danger zones and encroachment. See *Minimizing encroachment into vulnerable areas*, above.

Post-Mitch: Where Is VGT Being Applied In The Aftermath ?

Clearly Hurricane Mitch's impacts have stirred a great deal of interest in VGT. As previously mentioned, a number of multilateral and bilateral donors, NGOs, private companies, and government agencies are recommending and promoting its use in their Central American post-Mitch construction. Among them:

® World Bank – in its ongoing projects in forestry and agriculture, in its new investment programs for road construction and rehabilitation, riverbank stabilization, rehabilitation of hydraulic works and irrigation systems, and in projects under preparation for watershed stabilization.

® Interamerican Development Bank – in its ongoing projects for watershed protection for hydroelectric dams, and in its new investment programs for road construction and rehabilitation.

® The US Army Corps of Engineers – in landslide, gully and riverbank stabilization.

® The United States Agency For International Development – in watershed stabilization and upland agriculture.

® CARE International – in rural road protection and stabilization and upland agriculture.

® Chiquita Brands and Tela Railroad Company – in construction and rehabilitation of drainage canals in banana plantations.

® Costa Rican, Salvadoran, Honduran and Nicaraguan Minstries of Transport – in road construction and rehabilitation.

® Panama's National Authority For Reverted Areas – in the Panama Canal watershed for roads, forestry and agriculture.

Will these "recommendations and promotions" result in concrete actions on the ground ? Will VGT be applied as a key technology in the aftermath of Mitch ? It remains to be seen. At this point there is simply not enough material in the region to meet the potential demand. The region will have to see a tremendous effort in propagating planting material over the next couple of years if the potential is to be realized. It is now a year later and only CARE and Chiquita Brands have made any significant investments in vetiver propagation.

III. Conclusions

VGT can play a key role in disaster mitigation and vulnerability reduction. However, we should not get too carried away on defining the potential for its impact. The purpose and role of VGT in disaster mitigation and vulnerability reduction is to protect and conserve, not nature, but our interventions within nature and our attempts to manage nature for our own ends. Extreme events like Hurricane Mitch create conditions which simply overwhelm our works and our fabricated systems. As such, VGT is not and cannot be a substitute for appropriate siting of infrastructure, for avoiding encroachment into flood plains and other vulnerable areas, for halting watershed and soil degradation, in short, for overall good natural resource management and land stewardship, for common sense, and for quality designs and construction.

Having said that, VGT can be integrated into our systems in order to make them 'more resistant' to disaster and 'more efficient' at surviving them. It can extend their useful lives between extreme events and increase their margins of safety. The success of VGT in protecting roads and infrastructure in El Salvador and in saving farmer's fields in Honduras during Hurricane Mitch proves this to be true. And, we know it can do so at such a reduced cost that should allow for its much broader application.

Finally, too often we forget, until a disaster comes along to remind us, that it is not enough that we build or design for average conditions. Engineers remember this instinctively. Natural resource professionals often do not, especially those working with the rural poor. We accept soil and crop management systems and unprotected feeder roads because we understand the farmer's and poor community's logic and time horizon; an economic calculus that does not necessarily pay attention to the medium and long terms. But what happens when the 5-year event overwhelms the pineapple, sugar cane and fallowed strip hedgerows? and the 10-year event the tree hedgerow? and the 25 year event closes the only access road for a year or more ? Or, as in the case of Mitch, an even more extreme event forces tens of thousands of rural households off the land and into urban areas whose economies cannot absorb them? . While we may not know with precision the limits of VGT, we do know that for many applications no other hedgerow or soil stabilization plant has proven more effective. As appropriate, VGT should always be included as an option in farming systems and bioengineering applications where hedgerows or soil and

slope stabilizing plantings are called for.

Certainly, for the next few years in Central America we are assured that all natural resource management, civil engineering, rural and urban development professionals will be reevaluating what constitutes "good practice" and comparing it against what they saw happen with their own eyes when Mitch hit. If we can get enough planting material produced and distributed and enough good technicans trained, maybe the next time around VGT success stories will be too numerous to tell.

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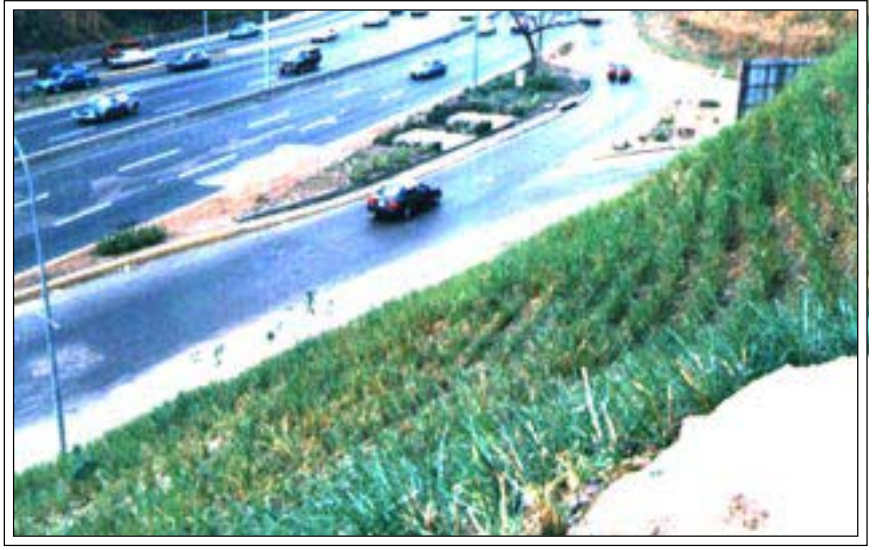
End Notes

1 A cover cropping technique: leguminous cover crop is not incorporated into the soil, rather it is : (i) slashed and the main crop is planted with a minimum till approach either before or after the cover crop is slashed, or (ii) the agricultural crop is planted (usually maize, in this case) and the cover crop planted into the field some weeks after the main crop comes up.

2 The "Quesungual" system is indigenous to the sloping lands in the humid subtropics of southern Honduras: small holder system (<2 ha); natural regeneration (150 to 500 trees/ha); pruning of trees at 1.5 to 2 m; residues and weeds slashed and left as mulch; associated with bean, corn, sorghum; use of 65kg urea/ha with grain crops beans climb or are hung on pruned trees; fields are not burned to promote regeneration of trees for next year. From farmer's perspective: reduced labor and costs; conserves soil moisture; fuelwood and mulch from tree prunings; trees provide support to bean crop and for harvested corn.



VENEZUELA: Stabilization of steep highway cut in Caracas using VS. VS should be used to rehab Caracas Flood Dammage.

VETIVER TECHNOLOGY DISSEMINATION IN CHINA FROM AGRICULTURE TO ENGINEERING

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Paper presented at the Second International Vetiver Conference, Thailand, January 2000

Soil erosion resulted in soil fertility decline and ecological environmental deterioration and formed one of the most critical issues facing our global society. Following increasing population this problem became more serious. For example, the total erosion area in China increased from 150 million hectares in 1950's to 170 million hectares at present, which accounts for 1/6 of the country land, of which soil erosion takes place in the cultivated lands for 45.4 million hectares, almost 1/3 of the total cultivated land (Zitong Gong and Guobao Luo, 1998).

Although there are a lot of soil conservation measures, the most outstanding of these is the use of vegetative soil and moisture conservation measures that are cheap, replicable, sustainable, and fully effective in stopping erosive degradation and increasing crop yield. Many examples from all of the world showed that vetiver as a boundary hedge to be the ideal plant to conserve soil and rehabilitate eroded land.

Background of vetiver technology development in China

The valuable grass vetiver (*Vetiveria zizanioides*) was disseminated to China in late 1980s as a plant for soil erosion control hedges, although it had been introduced into the county as early as in 1950's as a plant for extracting oil from its roots. Since 1980's, the Vetiver Grass has been experimented or tested in most provinces in southern China, as in Jiangxi, Fujian, Sichuan, Hunan, Guizhou, Hainan, Guangdong, Gansu, Henan, Shandong, and Zhejiang Provinces. The dissemination of the technology was promoted through World Bank supported Red Soil Project (Hu Jianye and Xue Huixian, 1998) , while some of the activities were also involved by Asian Development Bank (B. Haagsma et al, 1998). The followings are some results:

Some nurseries have been established and experiments were carried out or proposed on the biological characteristics; hedge establishment and maintenance; hedgerow impacts on soil fertility, moisture, crop yield, and soil losses;
Vetiver hedgerows were established in tea, tea oil (*camellia*), or citrus plantations in many provinces;

- The green Vetiver Handbooks was translated and distributed countrywide;
- Vetiver was used to feed fish, livestock, and to mulch ground surface of orchards;
- Vetiver hedgerows were established to protect river banks and fish ponds;
- Vetiver was planted on saline soil to ameliorate the soil properties as did in Fujian Province of southern China;
- Vetiver pruning were used to cultivate edible fungi and to make small items.

To speed up the extension of the technology in southern part of China, where 70% of the land is mountainous and soil erosion proved to be a critical problem, the China Vetiver Network (CVN) was established at the end of 1996. The main task of CVN is countrywide vetiver technology extension, i.e., to extend vetiver technology to new area or to use the grass to new applications.

Multiple measures for vetiver technology dissemination

National information service through CVN publications. The China Vetiver Network was developed based on and in cooperation with the existing national agroforestry network which has been developed for more than seven years with over 1,000 members. The national information service focus its attention on the southern part of China where tropical and subtropical climate dominate. The vetiver publications were distributed to many national universities, research institutions, governmental offices, provincial institutions, and also many county level and some township level extension stations. Many disciplines were involved, including soil and water conservation, agriculture, forestry, ecology, environmental protection, botany, and soil science, etc. The publications include:

- Vetiver Newsletter in Chinese, 4 issues with total 4000 copies each year were disseminated. The newsletter introduces new development, new technology and activities in China and foreign countries.
- Vetiver Fact Sheets (Vetiver & Soil Conservation), 4 issues totaling 8000 copies each year which introduce substantial technology to extension stations were mostly distributed to county extension stations.
- Agroforestry Today, a quarterly journal in Chinese published for 7 years, in which the vetiver grass being one of the major subjects were distributed with an averaged circulation around 1,200 copies each issue.
- Vetiver Research and Development, a proceedings of International Vetiver Workshop held in Fuzhou of China 1997, totaling 1000 copies distributed (Liyu Xu, 1998).

Different publications were produced and distributed to different

readers with different cultural background from scientists to master farmers. It bridged the gap between research and extension and accelerated the dissemination of the technology.

Technology dissemination through public mediums. Although many thousands of copies of vetiver publications were released countrywide in the past few years, there was still a strong demand for vetiver information dissemination. As a large agricultural country, there are thousands of research institutions at from national to provincial to prefecture level. Besides, there are many thousands of extension stations at county and township level involving agriculture, forestry, soil and fertilizer, soil and water conservation, livestock etc. Besides, there are also thousands of institutions involving in engineering subjects and also ecology and environment. To accelerate the technology extension, multiple papers introducing vetiver were prepared and published in national or regional journals, newspapers, and television stations. The followings is just a few of examples:

- Chinese Journal of Ecology,
- Soil and Water Conservation,
- Soil Science,
- Soil and Water Conservation in Fujian,
- Science of Jiangxi Province,
- Resources and Environment in the Yangtze Valley,
- Reference Information (a daily newspaper),
- Journal of Ecology.

Conferences and training courses. To promote vetiver technology dissemination, various conferences were organized by CVN in cooperation with different regional, national, or international institutions. These conferences provided opportunity for scientists and technicians to exchange ideas, learn new technologies, establish cooperation and linkages, and seek for new projects with joint efforts. Besides, many small training courses were held for master farmers and technicians to disseminate substantial technology.

For example, supported by The World Bank, The Vetiver Network, Natural Science Foundation of China, an international vetiver workshop was organized in Fuzhou of China in October 1997 and 100 participants attended the workshop. The main topics include:

- Results and achievement of vetiver research, experiments, application, and extension in the past decade.
- New vetiver applications and its management of extreme soil rehabilitation (seriously eroded red soil, mobile sandy dunes, toxic soils, etc.), watershed management, waterway stabilization, earth works reinforcing, pollution control, disaster prevention, etc.
- The needs of vetiver application to satisfy farmers' basic needs (fuel production for example).
- Application and management of vetiver in different agroforestry systems and different area.
- Economic and policy consideration on vetiver application and extension.
- Considerations and proposals for new vetiver projects.

Through the workshop many old users learnt new vetiver applications, while new users obtained basic information and started their tests after the conference. And many vetiver users established cooperation with their neighbors.

Just two years later, another international conference titled "Conference on Vetiver Bio-Engineering Technology for Erosion and Sediment Control and Civil Construction Stabilisation" was organized in Nanchang October 1999. In addition, some other meetings with vetiver as the only one or one of the major topics were held by CVN or its cooperative institutions in the recent few years, such as:

- South China Soil and Water Conservation Meeting (Xiamen),
- Soil Erosion and Conservation Workshop (Jiangxi),
- Vetiver Network Meeting of Fujian Province (Fuzhou)
- Yangtze River Flooding and Soil Conservation (Wuhan),
- Sustainable Agriculture in Yangtze River Basin (Nanjing),
- Vetiver for Edible Fungi Cultivation (Fuzhou),
- One-day Training Courses in Fujian and Anhui Provinces, etc.
- International Conference on Vetiver Bio-Engineering Technology for Erosion and Sediment Control and CivilConstruction Stabilisation (Nanchang).

All of these conferences plus many small training courses played an important role in disseminating vetiver technology and establishing follow up cooperation. Because the different meetings put emphasis on different subjects and different groups of people, the vetiver technology was disseminated to from universities, national research institutions to extension stations at county level or township level.

Joint field surveys and investigations. Aiming at disseminating vetiver technology and exploring new users and new vetiver applications, field surveys and investigations were carried out in Fujian, Jiangxi, Guangdong, Hubei, Hunan, and Anhui provinces in the recent few years. These investigations were organized by the China Vetiver Network and cooperated by numerous multi-disciplinary institutions at national, provincial, prefecture, county, and township levels. Through these investigations, team members learnt experiences from established vetiver application models and proposed new applications. In addition, by distributing vetiver publications and discussing with local technicians and master farm-

ers, team members encouraged more and more people to test and use the grass.

Demonstrations and visits. Watching is better than hearing. To encourage people to use vetiver technology various demonstrations were established by CVN in cooperation with numerous institutions. The demonstrations showed people with different applications, such as:

- vetiver for tea and orange tree garden terrace protection,
- vetiver for red soil amelioration,
- vetiver as a component of agroforestry systems,
- vetiver for newly built terrace stabilization,
- vetiver for edible fungi cultivation,
- vetiver for river and coastal bank and fish pond stabilization,
- vetiver for sand dune fixing,
- vetiver nursery management.

Accompanied by the organization of conference tour, these different models were extended more quickly and smoothly. Most of the demonstrations were established at sites with transportation facilities and by local technicians acting as interpreters, which was good for visitor to accept and duplicate new technology. Different demonstrations were established for different group of people. For example, in AgriWorld of Suzhou city the grass was planted along river banks, field borders, ditches as a 'environmental grass' introducing to college and middle school students.

Distribution of planting materials and mini-grants. In order to encourage new users to start vetiver program mini-grants was established and disseminated to the institutions with different disciplines. For example, in 1998, altogether US$ 10 375 was sent to 17 recipients from 7 Provinces. The mini-grants were approved based on:

- the applicants' responsibility, i.e. it is hoped that the grant recipients can do work well and very possibly to send feedback to CVN;
- the regional distribution and subject balance;
- if the recipients can seek money from other sources.

In addition, CVN organized millions of planting materials and transported to hundreds of institutions free of charge. All of these encouraged more scientists and technicians to test and use the grass. So far most of the recipients sent us feedback and used the mini-grants and/or planting materials very effectively and successfully. As most of the recipients were those who did not know or did not see the grass before, the first thing they did when they had received planting materials was to establish nursery for reproduction. And then they distributed both planting materials and technology to their neighbors.

Vetivertechnology introductiontoengineering institutions. General speaking, in the past decade since 1980's the vetiver grass has been used mostly for agricultural purpose. That is millions of hectares of range land was protected by vetiver grass. However, in the recent 20 years following national economic reform the rapid development of various constructions led to dramatic disturbance of earth materials and resulted in large amount of new soil erosion, that influenced agricultural production and caused the destruction of ditches, dams, and reservoirs and caused frequent flooding which threatened people's life. Taking Guangdong Province as an example, in the period of 1986-1992, the agricultural practices caused 811.30 km2 soil erosion with a amount of soil losses for 21 716 100 m^3, accounting for only 28.0% and 10.6% of the total erosion area and soil loss respectively (Li Guangzhi and Guo Suoyan, 1998), i.e. the nonagricultural practice caused 72.0% and 89.4% of the total erosion area and soil loss respectively. Most of the eroded area and most eroded materials was caused by mining, construction of highway, railway, power construction, quarry, etc. (table 1). These nonagricultural practices caused huge sediments in ditches, rivers, and reservoirs, and dramatically influence agricultural production and threatened people's life. Of nonagricultural factors, the construction of highway consisted of an important component. In China for example, since the national economic reform the construction of highway forms the major component of economic development and was deemed as an important channel for poverty alleviation. The total length of highway increased from 1,118 000 km in 1994 to 1,186 000 km in 1996. The annual increase reached 34 000 km. However, caused by financial limitation many highway embankments were not properly protected and caused serious new erosions.

Consequently, we decided to do our best to introduce vetiver technology to highway and other engineering institutions:

(1) CVN translated the article on vetiver grass in engineering application written by Diti Hengchaovanich into Chinese and distributed to 1 200 highway institutions via our Vetiver Newsletters.

(2) In cooperation with experts and engineers from Highway Bureau of Jiangsu Province, and Survey and Design Academy of Communications of Jiangsu Province, we prepared articles to introduce vetiver and its application in highway aspects. These articles were published in several highway journals as:

- Highway Journal of China,
- East China Highway Journal,
- Guangdong Highway Journal,
- Newsletter of Highway Society of Jiangsu Province,
- Science and Technology of Communications of Zhejiang Province,
- Proceeding of National Super Way Conference, Kunming, November 1998,
- Highway Survey and Design

of Fujian Province,

- Science and Technology of Communications of Yunnan Province.

(3) The CVN introduced vetiver at several regional and national highway conferences, such as East China Highway Conference in Xiamen in June 1998, National Superway Conference in Kunming in November 1998.

(4) In addition to the International Vetiver Workshop organized in Fuzhou October 1997, we organized the International Conference on Vetiver Bio-Engineering Technology for Erosion and Sediment Control and Civil Construction Stabilisation in Nanchang in 1999.

(5) CVN invited senior engineers and directors to go abroad to visit demonstrations. When they came back they acted as active technology disseminators. It was proved that they played a very important role in technology dissemination.

Now, almost all of the highway institutions from national to provincial to county level knew vetiver and start or wish to use the grass. Besides, some of the institutions from railway, mining, power stations etc. also knew the grass more or less.

Experiences in national networking

From above description we can see that CVN has played an important role in vetiver grass technology dissemination and extension through out the country. General speaking, what CVN has done is to encourage people as many as possible to test vetiver and to transfer the technology to others. Methodologically, the networking is to find factors which might influence VGT dissemination and solve problems on time so that VGT can be disseminated and developed more healthily and smoothly. Following is some examples.

Application models Although VGT is easy to grasp, it may be failure if the technology can not be properly used. The technology was introduced into China for years. However caused by language problem much experience obtained from foreign countries was not fully transferred into China. Once the technology was not properly used it would act as a negative sample showing people that VGT was not so successful as expected. To solve this problem CVN established some demonstrations in different province to show people how to use the grass under different conditions and for different uses. For example, during the very hot and dry season we demonstrated farmers to use vetiver pruning as mulch to reduce evaporation and protect crops.

Keeping VGT out off secret A opposite example is that when people used VGT successfully and got profit from selling planting materials, contracting projects with highway bureaus, cultivating mushrooms etc., they may want to keep it in secret, in order to make more profit without competition. As a result, the dissemination of technology was again influenced. To solve this problem CVN disseminated the basic knowledge and successful experiences via its publications with large circulation in order to break through possible blockades.

Quality control Following increasing enthusiasm in using vetiver for highway stabilization, CVN established bridge between highway institutions and farmers who produce planting materials so that the highway institutions got plenty of planting materials to start their protection job while farmers got considerable profit from selling seedlings. Unfortunately, another problem occurred. Some farmers sold their low quality planting materials planted many years ago and accompanied by cooked account of the amount of tiller numbers to earn money, which caused the damage of highway application. To solve this problem CVN prepared a paper on the quality of planting materials and widely distributed to highway institutions telling them how to select high quality planting materials.

International exchange VGT is a technology without borders. In the recent two years CVN invited international experts from various countries to visit China introducing their experience. For example, many China's highway institutions got interests in vetiver application because vetiver can save them 90% costs compared with traditional concrete protection. They established demonstrations themselves, or they contracted the projects with agronomists. However each of them could not arrange demonstration successfully as done by Mr Diti from Thailand. Therefore we organized an international conference to invited Diti and other international experts to give lectures and to give in situ comments to both engineers and agronomists. We encouraged our scientists and engineers to study foreign experiences and to learn from each other and to co-establish demonstrations. Besides, we organized Chinese engineers to visit foreign countries such as Thailand and Philippines.

Inviting partners from multiple disciplines Since many disciplines involved in VGT while each discipline acted as an independent kingdom, we must invite people from different disciplines to study and disseminate VGT. For example during the workshop in Fuzhou 1997 which was co-organized by Fujian Provincial Soil and Water Conservation Office there were no engineers to attend because engineers might consider it to be non of their business. To solve this problem we invited chief engineers from highway constructions to visit foreign countries and then invite them to coorganize the "Conference on Vetiver Bio-Engineering Technology for Erosion and Sediment Control and Civil Construction Stabilisation" in Nanchang 1999. Most of the conference participants were engi-

neers. The method was proved to be very successful. For the same reason we invited engineers to co-prepare articles for various engineering publication.

To sum up, VGT has developed and disseminated very quickly in the recent few years through national networking. There will be a great jump in the 21st century.

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MISCELLANEOUS MEANDERINGS OF A MILLENNIUM MAN IN SOUTHERN AFRICA

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Introduction

In November 1996 I was largely unaware of the existence of the "miracle grass", and soil and moisture conservation and land rehabilitation were only peripheral interests. Then three men; Dick Grimshaw, Tony Tantum and Paul Truong descended on me and turned my professional life upside down. In the first article of the first ever SAVN Newsletter I described Vetiver as the "conservationists' Cannabis." Unlike Bill Clinton I inhaled deeply and, just over three years on, I am firmly hooked. Still wet behind the ears, here I am attending my first World Vetiver Conference and looking forward to meeting similar junkies who have become e-mail and Vetiver soul mates. How far have I progressed into addiction? Even my prospective mother-in-law has been recruited into SAVN. How much further can one go?

What follows is largely from a personal and rather parochial view of coordinating the Southern Africa Vetiver Network for the past three years. The bias is African, particularly South African, and the focus is developing countries and the challenges we face as we enter the new millennium.

Coordinators of networks promoting Vetiver grass technologies operate at numerous levels and scales, and in contrasting physical and socio-economic environments. The roles of David Jobson in White River covering Mpumalanga (a province in South Africa), myself in Pietermaritzburg covering Southern Africa, and Dick Grimshaw in Leesburg, Virginia covering the world are fundamentally different. Yet we all face similar challenges:

- How do we secure funds to sustain our networks?
- Who do we target with support and promotion for maximum leverage?
- Where and how do we source relevant expertise and information for particular applications?
- What research should the network be promoting?
- Where do we find other champions to spread the load?
- How do we counter resistance to the technology?
- What is the most effective way of disseminating information on Vetiver?
- To what extent do we involve ourselves in works projects and propagation?

Numerous other questions also pass through all our minds. Obviously, in many cases, we will have different answers depending on where we find ourselves. Different circumstances demand different solutions. This paper does not attempt to dictate what the various solutions to particular challenges might be. Instead, it simply puts forward a number of ideas on how some key challenges might be approached.

Sustaining a network – where do we find the money?

The perennial problem – how do we pay the bills? In the past numerous networks, including SAVN, have been reliant on donations and grants from international funding agents and large private corporations. The fortunes of the networks were dictated by corporate sector and international agency policy shifts – this year soil conservation might be a priority so money for Vetiver roles in; next year poverty alleviation is the priority so the money supply dries up. Clearly, the lack of consistency and control rendered this funding source unsustainable. The challenge here for networks is to move away from donation based funding to investment based funding – investment by those who will see either direct or indirect financial returns, or some other form of return for what they are investing. This is going to demand a fundamental change in the way we conceptualise and operate our networks. For individuals and organisations to invest they are

going to want to see a service based network – if Anglo American Corporation is paying a membership subscription its mine-based environmental managers should have the latest Vetiver rehabilitation technology or advice at their finger tips. Information dissemination, as an example, will no longer be based only on what we as coordinators think is important but also on what the market regards as important. A lot of good can come out of such a shift. Network members are likely to be drawn closer. The network will no longer be some distant 'nice-to-have' free service. Instead it will be close at hand and the vested interest in its survival will be strengthened. Also, if a service is paid for its perceived value will increase. This is all very well for the Anglo's and other corporate giants who can splash out a tiny fraction of a percent of their turnover on a Vetiver network subscription. But what about Siphiwe Zondi of Biyela, central Zululand who is unemployed, who obtains occasional income from sales of Cannabis, and who uses Vetiver hedging for contouring and to hide his illicit crop from prying eyes. How is he supposed to pay – the odd parcel of 'pot' to the coordinator? Clearly, we have to look to other mechanisms and some form of cross-subsidisation has to come into play. A solution we are developing is to approach ten to twenty large mining and civil construction firms, commercial rehabilitation companies, government departments and parastatals who have a direct interest in Vetiver to become core corporate investors in the network. Conventional network members will pay a nominal fee and those who can't pay, predominantly the rural poor, will receive subsidised (free) membership. This form of investment will be linked implicitly to the level of service - through their operational divisions, core corporate investors are likely to demand greater services, normal members generally only want to be kept informed, and the rural poor only have access to certain network services.

Another way of sustaining a network financially is by developing a commercial division that effectively subsidises the network. There are definite opportunities in this direction but there are also problems. Let's use the Institute and SAVN as a particular example. We field numerous requests from contractors requiring Vetiver stock or technical services. One option is to levy a commission on the sales we facilitate. This has potential but is likely be an administrative nightmare. It also increases the price of stock; something we would prefer to avoid. Another option is to supply stock or services directly ourselves. With our agricultural training farm that contains a Vetiver nursery and with the expertise that exists within the Institute we have the capacity to do this. In this way we would certainly maximise the amount that could be ploughed back into the network. However, as operators of the network this places us at an immediate competitive advantage and I foresee conventional commercial operators crying 'foul'

Targets

Who do we target our promotion and support at to obtain maximum leverage? Again, it depends on what level the network is operating at. However, here are few ideas. When operating a national or regional network there are four specific areas where promotion and support could be directed:

Provincial and regional government departments/ parastatals: In most developing countries the agent of service delivery is regularly a government department or a parastatal. In South Africa much of agricultural extension is within national and provincial agricultural departments. These departments also contract in consultants, private sector agencies and NGOs to assist in delivery. If these departments are familiar with and supportive of Vetiver technologies they will write the various applications into project briefs. This forces their clients and contractors to make use of the technology. A parastatal such as Umgeni Water (bulk water infrastructure and supply) is a specific example of where an organisation that is familiar and supportive has written the use of Vetiver technology into the technical briefs of numerous works projects. Umgeni Water has actually gone a step further by setting up a nursery to supply stock to its external contractors. With encouragement, those organisations that regularly have large civil construction projects can combine entrepreneurial development options using Vetiver with large-scale rehabilitation and stabilisation operations. These organisations generally know at least two years in advance where large works projects will take place. They can identify local entrepreneurs, support the establishment of nurseries, and when the rehabilitation takes place can purchase the locally available Vetiver stock – both sides benefit.

Local Champions: Coordinators of networks rarely have the time or resources to engage Vetiver propagation and works projects directly, or to network at the very local level. In fact, this is often counter-productive as the effort could be better spent on more strategic leverage. We need to rely on local individuals and organisations to do this. These local champions require continual and pro-active nurturing, support and encouragement so as to lever maximum activity at a local level. Where do we find these champions and what are we looking for in a champion? Beyond an obvious interest in Vetiver, ideally we need to source individuals that are located in an organisation with a natural resource or agricultural focus. The day-to-day activities of the individual should regularly bring them into contact with activities and individuals with interests in or need for rehabilitation and stabilisation works. They

should preferably be local and settled rather than an external temporary staff member. Individuals from development, conservation and agricultural NGOs make ideal candidates. They usually have extensive networks ranging from government through the private sector to rural communities. They are well placed to lever funds, and they can generally operate more freely than individuals located in government and the private sector.

Mass circulation publications: The mining, civil construction, rural development, conservation and agricultural sectors all have widely circulated technical and non-technical publications and they are generally looking for pertinent articles. Articles specifically designed for these sectors can have a considerable positive impact on Vetiver technology use.

NGOs: In less developed countries, especially those where government's ability to delivery is limited, the responsibility often rests with a variety of non-government organisations. In South Africa, up until recently, small-scale farmers and rural residents generally knew more about Vetiver than the other sectors. This was because NGOs such as Eco-Link, The Valley Trust and the Institute operating in the rural development, conservation and agricultural sectors had actively championed it. These organisations are usually very effective in accessing communities and introducing new technologies as part of their operational activities.

Information dissemination With the advent of electronic networking and the move to web-based publications access to and dissemination of information on Vetiver has become far more efficient. Information is at one's fingertips, world experts are an e-mail message away and, in the case of our most accommodating Vetiver experts, responses are often immediate. However, in developing countries the vast majority of people who could or do obtain benefits from benefits from network membership do not have access to telephonic communication, let alone the Internet. The challenge in the new millennium is the effective dissemination of information on Vetiver in an accessible format to these members. Conventional postage of newsletters and other information such as simple guidelines and fact sheets must remain at the core of network activities.

Research

There exists a superb foundation of research for Vetiver technology. Much of that research is readily accessible. In developing countries the challenge is not to conduct technical research but rather to use existing technical research to inform and strengthen our methods of application and to increase geographical areas for application. With this in mind two technical research efforts that might have merit are the following:

- To determine if any existing cultivars perform better than others in the cooler high altitude environments. Alternately, although I am personally opposed to genetic engineering, there would be considerable merit in creating a genetically modified variety that performs in more temperate climates. I must admit that the vision of Vetiver hedgerows criss-crossing the hills and dales of Ireland or Wales appears a little perverse. However there are numerous sites in cooler high altitude locations of developing countries where rehabilitation would benefit considerably from Vetiver applications.
- To determine more precisely the impact Vetiver has when used in landfill site rehabilitation. We have seen how the flow of leachate from these sites is curtailed when Vetiver is planted but what is happening to the toxic substances? Are they being retained on-site or is Vetiver effectively breaking them down and converting them into something more benign.

For me the major research challenge for developing countries is in the realm of business and entrepreneurial development. Unemployment and a low skills base plague Southern Africa. It is also plagued by severe land degradation largely as a consequence of rural poverty. We need to research business development that provides entrepreneurial opportunities and income for the rural poor and at the same time contributes to improved caring for the natural resource base. Vetiver is an ideal agent that can contribute to this - technologies are simple, markets exist, and the natural resource benefits have been unequivocally demonstrated. We need to analyse the entire production system from propagation through to sales and marketing, identify and find solutions to various constraints and pitfalls, and demonstrate success through pilot projects. The Institute will be engaging this as an initiative over the next two years.

Conclusion

Despite all the challenges we face, network coordinators can take heart from the fact that we are promoting and supporting an invaluable technology with future uses that we have yet to dream about. I predict that, as the ethic of natural resource custodianship evolves so will the demand for our services increase and, with this demand, so will the resources necessary to sustain our networks role in. I don't think I am out of a job just yet!

A NEW NURSERY FOR FINCA CRISTINA COSTA RICA

by Linda Moyher, Paraíso - Costa Rica

There is a new vetiver nursery in full production in Paraíso, Costa Rica. Over the past six months we

have been distributing small quantities of planting material among the local farmers, but we now have sufficient quantities available to distribute with no rationing. Our operation is not for profit but for promoting soil conservation among small and medium-sized farmers of Paraíso. The price we ask for plants is minimal, just enough to cover the cost of the transplants and maintenance.

At Cristina Farm (*Finca Cristina*) we have always been aware of the need to protect the soil which is the resource that permits us to earn a living. (Finca Cristina is an organic coffee grower and roaster owned and operated by Linda Moyher and her husband Ernesto.) On many occasions we have seen the force and the fury of the water that washes mercilessly over the denuded fields and the unprotected riverbanks. Here in Paraíso the rains have fallen for more than twenty-two months without any summer or dry season; our neighbors' losses are evident in the chocolate colored streams and rivers. Cabbage and potatoes can be replanted, but each time the soil has less to give and its productivity is more limited.

In November 1997 we obtained our first vetiver plants from Dr. Briscoe which we planted along the principal drainage ditch along with a few plants behind the house. Later we requested another sackful in order to do some trials according to the instructions published in the Vetiver Newsletter #18. We tried leaving some plantlets to soak for several days in water and another batch to soak in manure tea. We planted different batches—some straight up (vertically) and others at a 45° angle. The results were good, they all sprouted and those that had soaked in the manure tea and were planted at 45° grew best.

Impressed with what we had learned and motivated by Peace Corps volunteer Dominic "The Vetiver Kid" Ackermann, we wanted to do more. We requested assistance from the *Red Latinoamericana de Vetiver* (LAVN) and Jim Smyle and Joan Miller paid us a visit. They inspected the area we had chosen to plant the nursery and they showed us various techniques for planting and advised us about the project.

We had chosen the particular spot, not only because it is flat and treeless, but also it is located between the coffee fields and the river. For many years we had tried planting it with vegetables and beans, and as a coffee nursery without good results. We did not know why, but we decided to try vetiver since all the literature reports that it would thrive in poor soils. This turned out to be an excellent decision because the vetiver has turned an empty lot into a productive area filled with wildlife. Then we realized that it was a drainage problem and the high water table that made the site unproductive until now. This the vetiver did not mind at all, and in fact it is well adapted and has thrived in the wetness. Because of the abundant rainfall the site resembles a swamp which has become a rich habitat for different species. There are many insects and spiders that provide good feeding for the many birds that have been spotted there such as migrant warblers, wrens and the beautiful indigo bunting.

In June 1998 we received generous monetary assistance from the *Red Latinoamericana de Vetiver,* and we set to work immediately. From a nearby farm we dug up sufficient material to plant in one day. The nursery site had been already cleared and we used the existing seed beds from the previous year's coffee nursery. Three workers separated the material and planted 2,500 individual tillers at 40 centimeters between plants in three rows. This represents a total area of 350 square meters.

The tillers showed no great enthusiasm for sprouting since the mother plants had been sprayed with herbicide shortly before we dug them up. Since it was the only planting material available in the area, we had no other option than to use it or postpone the project for a year due to the pressures of time and work on the farm. This represented a significant delay due to slow sprouting and growth, but finally the plantlets recouped their strength and survived. Today there is no evidence of ill effects from the pesticide in the nursery although the vetiver has all died out on the farm from which we originally got the planting material.

We have not applied any fertilizer. The weeds grew rapidly during the first six months, but we only did two weedings. At nine months the plants closed in completely and no more weed control was necessary. But ever cautious because of the poor luck we had with other crops on the same site, we did not care to risk all the nursery plants there. Also, for reasons of curiosity and scientific interest we planted some in other areas of the farm where the soil and conditions varied. Furthermore since vetiver is not very well known in Paraíso, we wanted to plant some plots to demonstrate the multiple applications of vetiver for our many visitors.

The demonstration plots are:

1. bank stabilization around the sedimentation tank
2. coffee field drainage ditches
3. contour planting for terracing on an eroded hillside
4. reclamation of impoverished soils
5. boundaries and windbreaks for vegetable plots
6. test plot for poor sandy soil
7. use of the leaves as mulch in various places

One year after planting we harvested the first 75 clumps that upon dividing yielded 1,350 tillers for the first sale. The largest clump yielded 62 plantlets while the average was only 18. We sold 1,000

and enlarged the nursery area with 350 new plants. As of today the nursery is double its original area, allowing for a secure supply of planting material.

To date we have sold 4,600 plants and the demand is growing. With an average of twenty-five tillers the clumps are now more vigorous than before. Planting material from our nursery is now prospering in the following areas of Costa Rica:

1. Lankester Botanical Garden of the University of Costa Rica;
2. Coffee mill in Orosi for bank stabilization of the oxidation ponds;
3. Coffee mill in San Marcos for bank stabilization of the oxidation ponds;
4. Organic coffee farms in Pejivalle, Santa Maria de Dota, and Paraíso;
5. Internal roads on a coffee farm in Orosi;
6. Public road in Quepos;
7. Rural development project in Paraíso;
8. Restoration of a creek bed after a flood in Cachi;
9. Erosion control on fruit farm in Orotina; and
10. Small quantities among neighbors;

We have observed that the vetiver roots form a thick strong network to a depth of approximately 20 centimeters, even though the literature reports greater penetration. This we attribute to a combination of hard clay soil and a high water table. Another limiting factor for vetiver growth is the lack of sunlight, which suggests that the ditches in the shady coffee fields will require a different treatment.

From this experience we have learned the following lessons.

1) For a robust nursery you should use only the best quality planting material. If there are small tillers they should be planted with two or three together to assure survival and vigurous growth.
2) Periodic pruning stimulates growth and lets in sunlight.

We are not trying to make a profit from our nursery operation. Nevertheless, it should be self-sufficient. The tasks are done after regular working hours so as not to interfere with normal farm labors. This provides an additional income for the workers who have learned to appreciate the vetiver and have even taken plants for their friends to plant. The principle purpose of the vetiver nursery has always been for the use and benefit of the small farmer and this is being fulfilled.

At the Second International Vetiver Conference in Thailand these skilled Thai handicraft workers demonstrated their skills in basketing making with vetiver grass. Thailand is willing to train foreigners in these skills if they wish to come to Thailand. Photo Credit: Dick Grimshaw

Thailand: completely rehabilitated from wasteland to a beautiful forest in seven years using VS. This drianage line is ponded by a small dam and proteced by vetiver. Photo credit: Dick Grimshaw

A VETIVER INDEX
VETIVER NETWORK FILES FOUND ON THE HOMEPAGE
http://www.vetiver.org
Go To
VETIVER INDEX

CONTENTS BY SUBHEAD:

AGRICULTURAL USES OF VETIVER
AGRONOMY
BIBLIOGRAPHICAL INFORMATION
BIO-ENGINEERING
COLD CLIMATE GRASSES (warm season grasses)
CONFERENCE ANNOUNCEMENTS
DATA BASE
DISASTER MITIGATION
DISSEMINATION OF VETIVER TECHNOLOGY
ECONOMICS AND SOCIAL ISSUES RELATED TO VETIVER
EDITOR'S NOTES
ENVIRONMENT AND VETIVER
FLOOD CONTROL
FORESTRY AND VETIVER
FORESTRY TECHNICAL
FRENCH TRANSLATIONS OF SELECTED PAPERS FUNDING SOURCES GENERAL VETIVER (OVER VIEWS)
GENETICS AND TAXONONOMY
GROUND WATER AND VETIVER
MEDICINAL AND INSECTICIDAL USES OF VETIVER
MINING AND VETIVER
NETWORKS
NEWSLETTERS
OTHER TECHNOLOGIES
PARTICIPANTS (VETIVER NETWORK)
PETROLEUM INDUSTRY
POLLUTION CONTROL AND VETIVER (VETIVER AND TOXICITY)
PUBLICATIONS
ROAD/ HIGHWAY INFRASTRUCURE VETIVER APPLICATIONS
SOIL AND WATER CONSERVATION APPLICATIONS OF VETIVER
SPANISH TRANSLATIONS OF SELECTED PAPERS
VETIVER SUPPLIERS AND CONSULTANTS
WETLANDS AND VETIVER

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VETIVER SUPPLIERS AND CONSULTANTS

MARKET PLACE — VETIVER CONSULTANTS AND VETIVER SUPPLIES

WETLANDS AND VETIVER

1. Application of Vetiver Grass Technology in Off-Site Pollution Control
2. Streamside Buffer Strips Improve Water Quality and Provide Wildlife Habitat
3. Tolerance to herbicides under selected wetland conditions
4. Wetland Research in Australia

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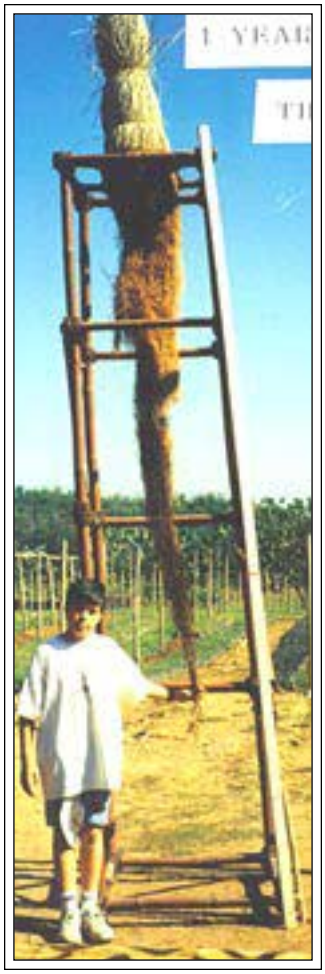
An example of Thai "fine" handicrafts based on vetiver grass weaving material.
Photo Credit: Dick Grimshaw



NO WORDS NEEDED

Table of Contents

THE SECOND INTERNATIONAL CONFERENCE ON VETIVER. VETIVER AND THE ENVIRONMENT. 1

VETIVER AND WATER -- AN ENHANCED PERSPECTIVE 2

WHERE DO WE GO NEXT? 3

A TECHNICAL DESCRIPTION OF VETIVER GRASS TECHNOLOGY (VGT) .....`4

THE GLOBAL IMPACT OF VETIVER SYSTEMS 5

NEW BOARD DIRECTORS APPOINTED TO VETIVER NETWORK MISCELLANEOUS NEWS 8

DEVELOPMENT MARKETPLACE A WORLD BANK INITIATIVE STABILIZING HOMES ON STEEP HILLSIDES IN SOUTHERN CALIFORNIA 9

VETIVER SYSTEM FOR ENGINEERING 10

THE SECOND INTERNATIONAL VETIVER CONFERENCE --THAILAND -- A SUMMARY 12

EROSION CONTROL IN AGRICULTURAL AREAS: AN ETHIOPIAN PERSPECTIVE 14

THE PILOT PROGRAMME FOR PROMOTING VETIVER GRASS IMPLEMENTED BY THE PEOPLES RURAL EDUCATION MOVEMENT (PREM),ORISSA,INDIA).....20

TABLE OF CONTENTS

BEST PRACTICES -- ESTABLISHING A NATIONAL VETIVER DIFFUSION PROGRAM: EXAMPLE OF MADAGASCAR, A COUNTRY ERODING INTO THE SEA. 29

EXPERIENCES OF THE LATIN AMERICAN VETIVER NETWORK - DISSEMINATION AND PROMOTION 36

PACIFIC RIM VETIVER NETWORK. OVERVIEW OF OPERATIONS 40

EUROPEAN AND MEDITERRANEAN VETIVER NETWORK -- UNDER A MEDITERRANEAN CLIMATE 44

THE VETIVER NETWORK PHILIPPINES NETWORK DEVELOPMENT DECEMBER 1996 - 1999 46

PROMOTION OF VETIVER GRASS TECHNOLOGY IN THE PHILIPPINES: THE VETFARMS INC. EXPERIENCE 54

DISASTER MITIGATION AND VULNERABILITY REDUCTION: PERSPECTIVES ON THE PROSPECTS OF VETIVER GRASS TECHNOLOGY 53

VETIVER TECHNOLOGY DISSEMINATION IN CHINA FROM **AGRICULTURE TO ENGINEERING 62**

MISCELLANEOUS MEANDERINGS OF A MILLENNIUM MAN IN SOUTHERN AFRICA 67

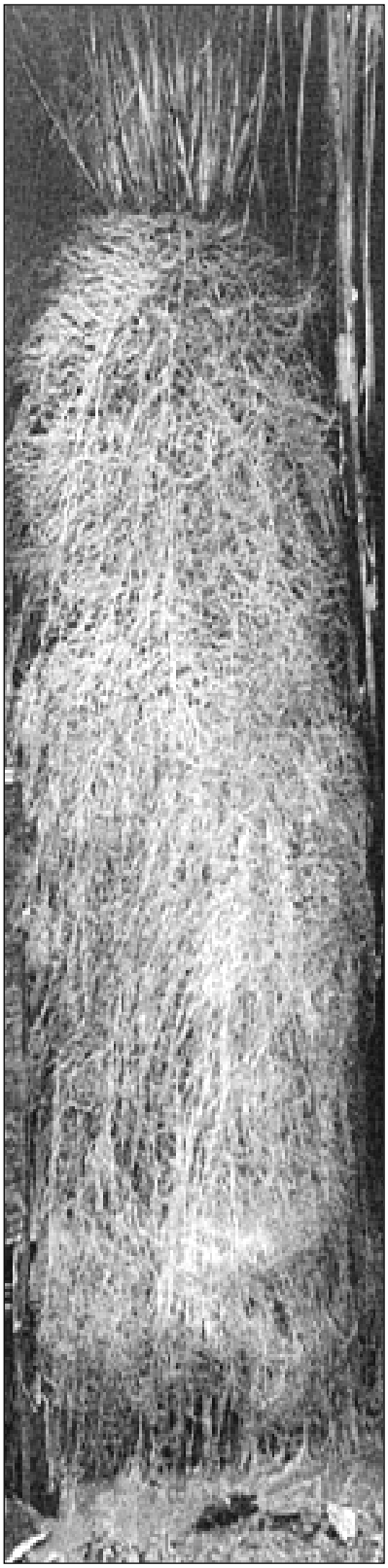
A NEW NURSERY FOR FINCA CRISTINA COSTA RICA 68

A VETIVER INDEX --VETIVER NETWORK FILES FOUND ON THE HOMEPAGE THE VETIVER NETWORK 71

DIRECTORS AND OFFICERS THE BOARD 80

COORDINATES OF REGIONAL AND NATIONAL VETIVER NETWORKS 80

New friends - Oscar Rodriguez, Tony Tantum, Bood Hickson - Thailand 2000. Photo Credit: Dick Grimshaw



Thirteen months of vetiver root growth - 2 meters - Diti Hengchaovanich's pride and joy! Photo credit: Ditii

Vetiver grass was planted on a very unstable highway slope in Queensland. Top left shows how all the local grasses had been destroyed by the "tar" leachate from the road. Top right shows newly planted vetiver (12/22/98). Bottom left shows vetiver struggling to survive, much of it looks dead ((6/4/99). In February 2000, all the vetiver had fully recovered and the slope was stable.

Note the random planting of vetiver in upper right. This was deliberate in order to prevent build up of water on the slope (behind a conventional hedge) thus reducing soil pore pressure and chance of slippage. In fact undr this system vetiver acted as a water pump and removed excess water. Phot Credit: Paul Truong.

VETIVER NEWSLETTER NUMBER 22

NOVEMBER 2000

TABLE OF CONTENTS

- **Vetiver Network Evolves: TVN Announces Organizational Changes**
- **Message from Dick Grimshaw**

Announcements

Royal Patronage for TVN

Heineken Brewery Funds Training Program in Thailand

VN To Print Promotional Brochures

TVN Receives Grants From Royal Danish Government And The William Donner Foundation

New Technical CD-ROMs Available

Tanzania Goes Green: ***Nyasi za Vetiva - Huhifadhi Rutuba na Unyevu wa Ardhi na Kuzuia Mmomonyoko***

Call for Preproposals: Funding Available For Donner Foundation Vetiver System Research Grants

Vetiver On The Internet

Letters

Network News

- TVN Adds National Networks
- CVN Sends New Years Greetings With Postcards
- Growth In The Latin American Vetiver Network

Country Reports

- Vetiver Development In China In 2000
- Bali Hosts Vetiver Conference
- Ecuativer - Vetiver System Ready To Take On Ecuador's Environment
- Surprise Factor In Senegal
- Ghana Gold Mine To Rehabilitate With Vetiver
- Ecuadoran Promotes Sustainable Farming Using Vetiver System

Technical Papers

- Observations on the Formation and Character of Vetiver Tillers
- Vetiver Grass: Useful Tools Against Formosan Subterranean Termites Can Be Found In Nature
- Laboratory Tests Of Water-absorbing Gel For Vetiver Planting
- LSU AgCenter Researcher, Louisiana Businessman Team Up to Develop New Termite Control Material
- Case Study: Miles Bentonite Mine, Queensland - Australia

Vetiver Network Evolves: TVN Announces Organizational Changes

By Joan Miller, Coordinator - TVN

Many of you may notice the change in newsletter design, but you may not be aware of the changes which have occurred in The Vetiver Network (TVN) since publication of Vetiver Newsletter 21 in February 2000. Richard Grimshaw, President and Coordinator of TVN, moved to the Pacific Northwest Region of the United States in April. In July, Jim Smyle and I (formerly of the Latin American Vetiver Network in Costa Rica), returned to the Washington, DC area and have relieved Dick of much of the work associated with the operation of TVN. I have taken over the responsibility of TVN coordination and have set up the TVN office in our home in Arlington, Virginia (just 3 miles from Washington, DC). My responsibilities include publication of The Vetiver Newsletter, administrative duties, answering correspondence and requests of individuals, and coordinate and assist with regional and country-level network coordinators. Dick is still closely involved with TVN activities; he has been appointed Treasurer of TVN and is hoping to be able to devote more time to fundraising activities.

Other official changes have occurred in the organization of TVN as well. Dick has stepped down as President of TVN and remains Chairman of the Board, while Jim Smyle has assumed the office of President. As previously mentioned Dick has taken the newly created position of TVN Treasurer and I have been appointed to another newly created position of Vice-President and Coordinator. Mark Dafforn remains as TVN Secretary. An additional board member has also been added: Dr. Sumet Tantivejkul of Thailand.

Many of the changes reflect a new stage of development for TVN. Discussions at the Second International Vetiver Conference in Thailand in January led to the decision that it was time for others to become more directly involved in the management of TVN and that Dick needed assistance in order to improve efficiency. You can be assured that TVN is still an active organization and managed by individuals who are deeply committed to and knowledgeable of the Vetiver System. Jim Smyle authored the first nine Vetiver Newsletters when he worked at The World Bank under Dick Grimshaw. I was responsible for establishing the Latin American Vetiver Network to help promote VS in Spanish, to Mexico and Central and South America. Oscar Rodriguez of Venezuela has assumed the position of Coordinator of the LAVN.

I look forward to comments, suggestions and correspondence from TVN members; please to not hesitate to write us. - Return to top -

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Message From Dick Grimshaw

This 22nd newsletter is a milestone in TVN's history. We have a new newsletter format and a new team operating TVN. I know that Jim Smyle and Joan Miller will do an excellent job in taking TVN and the Vetiver System to new heights. They will be able to do this because TVN and its affiliated networks (last count 24) truly represent an international effort to deal with soil and water conservation, and the stabilization and rehabilitation of man made problems relating to soil and water. Nowadays most of the new Vetiver initiatives are being made by national network members, and we rely more and more on these people to undertake these initiatives and take responsibility for the results.

Since Jim Smyle and I started networking Vetiver information in 1989, communication systems have changed dramatically as a result of the Internet. Thus we have been able to communicate rapidly and effectively assuring quick decisions and rapid turn round of information. TVN's homepage has become an important source of information and receives more than 1500 hits a month. Over this same period a few but important institutions including the **World Bank, the Royal Danish Government, the Wallace Genetic Foundation, the William H. Donner Foundation Inc., and The Royal Development Projects Board of Thailand** have been extremely generous in providing grant funds and/ or services to support the world-wide Vetiver initiative. In addition, practically every bilateral and multilateral donor agency has included the Vetiver System in their projects where relevant.

I would like to make special mention of **His Majesty the King of Thailand's** Vetiver initiative. His understanding of the technology and his conviction of its value for Thailand resulted in: a huge research undertaking, practical applications and demonstrations in Thailand, the generous sharing of information through two Thai-sponsored international Vetiver conferences and the training of foreign Vetiver users. In addition Thailand sponsors the Pacific Rim Vetiver Network (PRVN) that has developed into our most important affiliated network. PRVN has published some excellent technical bulletins that have been made available to TVN users around the world. We are very proud that **Her Royal Highness Princess Maha Chakri Sirindhorn** of Thailand accepted our invitation to be TVN's Patron.

In early years we relied mainly on governments to disseminate Vetiver information through their extension services; this did not always work well. More recently we focused on establishing national networks and supporting NGOs. This approach has generally worked well. Most recently we have seen important private sector involvement in the Philippines, Australia, China, Central America, Madagascar, South Africa and Thailand. We believe this involvement will expand rapidly as more companies see the value of the technology. Private sector participation has accelerated as a result of the widening range of applications of the Vetiver System, particularly for engineering.

We still have a long way to go. More research is needed to determine the limits of its use and application. We see huge potential for Vetiver in improving both quantity and quality of water, and for the rehabilitation of vast areas of land that have been destroyed in the process of mining and infrastructure development. It is a known fact that in Guangdong Province of China, 80% of all sedimentation is derived from construction sites. In that province, Vetiver Systems have been conclusively proven to be the most effective and least costly solution for rehabilitation and stabilization.

To conclude I want you to know that having handed over the Presidency of TVN to Jim Smyle I have no intention of fading from the Vetiver scene. I will remain as Chairman of the Board and for at least the next year will be TVN's Treasurer. My intention is to focus on fund raising and creating awareness amongst policy makers of the value of the Vetiver Systems. Both are important. We need to raise funds that will help support national networks either directly or indirectly; and we need to make key policy makers aware of the value of the Vetiver System in the many areas of its application. The Vetiver System is not a technology confined to the agricultural sector, but rather to practically any sector that has natural resources links.

Dick Grimshaw, Bellingham, WA., October 15, 2000 - Return to top -

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Announcements

Royal Patronage for TVN:

Her Royal Highness Princess Maha Chakri Sirindhorn Of Thailand Welcomed As The Vetiver Network's Patron

In July, 2000, The Vetiver Network (TVN) received news of the acceptance of Her Royal Highness Princess Maha Chakri Sirindhorn of Thailand to serve as the patron of TVN. Richard Grimshaw, President of TVN released the following official announcement to Vetiver Network Coordinators:

> *I learned today that HRH Princess Maha Chakri Sirindhorn of Thailand has of July 6th, 2000 graciously accepted the invitation of TVN's Board of Directors to be the Vetiver Network's Patron.*
>
> *This is indeed a great honor for us. The acceptance of HRH as Patron recognizes His Majesty the King of Thailand's great interest and support in the Vetiver Grass System, and HRH's own interest and support for this important technology.*

HRH's official involvement with the world wide Vetiver initiative should be of great benefit to regional and national vetiver networks. Since your networks are affiliated to TVN she will be your Patron too. I know that you will use her patronage respectfully and wisely -- she and her support may be of great help in drawing the attention of country leaders and policy makers to the problems relating to the lack of effective soil and water conservation measures, and the importance of vetiver in mitigating many of these problems in an efficient and low cost manner, and the need for funding. On behalf of the entire membership of TVN, I would like to extend a heartfelt "Thank you" to HRH Princess Maha Chakri for her patronage. - Return to top -

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Heineken Brewery Funds Training Program in Thailand

The Heineken Brewery Co. Ltd. provided a grant of $50,000 to the Office of the Royal Development Projects Board (ORDPB) of Thailand to promote the use and utilization of the Vetiver System (VS). Heineken, in promoting its green label image and being dependent upon sources of clean water for its product has chosen to support environmentally beneficial technologies; especially those that involve the conservation of clean water, such as Vetiver. The Vetiver Committee of the ORDPB has decided to use this Heineken Fund for two main activities, (i) training for Thai and international participants, and (ii) dissemination of technology through publications, CD-ROMs, video tapes, etc. The main objective of the course is that after the training, the trainees will become familiar with the technology, appreciate what is being done in research, experimentation and application, and have concepts on how to promote the technology in their own regions and country environments.

The course, scheduled for 19-30 November 2000, will include lectures, laboratories, field works, and study tours on all aspects of Vetiver use and utilization. Course topics will include the importance of VS, propagation techniques and nursery management, the use of VS for both agricultural and non-agricultural activities, and alternative uses for Vetiver leaves and other plant parts. This practical, hands-on training will provide a good opportunity for trainees to learn all the techniques of propagation and planting out in the fields for different purposes. There has been great interest in the training course from regional Vetiver coordinators and individuals in attending this course. We are hoping that the success of this will lay the groundwork for further involvement from Heineken and future training courses in both Thailand and other parts of the world. - Return to top -

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TVN To Print Promotional Brochures

The Vetiver System: A Proven Solution For Agriculture, Environment And Infrastructure Protection. This is the tentative title of the first of several brochures to be produced by TVN over the next year. With funding provided by The Royal Danish Government, we plan to produce a simple color brochure in English to elevate the profile of the Vetiver System for policy makers, planners, private companies, potential donors, and professionals. As a follow-up to this, a second set of brochures is planned which cover the use of VS for other technical areas: VS for Agriculture; VS for Environmental Remediation, Pollution Control, and Reclamation; and VS for Infrastructure Protection and Roads. Large quantities of these will be printed and distributed to local networks and will have space for local contacts to be added. It is hoped that it will also be available on the Web page for others to access as well. - Return to top -

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TVN Receives Grants From Royal Danish Government And The William H. Donner Foundation

In the past months, two components of the "Vetiver 2000" proposal have received funding. The **Royal Danish Government, Danida** granted TVN approximately US$108,000 to cover dissemination of VS information and technology. Another US$100,00 was granted to TVN by the **William H. Donner Foundation** to fund the next Vetiver Awards program (to be awarded prior to 2004) and to provide matching funds for VS research projects (see page 5).

A large portion of the Danish grant (approximately 25%) has been allocated to produce another printing of the green booklet "Vetiver, The Hedge Against Erosion" in English, Spanish, and Portuguese. Additionally, TVN is funding production of the booklet in previously unavailable languages. New versions are to be available in French, Kiswahili, and Indonesian and will be produced by country Networks in order to reduce printing and distribution costs. Other funding will be used by TVN for future publications of "The Vetiver Newsletter", production and reproduction of CD-ROMS and videos, and the publication of a Vetiver System brochure for promotional use, etc. For Regional and Country Vetiver Networks we have allocated grants of US$1,000 each for "knowledge transfer" which includes financing of the development, production and distribution of promotional and technical instruments such as newsletters, homepages, CD-ROM production and replication, brochure development, etc.

During the past few months, TVN has been fortunate to receive renewed funding from another of our key donors. The **Wallace Genetic Foundation** has provided US$76,000 of which $61,000 will be used for special research, under the responsibility of **Dr. Paul Truong** of Queensland, Australia, relating to Vetiver and water. These funds will be matched by the Government of

Queensland and the University of Southern Queensland. The balance of $15,000 will be for research on the cold tolerant "jiji" grass in China, under the responsibility of **Dr. Liyu Xu**, coordinator of the China Vetiver Network. - Return to top -

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New Technical CD-ROMs Available

Dr. **Paul Truong** (Queensland Department of Natural Resources in Brisbane, Australia) has recently released two CD-ROMS on the Vetiver System. The first, ã**Vetiver System Techniques**ä, is a collection of several of Dr. Truong's previous technical CD-ROMs as well as new topics which relate to the various uses of the Vetiver System. The content of the disk are as follows:

- Vetiver Grass System: Research, Development and Applications in Queensland, Australia (1988-1997);
- Vetiver Grass System For Flood Erosion Control, A Pictorial Record (1993-1996);
- Vetiver Grass Technology for Infrastructure Protection, A Pictorial Record (Revised Edition 1999);
- Vetiver Grass Technology for Environmental Protection: A Pictorial Essay (January 2000);
- Vetiver System for River Bank Stabilization - A Pictorial Essay (March 2000).

Included in the above are photos, text and data supporting VS for each use. The second CD-ROM, ãVetiver System Resourcesä includes the following and more:

- Report on the Second International Conference on Vetiver: Vetiver and the Environment (Paul Truong);
- A Look See at Vetiver Grass in Malaysia (P.K. Yoon);
- Vetiver Grass: The Plant (Paul Truong);
- The World Bank Slide Set (Dick Grimshaw and John Greenfield);
- Vegetative Barriers a New Upland Buffer Tool USDA-ARS (Seth Dabney);
- BioEngineering Conference, Manila 1999 (Paul Truong);

Copies of the CD-ROM can be purchased from TVN at a cost of US$10 each. Please send an international money order, in US$, made out to 'The Vetiver Network' to TVN, 3601 N. 14th

Street, Arlington, Virginia, 22201, USA. - Return to top -

Tanzania Goes Green:

Nyasi za Vetiva - Huhifadhi Rutuba na Unyevu wa Ardhi na Kuzuia Mmomonyoko

This is the title of a new translation of the green book "Vetiver Grass, The Hedge Against Erosion". This version, for those of you who are unfamiliar with the language, is the Kiswahili translation, made possible by the efforts of Anthony Makoye of the Tanzania Vetiver Network (TAVEN).

Copies may be obtained by contacting TAVEN at :

P.O. Box 31050

Dar Es Salaam

Tanzania

Tel: 255(0) 744273386

Email: vetivertz1999@hotmail.com

- Return to top -

Call for Preproposals:

Funding Available For Donner Foundation Vetiver System Research

Grants

The Vetiver Network is pleased to announce a continuation of its Vetiver System (VS) research grants program. In anticipation of the Third International Conference on Vetiver in China in 2004, TVN wishes to encourage research on the theme "Vetiver and Water". Through the generosity of the William H. Donner Foundation, TVN will award grants totaling $45,000, for research on water-related aspects of Vetiver. TVN will fund **up to 50%** of the proposed research, the remaining 50% to be provided by additional sources. Applications for funding under $2000 are strongly encouraged, and small enabling grants ($100-1000) are especially favored, as is collaborative and interdisciplinary research. The maximum funding for an individual grant is $9000, which with matching funds would require a total budget of at least $18,000.

Preproposal Process

Provide TVN with a Statement of Research (less than 250 words) which describes the scope of work, including testable hypothesis and anticipated results. Clearly state total budget and amount requested from TVN. Any topic will be considered for funding; priority will be given to research on VS interrelationships with water quality, quantity, and/or distribution. (For those who are interested, the following articles by Dick Grimshaw discuss this topic: Vetiver Newsletter 22 "Vetiver and Water, an Enhanced Perspectiveä and <http://www.vetiver.org/TVN_editors_re.htm>). For preproposals considered of potential interest, TVN will request a complete research proposal; the level of detail required will depend on the size of the request and the nature of the research. Matching funds commitments (which can include both in-kind and cash contributions) must be documented prior to award. TVN may also assist, without further obligation, in providing review recommendations and contacts for potential collaboration.

Submissions

Please send all preproposals (mail, email, or fax) to

The Vetiver Network

ATTN: Donner Research Grants

3601 North 14th Street

Arlington, Virginia 22201

USA; vetiver@vetiver.org

fax: 001 (703) 243-6203

There is no deadline for submission. Further details will be posted on The Vetiver Network homepage (www.vetiver.org). - Return to top -

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Vetiver On The Internet

Below are listed several web sites which include VS technology.

http://www.wrweb.com/skylake.htm (a project in northern Thailand using vetiver for erosion and fire control)

http://www.jamesroe.com/rural/vetiver.htm (A project in Oaxaca, Mexico who have developed a Vetiver program and established a nursery)

http://www.afn.org/~afn29600/l1.html (Robert Walle, soil/water scientist worked with Vetiver and erosion control technologies in Honduras)

http://www.sedlab.olemiss.edu/uep_unit/projects/Dab_veg/index.htm (Seth Dabney of the USDA National Sedimentation Lab in Oxford, Mississippi, USA "Vegetative Barriers - A New Upland Buffer Tool". Site includes text, diagrams and photos to describe the definition, purpose and benefits of vegetative barriers, descriptions of hedge arrangements, how they function, effects on water flow and sedimentation, and more)

http://www.chiangmai.ac.th/abstract1999/Abstract/agi/abstract/agi980062.ht

ml (Abstract: "Free-living Nitrogen Fixing Bacteria in the Rhizosphere of Vetiver Grass ...", Faculty of Agriculture, Dept. of Soil Science, Chang Mai University, Thailand)

http://www.ostc-was.org/thaitech/99news_03.html (Article: "The Breeding of Vetiver in Plastic Tubes", Thailand Institute of Scientific and Technological Research)

http://www.ihe.nl/he/dicea/clm32/clm3251.htm (Vetiver technology homepage of Inter. Inst. for Infrastructural, Hydraulic and Environmental Engineering at Delft)

- Return to top -

Letters

China

From **Liyu Xu**, China Vetiver Network Coordinator:

In the Spring of 2000, over 30,000 Vetiver tillers were transported to Nanyang City in Henan Province, which is a northern province in China. The city is situated at 40º North latitude; the highest temperatures can reach over 40ºC, and the lowest temperatures usually -10ºC to -14ºC, with a minimum of - 20ºC. In Nanyang, although Vetiver did not grow as fast as in the southern part of China (Fujian Province for example) it still reached 150 cm in one growing season and was not equaled by any other grasses tested.

·Now Vetiver is planned to be used for stabilizing stream banks and environmental protection for the large project "Drawing Water from Yangtze River to North China Plain" that has been considered for decades and is going to be implemented because the water shortage is becoming more serious in the recent years in northern China.

From **Xia Hanping,** South China Institute of Botany, Guangzhou:

I recently had a chance to visit the main Vetiver projects conducted by Mr. Hong and Xu in the first half of this year.

The Xinfengjiang Reservoir Project conducted by Hong is composed of two parts, one is an up-slope of the highway accessing to the reservoir, about 7,000 m2, accounting for approximately 90% of the total area, and the other is located on the reservoir slope, nearly 1000 m2, and over

10% of the project's area.

The project was not finished until May 15th; so Vetiver only had a month of growth when I visited the site on 18 June. All in all, Vetiver planted on the highway did not grow well, and the survival rate was no more than 80% probably due to drought and high temperatures, but those planted at the reservoir had a survival rate of over 95%, in spite of the fact that it was planted later than the former, and all the seedlings were simultaneously dug up from the nursery and carried to the work site at the same time. After finishing the visit, I advised them to fill gaps by planting new seedlings, and to apply some fertilizer; which they did. This year up to the time of my visit, rainfall has been very little and the water level in the reservoir dropped from May to June! Now the Vetiver along the reservoir's banks are 7-8 m above the water level. At the time of planting the water level was only 3 m below the Vetiver. All seedlings used by Hong are bare-rooted.

Photo: Vetiver planted on slope above the reservoir in the Xinfengjiang Reservoir Project Guangdong, China.

As to Xu's quarry project implemented in Shenzhen, it seemed to have a better result than Hong's, this is likely because:

1. Xu's project was planted earlier (by two weeks);
2. Xu used bag-seedlings;
3. Xu included other plants, including *Paspalum notatum*, *Wedelia trilobata*, *Parthenocissus* sp.; and
4. Xu got sufficient funds to establish the project whereas Hong has not received anything for his reservoir project. The head of Shenzhen Municipal Minerals Administrative Bureau was satisfied with the results after he visited the project and decided that other quarries in Shenzhen needing restoration will be handed to Xu to implement.

I am extremely busy with my work, especially after CCTV broadcast the Vetiver program in the middle of April. This also indicates that Vetiver will be very promising in southern China, particularly in Guangdong. I am very confident of Vetiver's success in China.

Philippines

From **Edwin Balbarino**, Farm and Resource Management Institute/ Philippine Vetiver Network (VETINETPHIL)

Recently, I spent one week in the Sagbayan, a mountain town selected as our site for the on-farm research project for corn. I am the project leader and will introduce Vetiver side-by-side with other corn farming technologies. From Bohol, I went to Mt. Malindang, Mizamis Occidental, Mindanao for three batches of farm planning workshops in three different areas of Malindang. A total of 75 farmers participated in the workshop and about 75% of them included Vetiver in their soil and water conservation plans. The planting materials will be supplied by the VETINETPHIL members in Mindanao. Mt. Malindang is about 2,500 meters above sea level. It is a government-declared protected area and an international NGO is working in the buffer and agricultural zones to help farmers improve their farming systems to minimize population pressure in the protected area.

I also visited a Department of Public Works and Highways road project in the town of Bonifacio that uses Vetiver to stabilize slopes.

·I passed the housing sub-division project on the mountain of Cebu City which we supplied with bagged Vetiver slips to stabilize the slopes in blocks 10 and 11. Our farmers in Leyte supplied the planting materials. The delivered Vetiver (30,000) has not been planted yet because the big gullies have to be back-filled first. - Return to top -

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Network News

TVN Adds National Networks

Since the last publication of The Vetiver Newsletter in February 2000, there have been 14 new national vetiver networks established, 11 of which are located in Latin America (see article this page). The other three networks outside of Latin America are the **Tanzanian Vetiver Network** (TAVEN), the **Indonesian Vetiver Network** (IDVN) and the **Indian Vetiver Network**.

TAVEN is coordinated out of Dar es Salaam, Tanzania by **Anthony Makoye**. Activities thus far

have included dissemination of a promotional document titled "Highlights on Vetiver Grass Technology" which was well received by the Tanzanian Parliamentary Environmental Committee, development of a VS promotion team, translation of "Vetiver, The Hedge Against Erosion" into Kiswahili (to be published this year), completion of "Vetiver Grass for Soil Erosion Control: A Planting Guide" (also to be published this year), and the establishment of 5 nurseries and 10 demonstration sites around Dar es Salaam with plans for expansion. Contact information: TAVEN, P.O. Box 31050, Dar es Salaam, Tanzania, Email: VetiverTz1999@hotmail.com

The Indonesian Vetiver Network, is in the process of establishing a formal NGO network coordinated by **Mr. Indrawan Suparan**. IDVN is comprised of an advisory board of three Advisors for: Research on VS, Government-related issues, and the mining sector. Coordinators for IDVN include Indrawan Suparan who is to serve as Chairman and Coordinator of IDVN and as coordinator for Java and Kalimantan; **Mr. David Booth** as coordinator for Bali and East Indonesia, and **Mr. Edison Purba** as coordinator for Medan and Sumatera. Activities have included the development of a website at: www.vetiver.bizland.com/ and the current project of translating and publishing the green book "Vetiver, The Hedge Against Erosion" into Indonesian, development of a color brochure and CD-ROM to introduce and promote VS technology in all technical areas. Contact: Indonesian Vetiver Network, Indrawan Suparan, Jl. Arco Raya Buntu B16, Cipete Selatan, Jakarta 12410, Indonesia; Fax: +62 21 769-0906; Email: isuparan@telkom.net

The Indian Vetiver network is being established as an NGO by **Rajan Gandhi** in New Delhi. This network is being developed in order to increase knowledge, awareness and interest in VS amongst everyone from farmers to government institutions to the corporate sector to NGOs to researchers, etc. Plans for the network involve publishing a wide variety of informative material (brochures, books, research); developing a reference library focusing on VS; organizing lectures, seminars and workshops; and providing field and classroom training on VS. These are just a few of the objectives outlined by the network. Currently in production is a promotional video as a cooperative effort by Mr. Gandhi and Indian filmmaker **Smita Shah**. It is hoped that this short video focusing on the benefits of VS for India will help in fundraising activities of the Indian Vetiver Network. Contact India Vetiver Network, Rajan Gandhi, 12 Amrita Shergill Marg, New Delhi 110 003, celular phone: 011 98102 92484, Email: mistral@satyam.net.in - Return to top -

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CVN Sends New Years Greetings With Postcards

Dr. **Liyu Xu**, Coordinator of the China Vetiver Network, has recently received a grant through the Danish 'Information Transfer' Grants Program of the Vetiver Network for his project

"Dissemination of the Vetiver System through Postcard Distribution". Although past publications have impacted the extension efforts of VS in China, it was felt that dissemination was not wide enough nor were materials adequately shared. To strengthen dissemination efforts Liyu has proposed a low-cost method to increase visibility of VS in China. A high quality New Years postcard with pictures of uses of VS will be widely mailed during the Spring Festival Season (just prior to the planting season) which normally are exhibited in public by recipients, thus increasing their visibility. Approximately 8000 postcards will be sent to individuals in the private sector, extension stations, highway and railroad engineers and companies. This is a creative idea which we hope will produce increased interest in China. - Return to top -

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Growth In The Latin American Vetiver Network

The Latin American Vetiver Network (LAVN) has undergone many changes since publication of Vetiver Newsletter 21. With the departure of Joan Miller and Jim Smyle in late June, 2000 a new coordinator was named and eleven country networks established throughout the region.

Dr. Oscar Rodriguez has taken over coordination of LAVN from Maracay, Venezuela where he is on the Faculty in the Department of Agronomy at Central University of Venezuela. He is a Professor specializing in soil and water conservation and has published numerous papers based on his research in soil conservation on hillslopes utilizing live hedges (including Vetiver), mulch and other covers. Additionally, Dr. Rodriguez developed a project funded in 1996 by TVN's Grants for NGOs Program with the Conservation Society of Aragua, which promoted the use of Vetiver hedges in the State of Aragua. As a result, Dr. Rodriguez also was awarded one of the First Prizes of The King of Thailand Awards at the International Conference on Vetiver in Thailand in January 2000.

The LAVN will continue to publish the *Boletin Vetiver* in Spanish, serve as a dissemination point for information and contacts, particularly for the country networks in the region. It is also hoped that they will develop a new Web page in Spanish for the LAVN.

In addition to the transfer of the LAVN to Venezuela, to enhance overall effectiveness, volunteer country coordinators have been found in most countries in the region to take on some of the responsibilities within their country or region. This should help improve the dissemination of literature, provide local points of contact for those interested in learning more about VS and where to obtain planting material, increasing participation and membership in LAVN, and provide better feedback to LAVN and TVN regarding Vetiver programs within each country.

The contacts for the LAVN and the eleven networks are:

The Latin American Vetiver Network *Dr. Oscar Rodríguez - Coordinator* *Sociedad Conservacionista Aragua* *Apartado Postal 5115* *El Limón-Maracay 2105* *Venezuela* *Tel/fax: (58) 043 831734* *Email: red_vetiver@hotmail.com*	***Venezuela*** *Germán Trujillo Rada* *Red Venezolana de Vetiver / SCA* *Aptdo. 5115* *El Limón - Maracay* *Venezuela* *Tel/fax: (043) 36.18.20* *Cellular: 016-543.32.44* *Email: germantr@telcel.net.ve*
Brazil *Eng. Rogério de Souza Lima* *Caixa Postal 33130* *Rio de Janeiro, RJ* *CEP 22442-970* *Brazil* *Tel: (55) 21 96259951 (cellular)* *Email: brasilvetiver@hotmail.com* *Homepage: brasilvetiver.homepage.com*	***México*** *Nicholas Dolphin & Ana María Le Moing* *LASOS* *Apdo. Postal 124* *Oaxaca, Oax. CP 68000* *MEXICO* *Tel/Fax: (52) 951 4 34 94* *Tel: (52) 951 1 05 65* *Email: Lasosac@yahoo.com*
Ecuador *La Red Ecuatoriana de Vetiver - Ecuativer* *Atn. Piet Sabbe* *Escuela de Ciencias Agrícolas y Ambientales (ECAA)* *PUCE - Ibarra*	***El Salvador / Nicaragua*** *Ing. Ronald Chávez* *NOBS Antierosión* *Km 21 carretera a Santa Ana* *Colón, La Libertad* *El Salvador*

Avenida Jorge Guzman y Pólit *Ibarra - Ecuador* *Email: bospas22@hotmail.com*	*Tel: (503) 338-4367* *Fax: (503) 223-9823* *Email: nobs@navegante.com.sv*
Peru *Dr. Julio Alegre* *Av. La Universidad 795 La Molina* *Apartado 1558* *Lima - Peru* *Tel: (51) 1 3486017 Ext: 2117* *Fax: (51) 1 3495638* *Email: j.alegre@cgiar.org*	***Panama*** *José Luis García B.* *Ave. Pablo Arosemena, 4847* *Aguadulce - Provincia de Coclé* *Panama* *Tel: (507) 997- 5365* *Fax: (507) 998-4638* *Email: cuty_99_1950@yahoo.com*
Andean Region (Chile, Peru, Bolivia, Argentina, Uruguay) *Mauricio César Calderón Sánchez* *Cuevas Nº 480* *Rancagua - Chile* *Tel: (56) 72 231936* *Email: rialmoca@conaf.cl*	***Colombia*** *Ing. Octavio Torres Jimenez* *A. Aereo 51748* *Barranquilla - Colombia* *Tel: (57) 3553183; Cel 033-6317583; Fax: (57) 3552836* *Email: cmailto:cuty_99_1950@yahoo.com*
Chile *Ing. Pablo Molina B.* *Manuel Antonio Maira 1011 Depto. 18* *Providencia - Santiago de Chile* *Tel: (56) (2) 22 59 146 ö 09 4404425* *Fax: (56) (2) 69 63 180*	***Costa Rica*** *Linda Moyher/Ernesto Carman* *Finca Cristina* *Apartado 1* *Paraíso 1-7100* *Costa Rica*

Email: vetchile@uol.cl	*Email: organic@racsa.co.cr*

Countries without coordinators in the region will be covered by the LAVN in Venezuela. - Return to top -

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Country Reports

Vetiver Development In China In 2000

By Prof. Liyu Xu, China Vetiver Network; Nanjing - China, P.R.

(The following are some of the recent correspondence sent to TVN by Liyu Xu, Coordinator of the China Vetiver Network. We tend to print a lot of articles from China, but they have truly exhibited a wide range of uses and experiences all in a relatively short time. Much of it can be attributed to the hard work of Liyu as well as Xia Hanping, of the Southern China Botany Institute. - Ed.)

Vetiver Beautifies a County Town

Qingliu County is located in the western part of Fujian province; it is a mountainous county with its capital of over 20,000 situated along a river. A highway project included construction of a large road cut on a mountainside across the river from the town. In 1997, a landslide left much of the mountainside in the river. After the removal of hundreds of thousands of cubic meters of earth and rock, a discussion took place on how to protect huge road cuts involving up to 20,000 m2 of earth. Traditionally, large road cuts are protected by concrete to stabilize the slope and prevent further sliding, which is not only costly, but an environmental issue. The county citizens did not want a huge concrete wall visible across the river which, they claimed, would "look like a tomb" when they looked out their doors. A suggestion from the Provincial Highway Bureau, led to the decision to use Vetiver to protect the cuts in conjunction with the limited use of concrete walls at the most critical sections.

Vetiver grass was planted in March and April 1999. Planting occurred in groups consisting of two rows: a pair of rows were planted along the contour with a spacing of 20 cm between planting units and 25 cm between the rows. There were 75 cm between each pair of rows. The survival rate reached 95%; the roots developed very well and it was impossible for a person to pull out a single clump just one month after planting. A dense, living fence formed after 3 - 4 months. Since the site was located on pure, semi-weathered rock containing very little soil, the Vetiver did not grow as well as in other locations, however, it did function by providing good protection. The total cost for Vetiver planting was only 45,000 Yuan RMB (about US$ 5,487),

plus the costs of planting materials (0.1 Yuan/per tiller). The cost was only 50% of using other types of grasses. The only additional treatment the plants received was dipping the roots in a clay paste before planting (to conserve moisture), burying the plants 6-8 cm deep, and watering.

Photo: Vetiver was used in conjunction with the limited use of concrete walls at the most critical sections to stabliize and protect to protect this large roadcut. This was accepted by local citizens who felt that the usual concrete wall structure used, would "look like a tomb" when they looked out their doors.

Vetiver for Highway Protection

This site was included as part of the demonstrations during the International Workshop on Vetiver in 1997 and the 1999 Workshop on Vetiver Bio-Engineering Technology for Erosion and Sediment Control and Civil Construction Stabilization. Great progress has been made since then by both NGO and highway institutions. At the most critical section of national highway No. 205, Vetiver was planted below the road on the fill slopes in April 2000 during the rainy season, with a spacing 20 - 25 cm within rows and 1.5 m between rows. An NGO called North Fujian Agricultural High-Technology Institution contracted the project with the Highway Bureau and guaranteed that the slope with 3,000 m2 should be protected and covered with vegetation within 6 months. However the slope was already covered by Vetiver and other grasses just 100 days after planting when we visited there (other grasses were interplanted to provide vegetative cover). Vetiver not only stabilized the highway embankment but also protected the state-owned barns down the slope.

In Meixian Township of Youxi County, the newly constructed LongKou Highway, was protected using Vetiver planted on a slope of over 8000 m2 by the County Communication Bureau in October 1999. When we visited there in July 2000 (nine months after planting) the grass averaged 140 cm high with 10-15 tillers/clump. The highway was stabilized and the rice field down the road was also protected. The highway bureaus are enthusiastic about using Vetiver

because it has been found to be inexpensive, easy and has reduced the conflicts between the highway bureaus and farmers. Prior to the application of Vetiver grass, farmers often went looking for financial reimbursement due to losses incurred when their rice fields were buried by the sediments eroding from the highway embankments.

Vetiver Protection for Fish Ponds and Windbreaks Appeal to Farmers

Some people may remember that Madam Zhang coordinated the planting of Vetiver on Pingtan Island. Now the farmers themselves are enthusiastic about Vetiver and continue to plant hedges to protect the banks of fish ponds. Additionally the hedges filter sediment flowing into the ponds which otherwise cause problems for young fish.

Another farm application being used is to plant Vetiver along the ridges of their plots to form windbreaks to protect vegetables and crops. On Pingtan Island, strong winds lead to the planting of *Casuarina equisetifolia* windbreaks which were ineffective for crop protection. Farmers have become fond of planting Vetiver instead as windbreaks which occupies a minimal amount of land and has been observed to grow to a height of three meters high in one year. Some farmers have joined together and organized private groups which contract out their services on projects with engineering institutions. Additionally, the also encourage other farmers to plant Vetiver and provide planting materials. The Pingtan Charity Association has invited the China Vetiver Network to coordinate and organize training courses (the first of which will be held in September, 2000) to disseminate information on VS and train farmers.

Photo: Vetiver planted as a windbreak on Pingtan Island to protect a farmer's field of peanuts. Previous use of *Casuarina equisetifolia* did not function well as windbreaks.

Cut and Fill Establishment

VS can be used on both cuts and fills of embankments, but the survival and growth rates have differed significantly between the two. Generally speaking, Vetiver grows very well on fills. Experience has shown that it is important to replant if it is washed away during heavy rains and to repair any newly emerging gullies during the first few months after planting.

For cuts, huge cuts in particular, the results have been quite different, depending on soil type, slope gradient and aspect. In sections with deep soils and gentle slopes, Vetiver grows well. Other sections with thin soils and steep slopes and lots of rock fragments, soil moisture is extremely low and Vetiver growth has been very poor. Therefore when using VS on a huge cut requires different management techniques such as increased irrigation and fertilizer particularly during the first few months after planting to ensure a healthy and even hedge. Some sections may require the construction of small terraces to retain moisture, and use of containerized seedlings.

Demand for Planting Material Exceeds Supply

In addition to those projects mentioned above, the highway institutions in Fujian, Zhejiang, Jiangxi, Yuannan, and many other provinces were very busy with planting Vetiver during the Spring of 2000. In Jiangxi Province, over 10,000 m2 of Vetiver was planted for highway embankment protection around the Poyang Lake in Duchang County. Similar demonstrations were established in Xingguo and Xingyu Counties. In Lishui Prefecture of Zhejiang Province, Vetiver was planted in 1999 and 2000 for highway stabilization in the mountains. VS was also used for dam stabilization and quarry re-vegetation in Guangdong Province, and on copper mine tailings and gold mines in Jiangxi and Fujian Provinces, respectively. As a result, there was an unprecedented shortage in planting materials in the spring of 2000. All of the planting materials in Fujian and Jiangxi, the two largest production provinces, were sold out and the price per tiller increased from 5 cents RMB to over 15 cents RMB. To meet the demand for planting materials, many new private companies in Fujian started to establish large scale nurseries in the autumn of 1999 and spring of 2000.

VS for Quarry Rehabilitation in Shenzheng

Shenzheng is a new city established since the economic reform. To meet the needs of construction, quarries have appeared around the city causing serious point-source erosion, and threatened production of building materials. For environmental protection, two types of slopes need revegetation; loose fill formed by particles and fragments left by quarrying which are vulnerable to collapse; and cuts formed by quarrying activities, which are difficult to excavate for planting.

In the past on the fills, local authorities planted trees along with sand-filled bags on the contour,

but the bags were decomposed within 3 months and they were wash away during the rainy season.

The Luhui Garden Engineering Co. Ltd., a private company, was contracted by the local Geology and Mining Bureau of Shenzheng City to recover and revegetate the site. They prepared ditches and planted Vetiver tillers on the loose fill, and dug holes and planted containerized Vetiver seedlings on the semi-weathered rocks of steep cuts in April 2000.

VS For Slope Stabilization

A large 8000 m2 roadcut on coarse granite in Heyuan County of Guangdong Province was seriously eroded and void of vegetation. Elephant grass was planted a few years ago to rehabilitate the site, but its growth and survival rates were low. The slope was subject to erosion with numerous gullies several meters deep. The Hongri Turf & Forage Company introduced Vetiver to stabliize the slope. In April, during the rainy season, Vetiver was planted at a spacing of 1.5 m between rows and 15 cm within rows and fertilized with manure. In spite of a dry rainy season, the survival rate was 85%. In June, Vetiver was re-planted in areas where survival was low and fertilized. In August, the plants were 1.8 - 2 m high with 20 tillers per clump and the slope completely stabilized.

VS for Reservoir Landscaping

A common problem found around reservoirs is the barren strip on the shore often tens of meters high, caused by the fluctuation of the water level in the reservoir. In recent years reservoirs have become recreation sites and efforts to vegetate the banks have been unsuccessful. In the Spring of 2000 a private company established a demonstration site planting Vetiver on the unvegetated bare reservoir banks which after 4 months were greened up completely.

VS Protects Buildings

In Zhongshan (Sun Yatsen) City, building sites located on the tops and base of hills are in need of protection. Generally, concrete walls were built at the base of the hills which did nothing to stabilize the slope above where a few trees and grasses are grown. At the end of May 2000 a 45º slope of area 2000 m2 was stabilized using VS on contours planted by Hongri Turf & Forage Company . Three months later the Vetiver was 1 m high and slope stabilized.

VS Information Dissemination

The private sector has been using some creative means to distribute information on VS. For example, a dance, given the theme 'clean water and blue sky', was organized by the education bureau and Luhui Garden Engineering Co. Ltd. At the Guangdong Arts Center, VS was introduced for environmental protection using the slogan "return us a blue sky, and return us

clean soil".

Cold Tolerance - "Where Vetiver Cannot Grow"

Last year, Vetiver grass was introduced to Luliang Prefecture of Shanxi Province on the Loess Plateau to see if it could grow along the Yangtze River Basin. On 25 May 1999, 10,000 tillers were planted in a carbonaceous loess-derived soil (wind blown silt deposits). The survival rate was 40% and received irrigation in June and July. Before winter, the grass was irrigated again and buried with soil. In March 2000, the grass had not started growing and it was discovered that the roots had died, likely due to low temperatures. The lowest temperature was -20.8ºC last winter, and the top 46 cm of soil experienced freezing. There were 12 days where the temperature ranged from -17º to -20ºC. (It should be noted though that prior to planting, the plants spent 5 days in transport and may have suffered from moisture stress. The grass was transported in bags which were ventilated; temperatures reached over 30ºC, which would have aggravated moisture loss and some plants might have in dessicated soils which separated from the roots.)

In summary, Vetiver cannot be planted where soil freezes for several days, although it has been found to be tolerant to temperatures as low as - 15.9ºC. (In Jiangxi Province, it has been recorded to survive and grow well after a winter where the temperature reached a low of -15.9ºC.) Thus it is recommended that Vetiver be planted no further north than the Yangtze River Basin. - Return to top -

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Bali Hosts Vetiver Conference

(Excerpt from ÎBali Conference Summary' by David J. Booth, founder of the Ekoturin Foundation, Bali - Indonesia)

In late May 2000, a conference sponsored by **Ekoturin Foundation**'s East Bali Poverty Project was held to provide technical assistance for establishing Vetiver planted in East Bali, Indonesia and to promote the use of the Vetiver System (VS) to the Indonesian Government, NGO's and private sector individuals. Additionally, the conference served as an initiation of the East Indonesia branch of the Indonesian Vetiver Network. **Edwin Balbarino**, Coordinator of the Philippine Vetiver Network, was invited to provide technical assistance for the conference.

The ÎEast Bali Poverty Project' (EBPP), is a non-profit foundation with a mission to improve the lives of thousands of disadvantaged children living in abject poverty in isolated mountain villages that lack the basic rights of running water, sanitation, nutrition, education and healthcare.

There are many hectares of unfarmed land in Indonesia due to problematic farming conditions e.g. contours of land, height of land, extreme weather systems. This creates two main problems: 1) the sloping upland areas cannot be farmed as there is not a stable flat platform for cultivation; and 2) the combination of the sloping land, no trees (to act as barriers), and heavy rains creates extensive soil erosion.

One of Ekoturin's goals is to improve nutrition and aim for long-term food security by improving agriculture using the Îpermaculture' system for organic farming techniques. This is where Vetiver comes in. VS can help in the transformation of steep farmland on volcanic slopes, that currently support only corn and cassava, to flatter and more arable land which can grow more nutritious crops and reduce dependency on cassava. Implementation of VS would allow natural terraces to form on the steep farmland during the monsoon season and soil fertility would be improved through the addition of compost, iodised fertilizer, and worm castings. Subsequently, a balance of fruits and vegetables is to be planted on the improved farmland.

Eighty three thousand Vetiver slips were planted in three different locations of the EBPP on the arid eastern slopes of Mounts Agung and Abang, at altitudes ranging from 900-1,200 meters, in March 2000. The main purpose of this initial batch was to control erosion on the steep mountainsides during the next rainy season. Soil type, pH, climatic conditions and topography will be recorded and designated as research sites. In these three zones, Vetiver will be monitored monthly for height and shoot multiplication. This will be an ongoing process throughout the cultivation of Vetiver in Bali. All the information collected over the first 6 months and into the future will be available for Vetiver members to analyse and evaluate.

Initial trials will include pilot farms of approximately 400 square metres. In addition to planting trees as an integral part of the permaculture system, it is hoped that eventually Vetiver will be the key to reforestation, and the start of a Îfood forest', thus revitalising the ecosystem in this presently harsh environment.

The following series of questions were posed by conference participants and their responses provided by either Ed Balbarino (Philippine Vetiver Network), **David Booth** (Ekoturin) or **Richard Wendt** (a permaculture farmer with VS experience):

Q. Is there is a risk in importing species not native to Indonesia? Isn't it better to use an established crop such as lemongrass?

A. No. Lemongrass is not as strong as Vetiver ö it has a shorter life expectancy and cannot withstand the same extreme environmental conditions, and thus cannot be farmed in the same manner.

Q. Is it a similar crop to Alang-Alang?

A. Yes, Vetiver is similar to Alang-Alang, but is much stronger and has many more benefits and uses.

Q. Does Vetiver have the potential to aid in the reinforcement of riverbanks and reduce landslides? (These are major problems in Indonesia during the monsoon season)

A. Yes. Vetiver has the potential to aid in this area, however this is an area for more advanced research in the future of Vetiver use in Indonesia.

Q. Vetiver was introduced to Indonesia many years ago, and failed.... this does not give us much confidence to try again.

A. Vetiver was primarily farmed for the production of oil extracted from the roots and farmers were led to believe through ignorance that it would be a sustainable source of wealth and income. However the problems arose when the demand for the oil declined and the industry collapsed. This was not the fault of the plant but an error of judgement in farming incentives and initiatives. The key to the success of Vetiver is in the application of the crop to maximise its full potential.

Q. If Indonesia is a vast country with varying degrees in environment and climate, everyone will have different natural resources to work with, is this a concern?

A. The cultivation of Vetiver is a learning process, whereby information needs to be shared in order for errors to be minimised and potential to be realized. That is why there are regional, national and international Vetiver networks throughout the world. They function as an information network for members to share previous and current farming practices and knowledge. The vision is to create a network within Indonesia to function as a basis for the cultivation of Vetiver throughout the Archipelago; it will require a network of members to work together to grow. - Return to top -

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Ecuativer - Vetiver System Ready To Take On Ecuador's Environment

By Piet Sabbe, Coordinator - Ecuador Vetiver Network

On September 15th the board of Directors of the Catholic University of Ibarra approved a proposal of Mr. **Scott Wilson** to incorporate the new Ecuadorian Vetiver Network - Ecuativer into the 'Escuela de Ciencias Agrícolas y Ambientales (ECAA)' with Mr. **Piet Sabbe** as coordinator.

Up to that date Piet Sabbe, a Belgian settled in Ecuador since 1991, formerly with Fundación Golondrinas, had been promoting the Vetiver System (VS). Mr. Sabbe has many years of experience with VS on his own farm "The Bospas Forest Farm", established in 1995, with an adjoining tree nursery.

An agroforestry demonstration site with the system of induced terracing was originally applied using trees from the nursery planted on contour-lines. Mr. Sabbe was not satisfied with the performance of the tree hedges because trees are slow growing and the gaps between trunks allowed run-off. He experimented with bushes (*Cajanus cajan*, *Crotelaria* and *Desmodium*) and lemon grass, without good results.

A World Bank publication introduced him to Vetiver grass which is now a very important element of a viable and sustainable alternative to the damaging agriculture techniques currently practiced in the Mira-valley, in Northwest Ecuador, where his farm is located.

Up to 1,200 meters above sea level, Vetiver responded well to planting in all types of soil and since then Piet has systematically used Vetiver in all contour planting, to stabilize waterworks and previously eroded land at the edges of the field, and has had excellent results. Convinced of its efficiency, Piet has promoted VS, travelled throughout the country with bags of Vetiver slips and with the famous green booklet in Spanish "Vetiver, La Barrera Contra La Erosión".

As a result VS is now successfully used in at least 4 locations in the country, and is being researched by 2 companies. A shrimp producing company, eager to find a vegetative cover and reinforcement for the earth walls around the shrimp ponds, is investigating the resistance of Vetiver to different levels of salinity. A cement plant is working to define under what conditions VS can be used to reclaim their quarries using vegetation.

With the establishment of the "Red Ecuatoriana de Vetiver - Ecuativer" within the Catholic University of Ibarra an academic dimension is being added to the Vetiver story in Ecuador; students and researchers are invited to conduct research in all possible applications of Vetiver and it is hoped that a new generation of engineers will include VS in their package.

Despite the social unrest and political turmoil in Ecuador since 1997, Ecuativer is convinced that within the next several years VS will be accepted and applied as a standard method for erosion control and soil conservation by the national authorities, NGO's, and private companies and will be prepared for the next 'El Niño' in the year 2006 or 2007.

Photo: Bospas Forest Farm in the Mira Valley of Ecuador where VS is an essential component. A worker is cleaning out an irrigation canal protected by a Vetiver hedge.

Reports received in the last weeks have indicated that:

1. So far, VS has not been used on a large scale [in Ecuador].
2. Farmers and some NGO's reject the use of Vetiver because cattle do not like to eat it. In other words, the argument is that Vetiver has no economic value to them.
3. In other areas, mainly in very dry areas in the south of the country, Vetiver is only used as a fodder substitute as other grasses (such as Dhalis [*Panicum maximum]* or rye grass) do not grow in the region because of the drought. In these areas VS is not yet used for erosion control.
4. Authorities do not have any interest in VS. Many NGO's who have heard about VS but do not know the details, are reluctant to promote and use it.

Ecuativer expects to spend a lot of time and energy on promotion of VS in Ecuador. Attending conferences, writing articles for specialized magazines and setting up a homepage on the Internet will be part of the efforts to improve the understanding of VS here.

Requests for detailed information about VS in Ecuador and suggestions from readers in other parts of the world are welcome. Contact:

Ecuativer - La Red Ecuatoriana de Vetiver

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- Return to top -

Surprise Factor In Senegal

Vetiveria zizanioides in Senegal is not well known and rarely used for its soil or moisture conservation properties. That's because it is traditionally used for purposes far from what the professional agronomist, environmentalist or engineer advises. The wild variety (*V. nigritana*) is found along river banks and wetlands, mostly in the south. The root of the plant (*tiep* or *sep* in Wolof language) is much shorter than *V. zizanioides* and has multiple purposes. Found in urban markets sold in clumps of about 30-40 roots and 50 cm in length. It is used to disinfect and to eliminate pathogenic bacteria from water by boiling strands of the root in water. Women say that a future groom is given the "root water" to drink for a week prior to his wedding. The bride is given the water on the wedding day and is sometimes rubbed with it. A few roots are placed in a

drinking water bottle to give it "a good scen" and is given to small infants and lactating women with slight cases of diarrhea. Up until now, there has been very little Vetiver grown commercially, but that might be changing soon.

Criss Juliard
DynaEntreprises/Chemonics International - Return to top -

Ghana Gold Mine To Rehabilitate With Vetiver

Normandy Ghana Gold, the operating company for the Yamfo-Sefwi gold project in their support to local communities have established approximately 50 hectares of Vetiver grass to supply future rehabilitation and erosion control at a proposed mining project. (Source: Normandy Mining Limited - 2000 Annual Report, p. 28). - Return to top -

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Ecuadoran Promotes Sustainable Farming Using Vetiver System

The Vetiver Network is pleased to congratulate Vetiver Network member **Maria-Eliza Manteca Oñate** as one of five international winners of the Year 2000 **Rolex Awards for Enterprise**. **Fundacion Golondrinas**, the NGO founded by Maria-Eliza in 1996, set up a nature reserve on the Cerro Golondrinas where there also exists a model farm where improved agriculture techniques such as permaculture and agroforestry are being used to rehabilitate a very degraded region of Ecuador.

In 1997, Fundación Golondrinas received a US$10,000 grant from TVN as part of its Grants to NGOs project. Their project had the objective of conserving natural resources and the restoration of farm land involving the introduction of Vetiver Grass technology to farmers and rural communities through a process of training and demonstration. The grant helped to fund a Vetiver nursery and to promote the Vetiver System for local adoption at the community level. The project has been successful primarily because it incorporates the participation of local farmers.

Read about the project and the Rolex Awards at: www.rolexawards.com and about Fundacion Golondrinas at: www.ecuadorexplorer.com/golondrinas. - Return to top -

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Technical Papers

Observations on the Formation and Character of Vetiver Tillers

Chen Xuhui (Guizhou Academy of Agricultural Sciences, Guiyang, China and R.D. Hill (Dept. of Ecology and Biodiversity, University of Hong Kong, Hong Kong SAR, China)

Tillering speed, the quantity and quality of the Vetiver tillers will directly influence its propagation rate, the formation of hedgerows and the supply of grass for fodder and other purposes. Experiments were conducted at two sites in Guizhou Province, China, from 1995 to 1998 to examine aspects of tiller formation and methods to accelerate this process. Work was supported by the University of Hong Kong and latterly by the Kadoorie Foundation, Hong Kong.

Experiments were conducted at two sites, both subtropical. The Guiyang site is south of Guiyang City, lat. 26o35'N, long. 106o43'E, at an altitude of about 1100m a.s.l. Mean annual temperature is 15.3oC and mean annual precipitation is 1175mm. The Luodian site, to the south, is located near lat. 25o28'N, long. 106o37'E, at an altitude of approximately 560meters above sea level. There the mean annual temperature is 19oC and the mean annual rainfall is 1177mm. The climate is subtropical monsoonal with dry winters, during which little rain may fall for three or four months, with wet summers during which high-intensity rainfall episodes are characteristic. Soil moisture deficits probably occur in 4-5 months of the year.

Tillering

A single hill of Vetiver containing three tillers was planted in the nursery at Guiyang in April 1995. By the end of that year it had sprouted 33 tillers. Subsequently it was trimmed once yearly in March. Without replanting, the number of tillers counted each year in December, totaled 106, 191, 303 tillers in 1996, 1997 and 1998, respectively.

Tillering and Soil Types

Slips were planted, 2-3 per hill, at Luodian in March 1998. The same fertilizer was applied, and no irrigation was provided. Seven months after planting the number of tillers per plant averaged respectively 13.4, 16.1 and 24.2 for the three planting sites. It seems likely that these results reflect the different nutrient status of the sites; the third site especially had somewhat better organic matter and total nitrogen levels as well as substantially better P..

Tillering on Same Soil with Different Fertility Conditions

This trial was conducted at Luodian on sloping land with a Hapludult soil type, comparing tillering performance on farmland and on previously-abandoned, bare, eroded land. Whereas soil pH and total N were similar for both sites, the farmland had about 27% and 535% more available

N and P, and 32% less available K. Vetiver was planted in April 1995 and the number of tillers per plant was counted in August of each year, 1995-98. Results are given in **Table 1**.

The number of tillers per hill on the farmland was about double that on the bare, eroded land, except by 1998. By 1998 the plantings on bare land had to some degree caught up. This may suggest that on poor sites, while initial establishment and growth is slower eventually there is some degree of convergence in performance.

Table 1. Average Number of Tillers per Plant, 1995-1998

Year	On Farmland	On Bare land
1995	17.2	8.7
1996	21.9	8.8
1997	23.6	10.7
1998	19.9	11.4

Tillering and Moisture Supply

As is well known, Vetiver resists drought, capable of surviving for long periods. But during droughts it grows little or not at all so that irrigation is effective in promoting tillers. Two small plots, each containing 24 tillers were planted with an average of 2.5 tillers per hill in April 1998 at Guiyang. No fertilizer was applied. Severe drought followed from August to December. During this time the irrigated plot was watered to saturation once a month in September, October and November. In December the number of tillers per hill in the irrigated plot and an unwatered control plot was counted. On the watered plot there was an average of 23.5 tillers per hill compared with only 15.8 tillers per hill on the unwatered plot. Both plots were on good alluvial soil.

Tillering and Fertilizer Application on Poor Sloping Land

A trial conducted in 1996-1998 on the bareland Luodian HapA trial conducted in 1996-1998 on the bareland Luodian Hapludult aimed to show the difference between fertilizer application and no fertilizer application. Eight different fertilizer treatments were used - single applications of NPK, NP, NK, PK, organic manure, organic manure plus NPK (six treatments), as well as 2-split and 3-split applications of NPK. **Table 2** gives average number of tillers per hill annually.

Table 2. Tillering with and without Fertilizer (tillers per hill) on Poor Sloping Land

Time	With fert.	Without fert.
May, 1996	2.00	2.00
Aug, 1996	4.31	2.55
1997	6.77	4.22
1998	5.46	4.85

Without fertilizer, tillering was slower but by the end of the trial had to some degree caught up.

Effect of Trimming on Tiller Formation

Trimming stimulates the development of tillers. What is an appropriate period before the first trimming is important to know. A trial was conducted at the Luodian site in 1996-1997 (with three replications of each plot of five hills). Trimming at 20-30 cm began three months after planting in March 1996 and continued every month for a treatment. The number of tillers per hill, initially three, was counted in December 1996 and April 1997 for both the treated and untrimmed (control plots). Tillers were counted as "total" and as "effective" i.e. "effective" are unjointed, plantable tillers. Results are given in **Table 3**.

Table 3. Comparison of Trimmed and Untrimmed Hills (tillers per hill)

Initial Date Trimmed	No. Tillers (26/12/96)		No. Tillers (9/4/97)	
	Total	Effective	Total	Effective
14/6/96	7.7	4.7	8.5	5.4

21/7/96	8.2	5.4	8.8	6.1
22/8/96	9.2	7.8	10.2	8.6
22/9/96	12.4	11.5	13.8	13.0
25/10/96	11.3	11.3	12.5	12.5
25/11/96	11.2	11.2	12.7	12.7
Untrimmed	15.8	10.4	16.5	10.9
Note: Planting in March 1996 and no trimming after Nov. 1996				

Table 3 suggests that trimming as a means of increasing the number of usable tillers needs to be initiated at the suitable time. It is clear that for first trimming six months after planting, i.e. trimmed in September 1996, the number of tillers was the most and resulting in a higher usable tiller-rate, the benefits continuing until the following April. By contrast untrimmed plots continued to produce significant unusable material, around 33 per cent, as measured in December and the following April.

Tillering Rates (tillers per hill)

In subtropical Guizhou the usual practice is to establish Vetiver nurseries in March, at the beginning of the wet season and to plant out in the following wet season, the rainy summer being too short to ensure adequate multiplication and then to be reasonably sure of sufficient moisture at planting out. A further trial, using untrimmed material, was conducted to establish seasonal rates of multiplication.

It will be seen that although the proportion of unusable material fell somewhat as the hills matured, it was nevertheless still high, rising again by July 1997 when inflorescences formed for a second time. These data, in conjunction with those presented earlier, suggest that irrigation and early trimming may succeed in producing sufficient plantable material more quickly. Clearly, the present practice leads to the production of over-aged material though an earlier date for nursery planting would, in all likelihood, encounter the problem of excessively low temperatures.

Optimal Planting Densities in Nurseries

At present almost all Vetiver in China is planted as bare-root slips. The current planting density

in nurseries is 40 cm between rows and a hill interval of 10 cm, i.e. about 250,000 hills per hectare with three tillers per hill. Trials were conducted in 1997 and 1998 to explore the question of optimal planting density. Trial 1, with three tillers per hill, began in May 1997 and measurement in September and November. See Table 4.

Table 4. Effect of planting density on propagation rate of Vetiver

Date Measured	Planting pattern	Initial density hills (x10-6/ha)	Tillers (x10-5/ha)	Tillers/hill	Propagation rate
Trial I					
Sep 25 1997	0.333m x 0.200m	1.5	2.42	16.10	5.37
	0.250m x 0.167m	2.4	2.49	10.38	3.46
Nov 24 1997	0.333m x 0.200m	1.5	3.02	20.13	6.71
	0.250m x 0.167m	2.4	3.22	13.40	4.47
Trial II					
Sep 28 1998	0.333m x 0.167m	1.8	2.34	13.27	6.50
	0.250m x 0.167m	2.4	2.50	10.40	5.20
Oct 29 1998	0.333m x 0.167m	1.8	2.73	15.15	7.58
	0.250m x 0.167m	2.4	2.76	11.48	5.74
Nov 30 1998	0.333m x 0.167m	1.8	2.83	15.72	7.86

	0.250m x 0.167m	2.4	2.83	11.80	5.90

Conclusion

In the subtropical areas of China, Vetiver is mostly propagated by the cuttings from Vetiver clumps, which consist of tillers and corresponding root systems.

Therefore, to explore the formation process and character of Vetiver tillers and the methods to speed up tillering is of great significance. The result of observations indicated that Vetiver grasses possess strong tiller ability and great resistibility to adverse growing conditions, but suitable soil type and higher fertility will promote the growth and tillering of Vetiver. Tillering ability is also affected by irrigation or fertilization under the drought conditions on the barren lands.

The trial results showed that reasonable trimming of Vetiver grasses is a effective method to speed up the sprouting of tillers, and the suitable period initial trimming is six months after Vetiver was planted. It can also be seen that Vetiver grass possesses great self-regulation ability. Although the density of Vetiver cuttings planted may be greatly different, the tiller numbers are nearly the same about six months later. The suitable density of Vetiver slips in the nursery is about 1.5 x 106~1.8 x 106 plants per ha i.e. planted with a space of about 0.4m x 0.15~0.167m. As for the suitable tiller number per hill for Vetiver to be planted in nursery or field, two gives good results in terms of propagation and survival rates as well as economizing in planting material. However, further work is required to establish the relative efficiency of two tillers per hill or three in ãhedging upä and controlling erosion.

One clear problem for the province is how to obtain tillers of the optimal age for hedgerow plantings. The current practice of holding nursery stocks over the dry season before planting out is imposed by the cool spring weather early in the Vetiver production cycle, consequent fairly slow growth and the risk of drought from July or August onwards. To shorten the production cycle may be difficult. Yet not to do so was the risk of using poorly-performing over-aged material. Winter production using irrigation is probably not feasible anywhere in the province as it is too cool. This is in contrast to southern coastal provinces such as Hainan and Guangdong where such production is certainly possible in coastal areas. Under present conditions, nursery production in the warmer coastal areas with rapid shipment inland is not feasible.

Despite the difficulties, field plantings of Vetiver have been successful in Guizhou and will continue to be so provided that poor-quality tillers are discarded. One possible means by which production may be speeded up is by the use of growth hormones in the nursery. A Hong Kong trial (Vetiver Newsletter, 20) indicated enhanced root production in the nursery although field

performance after planting out is still being evaluated. - Return to top -

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Vetiver Grass: Useful Tools Against Formosan Subterranean Termites Can Be Found In Nature

Lara Maistrello and Gregg Henderson, LSU Ag. Center, Dept of Entomology, Baton Rouge, Lousiana, USA

Vetiver grass (*Vetiveria zizanioides*) is an Indian native plant whose domesticated type is cultivated worldwide in tropical and subtropical regions for its efficacy against soil erosion and for the commercial importance of its oil, extracted from the roots. People may be familiar with this plant since many soaps, perfumes and after-shave include Vetiver oil as active ingredient. Moreover, nootkatone, one of the 300 components of Vetiver oil, is used to aromatize drinks with its distinctive grapefruit flavor. What people ignore is that the same pleasant aromas ·can be our next, natural remedy against those exotic, tiny, whitish bugs devouring houses and any kind of wooden structures, and represent the major insect pests in the southern United States.

As part of our research on natural product efficacy against Formosan subterranean termites, we are performing experiments to test the response of *Coptotermes formosanus* to substrates and food sources treated with Vetiver oil and some of its components, like nootkatone. The results show that these compounds are able to disrupt termite behavior and physiology as a consequence of direct physical contact, ingestion, or exposure to the vapors. In the presence of this compounds termites show a ãlingering behaviorä, remaining on the surface all clumped together, unable to organize themselves to reach potential food sources through tunneling activity or building shelter tubes. Moreover, ingestion of wood treated with Vetiver oil or nootkatone causes the progressive death of the protozoa living inside the termite gut. Killing these symbiont microorganisms, on which these insects rely on for the digestion of their wooden food, would mean a progressive decline of a termite colony through starvation, until total extinction.

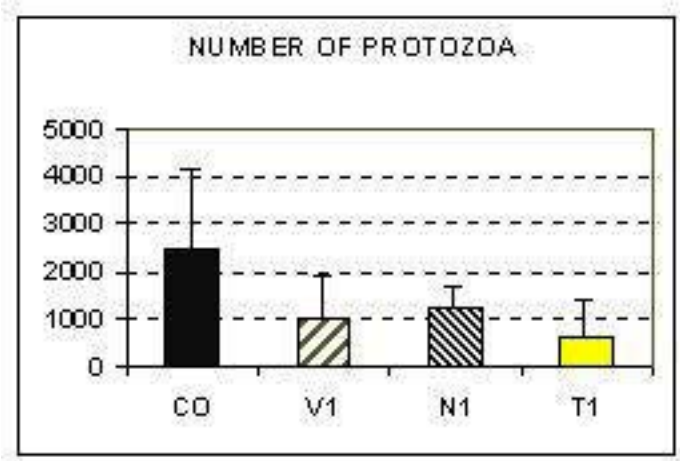

Figure 1. Tunnel length of the Formosa subterranean termits through sand to reach food source.

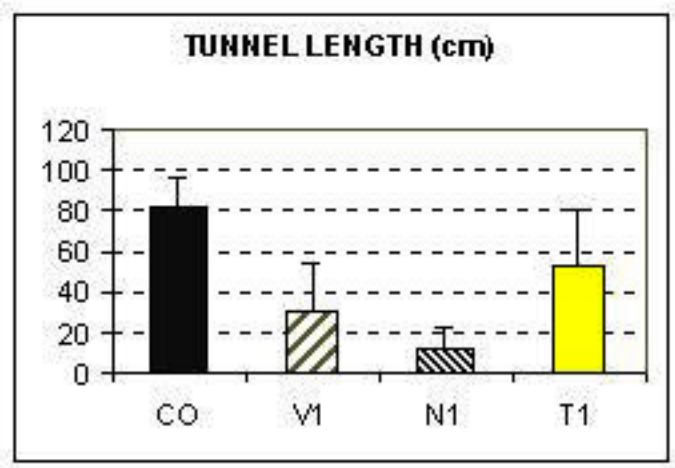

Figure 2. Protozoa population in termite gut.

Figure 1 show the results of an experiment in which Formosan subterranean termites had to tunnel through sand in order to reach the food source, a wood slice which had been treated with 1% solutions of Vetiver oil (V1) or nootkatone (N1) or Tim-Bor ®, a commonly used pesticide to prevent wood damaging by termites (T1).

The effects on the protozoa population (average number of protozoa per termite gut) show that wood treated with Vetiver oil or nootkatone was as effective as the one treated with Tim-Bor ®, inducing a high, significant reduction in the number of these microorganisms, indispensable to termites. - Return to top -

Laboratory Tests Of Water-absorbing Gel For Vetiver Planting

R.D. Hill (Dept. of Ecology and Biodiversity, University of Hong Kong, Hong Kong SAR, China)

In monsoonal climates, a major hindrance to the growth of Vetiver seedlings is moisture stress in winter. (It has now been established that at temperatures below about 10ºC Vetiver makes little or no growth, with low growth in the 10-18ºC range where water is not a limiting factor). To some degree, stress can be offset by the use of moisture-retaining materials at planting. In Hong Kong, for example, the proprietary alginate 'Alginure' has been used routinely in field trials. This note discusses the possible use of a synthetic long-chain polymer know as "Polysorb'.

"Polysorb' is of Australian manufacture and has been used in semi-arid parts of that country as an added material when trees are planted. Its water-absorbing capacity is considerable. A laboratory test at the Department of Ecology and Biodiversity, University of Hong Kong, involved placing a weighed quantity of approximately three grams of "Polysorb" in each of eight beakers to which 250ml of tap-water was added and left to stand of 48 hours. The beakers were then inverted, allowed to drain for 24 hours and the expanded "Polysorb' weighed. The average weight increase (eight replicates) was 79.2 times with standard deviation of 3.1 times.

This encouraging result led to a further experiment using Vetiver slips. Thirty-three bundles of Vetiver slips were assembled, each containing three slips and one gram of Polysorb, wrapped loosely in newspaper. An additional 33 bundles, each containing three slips and about 80g of wet ground-up newspaper as mulch, also wrapped in newspaper, acted as the control. The bundles were set out in trays in a greenhouse and watered irregularly to simulate the local regime. No fertilizer was added.

After eight weeks growth, the bundles were opened and the number of tillers counted. The average number of tillers in the 'Polysorb' bundles was only 0.27 (s = 0.57) compared with 2.27 tillers per bundle for the paper mulch bundles (s = 1.28).

Those tillers that survived in the control bundles made good growth, most reaching half a metre from an initial 20 cm. Few tillers in the 'Polysorb' bundles survived and those that did made poor growth. The major reason for the poor performance in 'Polysorb' seems to have been mechanical stress coupled with periodical water stress. It was observed that the degree of swelling and contraction of the 'Polysorb' was so great that the slips were physically raised and lowered in the trays as the material responded to wetting and drying, much in the manner in which tree seedlings are moved by the formation of needle-ice in freeze-thaw situations.

These results do not indicate that 'Polysorb' should not be used but they do suggest that some care must be used in its use. Where soils are loose and porous, planting Vetiver with a small

quantity of 'Polysorb' mixed with the soil may be effective in improving water retention. However, in the winter-dry hard, almost indurated sedentary soils of Hong Kong - and of much of southern China - it seems possible that the very considerable swelling of 'Polysorb' when wet may exert mechanical force on the slips, inhibiting growth. Clearly the trick would be to establish an appropriate 'dose' of 'Polysorb' such that water retention is enhanced without the risk of excessive swelling and shrinkage leading to damage of the slips. - Return to top -

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LSU AgCenter Researcher, Louisiana Businessman Team Up to Develop New Termite Control Material

A grassy plant used worldwide for erosion control may provide another weapon in the arsenal to combat subterranean termites, according to research conducted by the LSU AgCenter.

Dr. Gregg Henderson, an LSU AgCenter entomologist, learned of Vetiver grass's potential as a termiticide from Don Heumann, a nursery and greenhouse operator in Metairie.

"Don brought me some Vetiver plants about two years ago", Henderson said. "There was a growing interest in termites then, and I was getting a lot of calls from all kinds of people. But Don was earnest, so I took a look at what he brought." Because he was aware of the growing damage termites are causing in the New Orleans area, Heumann thought he might have uncovered a possible solution to the termite problem. "I was growing marsh grasses and other grasses in greenhouses and noticed that there were no bugs in the greenhouse with Vetiver,"Heumann said. "Everyone knew it has agents against certain bugs - people used to use it in sachets to control moths - so I decided to do my own insignificant testing on termites," he added. After Heumann decided he might be on to something, he took some plants to Henderson.

Vetiver, it turned out, is both a repellent and toxic to termites. "Our first experiment was with ground roots in sand", Henderson said, explaining that termites avoided going through the sand when it was introduced into a termite colony.

Henderson's second experiment extracted oils from Vetiver roots, and the oils also repelled termites. Henderson isolated several compounds from the Vetiver oils and discovered a chemical called nootkatone was responsible for turning away termites. The substance is also found in Alaskan yellow cedar. "We've sprayed sand with nootkatone, and it's still active after one month," Henderson said. "As a contact material it repels termites, and its vapor is toxic to them."

The LSU AgCenter has filed for a provisional patent on the use of nootkatone as a termite repellent.

Henderson and Heumann are included as co-inventors along with Dr. Roger Laine of the

AgCenter's Department of Biochemistry.

Widely known for its effectiveness in erosion and sediment control, Vetiver grass is highly tolerant to extreme soil conditions and is often used to rehabilitate contaminated lands. The deep roots anchor the plant and hold soil together on hillsides and contours. The plant's ability to grow large roots in extreme conditions makes it an ideal candidate to provide large quantities of nootkatone.

The inventors expect ground Vetiver roots containing nootkatone can be mixed with other plant materials to produce garden mulches that repel termites, while extracted oils can be applied to the soil to serve as a termite barrier.

"Much mulch is actually termite food," Heumann said. "Treating it with Vetiver oils would be very effective."

Researchers are looking at nootkatone for treating wood and soil in addition to mulches. "It's a natural product," Henderson said, adding it could create an effective barrier in the soil with regular applications at low concentrations.

"We also know nootkatone will kill termites in its gaseous state, and it has low volatility like mothballs," Henderson said. "It also may be usable against other household pests such as moths and carpet beetles.ä

More research must be done before the product can be brought to market, the inventors said. "This has potential, but it needs to be tested," Henderson said. "No one product will solve the termite problem.

"We need an integrated pest management approach" he added.

Henderson was quick to point out the discovery of Vetiver grass as a source of a new termiticide is an example of how an inquisitive businessman working with a university researcher can bring new products to society.

"It's a perfect example of a public-private partnership," he said.

(LSU AgCenter News: www.agctr.lsu.edu/1ns0601.htm) - Return to top -

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Case Study:

Miles Bentonite Mine, Queensland - Australia

(Extract from GROUNDWORK official publication of the Australian Minerals & Energy

Environment Foundation, Vol.3 (4) September 2000)

Introduction

Commercial Minerals Limited, operates a large bentonite mine and processing plant at Gurulmundi, some 35 km north of Miles, Queensland - Australia.

One of the major ecological concerns for the mine is the effect sediment laden stormwater run-off from disturbed areas may have on surrounding catchments.

In planning for rehabilitation, it was clear that the entire area would benefit from vegetation coverage to protect the soil from erosion. Due to the high sodium content, limited available moisture and low nutritional value of the bentonite spoils, the vegetation required for rehabilitation of this site had to be a specifically resilient species.

Field trials were conducted to determine the ability of Vetiver grass to establish on highly sodic bentonite spoils and to assess the effectiveness of using Vetiver grass for erosion and sediment control, for promoting growth of other plants and for hiding signs of visible erosion.

Results

The following results were observed in the period up to 10 months from planting:

- Mulching encouraged extensive shoot growth, with an average of 3 cm/week over the first three weeks.
- Areas with extended growth from the use of fertigation techniques were found to be extremely palatable to roaming cattle.
- Heavy rain inundated the Vetiver rows, with some plants being submerged for 2.5 weeks. After the water had evaporated the plants were still in healthy condition with general height retained, but little growth occurred whilst the soil was water logged.
- Samples of the runoff water were collected upstream and downstream of the Vetiver hedges during peak flow. Tests indicated that the Vetiver hedges were effective in removing most of the solids from clay contaminated storm water.
- The amount of sediment trapped by the hedges varied with the conditions of the hedges. When the hedges were complete (with no gaps), up to 200 mm of sediment was trapped, with the sediment texture predominately made up of sand and clay and less than 5% silt.
- The hedges supported 100% soil moisture saturation within a 3.4m arc along the rows. The result, deeper cracking of the soil, increased moisture retention to a greater depth

thus promoting the establishment and growth of both sown and volunteer species.

- Monto Vetiver has flourished under the harsh conditions of the trial zone including extremes in temperature and rainfall. Growth averaged 600 mm in height and 100 mm in plant base diameter after 10 months.
- The sediment trapped by the Vetiver rows now hosts several annual and perennial species, which are currently only found upstream of the hedges within one meter of the actual rows.
- The short rows planted across the drain grew particularly well, reaching approximately 1.8m in six months. These rows were very effective in trapping sediment and stopping the scouring of the drain floor.
- Vetiver has also successfully stabilised the steep batter around the dam.

Conclusion

Results clearly demonstrate that Vetiver grass will establish satisfactorily on extremely sodic soils when adequately supplied with fertiliser and water. The hedges are effectively achieving the stated objectives of the trial, namely diffusing concentrated flows, trapping sediment (which supports other plant growth) and in reducing signs of visible erosion.

For further information contact Owen Bevan (07) 4628 2108. - Return to top -

May 2001
Number 23

The Vetiver Network

VETIVER NEWSLETTER

A NEWS MAGAZINE PROMOTING THE VETIVER SYSTEM
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VETIVER SYSTEMS – THE DISSEMINATION AND ADOPTION ISSUE

By Richard Grimshaw, Chairman - TVN

Criss Juliard in his paper *"Best Practices Establishing a National Vetiver Diffusion Program"* (see TVN Newsletter #21) asks the question, "*If Vetiver Grass Technology is so simple, inexpensive and good for the health of the soil, why isn't it promoted more broadly on a national scale in the same way vaccinations are promoted to preserve an individual's health?"*

I would add: "*Why do some farmers and engineers use the technology and others do not?".* These questions and others like them must be answered if we are to move ahead more rapidly with the application and use of Vetiver Systems as we now refer to a bundle of vetiver grass technologies.

Criss Juliard continues "*The answer is not related to the attractiveness of the technology, but to the challenge of dissemination*".

I agree. I would like to illustrate this challenge by some experiences – good and bad.

Thailand has done wonderful work in researching and demonstrating VS but it has not been used as widely as expected.

Research carried out in Thailand by Suchart Montrekusol et. al. of Chiang Mai University (titled: *Farmers' Perception and Practices in Vetiver Grass Cultivation for Soil and Water Conservation in Mae Rim District, Chiang Mai Province*) had the following observations and conclusions:

"*Most farmers applied integrated farming systems. Eighty-eight percent of the farmers accessed agricultural information through neighbors and television, while they received information on using vetiver grass for soil and water conservation from government extension workers.*

"Farmers' knowledge and understanding of soil conservation and soil fertility....(and) of soil and water conservation using vetiver grass were at a good level.

[However, at the level of practical application]... "*the problems identified included: inappropriate timing in delivery of vetiver seedlings, insufficient knowledge on vetiver grass field application, insufficient labor and equipment, and insufficient knowledge on the other uses of vetiver grass.*"

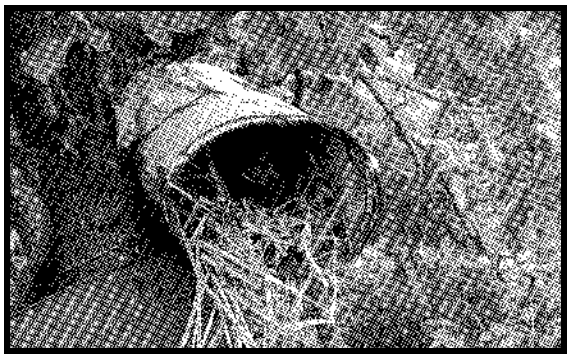

Photo 1. An alternate use for vetiver grass biomass discovered in the Eshowe area of rural KwaZulu-Natal, South Africa

Photo credit: Duncan Hay

INSIDE:

Announcements.....3
Letters.....7
Network News.....8

Country Reports
El Salvador.....10
Mexico.....11
Costa Rica.....13
Cameroon.....13

Technical Papers
Insects on Vetiver - Guam 16
Insects on Vetiver - China 17
Role of Vetiver in Stone Line Stabilization in Burkina Faso.....18

Vetiver Network Contacts.....20

These results suggest that the government's extension program is not very effective. All of the problems identified by the farmers constitute the most basic things. Could it be perhaps that the government extension workers are not well-trained? well-supervised? not sufficiently motivated? unable to visit farmers more often to participate in solving problems? What is the problem?

Problems with the transfer of knowledge through public extension services are common in most countries. We too often see poorly organized and poorly motivated government extension services. In the case of VS, we generally encounter an almost complete lack of capacity for getting basic planting material to farmers; or ability to develop that capacity in the face of farmer demand. In many countries, the responsibility for soil conservation has been passed to specialized departments. These may or may not support VS. And, where they do, they tend to look narrowly at its use and applications and fail to promote all the other valuable aspects of the technology, including, yield increases, moisture conservation, fertility maintenance, mulching, forage, thatch, etc. They too share the inability to manage the supply of plant material.

In contrast, in Zambia, the Christian Reformed World Relief Committee (CRWRC, see http://www.crwrc.org/index.html) - has been working with VS in the Eastern Province. CRWRC describes its program below.

"The Government of Zambia introduced vetiver grass to the Eastern Province of Zambia late in 1996, so to date we have had 4 growing seasons. The initial supply was managed by Agriculture Officers of the government, but one facilitator of the Reformed Church in Zambia's Planning and Development Department (RCZPDD) received 250 splits to establish a nursery where water was available. The nursery stock grew well and since that time the program has been giving vetiver splits to farmers from the nursery every year. In this specific location farmers only receive small amounts of vetiver and are responsible for propagating and replanting their own vetiver. In other areas that RCZPDD works, facilitators now network with government officers to get farmers larger amounts of around 5,000 splits of vetiver.

"...the program often introduces farmers to vetiver alongside several other soil stabilizing and improvement techniques. Vetiver is introduced and supplied to farmers only when contour bunds are properly measured and earthen contour ridges (of about 6'' high) are constructed. In the past, farmers reported that after a rainfall surface moisture could be gone in 1 to 3 days. With contour bunds, contour planting and ridging, farmers have found that surface moisture will be present for 1 to 3 weeks. Farmers have found that having vetiver on the contour bunds stabilizes them, reduces labor intensive annual maintenance, and prevents them breaching at the time of heavy rain. We have found that if farmers plant vetiver on their contour bunds they are more likely to continue establishing contour bunds with vetiver.

Although many more farmers have implemented contour bunds than have planted vetiver, we have found that if a farmer starts with vetiver he will be convinced of it, and will continue to plant it and will give splits to others as well. Farmers who experimented with vetiver in problem areas where erosion was a clear problem found that it takes about two years to become well established, but after that there will be little erosion and the former gullies will be filled in. One farmer had a washout that was as deep as his leg. Now, four years later you can't tell there was ever a problem. This farmer is convinced, and has been giving vetiver splits to fellow farmers to help them with problem areas. Farmers generally take splits from the existing band while leaving half of it there if they have no nursery. The original line will not be weakened much. Farmers have found that drought resistance (Zambia experiences 7 1/2 to 8 consecutive months with no rain) is not a problem if new splits are planted two months before the ends of the rains. Once established lack of moisture hasn't been a problem at all.

"Farmers have found that vetiver does need a bit of maintenance. Some farmers like to cut it back to 50cm, which can be done quite easily with a very sharp sickle at the beginning of the rainy season. In some cases this is done to take out the dead shoots and to stimulate new growth, in other cases it is done so the farmer can plant closer to the vetiver. No problems were found with vetiver spreading or causing other problems. Animals were reported to eat a bit of it, which appears not to harm either plant or animal. In the event that a plant does die out farmers have waited until the next rainy season to replant.

"With vetiver becoming more available and with farmers understanding its potential we feel that contour bunds will become more permanent structure. In the past, with only earth structures contour bunds not only broke with excess water, but if they where not maintained for a year or two they virtually disappeared. With vetiver established on ridges, contour ridges will maintain themselves much better and become very permanent structures, encouraging other soil conservation and water retention techniques".

This appears to be a successful introduction of VS by an NGO, after a government agency had taken the first introductory steps. Note the NGO actively works to bring plant material to participating farmers and is also working with government agencies. I suspect that there is a "push-pull" syndrome at work.

Another example of NGO/community success with vetiver is LASOS in Mexico. In 1995, a small local group called Suelos Agua y Semillas de Oaxaca (SASO) found a source of vetiver grass in Chiapas (a neighboring province). SASO became an NGO called LASOS, A.C. in 1997, and with the help of the Comisión Oaxaqueña de Defensa Ecologica, started a program for erosion control and soil restoration involving local farmers, **(continued on page 5)**

ANNOUNCEMENTS

TWO NEW PUBLICATIONS AVAILABLE FROM THE PACIFIC RIM VETIVER NETWORK AND THE OFFICE OF THE ROYAL DEVELOPMENT PROJECTS BOARD, THAILAND

Heineken Breweries Co. Ltd of the Netherlands donated US$50,000 to the Chaipattana Foundation of Thailand to promote the use of vetiver. In turn, the Office of the Royal Development Projects Board (ORDPBN) used the funds for training and dissemination of VS technology. From 19-30 November 2000 in Thailand, a training course was attended by 31 trainees from 15 countries. The training manual developed for the course includes basic information on the vetiver plant, propagation techniques, agricultural and non-agricultural applications, and alternative uses. The manual, *Manual of the International Training Course on The Vetiver System,* as well as a post-training report, *Report of the International Training Course on The Vetiver System* are available from the ORDPB. Please contact:

Suwanna Pasiri
The Office of the Royal Development Projects Board
78 Rajdamnern Nok Avenue
Dusit, Bangkok 10200
Thailand
Tel: (66-2) 280-6193
Fax: (66-2) 280-6206
E-mail: pasiri@mail.rdpb.go.th

VETIVER BOOKSTORE

The following items are available for sale from The Vetiver Network:

Printed Publications: US$5 each (unless otherwise noted)

Vetiver Grass - The Hedge Against Erosion (English and Spanish), 2000

Vetiver Grass - A Thin Green Line Against Erosion, National Academy of Sciences, 1993

The Vetiver Newsletter - past issues $1.00 each

CD-ROMS: US$10.00 each

Vetiver System Resources, Compiled by Dr. Paul Truong, 2000

Vetiver System Techniques, Dr. Paul Truong, 2000

Vetiver - La Barrera para Bioingenieria, Red Latinoamericana del Vetiver/Banco Mundial, 1999

Videos: US$15.00 each

Vetiver Grass - The Hedge Against Erosion (PAL and NTSC versions), 1996

Vetiver - La Barrera Contra La Erosion (NTSC), 1996

Vetiver - La Barrera Para Bioingeniería (En Protección y Estabilización de Infraestructura), (NTSC) 1999

Slide Sets: US$15.00 each

Vetiver Grass Hedgerows - A Photo Essay and Other Selected Data and Information, The Vetiver Network, 1999

The Vetiver Network accepts payment in US dollars via International Money Order, check draft from a US bank account, or cash (if feasible). Please contact TVN at: vetiver@vetiver.org, or 3601 N. 14th Street, Arlington, Virginia, 22201, USA for details. Proceeds from sale of items are used to subsidize associated mailing and production costs. v

THE VETIVER SYSTEM - A PROVEN SOLUTION

You will find enclosed with your newsletter a promotional brochure produced by The Vetiver Network. When unfolded, the brochure becomes a full color poster measuring 16.5" x 23.25" and summarizes the problems for which vetiver is applied, why vetiver is a useful plant, and summarizes the use of VS for agriculture, bio-engineering, water-related applications, bio-remediation and other uses. Production was made possible thanks to work donated by commercial artist Xi Shing Chang of South Carolina, USA and Premier Publishers of Bellingham, Washington, USA who subsidised printing costs as a donation to TVN. If you would like to request additional brochures, please contact TVN. Versions of the brochure in other languages such as French and Spanish will likely be produced in the future. v

The Vetiver Network Awards Program

The Vetiver Network is pleased to announce the third series of Vetiver Awards, made possible thanks to a generous grant from the William H. Donner Foundation. TVN will award a total of US$45,000 in prize money, distributed as described below. In anticipation of the Third International Conference on Vetiver, to be held in China in 2004 and whose theme will be "Vetiver and Water", one theme of the awards will be Vetiver System applications in relation to water. As always, the TVN hopes to receive many nominations for each category. The competiton for the Vetiver Awards, in years past, has brought out information that significantly increased our knowledge of vetiver's uses, applications and benefits. The deadline for nominations will be 1 October 2003. Award winners will be announced in early 2004.

Eligibility

All vetiver users are eligible, be they individuals or groups, who have shown initiative in research, or utilization or promotion of the Vetiver System. These may include farmers, technicians, NGOs, students, scientists, researchers, private companies, innovators, etc. who have produced and documented concrete, repeatable results.

Award Categories

Awards will be given in six categories:

1. Water Applications
   a) Watershed Protection/ Improvement

   b) Engineering – Natural and Constructed

   c) Quality – Pollution Control and Treatment

2. Engineering/Infrastructure Protection

3. Land Reclamation

4. Dissemination

5. Country Vetiver Award

6. Farmer/User Awards – Regional
   a) Asia
   b) Africa
   c) Latin America
   d) Other

7. Vetiver "Champion"

Award Value

Awards will range between US$500 and US$3,000 for first through third prizes.

Documentation

There is no award application form. Nominations may either be from individuals regarding their own work or be made by another person. Documentation can consist of many types of information (personal accounts, reports, articles, photographs, scientific papers, testimonials, etc.). We strongly encourage the inclusion (where relevant) of photographs and "before" and "after" photographs whenever possible. **Please be as brief and clear as possible.**

The following should be mailed to The Vetiver Network:

Name and address (phone, fax, and email if possible) of nominee

Name and address (phone, fax, and Email) of nominator (if applicable)

Project information:

Location of Project

Description of Project

Accomplishements of Project

Importance of Project

Supporting Documention (optional, but useful in determining awards)

Name and address of a reference who is familiar with the project

Award Selection

Projects will be judged on the following:

Merit: Quality of thought and methods used to accomplish the project's goals.

Relevance: Project's potential to protect/improve the environment or lower costs or improve quality of life or other noteworthy impacts.

Innovation: Originality, including using old ideas in new ways.

Application: Demonstrated usefulness of the results.

Extra credit will be given (where relevant) to those who include practical details of benefits and costs or a benefit/cost analysis or efficiency analysis (i.e., benefits/costs of Vetiver System compared to traditional or other systems).

Award Category - Details

Within these categories there are no pre-defined topics. The creativity and innovation of the user is the only constraint. The ideas listed below in each category are only illustrative to give a clearer idea of what might be interesting.

Water Applications – The theme of the International Conference on Vetiver in 2004 in China is "Vetiver and Water". Most Vetiver System applications can be thought of in terms of its relationship to and effect on water through:

a) Watershed Protection / Improvement – Use of VS for protecting and improving the quality of water through treatment of a watershed, streambanks and streamside buffers, for soil moisture and/or groundwater improvement, reduction of sedimentation, etc..

b) Engineering – The use of VS to protect and stabilize the banks and channels of natural and constructed waterways and dams.

c) Quality – Use of VS to control and treat polluted surface water, groundwater and wastewater

Bioengineering Applications – Use of VS for stabilization and protection of buildings, roadsides, railroads, bridges, industrial sites, landfills, cut-and-fill slopes, and other infrastructure or engineering applications, for slope stabilization in vulnerability/hazard reduction, etc.

Land Reclamation – The use of VS for reclamation of abandoned and polluted, toxic lands, degraded sites, gully stabilization, mine spoils and slimes stabilization and revegetation, improvement of extreme soils, etc.

Dissemination – Original publication, brochure, pamphlet, video, multimedia, etc.

Country Vetiver Award – Award given to acknowledge the best overall achievements and results of a countrywide VS program.

Farmer/User Awards – Award to acknowledge the utilization of vetiver by individuals to improve the quality of their lives through economic and environmental improvements via increased production on agricultural lands, economic/environmental improvement and/or other uses of VS such as providing mulch, fuel, artisanal uses, livestock fodder, etc. There will be awards made in each of the following regions of the world: Asia, Africa, Latin America, Other (any region outside the above)

Vetiver Champion – Open to nominations for people who have been instrumental, either in their country (region, globally) or technical area (for example, research, soil and mositure conservation, etc) in effective and dedicated promotion, investigation, improvement, etc. of the use of the vetiver system.

Please send nominations to:

The Vetiver Network
3601 N. 14th Street
Arlington, Virginia 22201
USA

Please include a self-addressed card which we can then return to you to acknowledge receipt of nomination. **v**

(continued from page 2) communities, government and non-government organizations and researchers. Originally, SASO began the project with 40 plants and there are now more than 50 nurseries growing vetiver grass throughout the state. Vetiver grass has been grown successfully in all the major soil and climate conditions of Oaxaca. Hedgerows are already beginning to form natural terraces and groups of women are cultivating vegetable gardens between the hedges. We have many other examples of this type of program, but in nearly every case success has occurred where NGOs and other agencies have worked together with farmer communities.

The CGIAR research institutes have generally not shown much interest in VS. I am not sure why (perhaps "a not invented here" problem?) and yet some individuals within these institutions have extended the technology significantly within their own area of operations. **Julio Alegre** - the ICRAF head in Peru – after visiting Kenya and seeing vetiver's potential and took the technology to Peru, he writes:

"You will not believe it but the 10 vetiver slips that I brought from Nairobi, Kenya, 5 years ago, and propagated in Yurimaguas, Peru (humid tropics) and distributed to many sites in Peru and are now used by many farmers in ecosystems from the sea level up to 4,000 m. above sea level. Most of the developments projects from the highlands (very sloping areas) are requesting the vetiveria and farmers from the tropics are supplying these material and they are getting very good economic benefits. Next phase of my research will be to combine agroforestry leguminous trees with vetiveria for double benefit, soil conservation and nutrient recycling in sloping areas of the high jungle of Peru."

The sad thing is that ICRAF headquarters in Kenya appears to take no notice of the success of their own man!

Criss Juliard, who developed a very effective vetiver program in Madagascar, summarizes what he considers the ingredients for successful VS dissemination:

"Madagascar is a best-case experience where a need to protect roads, safeguard hillsides, and improve poor agricultural soils in a particular area helped catalyze and shape a broad-based, national vetiver dissemination program. This program appears to have led to the sustainability of the technology. The Madagascar approach evolved over a three-year period and consisted of actions that: a) brought interested people and organizations together committed to vetiver, b) insured reliable and timely supply of vetiver plants to end-users, and c) applied vetiver technology according to site-specific needs. The approach was low cost, involved information campaigns, used demonstration sites for practical applications, and benefited from research and applications developed in other countries. Success can be attributed in part to close relationships with the four target groups in the vetiver communications and implementation plan: a) village associations, b) private producers, c) local elected officials, and d) professional organizations, ministries and donors. Lessons learned from the Madagascar program could prove useful to practitioners hoping to establish a broad-based and sustainable vetiver program elsewhere."

Criss Juliard is highly sensitive to environmental needs and to groups working with the environment. He has a "green thumb" and is totally committed to the technology. I believe people like him can develop VS programs anywhere they work. He is a real vetiver champion just like **Ed Balbarino** of the Philippines, **Liyu Xu** of China, **Alemu Mekonnen** of Ethiopia, and the many other committed volunteers that have made vetiver work in communities.

In recent years the engineering sector has become more interested in VS. This can be attributed to a number of factors. **Diti Hengchaovanich**, a Thai CEO of a Malaysian construction company, introduced VS to highway construction (following early demonstration by **P.K. Yoon**) for the stabilization of steep slopes on express ways in Malaysia. Hengchaovanich initiated research to better understand the tensile strength of vetiver roots and their impact on improving the shear strength of soil. This work attracted the interest of engineers particularly in Australia

and China. Demonstrations by **Paul Truong** in Australia showed the effectiveness of vetiver on extreme soils, and following a workshop for Chinese highway engineers, VS came alive in south China.

In South China, 80% of all sediment flow is estimated to be point source from construction and mining sites. Liyu Xu, China Vetiver Network Coordinator, decided to focus his attention on the key agencies responsible for this construction, primarily highway, railroad, and municipal departments. He first focussed on highway engineers - including their bosses, and is now working with railroad engineers. This approach seems to have been successful as there are now many applications of VS being used on extreme sites in South China. In parallel, the Chinese private landscaping sector has become interested in vetiver and a number of companies are getting in to the VS business. They are learning fast, and in particular are learning that the production of large quantities of plant material is essential for a successful program, and also that quality VS application is very important.

In El Salvador a commercial company, NOBS, has been very successful in promoting VS, particularly in the highway sector. Its success is a result of committed leadership, huge plant supplies, and a technology that is low cost and very effective.

So where are we in the dissemination, promotion, adoption cycle? I think we are moving along quite well, and I believe we are about to enter a phase of an accelerated use of VS.

Why?

We have now been promoting VS in one form or other for 15 years. It takes time for VS-type technologies to become accepted.

Today there are many more vetiver champions, including reputable and serious NGOs, promoting the technology. NGOs are now seen and accepted as an important component of the development effort, particularly when working with communities.

The engineers involved in construction projects are increasingly seeing the value of VS as an effective and low cost substitute for more traditional engineering methods.

The commercial sector has become involved – VS is seen to be a profitable business.

In recent years solid research results confirm and support the anecdotal information that was only available in 1985.

There are VS demonstrations in nearly every tropical and semi-tropical country.

Plant material is being multiplied at accelerated rates, people at last understand that huge quantities of plant material is required, and are prepared to do something about it.

There have been some great success stories that have attracted a lot of interest.

TVN has received more grant funds and thus able to expand the publication of information about vetiver; as too have other networks such as PRVN and SAVN, the former has been particularly active in quality information dissemination.

In conclusion, the involvement by NGOs, and more lately the commercial sector, has been very good for VS. NGOs generally have a comprehensive approach and supply leadership, advice and plant material to the communities that they work with. The commercial sector has profit motive as priority, and therefore will work hard to 'market' the technology to potential users, particularly those in the construction and engineering industries. The commercial sector will also develop large vetiver nurseries for their own needs, as well as providing a plant supply source for start up NGO operations.

Not all government vetiver initiatives have been a failure, the more successful (e.g. Malawi, Ethiopia) are those linked to comprehensive development projects that provide both the technical advice and plant material to farmers, and where government policy makers and senior field staff are convinced of VS as a solution. Stand alone extension services (such as Training & Visit system) that provide advice but no inputs have generally not been very successful (India, Indonesia and Thailand). The best vetiver programs will be those that link government agencies, NGO's and the commercial sector with the users that they serve, backed by an initial supply of plant material and good easily accessible demonstrations. v

VETIVER RESEARCH PROGRAM UPDATE

The Vetiver Research Program, sponsored by the William H. Donner Foundation, has now received about 25 pre-proposals. Of these, the Research Committee has considered 13 of them of potential interest for financing and requested full proposals. The pre-proposals of interest have come from researchers in China, Nigeria, Indonesia, India, Nepal, Vietnam, Peru, Mexico, and Ethiopia. The topics which they cover include such things as vetiver's application for controlling erosion and stabilizing riverbanks along the Mekong River, investigating the contribution of vetiver to improved water quality and quantity in domestic wells in Ethiopia, purification of industrial wastewater and treating acid mine drainage in China, and reducing sediment and pesticide movement from agricultural lands in Indonesia.

The William H. Donner Foundation has been informed that the program is going well. Indeed we here at TVN are hoping to continue to receive more pre-proposals from you as, once the US$45,000 is committed, we will use the additional requests for research funding to approach possible financiers in order that we may continue and expand the research program. v

LETTERS

INDONESIA

Correspondence from March 2001 between David Booth of the East Bali Poverty Project (Ekoturin Foundation) and Norm van't Hoff of Terracapita located in Bali.

Hi David,

My name's Norm van't Hoff, I'm developing a company here to commercialise Permaculture and sustainable development principles. I also work with Petra on IDEP projects.

I've presently got a couple of clients interested in using vetiver for erosion control and wonder if you can supply the stock?

I need to know about minimum quantities and price and availability. If you can supply the plants, I think I can move fairly quickly on this. I'd like to catch the end of the wet season if possible. …

Hi Norm,

Sorry for my delay but we've been exceedingly busy opening our Charity Cafe in Lodtunduh. You must drop in & see our photo display of all our projects in progress, including the vetiver. With regards to availability of vetiver, we should have some available within about a month, from the 500,000 shoots we planted in December. However, I'd be grateful if you could indicate how much you need.

From our experience since planting our first batch in March 2000, providing there is a few days rain after planting, the vetiver will fare very well. We have surprised ourselves and many others by the amazing growth of most of what we planted last year directly into the sandy volcanic soil. I did in fact plant about 1,000 vetiver slips in my garden here in Dalung in December 2000, and some of that already has up to 20 shoots that can be split. It has grown at a staggering average of 3cm/day! v

MADAGASCAR

Mark Freudenberger, LDI/Chemonics International, December 2000.

Here is a report of a major railroad rehabilitation program in Madagascar, damaged through cyclones that has been corrected through vetiver technology. Engineering and design were done by two Thai engineers, **Dr. Uthai** and **Dr. Diti,** lent to Madagascar through the kindness of the Office of the Royal Development Projects Board.

The rehabilitation of a 162 km railroad recently included a major effort to plant and promote vetiver grass to stabilize extremely steep embankments that often blocked the railroad during heavy rains. The following is an excerpt from a report from the field.

The vetiver bio-engineering program [in Madagascar] is moving full force ahead at the beginning of this rainy season. Sixty thousand vetiver plants have been shipped from a private multiplication farm to plant on the 10 steep “danger zones” over the next couple of weeks by the railroad company. Farmers are planting the other several hundred thousand plants very actively. The hillside planting is so visible that passing travelers are commenting that villagers are planting this “strange new grass” in an orderly fashion. The community component is moving full force ahead with the 85 farmers – they are planting fruit trees, pepper, coffee, citrus to ensure that they have a stake in the maintaining the steep hills green and free from bush fires for land clearing and erosion. v

TAIWAN

Letter to Richard Grimshaw from Yue-Wen Wang, Assistant Professor, Dept. of Agronomy, National Taiwan University, Taipei, Taiwan:

Although Taiwan is a small island, transportation still contributes quite significantly to the cost of vetiver. I have coordinated a group of people to set up nurseries around the island to facilitate transportation. At this moment, there are two nurseries capable of commercial production in the southern part of the island about 3-hours drive from each other. There will be another nursery on the eastern part of island opening up in the spring.

In the past two years, I have been busy promoting the use of vetiver through several channels, including government officers and contractors. In the last three months, with the assistance from a engineering consulting company, I gave four seminars to groups of engineers and landscape designers from several major consulting companies to try to get the vetiver into their design from the very beginning. Those attending were very interested, but skeptical just as I was before visiting projects on field trips in the Philippines and Thailand. I knew this would happen and anticipated their skepticism by setting up field demonstrations which included one in the northern part of island along a highway in a mountainous area which performed well. Another demonstration site in a mudstone dominant area will be established in the spring. People dealing with vegetative ground cover in mudstone areas have exhausted all their skill and knowledge trying to establish plantings. The high pH (9.5) and terrible soil structure has defeated them and the size of the affected area has doubled in the past ten years to 200,000 acres. Mud slides after every storm (including small ones) are anticipated which has gotten the full attention of the government and citizens. I expect to convince people with less breath once the demonstration has been established. Since the site is yet to set up, I would very happy to get any recommendations from you.

[Dick responds, *I would add that what I have seen recently in Fujian is that you need to liberally fertilize vetiver on infertile and bad soils. Paul Truong can give you the best advice. You have done a grand job, and I hope that these demonstrations will really get the interest up of the local contractors and others. It takes time to get people to realize just how unique vetiver grass is. There is no other grass like it!!*] v

NETWORK NEWS

SAVN Progress Report, July 1999 – August 2000

Duncan Hay, Institute of Natural Resources, SAVN Coordinator, Scottsville, South Africa.

The Southern Africa Vetiver Network (SAVN) provides a valuable service to a broad range of stakeholders with a common interest in reducing and reversing the devastating effects of soil erosion and reduced water quality in our region. We promote and provide advice, demonstration and support on a technology that works and that is simple, affordable, replicable, enduring, has diverse applications and uses, and is environmentally friendly.

As occurred last year the majority of funding (the exceptions being the sponsorship from the Thai Government to assist two participants to attend the International Conference on Vetiver, and a publication grant from the German Development Service) for the reporting period was generated within South Africa. All these funders have a direct interest in improved soil conservation in the SADC region.

It is encouraging to note increased interest in and support for Vetiver Grass Technology (VGT) by the South African Government, particularly by the National Department of Agriculture.

Preface and Acknowledgements

Various agencies have allocated funds and other resources for specific and general activities carried out by the Southern African Vetiver Network since its inception. Their contributions are acknowledged with considerable gratitude. These are as follows: Anglican Diocese of Pretoria, Eastern Transvaal; Anglo-American and de Beers Chairman's Fund; British High Commission; The Development Section; David Brown (an individual); EcoLink; Institute of Natural Resources; Nedcor Community Development Fund; The Vetiver Network (International); Voluntary Service Overseas (VSO); Total South Africa; The Government of Thailand; The German Development Service (BED).

Since July 1999 a further two funders have made significant contributions which I would like to highlight. As part of the National Landcare Programme the Department of Agriculture has allocated a minimum of R 800,000 for specific project activities including the establishment of provincial networks in Mpumalanga, KwaZulu-Natal and the Eastern Cape Province; The Tony and Lisette Lewis Foundation has allocated R 150,000 to assist in the running of the Network and to fund the publication of a number of booklets and manuals.

A special mention of appreciation must go to Dick Grimshaw of TVN, Mark Dafforn of the National Academy of Sciences (USA), and Paul Truong of the Queensland Government (Australia). Their willingness to impart of their considerable knowledge on Vetiver has allowed us, in turn, to effectively service network participants in Southern Africa. Finally, a special thanks to Jane Zimmermann for her fund-raising efforts in an increasingly difficult economic climate.

SAVN is hosted by the Institute of Natural Resources in Pietermaritzburg. There are five other proposed or existing networks covering different regions in Southern Africa: Mpumalanga/Northern Province, Tanzania, KwaZulu-Natal, Eastern Cape and Swaziland. Each of these networks is autonomous but receives support (technical, information etc) from SAVN.

SAVN has a network of 630 individuals and organisations (an increase from 450 in July 1999) located in Kenya, Malawi, Tanzania, Zambia, Zimbabwe, Namibia, Botswana, Lesotho, Swaziland, Mozambique and South Africa. Of these Malawi, Zambia, Zimbabwe and South Africa have good representation. There are two other functional networks in the SADC region. The Mpumalanga Vetiver Programme (MVP) based at Nelspruit covering Northern Province and Mpumalanga, and providing support into Swaziland and Mozambique and the recently established Tanzania Vetiver Network (TZVN) operating out of Dar es Salaam.

Information Dissemination

During the reporting period, meetings and/or presentations were held with a diverse range of organisations and institutions in the public, private and civil society sectors. The network has a comprehensive website (www.inr.unp.ac.za/vetiver) linked to the international site (www.vetiver.org). It contains technical information on vetiver grass including the World Bank "green book". the SAVN newsletters, a database of SAVN members, and various reports. Seven newsletters have been compiled and distributed since the inception of the Network. The response to these newsletters has been positive and reinforces our view that they are central to information dissemination in a region where access to electronic communication is limited. The World Bank "green book" and the EcoLink booklet are out of print and stocks have run out. SAVN is currently reprinting and copies will be available in the near future. SAVN has produced two documents - Technical Specifications (a simple technical specification fact sheet for general distribution) and a photographic field manual is being developed. Formal publication will take place towards the end of the year (dependent on funding). SAVN has copied the vetiver video and it is available for a nominal fee.

Nurseries

The Network has supported the establishment of a number of nurseries (largely community-based) in KwaZulu-Natal and Mpumalanga. Large nurseries were 'discovered' at Bathurst and Tsolo in the Eastern Cape which will greatly assist in market supply in this province. Two other nurseries (at Bisho and Queenstown) will be planted this year. The erratic distribution of stock throughout the region remains problematic. Network

members are encouraged to promote nursery development and to report to the co-ordinator where stocks of grass might be accessed.

Training

As part of its small-scale agricultural training course the INR training farm, Nansindlela, has a module on vetiver grass technology.

Research and Conferences

The Network received several distinct genetic varieties of vetiver from **Dr. Robert P. Adams**, Director of the Plant Biotechnology Center at Baylor University in the United States. Despite spending seven days dehydrating in various aircraft holds most of the plants survived. Now that the plants have grown out it is the intention to carry out research on the relative ability of these plants perform in cooler climates. It is planned to establish 3 plots: one coastal, one at about 3000 feet altitude and one at about 5000 feet and look at relative performance of the genetic types within the plots and between the plots. We will try and locate sites with similar rainfall and soil characteristics with the only major difference being temperature.

In January 2000 four representatives from South Africa were invited to and attended the Second International Conference on Vetiver in Thailand. The conference provided a tremendous learning experience for these representatives in areas ranging from rehabilitation to vetiver-based craftwork production.

Future Activities

The following activities will take priority in 2000 and 2001:

- Continued recruitment into the network;
- Dissemination of information on a regular basis and on request;
- Support the establishment of other networks within the SADC region;
- Increase the supply of grass stocks through the promotion of nursery establishment;
- Identification and training of small scale contractors/growers to establish nurseries and apply the technology;
- Contextualise vetiver as a fundamental part of the national Landcare initiative; and
- Raise further funding for network and project activities. v

E-News From Latin America

Brazil Vetiver Network Starts E-Discussion group:

The RBVN (Brazil Vetiver Network) has initiated an idea exchange for vetiver–related topics in Brazil (in Portuguese). To visit the site, go to the RBVN homepage at:

www.brasilvetiver.00page.com

Suggested topics include: soil and water conservation; recuperation of degraded areas, slope stabilization, vegetative hedge technology, vetiver technology for agriculture, mining, and bio-entineering. Contact coordinator Rogerio Lima at <brasilvetiver@hotmail.com>. Please note that the Brasil homepage now has a new location at: brasilvetiver.00page.com v

Ecuador Premiers Homepage

Piet Sabbe, coordinator of the Ecuador Vetiver Network (Ecuativer) has developed a homepage which can be found at: www.ecuativer.com. Also there is a new email address for Ecautiver at: <info@ecuativer.com> v

LAVN Premiers New Newsletter

Boletín Vetiver No. 9 has recently been published by the new coordinator, Dr. Oscar Rodriguez in Venezeula. The 24-page newsletter includes translation of some documents previously unavailable in Spanish. These include: Vetiver Technology for Mine Rehabilitation, Application of Vetiver for Phytoremediation by Paul Truong, and Handicrafts with Vetiver in Thailand. Also a series of articles from Nicaragua are presented summarizing vetiver's use in soil and water conservation and bioengineering. The newsletter is available in PDF format via the TVN homepage or request a copy directly from Dr. Rodriguez: red_vetiver@hotmail.com v

Headlines from TVN's Homepage

The TVN Homepage (www.vetiver.org) has recently undergone some changes in appearance thanks to Dick Grimshaw, TVNs webmaster. Some headlines you'll find at the site include:

China Policy to Regreen Highways, Railroads and Other Construction Sites

Increased Use of Vetiver and a New National Network in the Mediterranean Area (EMVN Newsletter #5)

Application of Vetiver Systems to Hillsides and River Crossings in Madagascar

Vetiver and Wildlife Protection in Africa

***Vetiveria nigritana* and its use in Senegal**

Soil Conservation Practices in the Caribbean Archipelago

Vietnam: Mekong River Banks Heavily Eroded by River Boat Traffic - a Pictorial Essay

Log onto TVN's Homepage for more on these topics and other information. v

Inspiring Donor/Participant Experience in El Salvador

By Walt Dennig – California, USA

The following is a piece submitted by Walt Dennig of Santa Cruz, California, USA describing his experiences as a volunteer in a project in El Salvador. We'd like to hear from others who might have had similar experiences as volunteers working with vetiver in other countries. See TVN Homepage (http://www.vetiver.org/ELS_soilcon.htm) for an interview with Walt.

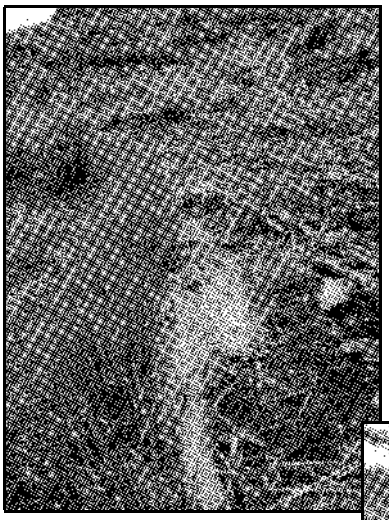

Photo 2 (left). A vetiver hedge not only filters soil particles, it can capture large quantities of debris.

Photo 3 (below). Don Alcides in his bean field with 4 vetiver hedges on the slope above him.
Photo credit: Walt Dennig

The Philosophy

Problems can be solved by many different types of approaches. Soil erosion control and water conservation, although a global problem, are, in the end, solved at a very low level (planting one tiller at a time). There are many organizations involved in both soil erosion control and water conservation; some are global and others are tiny. I think there is room for the individual donor/participant. For most of my life, I have supported large organizations, solving large problems on a grand scale. I've realized that much of the support is eaten up by an inflated bureaucracy. This has always annoyed me and I've wanted to donate at the ground level. So this is the form that I currently employ.

The Project Development

Several years ago, I travelled to Madagascar, in an attempt to set up a project in soil erosion control after having read the literature that Dick Grimshaw provided to me. I met a woman near Ranomafana whose family owned some land that could serve as a nursery and "development center". We developed the concept on paper, but after a while it got to be very complex and required the involvement of large organizations. I felt myself getting further and further away from the ground level.

Then I attended ICV-2 in Thailand in January 2000. There I happened to meet **Aldo Miranda Sol** (formerly) of NOBS Antierosion in El Salvador. We discussed my desires and he invited me to come to El Salvador. In May 2000, I visited El Salvador and Aldo hooked me up with the NOBS General Manager, **Ronaldo Chavez**. Ronaldo introduced me to NOBS' erosion control work with vetiver and also made arrangements with NGOs so I could see their work with vetiver and look for a situation that would work for me.

The organization that seemed most attractive to me was the Associación (formerly Fundación) de Amigos del Lago Ilopango (Director - **Jeannette Monterrrosa**). Since that first meeting, I have made three additional two-week trips to El Salvador. The relationship with the Amigos is very loosely knit and is more of a collaboration. They have two major funding sources and therefore two different sets of goals. I've chosen to work alongside the smaller of the two groups. The model is that extension workers promote the use of soil conservation and other agronomic measures in the villages on the near side of the lake. By the time I arrive, they have identified farmers' parcels that fit the type of involvement that suits me. We devise the plan together and I purchase the planting material from NOBS. They deliver it and the extensionists and I plant it. Occassionally, the farmers actually plant with us.

My plan is to return in 2001 for 3 separate, three-week trips during the rainy season. That's about the limit my budget will allow. My work in the USA is in residential remodeling which is fortunately lucrative enough to support my project involvement in El Salvador.

I've rented a house near the lake in San Agustin which is close to the parcels. My Spanish is limited, but improving and the people are most helpful.

During the following year, I think this paradigm of the "Individual Donor/Participant" will be established enough for me to begin then next phase. I want to continue what I'm doing and also include other individuals that participate on a one-time or intermittent basis. As this new model is developed, I'll keep you informed. v

Photo 4. A ravine has been protected with multiple rows of vetiver across the slopes.
Photo credit: Walt Dennig

Experiences From Mexico

THE VETIVER GRASS SYSTEM FOR STABILISING STEEP AND UNSTABLE SITES

By Nicholas Dolphin, Coordinator – Mexico Vetiver Network, Oaxaca, Mexico

Puerto Escondido in the State of Oaxaca, southern Mexico, is a small resort on the Pacific coast, popular with international surfers and local tourists. This stretch of coast was badly damaged by Hurricane Paulina in October 1998 and again by the earthquake in September last year (1999).

We were asked to install the Vetiver grass system to protect a housing development being built above an eroding beach cliff. The most serious problems are the large areas of loose sands (which were previously protected by the natural vegetation) and slides off the cliff top.

The climate on the coast is hot and seasonally humid, with an average temperature above 26º C, receiving about 1600 to 1800mm of rainfall annually. The rainy season normally starts in mid-June with a six week break from mid-August to the end of September, and terminates in mid-October. The heavy downpours experienced from time to time cause most of the soil erosion, however exposed sands on steep slopes can slide themselves when dried out.

We were asked to protect the exposed areas and the cliff top which were experiencing alarming erosion and slides caused by the earthquake destabilization. The erosion of the cliff top was also exacerbated by a badly designed road which channeled large quantities of rainwater onto the open flat area above the cliff; the water seeping deep down behind the cliff face further destabilizes it and also causes erosion of the lip despite attempts at engineered drainage channels. The slopes involved have gradients between 45 and 85 degrees.

Large gabions filled with soil and laid horizontally along the cliff were initially utilized to halt the erosion in the steep, exposed areas. The gabions are expensive, have a relatively short lifetime and 40% of them slipped in the earthquake. Vetiver was chosen as an alternative to engineering solutions because it enhances the natural environment and because of its deep root system, resistance to drought and very poor soils, its ability to both slow and divert moving water and its long lifespan.

The planting strategy, given we had 25,000 slips initially, was to:

- Stabilize the head of the cliffs with vetiver hedgerows to provide long term protection to the substrate and to divert flowing water into already protected;
- Densely plant vetiver on selected exposed cliff-face sites using the trimmed leaves for moisture retention and mulch.

Vetiver plants rooted in bags were recommended because the soils suffering the most serious erosion and in most urgent need of protection lack organic matter. However, the first planting produced impressive results and the client requested us to increase the planting so that three types of plant material eventually were used.

Photo 5. Black polybags filled with alluvial soil yield 100% survival rates.
Photo credit: Nick Dolphin

Photo 6. Soaking plants in water for 5 to 10 days before planting encourages root formation and thus increases survival rate.
Photo credit: Nick Dolphin

Bagged plants. Black polybags, measuring 15cm by 10cm in diameter, with rich alluvial soil as substrate **(Photo 5)** We have had 100% survival rates with these plants even in sand, when planted with the rich potting soil. Root depth reached 1 meter in one month. Seventy percent of the bagged plants were planted on the cliff top, shallow slopes and the pathway, and 30% on steep slopes.

Rooted slips. Planting slips were soaked in water for between 5 and 10 days to encourage new root growth before planting **(Photo 6)**. Planting 2 or 3 slips together as a planting unit has yielded a survival rate also near 100%. Root depth reaches a meter in about 2 months and vigorous new shoots appear approximately 15 days after planting. Thirty percent of these were planted on shallow slopes and 70% on steep slopes.

Clump slips. These are clumps which were divided and planted immediately after excavation. Up to 30% of these slips failed to produce roots, particularly in sandy areas. We have estimated that the root depth will reach 1 meter after 3 to 4 months and shoots begin to appear 20 days after planting. These were planted on steep slopes and the pathway.

Manure was not used to fertilize all the plantings and the comparison between manured and unmanured plants is significant. Animal manure has increased plant growth, speed of rooting and survival rate. For bagged plants it is preferred that manure is mixed in with the substrate. For the rooted and clump slips in the sandy

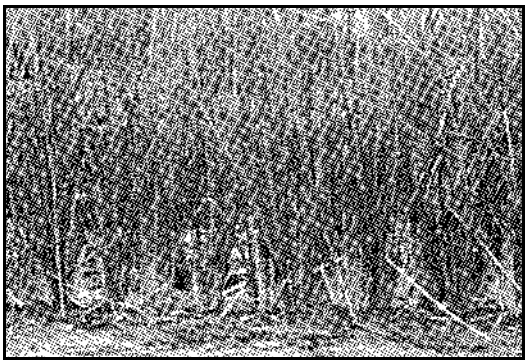

Photo 7. Six-week old hedgerow on shallow incline.

Photo credit: Nick Dolphin

areas, application of manure has reduced plant mortality from about 30% to10% and leaf growth has increased by approximately 100%.

Several planting techniques have been tried to suit the different types of terrain.

Shallow incline (0 to 5 degrees). Standard hedgerows were planted the length of the cliff top using mostly bagged plants into order to get rapid root penetration to stabilize the substrate where water accumulates behind the cliff. Thirteen to fifteen bags per meter were planted to establish an instant barrier to divert the flowing water. **Photo 7** is a close up of a hedgerow six weeks after planting. In some situations hedgerows are more closely spaced than required by the incline in order to increase root surface below ground as this is an area of potential landslide; these hedgerows are also designed to divert surface water into the already protected area on the horizon.

Medium incline (5 to 30 degrees). These areas were planted with either closely spaced contour hedgerows or dense, random planting where soils are particularly loose.

Steep incline (45 to 85 degrees). On the very unstable sand, three methods were tried: closely spaced contour hedgerows which are effective in most situations; rows supported by wooden stakes where unsupported slips washed out due to looseness of the sand and the steep gradient; and planting through felt sheets **(Photo 8)**. The idea for using felt sheets came up because the client had a large quantity of felt in sheets of white and gray, 2.5 and 3 cm in thickness. Two rows of holes were cut in each sheet with a distance of 80 cm between the pairs of rows. The felt has benefits such as reducing evaporation, suppressing weed growth (weeding is difficult on very steep slopes), and preventing surface erosion from rainfall impact. Sufficient rainfall penetrates the holes through which the vetiver is planted and through the felt itself to maintain moisture levels.

Cliff path. Stairs leading down to the beach were eroding very rapidly, the sides being mostly loose sand. The steps were reconstructed to drain the water to the side run-offs which were protected with vetiver and the steep slopes filled with close random planting of vetiver or very close hedgerows. In some places the slope was too steep and sandy for the vetiver to withstand slippage caused by moderately heavy rainfall without wood en stake retainers, upstream protection or very dense planting. The work is still in progress.

Trimming and weeding is a continuous process during the rainy season. The vetiver is trimmed and weeded on average once every two weeks. Leaves grow about 15 cm in a week. Weeds, in places guinea grass, can smother the vetiver within two weeks.

A full time team of six was trained over three days in mid-June at the onset of the rainy season. The team works six days a week on a fixed wage which means progress is slower than on piece rates but has the important advantage that the men can work at their natural rhythm and with greater care in planting slips. Following the training, twenty three days of monitoring and training in special techniques were given during the first two months. The foreman rapidly understood the Vetiver System and is doing an excellent job of planting and maintenance. Since the monitoring done at two months after planting, we have made occasional visits to sort out problems, which have been very few, and to discuss the client´s and foreman´s plans for planting new areas.

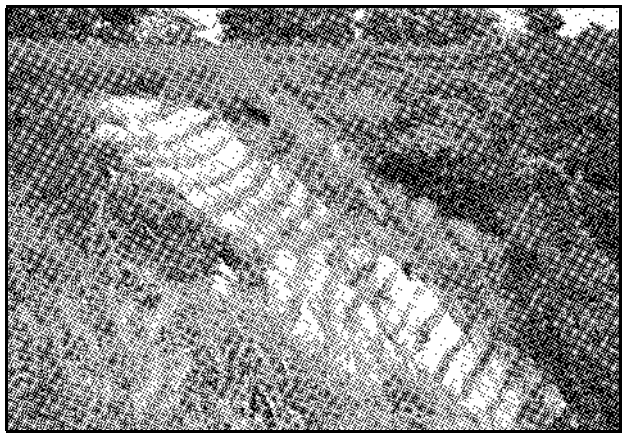

Photo 8. Felt sheets help reduce evaporation, suppresses weed growth, and protects against raindrop impact on the steep inclines.

Photo credit: Nick Dolphin

Lessons learned

Vetiver lives up to its name as an exceptional grass for stabilizing difficult sites and very poor soils. Attention to designing the site, selecting plant material and to planting and maintenance is needed to get good results.

As well as confirming requirements for the successful application of the VS, our experience with this project highlights the following:

- In difficult situations, such as unstable soils or steep slopes, experiment to get the best solution – vetiver is very versatile;
- Quality of plant material is crucial: to obtain sure and rapid results, bagged plants (when roots have extended to the bottom of the bag) or rooted slips (soaked in water inducing new roots after 5 to 10 days) are preferable;
- Manure significantly increases root and leaf growth and reduces failures in poor soils;
- Shade, whether from weeds or treesv badly affects plant growth; robust weeds can kill newly planted slips.

- Involve the client and the people in charge of the planting in planning and design of the site from the beginning. The success of this project is due to the enthusiasm and commitment of the client and his work team as well as the remarkable properties of vetiver grass.
- For a new client, rapid results generate enthusiasm and confidence and the willingness to experiment – it is worth spending time and money to ensure that the first demonstrations are as near 100% effective as possible.
- Training is very important to ensure careful planting and good maintenance. When training the work team of a client, as in this case, ensuring that the foreman is fully conversant with VS so that he can make his own decisions and adopts vetiver as his own project is well worth extra time in monitoring and supervision.

A core team of 6 people, including the foreman, working 6 days a week is responsible for planting and maintenance, sometimes supplemented by casual labor. The first plantings of vetiver took so well that our client decided to increase the number of plants from the originally planned 25,000 to almost 65,000 - equivalent to about 6 linear kilometers of hedgerow. By the end of this season's planting, we expect to have planted the equivalent of 10 kms of hedgerow. v

Costa Rican Coffee Cooperative Benefits with use of Vetiver

By L. Moyher, Coordinator Costa Rica Vetiver Network

At the beginning of January 2000, **Dominic Ackerman** revisited the Miramar coffee-growing zone in the province of Puntarenas, Costa Rica where several years earlier he had collaborated in conservation efforts as a Peace Corps Volunteer. His photos illustrate the Montes de Oro coffee cooperative's use of vetiver by applying it for the protection of costly infrastructure. Vetiver is used to mitigate the impact of heavy rains and to strengthen the earthen bases against the threat of rupture during earthquakes. v

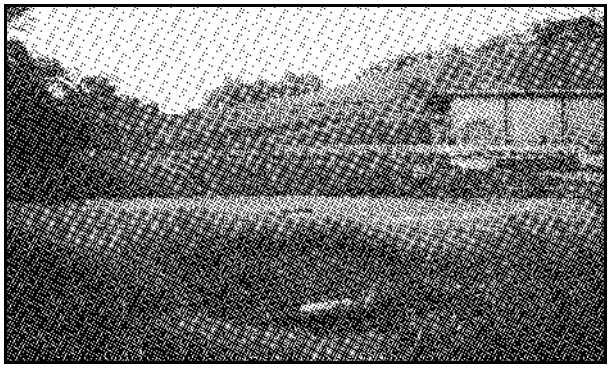

Photo 9. Transfer point showing vetiver protecting the bank from falling in on top of the pipes and keeping trash out as well.

Photo credit: Dominic Ackerman

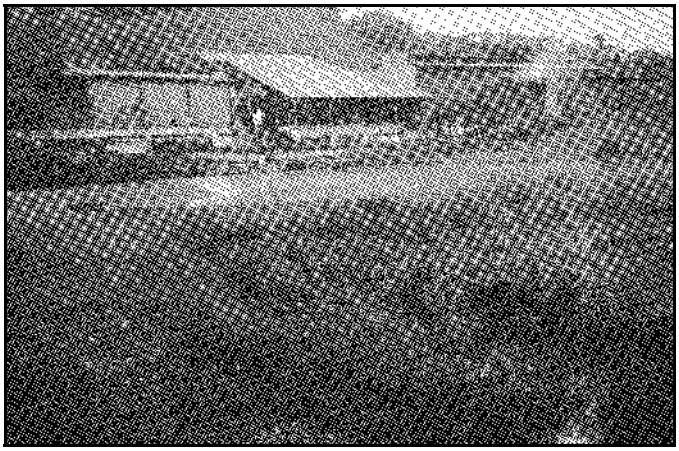

Photo 10. Overview of Montes de Oro coffee mill with early water treatment pond. Vetiver surrounds the area where the pipes transfer water to next pond.

Photo credit: Dominic Ackerman

Introduction of Vetiver Grass For Contour Farming and Roadside Stabilization in Ngie, Cameroon

The following article is based on a report submitted to The Vetiver Network in November 2000 by Elise Pinners, Joe Agba, Victor Njei, and Pascal Bokkers, Netherlands Development Organisation (SNV)

The Ngie Integrated Rural Development Project (NIRDP) implemented by (Netherlands Development Organization (SNV), has been working to introduce new and innovative farming systems to an area of Northwest Cameroon. The focus of NIRDP is on productive sectors such as agriculture, livestock, marketing and road maintenance and through this project has introduced the Vetiver System (VS) for both contour farming and roadside stabilization.

Ngie subdivision is part of Momo division, NorthWest Province, Cameroon. The altitude varies from 500 to 2000 meters with steep slopes which sometimes reach above 50%. Annual average rainfall is between 2500-3000 mm. The soils have developed from granite and are often rocky. Soil fertility is variable, ranging from poor to medium, depending on the type of soil fertility management that is practised. Low organic matter content and high rainfall often lead to nitrogen shortages and phosphate is often insufficient.

Participatory Rural Appraisals (PRAs) in 1997 and 1998 in the villages of Ajei and Tinechung identified soil erosion among its problems, as well as conflicts arising from forraging livestock encroaching on farms which caused considerable damage. Additionally the Ngie road was of significant concern due to its poor state and was often inaccessible for days at a time.

To illustrate options available to the farmers to address

Photo 11. Vetiver multiplication training session in Ngie, Cameroon. Suppliers of vetiver grass are required to attend the training prior to getting started.

Photo credit: Elise Pinners

the problems identified in the PRAs, farmer exchange visits were organized. Once farmers were aware of some of the innovative options open to them via the exchange visits, land-use planning workshops were organized to analyze land-use problems identified in the PRA and to develop action plans. These workshops were attended by local chiefs, administrative officials, and farmers (mostly women). The action plans identified the following activities for implementation: Paddock Farming (known as the Night Paddock Manuring Farming System); improvement of pasture management and fodder production; and soil conservation/contour farming using VS (vetiver was demonstrated as one of the options shown for use in contour farming and roadside stabilization by **Simon Ngwaimbi** – Coordinator of the Cameroon Vetiver Network and BERUDEP (Belo Farmers Union). The action plans were initiated via follow-up exchange visits and farmer-to-farmer training given by farmers in other areas already involved in the identified activities.

Multiplication Nurseries

Vetiver nurseries were established using plant material provided by a farmer working in the Belo region. Women farmers were chosen to be coordinators of the vetiver multiplication training which was given by farmers from BERUDEP. Training was initiated for group nurseries to provide material for contour farming and it was determined that demonstration sites should be set up along the Ngie road which was undergoing rehabilitation.

Contracts were drawn up involving the road contractor, CIPCRE (an NGO promoting farmer innovators), BERUDEP, village road maintenance committees and vetiver suppliers. Preference was given to women suppliers, because women generally contribute more of their labor to road maintenance than men, and this job was to be well paid. Women also may have greater interest in using vetiver for soil conservation, as they farm most food crops.

Speed of vetiver multiplication was not as rapid as expected because vetiver was sometimes inter-cropped with food crops, received insufficient manure application for fertilizing or was planted in shade. Currently, there are 5 nurseries in Tinechung, and 3 nurseries in Ajei.

The vetiver suppliers contracted to supply plants for the Ngie road, have also started their own private nurseries since the nursery sites belong to their road maintenance committee (RMC). Demand for planting material is growing and there is growing interest in producing vetiver, if not for the road, then for themselves on-farm or for other farmers. Prices charged are negotiated. At this stage there are 6 RMC nurseries and at least 6 small private nurseries in the villages along the road.

Contour Farming

In Tinechung, only 4 farmers have planted a vetiver hedge on their farm due to a lack of available planting material. The impact has yet to be evaluated with the farmers themselves, although additional farmers expect to be planting in March 2001 with the start of the next rainy season.

While waiting for an ample supply of vetiver in Tinechung, some women have experimented and concluded that the yield of beans growing along contour beds was higher than those from beds planted down the slope. The yield differences were obvious which has convinced other farmers to propose a 'by-law' that would oblige all farmers to farm along contours.

Roadside Stabilization

Pilot demonstration sites included unstable roadside walls with a high risk of collapsing (i.e. landslides) and culverts. Village road maintenance committees appointed vetiver suppliers that were to be contracted and paid for every clump produced which increased the status of vetiver as a valuable plant. CIPCRE sub-contracted the vetiver suppliers, organised training involving the farmer from BERUDEP, followed-up in the nurseries, and finally the planting on demonstration sites, all this in close collaboration with NIRDP. It was required that all vetiver suppliers contracted attend the vetiver multiplication training where they also learned of vetiver's other uses for on-farm soil

Photo 12. A newly planted nursery in Etwii in NorthWest Province of Cameroon.

Photo credit: Elise Pinners

conservation and use of the roots in storage of beans and maize to repel insects.

In September 2000, vetiver was planted on the side of the main bridge, and around a dozen culverts. Since the road rehabilitation was not yet completed, the technicians were hesitant to plant vetiver on roadsides as well. Unfortunately, the soil on the sides of the culverts sides had not been compacted prior to the arrival of the rainy season. As a result, soil and the newly planted vetiver were washed away by heavy rains.

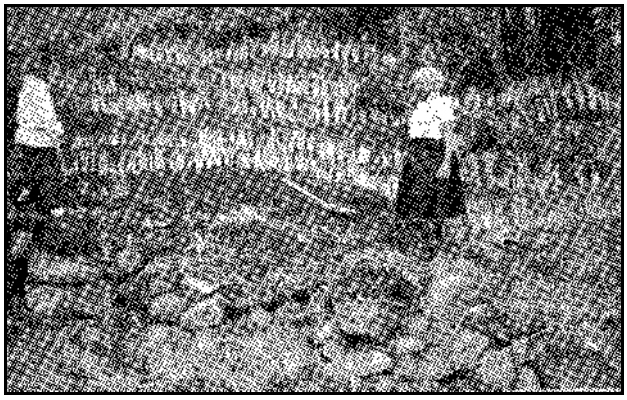

Photo 13. A wall above a road at 60%, planted with vetiver.

Photo credit: Elise Pinners

Another problem encountered was caused by the shortage of planting material. Instead of selecting only 1 or 2 sites to be properly and completely treated, it was decided to plant small (and insufficient) quantities at a dozen culverts. As a result, there was only a single line of vetiver planted on one or both sides of some culverts. It was concluded that it would be better to demonstrate VS correctly on one or two culverts only, and include a demonstration of roadside stabilisation at the same site.

Aditionally, it was determined that the single line of vetiver was planted too high on the culvert sides so that it appeared as if vetiver was actually supposed to prevent water from leaving the road on the culvert side. It was concluded that should be planted further down the slope so that water is not blocked from flowing off the road surface. Also, if there is a shortage of planting material, it would be better to start at the foot of the slope.

The problems described above were corrected in the weeks following initial planting when hedges were replanted by technicians and representatives of the road maintenance committees (including vetiver suppliers). One road wall about 6 m long and 3 m high, above the inlet of a culvert, was shaped to a slope of about 60º and planted with about 5 rows of vetiver (**Photo 14**). Additionally, a few rows of vetiver were planted on the outlet side of a culvert that which was well compacted (**Photo 15**).

Photo 14. Vetiver planted along the outlet of a culvert.

Photo credit: Elise Pinners

Conclusions

Contour farming: Timing of exchange visits is important. They should take place just before farmers start preparing their land, since they can adapt their farming methods (making contour beds and eventually planting vetiver on contour lines) at that time. During these visits farmers could be stimulated to start experimenting with contour farming, vetiver, and other improved soil fertility management methods.

Some have asked what role can vetiver play in preventing fires entering farms from grazing areas and whether vetiver hedges even prevent cattle from entering the farm. Other wonder what the limitations are of contour farming practices (including tied ridging and terracing) on extreme steep, stony slopes (where farmers in Ajei say that they cannot contour farm) and what role can Vetiver play on such sites.

Roadsides: On the roadsides where vetiver is not planted correctly, it is better to remove and return the plants to the nurseries. It is important to show only good examples so that people walking along the road draw their conclusions based on good utilization.

Vetiver for roadside stabilisation can only be applied on a large scale once roadwork has entirely finished. Application is also limited by the availability and speed of vetiver multiplication.

Organisational aspects for road maintenance: Many questions on road maintenance remain to be answered. For example, how can RMC's organise the continuation of the Vetiver multiplication and planting without spending money and how far can they rely on communal labour for multiplication and planting of vetiver? Clearly, more suppliers should be trained, but can RMC's rely on the moral obligations posed on the trained vetiver suppliers, to share their knowledge and experience and some planting material?

It may be necessary to remind the trained suppliers of the fact that they were appointed by their RMC to receive training and planting material, and generous payments for the vetiver supplied the following year. It may also be useful to emphasize that road maintenance is supposed to be a matter of communal labour. Is vetiver multiplication and planting for roadside stabilisation not part of communal labour? The purpose of all this vetiver planting is that, in the long run, time will be saved by less frequent or less work spent for clearing gutters and culverts; reduced occurrence of landslides needing clearing and reduced number of potholes and gullies to fill, (as these are caused by insufficient drainage). v

Scale Insects on Vetiver in Guam

By Dr. R. Muniappan (Agricultural Experiment Station, University of Guam, Mangilao, Guam 96923, U.S.A.)

In a recent survey of vetiver hedges in Guam two species of scale insects, which were not observed before, were collected. These insects were preserved in alcohol and sent for identification. **Dr. Douglass R. Miller**, Research Entomologist, Systematic Entomology Laboratory of U.S. Department of Agriculture, Beltsville, Maryland has identified them as *Aclerda* sp. poss. *takahashii* Kuwana (Aclerdidae) and *Aulacaspis madiunensis* (Zehntner) (Diaspididae).

This scale insect *A. takahashii* was first described by I. Kuwana from the specimens collected on sugarcane in Taiwan by Ryoichi Takahashi. The adult female is thick, soft, elongate oval, creamy to light brown with dark brown caudal end. It is found on the stem beneath the leaf sheath. The ortion of the body of the adult female not covered by the sheath bulges. White wax is found around the body. All stages of the life cycle of this insect, namely, larvae, pupae and adult females (except the adult males) are found on the stem, under the leaf sheath. Feeding of this scale causes discolored necrotic patches on the stem. Black sooty mold also develops at the place of infestation due to honey dew secreted by this insect. This insect has been recorded on the plants, *Miscanthus* sp., *Saccharum arundinaceum, Saccharum indicum, Saccharum officinalis, Saccharum spontaneum* and *Thysanolaena agrostis* in other parts of the world. Geographically it has been reported from Mauritius, Reunion, India, Malaysia, Pakistan, Philippines, Taiwan, China, Egypt and Brazil.

The other scale insect, *A. madiunensis* is found on grasses but it is a pest of sugarcane. It has been reported from Java, Malaysia, Singapore, Taiwan, Australia, Uganda, Tanzania, Malawi, Kenya, South Africa, Tuvalu, Papua New Guinea, Yap and Palau.

This is the first report of both these scale insects from Guam and also on vetiver. Of these two scales, *A. takahashii* seems to cause some damage to vetiver. It was also found on *Pennisetum polystacheon* growing closer to the vetiver hedges.

Scale insects, in general, are difficult to control by chemical means. Most of them are covered by waxy material and in addition on vetiver by the leaf sheath. In most cases, biological control is sought for suppression of the scale insect population.

A number of parasitoids namely, *Aphytis mytilaspidis* in Java and Singapore; *Aphytis* sp in Queensland, Australia; *Physcus flavidus* in Sabah, Java and Singapore; *Physcus nigriclavus* in Queensland, Australia; *Physcus seminotus* and *P. subflavus* in Uganda, Kenya and Tanzania and *Adelencyrtus miyarai* in Java, Singapore and Sabah were recorded on *A. madiunensis*. In fact, the parasitoids, *Coccobius nigriclavis* and *Aphytis* sp. from Queensland, Australia in 1972 and *Aphytis mytilaspidis* from Java in 1975 were introduced to Mauritius for control of *A. madiunensis* in sugarcane fields. Also, some species of lady beetles (coccinellids) are known to feed on scales.

I have not come across the reports of occurrence of parasitoids on *A. takahashii*. This means either I was not able locate the publications on this aspect or no one has explored in this area.

Vetiver clonal material was brought in to Guam from the continental United States either via Hawaii or directly. Because these scale insects were not reported from those areas, it would be of interest to trace the origin of their introductions to Guam. *A. madiunensis* has been recorded in the Micronesian islands of Yap and Palau. It is possible this insect got introduced to Guam from these neighboring islands. The source of introduction of *A. takahashii* to Guam requires further investigation.

Scale insects are highly cryptic and their presence could escape notice except under the most rigorous inspection regime. This necessitates the need for formal quarantine and phytosanitory procedures if it becomes necessary to introduce vetiver to a new location. According to Mr. **Mark Dafforn**, National Academy of Sciences, Washington, DC, because good quality vetiver germplasm has been shown to occur in almost every country, international movements should rarely be required and should always be carried out through established procedures involving the appropriate governmental authorities. Otherwise, the risk of transporting pests and diseases is too great.

Food and Agricultural Organization (FAO) has developed guidelines for safe movement of different crops. FAO and/or The Vetiver Network could possibly develop similar guidelines for vetiver. The absence of any reported serious pathogenic diseases or pests, except the scale insects, at present, a rigid quarantine inspection and dipping of the cleaned vetiver slips in an insecticide solution before shipment should be practiced. Of course, all shipments should accompany a phytosanitary certificate.

In addition, the impact of these scales, especially *A. takahashiii* on vetiver should be studied. Since this scale has been reported from some of the countries in Asia, Africa and South America, its occurrence on vetiver in these countries should be verified. If this insect proved to be a serious pest, varietal screening should be done for resistance and also the use of natural enemies should be explored. v

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INSECTS ON VETIVER HEDGES

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This paper is the third in a series done by the author on vetiver and insects.

Method and Content

Vetiver was introduced from Jiangxi Province into experimental sites located on and near Gao Feng Tree Farm (N 22 29'; E 108 21') in Guangxi Province. Daily observations of the insect populations found in these newly introduced plants were subsequently made during a period of 422 days. For purposes of comparison, the observation periods were considered to be split into two 211 day periods: "First Period" (the initial introduction period) from March 20 to November 15, 1998 and "Second Period" from Nov. 16, 1998 to July 14, 1999.

Visual observations were made during 30 minutes periods at the same time each morning, afternoon, and evening; random observations were also made. Observations were recorded on: species; number; time of day of observation; time and day of emergence; feeding, mating, flying and gathering habits; and preferred microhabitat. Comparisons were also made between hedges of vetiver grass hedges in rural plots and mixed vetiver grass/several other kinds of plants in urban gardens. Atmospheric temperature and relative humidity were record daily.

Results and Analysis

During the second period 102 species of insects were observed on vetiver hedges. The observed insects belonged to the Class Hexpoda and represented 14 Orders and 63 Families. The majority of the observed insects were of the Order Hymenoptera, representing 12 families and 19 species. The next most abundant were the members of the Order Lepidoptera, with 11 families and 18 species represented. Followed by: Diptera, 10 families and 14 species; Coleoptera, 8 families and 12 species; Orthoptera, 6 families and 8 species; Odonata, 3 families and 7 species. In total, 50 families and 78 species were represented from the above 6 orders; accounting for some 78% of the observed total.

Comparing these observations with observations during the first period: the order Isoptera was no longer represented and two new orders appeared - Thysanoptera and Neuroptera. This represented an increase by one in the number of orders, and an increase of 10 families and 23 species. Between the two periods, the number of species of rudimentary insects decreased whereas the number of species of higher orders, such as Hymenoptera, increased. In the first observation period, species number in the order of Orthoptera ranked second; in second observation period Orthopterans dropped to fifth in terms of species number.

Leaf - eating insects: 13 species of leaf-eating insects inhabited the vetiver leaves. Six species belong to Acridoidea family of Orthoptera order. The leaf-eaters were dominated by *Oxya intricata* (Stal) in both observation periods. *Chlorophorus annularis* (Fab), a pest on bamboo, and *Cylas formicaris* (Fab), a pest on yams and *Tessaratoma papillosa* Drury, a serious pest on longan and litchi trees were observed. The numbers of species of leaf-eating insects decreased from 13 to 4 as other annual grasses became available and as the vetiver entered into its second year.

Insects on spikes, culms and roots: Eight species of insects were observed on the spikes; of which the aphids were the longest lasting. On culms 6 species of insect were observed. *Xyleborus* sp. (a moth) was found on stressed plants on difficult sites and others plants exhibiting light-colors and weak leaves. *Saccharicoccus* sp., a sucking insect was found to damage, but not destroy, nodes of culms in the urban site. Labiduridae of Dermaptera order were observed to emerge on damaged culms and roots. Five species of insects were found on roots - earwigs, crickets, vinegar flies, a scarab beetle were observed. *Blattella germanica* (L) were found for the first time in this area on vetiver roots. Saprophytic insects - mycetophilids, Ostomatidae and springtails - were found on decaying roots.

Predatory Insects: Altogether 26 species of predatory insects were observed. Seven species belonged to the Odonata. There were 7 species of ants. In the second observation period, newly emergent species included: *Ropalidiidae* and *Delta campaniforme esuriens* (Fabricius); *Micraspis discolor* (Fab); *Vibidia duodecimgutata,* (Poda). *Nephus* sp. of the order of Coleoptera was a new discovery for the area. *Melanostoma scalare* (Fabricius) in the order of Diptera was found. The emergence of the Mantodea decreased in the second observation period, with only *Paratenodera sinensis* Saussure being found. The emergent days *of Vespa tropica leefmansi* Van der Vecht was also decreased. The emergent times of parasitic insects increased but the number of species was reduced during the second observation period. Only 5 species were observed: *Larvaevoridae, Ichneumonidae, Aphelinidae, Encertidae* and *Tetrastichidae* (which was a new observation, found on eggs of borers on the leaves).

Insects Inhabiting the Vetiver Hedges: There were 38 species in total inhabiting the vetiver plants. Species diversity was greatest in the mixed hedges in urban areas. *Musca domestica* vicina Macqurt and *Chrysomyia megacephala* Fab continuously inhabited the vetiver. Next were *Saccharicoccus* sp. and the aphids. Mating was observed of *Musca domestica* vicina Macqurt. The number of species and times of emergence of *Nematocera* increased after the vetiver was pruned in winter; these included: mosquitoes, midges, and *Psychodidae*. The presence of *Amata* sp., *Lampides boeticus* L. and *Pieris rapae* L. changed from temporary (first period) to continuous. The *Amata* sp.

especially was found in both rural and urban settings. *Lampides boeticus* L. would stay on the hedges overnight. Length of occupation increased for *Apis cerana* Fab. Among short term occupying insects, most were butterflies. Some insects such as *Stephanitis* (Stephanitis) *typica* (Distant) and *Coptosoma* sp. (which feeds on the seeds of *Gendarussa vulgaris*) would not stay on the vetiver.

Discussion

Waloff (1968) hypothesized that, with the changing age of a plant, its nutrient content and physical condition changes which in turn promotes succession among its insect population. The observations here support that hypothesis. For example, in the first period *Macrotermes barneyi* Light emerged but it didn't emerge in the second period. Feeding by *Oxya Intricata* (Stal) decreased in the second period from 45 to 19 days. However, in the second observation period *Catantops* sp. presence increased to nearly 20 days. The appearance of sucking insects decreased on the leaves and increased on the stems. Insects species during vegetative period and reproductive stage were different. For example, *Saccharicoccus* sp.and *Aphididae* became dominant insects only at the period of heading.

A greater diversity in plant communities is normally expected to result in a greater diversity of insect communities. This was found to be true in this experiment when comparing pure vetiver hedges in rural plots with mixed vetiver grass/other plant hedges in urban gardens. The greatest differences were found in the numbers of species of leaf beetles (*Amata* sp. and *Catantops* sp.) which always emerged in the vetiver grass hedges in rural plots where there were few natural predators; in the mixed plots in urban gardens not only were there more natural predators, but also more butterflies, saprophytic flies, etc. This is a preliminary observation.

Others have noted vetiver's high insect-resistance. This was also seen in this experiment. Insect-resistance is displayed in two characteristics: anti-feeding effect and endurance. These two behaviors appeared gradually over time in the vetiver plants. An example of this was the reduction in feeding over time by *Oxya Intricata* (Stal). These results indicate that there may be good prospects for use of vetiver to control insect pests in agroforestry management. However, much remains to be studied, including the appearance of *Chlorophorus annularis* (Fab), *Saccharicoccus* sp., and *Tessaratoma papillosa* which seemed to be attracted to the vetiver hedges. v

Role of Vetiver Grass in Stone Lines Stabilisation In The Central Plateau of Burkina Faso

R. Zougmoré, L. Thiombiano, F. Kambou and Z. Zida

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Abstract

Burkina Faso is located in the Sahel zone of western Africa. Soil erosion control measures have been emphasised on physical techniques like earth and stone bounds [bunds – Ed.], small dikes and vegetative barriers. These techniques have succeeded but their utilization is limited by the labor intensiveness and more importantly by the lack of stones in existence. A trial was held in the north central zone of Burkina to evaluate the suitability and adaptability of Vetiveria zizanioides hedge rows to insure good stabilization and durability of stone bounds. Two local species, V. nigritana and Andropogon gayanus have been used for comparison. Results have shown that after three years, V. zizanioides and A. gayanus grew well upstream of stone bounds and established a very tight line that stabilised the stone bounds. Rates of plant growth, regrowth, and biomass generation were also best despite a severe attack by termites. On the other hand, the performance of Vetiveria nigritana was the least impressive and did well only in conditions of increased humidity.

Introduction

The Sahelian zone is experiences the problem of temporal and spatial rainfall variability. Soil loss results from the high intensity rainfall which can reach I30 > 35 mmh^{-1}. Erosion is further worsened by scarce vegetative cover and by soil crusting. In Burkina Faso, rainfall runoff accounts for up to 40% of annual average rainfall, and soil losses of between 4 to 8 t/ha/year have been estimated despite average slope of under 3%. This has resulted in low soil productivity and poor crop yields.

Soil erosion control has especially put emphasis on the implementation of techniques which allow to the soil to absorb the maximum of rain water (ploughing, mulching, tied ridging, hoeing, etc.), but also by large popularisation of physical measures such as earthen bounds, stones bounds [bunds – Ed.], small dikes, etc. These techniques have shown tangible results and are much appreciated by farmers, but are labor intensive and stones are not abundant. Thus, research centred on hedge rows and grass strip utilisation are of increase interest. When propoerly installed, these measures are more durable and need little maintenance. This study aims to evaluate the suitability and adaptability of Vetiveria zizanioides hedge rows to insure good stabilization and durability of stone bounds.

Methodology

A trial was held in the agricultural research station of Kamboinsé, located at 12 km from Ouagadougou (Latitude 12°28N; Longitude 1°32W; Altitude: 296 m). The climate is a north Sudanian type with a long dry season and a rainy season which starts in May. The annual average rainfall for the last fifteen years is 750 mm and

occurs during the 6 months between May-October. Average temperatures vary from 24 °C to 38 °C. Vegetation is septentrional Sudanian type with species such as *Butyrospermum paradoxum, Parkia biglobosa, Lannea microcarpa, Adansonia digitata, tamarindus indica* and *Acacia albida*.

The experimental plot was installed in 1994 on a bare and degraded soil on a slope of 1.5%. The soil type is an Alfisol with pH of 6,7, a low organic matter (<1%), nitrogen (0.04%) and phosphorus (0.33%) contents.

Three stone bounds (SB) were established in July 1994 along contour lines with approximately 33 meters between diguettes [bund – Ed.]. On each diguette, 4 treatments were applied:

- T0: stone bound without grass strip
- Tvz : stone bound + Vetiveria zizanioides grass strip
- Tvn: stone bound + Vetiveria nigritana grass strip
- Tag: stone bound + Andropogon gayanus grass strip

Lines of each grass were planted 30 cm upstream of each diguette and distance between stumps (tillers) was 20 cm for all species. A 2 m horizontal interval was left between treatments. The field between diguettes was cultivated with peanut.

Measurements made during the 3 years of study were:

- Plant regrowth rate
- Plant height (every 7 days)
- Number of tillers formed (every 7 days)
- Soil moisture content on different zones of the field along 2 transects
- Dry matter production

Results and discussions

Soil water content: Soil water content decreased with distance upstream from the stone bounds with the highest water content observed immediately upstream of the stone bound. Water content increased downstream from uppermost stone bound.

Plant regrowth rate : Two weeks after planting (1994), tiller regrowth was good, notably for *V. zizanioides* and *A. gayanus* . The average plant regrowth rate was 97% for *V. zizanioides*, 66 % for *V. nigritana* and 82 % for *A. gayanus*. However, the regrowth of *V. zizanioides* and *A. gayanus* is homogeneous on all 3 stone bounds but increases from first (downstream) bound to third (upstream) bound for V. nigritana.

In the beginning of the 1995 rainy season, i.e., after eight months of drought, plant regrowth rate decreased for all species. Values obtained were 85% for *V. zizanioides*, 68% for *A. gayanus* and 34% for *V. nigritana.*

During the three years, *V. zizanioides* and *A. gayanus* illustrated good tiller regrowth (>80 %). On the other hand, *V. nigritana* appeared less resistant to drought with an average regrowth rate of 51%.

Plant height growth: During the first month after planting, plant growth was slow for all 3 species. Growth increased significantly during the rainy months of August and September before it stabilised at the end of the rainy season. The maximum height reached 103 days (27 July to 07 November) after planting was 103.5 cm for both Vetiveria species, and 203 cm for *A. gayanus*. Flowering was observed for all species in mid-October. Lines of three grasses (*V. zizanioides, Vetiveria nigritana,* and *A. gayanus*) were planted 30 cm upstream of each diguette and distance between stumps (tillers) was 20 cm for all species. In the second year, plant height increased appreciably reaching 3m for *A. gayanus*, 2.3m for *V. nigritana* and 1.5m for *V. zizanioides*. The greatest height for *A. gayanus* and *V. zizanioides* were measured on the intermediate diguette while *V. nigritana* reached greatest height at the first (upstream) diguette.

Evolution of stumps number: The number of stumps in 1994 increases from 2 to 6 for *V. nigritana*, 2 to 14 for *V. zizanioides* and from 2 to 12 for *A. gayanus*. The next year (1995), the number of stumps per plant strongly increased and reached 110 for *A. gayanus*, 36 for *V. zizanioides* and 27 for V. nigritana. During the third year, the number of stumps remained similar to that of 1995.

Biomass production and resistance to termites attack: The quantity of dry matter increased during the first two years, then decreased in 1996 (figure 6). *A. gayanus* produced more dry matter than the two vetiver species. Nevertheless, *V. zizanioides* biomass production was double that of *V. nigritana*.

Peanut production in 1995 and 1996 also increased. This could be related to soil physical and chemical property improvement by stone bounds and grass strips. The comparison of the three species concluded that *V. zizanioides* and *A. gayanus* suitability was interesting upstream the three diguettes. It was upstream of the first diguette that *V. zizanioides* obtained the best productions of biomass, despite the low soil water content at this zone. On the other hand, *V. nigritana* grew better upstream downstream of the stone bound, demonstrating that this specie is more demanding in terms of humidity (this species grows traditionally in bottoms and humid zones). Following an attack of termites in the beginning of 1995 rainy season, *V. zizanioides* shoots were better able to resist attack than the two other species.

Conclusion

This study showed that among the three tested species, *A. gayanus* and *V. zizanioides* were the most suitable for stone bounds stabilisation. The two species showed a resistance to termite attacks during the dry season so that their regrowth rate at the beginning of the following rainy season was satisfactory. *V. nigritana* seems to prefer conditions with good humidity. **V**

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The Vetiver Network

VETIVER NEWSLETTER

A NEWS MAGAZINE PROMOTING THE VETIVER SYSTEM
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TVN is an IRS-approved tax exempt non-profit foundation under code 501(c)(3).

WHAT'S HAPPENING AT TVN ?

By Jim Smyle, President - TVN

It has been approximately one year since our last Vetiver Newsletter and I am sure many of you have been wondering what has happened. In the past, TVN Newsletters had been published about two times per year; something to which we had all become accustomed. The reason for the long time since publication of the last Newsletter has nothing to do with a lack of new information and news. On the contrary, during 2001/2002 we have seen a lot of activity worldwide with the Vetiver System [VS]. Rather it has been due, among others, to the increase in activities by the Regional and National Networks, many of which are putting out two to three Newsletters per year and keeping their membership well-informed on relevant goings-on. Also, this last year has seen TVN's activities become much more web-based. All of the good information coming in is available immediately as it is published on the web. This now also allows the Regional and National Networks to rapidly get the information out to their 'unconnected' (via the Internet) readers. The key features of TVN on the web are:

TVN Homepage <www.vetiver.org>. The TVN website is a repository for all current and historic information on the Vetiver System. **Dick Grimshaw** is the webmaster and he keeps the site updated so that all the latest information is immediately available.

TVN Discussion Board. Inaugurated on November 30, 2001 this lively online discussion now has some 240 postings. See page 4 for a full listing of topics.

Photo 1. A women's group in China study their Vetiver System brochures provided to them by the China Vetiver Network.

Photo Credit: Liyu Xu

The Discussion Board is a handy place to get your technical questions answered or to share your expertise and knowledge with others. Register and join in on the Discussion Board at <www.vetiver.com/discus>. The archives of past discussions as well as the current, ongoing exchanges can be found there.

Email Queries. These days over 90% of the correspondence we receive comes through email (<vetiver@vetiver.org>). This allows **Joan Miller**, our TVN coordinator, to put people directly in touch with other users in their own country, with their national or regional networks (where these exist), or with our VS experts who can provide detailed technical advice.

Of course, we are not giving up producing newsletters, answering mail and sending out published information (like the ever popular

INSIDE :

Announcements.....3
Letters.....7
Network News.....9
Country Reports
Indonesia.....12
China.....12, 13, 15
Swaziland.....13
Guyana.....15
Technical Papers
Jiji Grass Evaluation.....16
Propagation Improvements.....17
Mediterranean Region Facts.....18
Submergence Tests.....18
Nurseries.....18
Road Stabilization.....19
Vetiver Network Contacts.....20

"Green Book"). There are still many of you who rely on TVN's 'conventional' means of getting information to you. However, at this time, because TVN is an all-volunteer effort, our slow down in conventional activities has also been due to a busy year in our "other" jobs. Unfortunately, this slow down has also come at a time when the global activities of TVN have expanded considerably and thus more opportunities. So, both for you who rely on hard copies of newsletters, information packages, etc. and for those who have yet to hear about the VS, we are hoping to improve our capabilities and overcome our limitations as a voluntary service. To this end, we have been looking at a number of alternatives:

- Forming a partnership with a Washington, DC-based private, non-profit, international development organization (ACDI/VOCA) which would operate the "Vetiver Information Network" (VIN) with a full-time coordinator, backed by an experienced and well-funded, non-profit development agency.
- Decentralize completely such that the national and regional Networks become the primary providers of information, with the web-site as a clearing house for global information.
- Other? Suggestions welcome.

So, while we may have been a bit slow this last year, the TVN and its members around the world have been working hard and getting results. Use and knowledge of The Vetiver System is now expanding at a faster pace than ever before. Here are just a couple of highlights:

The dates for the **Third International Vetiver Conference (ICV-3)** have been moved up by one year to October of 2003. The Conference will be held in Guangzhou and **Dr. Luo Fuhe** (President, Guangdong Academy of Agricultural Science and Director, Guangdong Provincial Grass Industry and Environment Association) has agreed to become the President of ICV-3 and take responsibility for providing the necessary arrangements for the event. These arrangements are the results of the hard work by **Prof. Liyu Xu**, the Coordinator of the China Vetiver Network, **Dr. Sumet Tantivejkul**, Secretary-General of the Chaipattana Foundation and Chairman of the Continuing Committee (CC) of the ICV, and **Dr. Narong Chomchalow**, Coordinator of the Pacific Rim Vetiver Network and Secretary of the Coordinating Committee for ICV-3.

John Greenfield's new and comprehensive book on the VS is just about ready for publishing. The book, entitled, *Vetiver Grass — An Essential Plant for the Conservation of Planet Earth,* has been several years in the making with John diligently scribbling away and patiently suffering the editorial comments of TVN members. John's new book pulls together the thousand plus year of history of vetiver grass and "*aims to provide planners in the government and private sectors with as much information as possible on this natural system of conservation for future application…"*, which it admirably does. The book will be available in August from Infinity Publishing.com. See page 6 of this newsletter for details.

In looking back over what we know has been accomplished in the last year what is striking is how one sees that it is people, not organizations or institutions that are making all the difference. **Criss Juliard** in Senegal has been particularly busy spreading the word, including setting up demonstrations, looking at applications for *Vetiveria nigritana* and traditional uses of vetiver as a decorative plant.

Additionally, you can find on the website reports on all the new developments over the last twelve months…any of which we would be happy to download, print out and send to those of you without any means of accessing the website. Among the these developments you will find: In **Vietnam**, vetiver is now being used to protect ditches and river bank properties. There is a 'Growing Vetiver Movement', in **India**, for soil and moisture conservation in tea plantations. In **Portugal** for highway landscaping. In **China** there are new projects in south China's Dabie Mountains; vetiver grass was demonstrated at a garden show for landscaping and handicrafts; and a Vetiver Conference was held by the Highway Bureau of Fujian Province. Reports were received from China on the "*Stabilization of a Railroad Embankment with Vetiver in South China"*, on work in the Datianshan Landfill in Quangdong Province, on the *"Stabilization Of a Building Site at Huizhou University in South China"*, *"Using Vetiver Grass Stabilization of a Sports Stadium Site"* and *"Environmental Mitigation - Landfill Stabilization and Cleanup Using Vetiver"*. In **Bali**, The East Bali Poverty Project is harnessing 'The Power Of Vetiver Grass'. In **Thailand** we have the reports from Thailand on *"The Use of Vetiver Grass System for Erosion Control and Slope Stabilization along the Yadana Gas Pipeline Right of Way"*, and *"Utilization of Vetiver as a Medicinal and Aromatic Plants"*. In **Madagascar**, the protection of infrastructure (railroads, ponds, highway) using VS continues to grow. In **Australia**, *"Brisbane Schists [have been] Stabilized with Vetiver Grass"*. Many of the new uses for the VS have been documented in Australia: for Waste Water Treatment, for Agrochemical Pollution Control, for Water Quality Improvement in Acid Sulphate Soils, for Landfill Leachate Control, for Algae Bloom, and for Treating Sewage Effluent.

Finally, as you may have heard, vetiver's taxonomic name has been changed from *Vetiveria zizanioides* (L.) Nash to *Chrysopogon zizanioides* (L.) Roberty. Do not expect to see a change in the name of the network… the VS remains the same, vetiver grass is what holds it all together, and TVN will carry on promoting it as a solution for your problems. v

ANNOUNCEMENTS

Third International Conference on Vetiver & Exhibition (ICV-3)

The Vetiver Network is pleased to announce the Third International Vetiver Conference in Guanzhou, Guangdong Province, in southern China from **October 6 to 9, 2003**. The theme of the conference is 'Vetiver and Water' and the focus will be on the Vetiver System's (VS) application to improve water quality and distribution in the environment. Topics will include application of VS for: runoff control, groundwater recharge, erosion control and slope stabilization, pollution control and water quality protection, purification of landfill and mining leachates, earthwork stabilization, plant production, extension strategies, and other grasses for water and soil conservation. The conference is being organized to focus on the needs of users of VS by concentrating on providing information and site visits to see applications and generate discussion to will help guide the practioner.

It is anticipated that participants from over 30 countries will attend. The conference will be conducted in English with simultaneous translation to and from Chinese. A conference announcement and registration form is posted on the Vetiver Network Homepage and at <www.ICV-3.com>. Information can also be obtained at: ICV-3 Office, Guangdong Academy of Agricultural Sciences, Wushan, Guangzhou 510640, tel: 86-20-85514259; fax: 86-20-87503358; Email: <office@ICV-3.com>. v

King of Thailand Vetiver Awards Announced

TVN has been informed that **Princess Maha Chakri Sirindhorn**, Chairperson of His Majesty the King of Thailand's Chaipattana Foundation, has agreed to grant US$10,000 from the Chaipattana Foundation for "The King of Thailand Vetiver Award" for the most outstanding works on vetiver. This is the third time that such an award has been made This award will be split into two prizes, valued at US$5,000 each; one prize will be awarded to the most outstanding research on vetiver and the other to the best program for dissemination of vetiver technology.

Nominations for the award may come from any person of any nationality. Please send nominations to:

Office of the Royal Development Projects Board
78 Rajdamnern Nok Ave.
Dusit, Bangkok 10300, Thailand
Fax: (66-2) 280-6206, 629-8915
Email: <vetiver@mail.rdpb.go.th>

Please include a self-addressed card that can be returned to the nominees to acknowledge receipt of nominations. The nominations must be postmarked on or before **30 June 2003**.

The announcement of the winners will be made in August 2003. The winners will receive the awards from Her Royal Highness Princess Maha Chakri Sirindhorn, the Patron of the Vetiver Network, on His Majestry's behalf. The presentation of the Award will be made during the Opening Ceremony of ICV-3 in Guangzhou, Guangdong, China on 6 October 2003. **The award does not cover the cost of participation at ICV-3.** v

Vetiver Network Awards Program Update… Nominations Wanted

The Vetiver Network reminds you that the third series of Vetiver Awards (announced in Vetiver Newsletter #23), totaling US$45,000 in prize money will be awarded thanks to a generous grant from the **William H. Donner Foundation**. In anticipation of the Third International Conference on Vetiver, to be held in China in October 2003, whose theme will be "Vetiver and Water", one category of the awards will be VS applications in relation to water. As in the past, the TVN hopes to receive many nominations for each category. The **deadline for nominations will be July 2003** (note that in Newsletter 23 the deadline was listed as October 2003 – this has been moved forward for the conference). Award winners will be announced at the ICV-3 Conference in October 2003.

As a reminder, the Awards categories are as follows:

- Water Applications (Watershed Protection/ Improvement, Engineering – Natural and Constructed, Quality – Pollution Control and Treatment)
- Engineering/Infrastructure Protection
- Land Reclamation
- Dissemination
- Country Vetiver Award
- Farmer/User Awards – Regional (Asia, Africa, Latin America)
- Other
- Vetiver "Champion"

Refer to Newsletter 23, Page 4 for details or check the Vetiver Network Homepage <www.vetiver.org>. v

Note address change for nominations:
The Vetiver Network
709 Briar Road
Bellingham, WA 98225
USA

780

Project	Recipient	Total Grant
Use of Vetiver (Vetiveria zizanioides) with Leguminous Species for the Conservation and Recovery of Soils.	Ing. Luis A. Arevalo, International Center for Research in Agroforesty (ICRAF), Peru	$ 9,000.00
Utilization of Vetiver for Treating Acid Mine Drainage Treatment	Dr. W.S. Shu, Associate Professor, School of Life Science, Zhongshan University, Guangzhou, China	$ 6,536.00
Relation Between Fats and Vetiver Grass and Counter-measures	Mr. Chen Shangwen, Researcher, Forestry College, Nanning University, Nanning, China	$ 1,720.00
Vetiver System For Erosion Control in the Central Highlands, Vietnam	Dr. Pham Hong Duc Phuoc, Department of Plant Physiology, University of Agriculture and Forestry, Thu Duc, Ho Chi Minh City, Vietnam	$ 5,300.00
A Study on Purification of Vetiver Man-made Wetland for Industrial Wastewater	Dr. Xia Hanping, Associate Professor, Centre for Ecological Research, South China Institute of Botany, The Chinese Academy of Sciences, Guangzhou, China	$ 8,000.00
Vetiver Grass Technology for Wave and Current Erosion Control in the Mekong Delta, Vietnam	Dr. Le Viet Dung, Department of Crop Science, University of Can Tho, Vietnam	$ 6,800.00
Assistance to Vietnam Donner Research Grant Projects	Dr. Paul Truong, Principal Soil Conservationist, Natural Resource Sciences, Brisbane, Australia	$ 3,000.00
Study on the Effectiveness of Vetiver Hedges in Reducing Sediment and Pesticide Movement from Agricultural Lands	Mr. Edison Purba, Lecture, Faculty of Agriculture, Universitas Sumatra Utara, Indonesia	$ 2,725.00
Growing Vetiver in the Polluted Water: Generating Income for the Poor in Peri-Urban Areas	Mr. Yudi Widodo, MSc., Senior Agronomist, Research Institute for Legume and Tuber Crops, Malang, Indonesia	$ 2,150.00
		$45,231.00

Table 1. Summary of research projects funded by the William F. Donner Foundation through TVN's research program.

Donner Foundation Research Grants – Update

Through the generosity of the William H. Donner Foundation, TVN awarded grants totaling $45,000 for research on water-related aspects of vetiver. TVN funded up to 50% of the proposed research, with the remaining 50% provided by the recipients. Above (Table 1) is a table with a brief summary of the proposals that were funded. v

New TVN CD-ROM Available

TVN has a new CD-ROM available for US$15 (including mailing). This CD contains amongst other files, the complete TVN website and all its associated files as of 1 April 2002. This CD contains practically everything we know about vetiver and is fully illustrated with color images. The CD also includes **Dr. P.K. Yoon's** *"Look See at Vetiver"* which Dick Grimshaw still considers the best compilation available of vetiver basics and research. Also included are the excellent posters on the VS prepared by **Paul Truong** for the Bonn Water Conference in Germany and a Vetiver Workshop in Australia. The printer-ready version of the VS brochure that was published in 2001 is also on the CD. If you would like a copy, please send a US$ check or money order to: The Vetiver Network, 709 Briar Rd, Bellingham, WA 98225 USA. v

The Vetiver Network Discussion Board

In January 2002, a TVN Discussion Board was initiated so that users could share their experiences, ask questions and receive answers from experienced users, and discuss a wide range of topics relevant to the application of VS. There are twelve topic areas, with discussions, archived on the site:

- Vetiver Grass Agronomy & Taxonomy;
- VS for Environmental Protection, including prevention of floods, landslides, & mining reclamation, carbon dioxide sequestering;
- VS for Engineering Site Applications;
- Vetiver Grass Nursery Planting Techniques, Propagation & General Management Issues;
- Vetiver Grass Sales Outlets;
- VS for Soil & Water Conservation & Erosion Control;
- VS Technology Transfer Issues & Networking;
- VS for Beach, Canal, Drainage & River Bank Stabilization;
- VS for Ground Water Improvement
- VS for Waste Water Improvement & Other Water Quality Issues;
- Other Uses of Vetiver Grass; and
- Other Technologies;

The discussion board can be accessed via TVN's Homepage or directly at <www.vetiver.org/discus > v

Tentative Program of International Training Course on Vetiver Handicraft-making

The **Pacific Rim Vetiver Network** (PRVN) is developing a two week training course on production of handicraft items.

The course will include several days devoted to the preparation of raw materials and tools needed, more than a week for learning how to produced vetiver handicraft products (such as boxes, trays, hats and baskets), and finally information on finishing and decorating products.

The course has not yet been scheduled, but if you are interested please contact PRVN at: Office of the Royal Development Projects Board, 78 Rajdamnern Nok Ave., Dusit, Bangkok

10300, Thailand, Fax: (66-2) 280-6206, 629-8915, Email: <vetiver@mail.rdpb.go.th> v

The Vetiver Website: How Useful Is It? Accessing What We Know About Vetiver

Our webmaster, **Dick Grimshaw**, has been operating and keeping TVN's website up-to-date for several years now. The website has become our most important repository of information. There, you will literally find every bit of information we have received that can be published in electronic format and it is all indexed and searchable. But, do people use it? The answer to that is "yes". We know it because of the volume of queries we get where people tell us that they found us through the website. We know it because the TVN website is referenced or linked on hundreds of web pages put up by universities, research centers, NGOs, government agencies, individuals, etc. We can also tell from the domain report which identifies the origins of visitors to this site by the suffix of their domain name and by our website report that gives a summary of the general statistics for the entire web site during the report time frame. For those of you who are interested:

Between October 31, 2001 and April 28, 2002 , the following number (see Tables 2 and 3) of requests and volume of information was transferred from <www.vetiver.org> to people from 21,190 different "hosts" or internet servers. v

Successful server requests	292,666
Total data transferred	7.18 GBytes
Total data transferred in last 7 days	263.34 MBytes

Table 2 (above). Number of requests received on Homepage for VS information (between 31 October 2001 and 28 April 2002).

Table 3 (below). Summary of origin and number of requests for VS information by region and most inquisitive countries.

Location Of Requesting Server	# of Requests	Most Active Countries
Unknown, Total	219,374	
Europe	20,940	France (4,166) & Italy (3,918)
East Asia	11,893	Thailand (3,177) & Taiwan (2,232)
Latin America & Caribbean	11,547	Mexico (2,716) & Brazil (2,455)
North America	10,654	USA (7,434)
Oceania	8,453	Australia (6,033)
South Asia	4,173	India (3,880)
Africa	2,551	South Africa (1,182)
Mediterranean	2,271	Portugal (1,915)
Middle East	810	Israel (422)
Total	**292,666**	

New Vetiver Products:

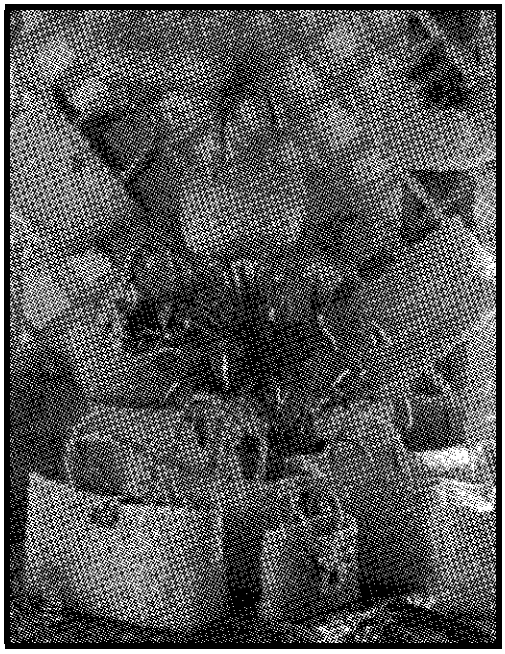

Photo 2. Some vetiver products produced as part of **Fundacion Polar's** vetiver Projects in Venezuela.
Photo credit: Fundacion Polar

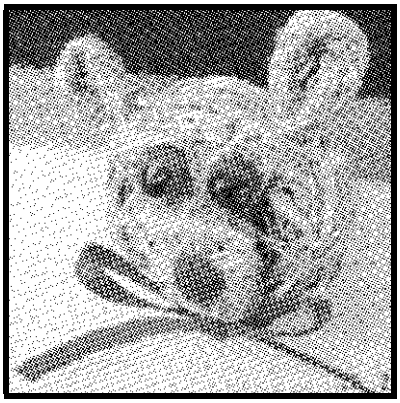

Photo 3. Madam Zhang Jin has started a handicraft business using vetiver products in Fujian, China.
Photo credit: Liyu Xu

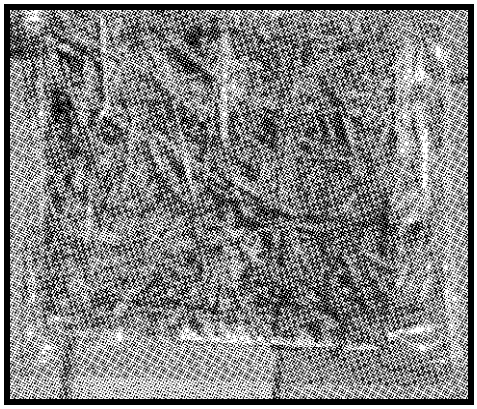

Photo 4. Erosion control mat made from vetiver leaves commercially produced in Sri Lanka.
Photo credit: Paul Truong

Publications

"Vetiver Grass - An Essential Grass for the Conservation of Planet Earth"

The above titled book is ready for publication authored by vetiver expert **John C. Greenfield** summarizing vetiver's history; the problems of erosion and degradation; its use (among others) as a plant for agricultural uses, erosion control and bioengineering, and environmental protection; worldwide experiences; potential for commercialization; propagation strategies; planning a country-wide vetiver program; a photographic summary; pests and diseases of vetiver; and a comprehensive index.

The book will be available in August 2002 (US$19.95 plus shipping) from:

Infinity Publishing.Com
519 West Lancaster Avenue
Haverford, PA 19041-1413 USA
<infinitypublishing.com> or
<www.buybooksontheweb.com>
fax: 610-519-0261

It should be available from Amazon.com and BarnsandNoble.com in late November or December. v

Publications from The Office of the Royal Development Projects Board in Thailand

ICV-2 Proceedings

The Office of the Royal Development Projects Board (RDPB) (in Thailand) has announced the publication of the "Proceedings of the Second International Conference on Vetiver" held at Cha-am, Phetchaburi, Thailand, 18-22 January 2000.

The 482-page ICV-2 Proceedings include an Executive Summary, the Keynote Address papers given by the winners of of the King of Thailand Vetiver Award, all the presentations made including "Experience in Putting Together Country-wide Vetiver Programs: Policy Issues, Expectations and Results"; "Vetiver and Natural Disaster"; "Soil and Water Attributes"; Pollution Control and Treatment/ Restoration and Rehabilitation of Disturbed and Contaminated Areas; Disaster Prevention; Training and Technology Dissemination; Basic Research and General Studies; and Alternative Uses and Socio-economic Values of Vetiver. The Proceedings are indexed by author and subject.

The Utilization of Vetiver as a Medicinal and Aromatic Plant with Special Reference to Thailand

By **Narong Chomchalow**, Assumption University Bangkok, Thailand - Publication of the Pacific Rim Vetiver Network (PRVN) Technical Bulletin No. 2001/1, September 2001.

This publication highlights the utilization of vetiver in traditional medicine, in pest control, and as a fragrant plant. Research on production of vetiver oil and reserach and development on the industrial potential of vetiver in Thailand are also described. The publication includes discussions on vetiver planting, environmental implications, socio-economic aspects, and industrial potentials.

Development of the Vetiver System in Guangdong, China

By **Xia Hanping** - Restoration Ecologist, South China Institute of Botany, Guangzhou, Guangdong, China - Publication of the PRVN Technical Bulletin No. 2001/3, December 2001.

(Excerpt from abstract) During the past 11 years, research on vetiver and the VS has made a great progress in Guangdong [China], and initiated a new concept, named 'Vetiver Eco-engineering'. Its demonstrations and application have also been extended into numerous fields such as reservoirs and rivers, highway slopes, landfills, quarries, mined land, and even city parks from its original use in soil and water conservation in agricultural. In recent years, there have been more institutions, agencies, and the private sector in Guangdong engaged in VS research and application resulting in a rapid development of the VS in this province. On the whole, development in VS has been most rapid in Guandong as compared with other provinces of China.

Copies of the three above publications may be requested from:

The International Affairs Section
The Office of the Royal Development Projects Board
78 Rajdamnern Nok Ave.
Dusit, Bangkok 10300, Thailand
Email: <vetiver@mail.rdpb.go.th>

"Vetiveria: The genus Vetiveria"

A book has been recently published on the genus Vetiveria. **Massimo Maffei**, a plant physiologist and Head of the Department of Plant Biology at the University of Turin, Italy, has edited a publcation of nine chapters, authored by twelve experts. The book describes the anatomy, physiology, biochemistry, essential oil biogenesis and chemical composition, distillation as well as production of plants for essential oil production and the use of vetiver as an ecological tool against erosion, soil pollution and many other applications.

The book can be ordered online at Amazon.com <www.amazon.com> or contact the publisher directly at:

Antonio Upali
Marketing Assistant
Taylor & Francis
11 New Fetter Lane
London EC4P 4EE
United Kingdom
Fax: +44 (0) 20 78422300
Phone for credit card orders:
+44 (0) 1264 343071

LETTERS

Vetiver & Roads

From **Mr. Chai Yangsong**, Highway Director of Fujian Province, China (forwarded to TVN by The China Vetiver Network)

Thank you very much for your concern on the highway greening of our province. As a worldwide-recognized grass, vetiver is an ideal plant for soil erosion control and fertility recovery. We have done our best to popularize the technology in the highway institutions in our province. The cities like Fuzhou and Nanping have planted the grass for major highways on a large scale since 1998, and Quanzhou and Ningde Cities have been planting since 1999. There are over one million tillers planted, most of them around national highway No. 316. On highway embankments planted with vetiver grass, slopes were stabilized and erosion was controlled.

Vetiver technology achieved good results in stabilizing slopes according to the application in our province. In the next stage our Bureau will popularize vetiver technology continuously. I hope to get your valuable comments and you are welcome to visit Fujian and provide more instruction to the highway greening of our province.

(Note: Fujian Province was the first province in China to use Vetiver System [VS] for highway embankment stabilization. The Highway Administrative Bureau released an official document in 1998 requesting engineers and technicians of all cities/prefectures and counties of the province to study VS, read the paper "Application of Vetiver Technology for Engineering Purposes", *and collect and share experiences in order to extend VS more rapidly and smoothly. The document was prepared by the China Vetiver Network based on* ***Diti Hengchaovanich's*** *technical publication by the Royal Projects Development Board in Thailand)*

Vetiver & Tea

From **P. Haridas**, Deputy General Manager R&D, Tata Tea Limited, Kerala State, India

I wish to inform you that I have been receiving the Vetiver Newsletter through your kind cooperation. I found the information contained therein of immense value for our tea plantations (Tata Tea Limited). I have introduced vetiver for soil and moisture conservation in our estates situated in the Western Ghats of India. Recently I have been transferred to our head office at Calcutta and I have started using vetiver in our Assam tea plantations. After going through your articles and the work in different parts of the world, I have no doubt that vetiver can be a powerful solution for soil erosion in our tea gardens. Is it not a coincidence that this grass was reported as the best soil conservation plant in tea by T. Eden way back in the 1940s?! I was convinced about its utility when I saw it in Sri Lanka in early 2000.

Vetiver & Handicrafts

From **Sudhakar Hegde**, Agriculturalist - India

I am a vetiver farmer from India. I grow vetiver in unused lands for oil production. I am also making footwear, caps, bags and handicraft items from vetiver. I came to know that a root length up to 2m can be harvested in 13 months.

Vetiver in Sagala, Kenya

From **Eric Jolliffe**, Peace Corps Volunteer, Sagala via Voi

Thanks for the long awaited information about [vetiver] nutrition. Now the livestock officers will have a little more respect for this grass. There are rumors around here that cows will not eat it. This should stop all that.

The vetiver grass we received in Sagala from Kisii is achieving a 52% survival rate in the main nursery here (674 of 1220 splits are living and thriving). The rest died for any number of reasons. Thankfully, **Mr. Essau Mwanganda** (nobody has done more for this grass in this district than he) had more vetiver grass plants ready for sale now than I originally knew about. We are also close to taking the final measurements in an experiment on corn and vetiver intercropping.

On the lighter side, we are also "signing up" balding guys around Sagala to test a vetiver grass "Rogaine" concoction. So far, I think we have 6 men who are enthusiastic about trying it. I certainly hope there are no side effects! Essau claims to be using the instructions from one of your past newsletters for this concoction. If it works, we're onto something BIG. Essau always gets a lot of laughs when he makes the claim about hair restoration.

If people ask you where in Kenya they can find commercially available vetiver grass, refer them to Sagala near Voi in the Taita Taveta District. Essau, **Mary Gonah**, and **Rebecca Maindi** currently have grass avilable for sale. The Mrura/Latah Nursery vetiver grass will be commercially available in January [2002]. For a 51% survival rate, we sure have a lot of it! Nobody there has e-mail yet, but **Arthur Maindi, Anthony Nyatta, Florence Juma, Evans Mwakya,** and **Joeseph Mwanganda** are the best people to contact.

Most of the people in Sagala who recieved a portion of the November vetiver shipment from Kisii, and who already had vetiver grass use it as boundaries around their small gardens. They like its soil moisture retention properties. It has become a revered and wanted grass, rivaling napier in its popularity.

Discovering Vetiver in St. Kitts, Lesser Antilles

Letter sent to **Katrin Scholz-Barth** [USA] from **Martin Lowell**, Lesser Antilles

…I am making progress on the vetiver project. The grass is well known here and is called *Kush Kush* or Arrow grass. Today I met with the

Sugar Corporation man in charge of the soil conservation program. We discussed the projects I have in mind for Ottleys and surrounding areas. I toured their vetiver nursery and they offered me as much as I want. I also toured several other areas where there are extensive plantings. They may even help with the labour needed to do the project.

I have surveyed the areas around Ottleys a bit more thoroughly in the last week and am very excited about the project. I am departing for the US [soon] and am working to have vetiver in the ground in key vulnerable areas before I depart. This includes the area we walked below the pond and also in the cut in our rainforest where I want it to trap sediments in the runoff water which periodically flows through the area. I am nursing 35 plants right now in pots so they will have some strength before they get planted in the darker forest areas.

Thank you so much for turning me on to vetiver. We are really going to accomplish something useful wtih this plant. I'll keep you posted.

Multiple Purpose Vetiver in Suriname

From **Dr. H.L. van de Lande**, Department of Biology and Chemistry, Anton de Kom University, Paramaribo, Suriname, South America

I received the package with the vetiver information early this week and went through practically all of it and have become even more enthusiastic about the wealth of application possibilities [of vetiver] for Suriname. I have a small ongoing program in sustainable agriculture at the University and with the PRODAGRIS Foundation. Within this sustainable agriculture program I started up a biopesticides program (begun with neem). I have been looking for an intercrop for the neem which could be planted under extreme conditions. I have started planting neem trees as part of a rehabilitation of mined-out areas (bauxite). Vetiver looks like the perfect answer for that purpose.

I also see excellent application possibilities for erosion control in river banks and roadsides along rivers (which are flooded especially in the rainy season). I have seen it growing in some Maroon villages, where it was most probably introduced for hedge planting and erosion control in sandy areas. Apparently no follow-up was given.

The general objective is to lay the basis for the promotion of the use of vetiver: erosion control, water management, pesticide development, rehabilitation of mined out areas (gold mining!) and leached-out areas, application as roofing material, handicraft development (with Maroons and Amerindians).

Vetiver and Export Crops

From **David Harvey**, Agriflora Small Scale Cooperative Scheme, Lusaka - Zambia

Currently I am working for 'Agriflora Small Scale', providing agronomical advice for small-scale farmers growing vegetables for the export market in Europe, South Africa and the USA. I had tried vetiver with great success in the northern province, and now we are to introduce it to our farmers. We currently have 470 farmers in 9 cooperatives and will set up central nurseries at each coop with lead farmers. Intially [vetiver] will be used for field boundaries and field subdivisions. The commercial rose growing operation has also being eyeing our nursery and will be planting vetiver around the nursery to stop dust and heat coming into the green houses and affecting rose yields.

Vetiver & Pests/Diseases

From **Mark Dafforn**, Research Officer, U.S. National Academy of Sciences, Washington, DC - USA in response to **Mr. Hervé Lapierre**, France

Mike Pease of the European and Mediterranean Vetiver Network forwarded [an inquiry] on aphids, mealy bugs, and virus disease in vetiver, in response to the sentence contained in the paper of Morakul, et al. in the ICV-2 'Preceedings' which reads, *"Perhaps the most serious pests are aphids and mealy bugs"*.

As you probably know, vetiver grass has proven to be notably unaffected by pests and plagues. This does not seem to be a transient observation. The heritage of agronomic knowledge about vetiver is deep, as it has been cultivated for thousands of years.

In response to your particular question, I am unaware of any insect-mediated viral disease causing a notable infestation in vetiver. In the past ten years, no viral diebacks have been reported to TVN. I have searched the recent literature (notably CABI and AGRICOLA, plus www.vetiver.org), and found no relevant references among the 300+ vetiver citations within the past 20 years. Pathologists working in the US, Australia, Taiwan, China, Thailand, South Africa, Mauritius, and other locations have not indicated virus disease in vetiver. Most intriguing, the Animal and Plant Health Inspection Service (APHIS) of the US Department of Agriculture has run a number of vetiver accessions through phytosanitary quarantine. These were all clonal material, and came from every continent but Australia (this material has been screened separately by the Australians). Vegetatively propagated grasses, as you know, tend to serve as viral magnets and long-term repositories of viral infestations. APHIS has not detected any viral pathogens in the 14 accessions screened thus far using standard analytical techniques.

This apparent lack of viruses in vetiver is remarkable and worthy of further investigation. One can only speculate that vetiver contains an effective array of antiviral substances. Nonetheless, this observation tends to support the position that aphids and mealybugs do not serve as notable vectors for viral diseases in vetiver.

For your information, probably the most complete census of insects on vetiver was made by **Chen Shangwen** of Guangxi University in Nanning, China. It can be found at:

<www.vetiver.org/AGR_insects.htm>.

Finally, in 1996 I presented a paper that included a discussion on vetiver as a potential disease vector: *The main pest-and-plague problems reported with vetiver have been few: fungal dieback from* Helminthosporium *and* Bipolaris*, bacterial leaf blight from* Xanthomonas*, sooty molds such as* Meliola*, stem borers and white grubs, maize cyst and root-knot nematodes, termites, and rats. The genus is susceptible to smuts from* Tilletiaceae *and from* Ustilaginaceae*. This is available on-line at <http://user.aol.com/vetiver-net/vip/vipthai1.htm>.* v

NETWORK NEWS

MEXICO (MEXVN)

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We present here a short report of the main activities and results obtained during the last 6 months. For climatic and budget reasons this period consists mainly in preparing for the next rainy season when planting can take place, and government funds are available for supporting the projects.

Promotion in Various Sectors

Private Sector. Organization of a one week field tour and negotiation with the staff of a firm (INARMEX) who decided to include vetiver in its panel of solutions for highways and water courses stabilization.

Following up of the negotiations initiated by **Nick Dolphin** with BANAMEX, an agreement was reached to make a first test in highway stabilization project; a 6.000 m^2 stretch will be protected.

Negotiations are on course with a private enterprise "Erosion Control Services" to install a nursery in the State of Zacatecas with the purpose of protecting roads, mining lands and dams.

Negotiations with several land owners (mainly in the State of Veracruz) are underway to produce vetiver on a large scale to respond to the increasing demand for plants.

Institutional & Community Sector. Through the Program for the Conservation and Restoration of Soils (PCERS), two projects are active. The first one, in a nature reserve (Lagunas de Chacahua, Coast region), combines VS and other engineering systems, for protecting agricultural land against river flooding and involves communities, SEMARNAT (Federal Department for Natural Resources) and CNA (National Commission for Water). The second one, in collaboration of the State Department of Agriculture is to restore a degraded area for reforestation around a dam near Oaxaca. In both cases, local nurseries were established to obtain enough material to be planted in the site at the next rainy season.

With the NGO LASOS, a community project is being expanded with the support of SEMARNAT in the Mixe for protection of irrigation installations and farmer's land. In the Coast (Pochutla), communities have been producing and using vetiver for more than three years, and now are working on a "territory management" process which will include reforestation, ecological tourism, etc. The research sector, SEMARNAT and, possibly soon, SAGARPA (agriculture ministry) are involved. A one week training with two weeks of on-site follow-up was carried out.

First contacts have been made for providing technical assistance to the SEMARNAT office (responding to their demand) in the State of San Luis Potosí. They want to install nurseries and make tests on degraded lands to allow for reforestation.

Promotion of VS is to be included by municipalities in their development programs. Participatory development of a practical manual for Natural Resources Management, and direct training and planning events with the local councils in the Cañada and Istmo regions have been agreed.

LASOS, in the Coastal Region, is following up on a project in road protection in Potchutla involving the municipality and SCT (Communication and Transport Federal Secretariat) and another one in Huatulco with the State Department for Tourism.

Civil Organizations. Through existing networks, promotion of VS has been done with several NGO´s who work with farmers and rural groups in the States of Oaxaca, Puebla, Tlaxcala, Veracruz and Querretaro. We have agreed to install a nursery and demonstration barriers in a strategic conservation region in the north of Oaxaca, incorporating vetiver in a vast agroforestry project supported by GEF, SEMARNAT and international foundations such as Ford, MacArthur and Kellogg.

We received and trained, a Dutch volunteer working with a civil organization on erosion control with rural groups in the State of Guanajuato (San Miguel de Allende). She is now doing the first promotion work there and we expect to have some news soon.

Vetiver Network Development in Mexico

The main activity has been the maintenance and improvement of the web page (which still needs some work to be perfect!), and developing the contacts through several channels, as mentioned before.

Other Activities

Networking. We continue with an active participation in PCERS management and activities. As PCERS has no

external funds, we are in a process of discussion to distribute the functions between each member. The Mexican Vetiver Network would mainly assume the communication and technical assistance activities in coordination with the agronomy research institute of Oaxaca, in this new scheme.

Promotion & Dissemination. We are working to fund and develop a video for the promotion of VS, specifically in agriculture land protection and continue to disseminate existing documents, using a combination of TVN and local material (photos, articles, field visits and testimonials), information and training events.

Funding. We have negotiated funds from SEMARNAT for the Mixe group, with LASOS providing the plants. In exchange, the group provided maintenance to LASOS's nursery and received the Dutch volunteer for her training.

We obtained funds from SEMARNAT for the elaboration of the video, (US$1,100) which contributes up to half the cost.

Conclusion

The current activities should lead to concrete products during the next rainy season.

The main difficulty we encounter is the complexity of the network of enterprises and government offices involved in civil engineering projects, amplified by the political and economic context.

A high priority is to develop the capacity to nursery vetiver in order to respond to the growing demand. v

Costa Rica (CRVN)

Linda Moyher, Apdo. 1, Paraíso 1-7100, Costa Rica; Email:<crvn@vetiver.org>

The demand for vetiver in Costa Rica is growing and our nursery has been expanded. Major buyers this year have been the sanitary landfill in San José and one of the Chiquita banana plantation in Siquirres.

We plan to plant a new nursery in Turrialba to serve the Guayabo area that was hard hit by storms in May.

CRVN is looking for a volunteer willing to spend a few weeks working in the new nursery and several "pro bono" planting projects. Room and board provided. Spanish helpful but not necessary. Strong back and tough hands required. v

Latin American Vetiver Network (LAVN)

Prof. Oscar Rodriguez, Apdo. 5115, El Limón-Maracay 2105, Venezuela; Telfax: (58) 043 831734; Email: <red_vetiver@hotmail.com>

I have in mind to develop an online course on vetiver as a free introductory guide to potential users and interested persons. I think this is the easiest way to reach many people and share basic knowledge and terminology on vetiver potential and applications.

I will try to transform the former workshops I conducted into an online course. The course developed in Thailand can also be a source for material. There is the possibility of organizing a small international meeting or course in Venezuela, inviting key persons (4 or 5) to develop particular topics of interest on vetiver. Fundacion Polar, has started some vetiver projects with social, economic and environmental goals. They have made a lot of progress in a year, so they want to give technical and scientific support to organizing the mentioned meeting. v

Ecuador (Ecuativer)

Piet Sabbe, Escuela de Ciencias Agrícolas y Ambientales (ECAA), PUCE - Ibarra, Avenida Jorge Guzman y Pólit, Ibarra - Ecuador; Email:<info@ecuativer.com >

We had to overcome a lot of obstacles before we got the vetiver Project in Esmeraldas set up. Now, vetiver is planted in the nursery of the University (2 hectares). This nursery should provide us about 1,800,000 new slips for future projects, in about 10 months. In collaboration with IngeConsult, and the Municipality, a site near the town has been selected for direct planting. We had planted already a small amount on another site (Barrio 20 de Noviembre) in December 2001, but that failed because of the severe drought and destruction by local people.

Mr. Aguayo of IngeConsult has been doing a very fine job with his report "Plan de Control de Riesgos." [Risk Control Plan].

He recommends to work in watersheds, where vetiver should be used to:

- control run-off (planted in hedges);
- stabilize the soil (hedges) (in some occasions it can be used to support concrete swales and channels); and
- recover the soil with vegetation (as a pioneer plant), in combination with trees and shrubs.

In recent weeks Fundaciòn Natura (FN) has been [requested] by Petroecuador to set up a reforestation program. [This] could be a way to show the efficiency of the VS to future sponsors. Nothing has been put on paper yet, but both FN and the Municipality are strongly in favor of using vetiver. v

Peru

Dr. Julio Alegre, Av. La Universidad 795 La Molina, Apartado 1558, Lima - PERU, Tel: (51) 1 3486017 Ext: 2117, Fax: (51) 1 3495638, Email:<j.alegre@cgiar.org>

ICRAF (International Centre for Research in Agroforestry) members, **Julio Alegre, Luis Arevalo, Abel Meza** and **Nelly Luque** are undertaking some research with vetiver and tree crops using Donner Foundation funds. The research site is located in Pucallpa. Vetiveria has been planted in double contour rows with peach palm (*Bactris gasipaes*) and *Inga edulis* (ice cream beans) or guava for fruit, fire-

wood and nutrient recycling. v

TANZANIA (TZVN)

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Towards the end of year 2001 various inquiries were received from regional authorities, mainly from North and Western Tanzania, for information on how they could control soil erosion, land degradation in the mining areas and control siltation in lake areas in an effective and low cost manner. In response we undertook to explain to them how vetiver grass could be deployed to curb such situations. Kigoma regional authorities (Kigoma town is on the eastern shores of Lake Tanganyika) approached TAVEN to carry out a detailed study with cost estimates as to how they can arrest the situation. The central drainage channel and other town infrastructure like the railway station, play grounds, etc. are full of silt which is hindering the efficient use; Lake Tanganyika is experiencing serious uncontrolled siltation which will soon obstruct navigation, anchoring and fishing activities; and the Tanzania Electric Supply Co. Ltd (TANESCO) has fuel reservoirs [tanks] near the lake which drip fuel on the ground which then seeps underground into the lake causing pollution and threatening marine life.

These problems, according to the authorities, need to be addressed immediately. Our quick evaluation, we require about US$35,000. A project proposal was submitted to donors, through the National Environmental management Council (NEMC)

Another inquiry was received from Kahama Mining Corporation, which operates a world-class gold mine at Bulynhulu regarding the use of vetiver grass to control land degradation and reclamation. We made available to them, 150,000 tillers of vetiver grass plants which are being used to control erosion, mining spoils, helping to revegetate the mine slimes.

Early this year TANROADS (Tanzania Roads Agency) approached us to find out how they could use vetiver grass to control spoiled roadsides, gullies, road-cuts and land fills. Their approach was based on the green booklets, *"Vetiver the Hedge Against Erosion"* and *"Nyasi Za Vetiva"* (a publication in the local language), they obtained from TAVEN and were distributed to all Regional Engineers Tanzania mainland offices. They are actually planting vetiver grass to control such erosion.

We see serious inclination by local people and institutions to adopting vetiver grass technology in the country. Institutions like TANROADS, mining companies etc. have realized the effectiveness of this technology. TAVEN is of the view that we embark on serious promotion of this wonder grass by organizing seminars in the country. We have recently approached our Tanzania Technology Transfer (TANT2), who in collaboration with the Faculty of Engineering, University of Dar es Salaam and supported by US Federal Highway Administration (FHA), carry out the task of improving the quality of road transport. TANT2 has shown interest in jointly organizing a one-day seminar tentatively scheduled for July/August 2002. We envisage inviting various individuals, NGO's institutions, agencies and are thinking of inviting one resource person from South Africa (SAVN), Mr. Duncan Hay, SAVN Co-coordinator.

Anthony also reports later...The Tanzanian government is now starting to pick-up VS. Government ministries are making many inquiries on its application. It is said 60% of Tanzania is semi-arid. The problems facing the semi-arid areas include gully erosion and overgrazing, hundreds of thousands of cattle pound the earth. This causes erosion, loss of top-soil cover and siltation of dams and other important water retaining structures.

This situation has frustrated government initiatives towards dam construction, since dams silt up before their economic time span. The seasonal rains are of short duration with high flow overtopping natural channels and worsening erosion. A siltation rate of 1% per annum would be acceptable, (i.e. 100 years life span of a dam). However under the situation in Tanzania, dams fill up within 5 to 10 years.

It is intended to use VS as a nationwide remedy to the problem using Watershed Catchment Management Principles (WCMP). Starting with a pilot project in four districts in the republic of Tanzania namely, Monduli, Magu, Shinyanga Rural and Kondoa. These are where small and medium sized earth dams are in place.

Note: Anthony requests from other vetiver networks and coordinators literature and photos which may be of use to them. v

RECENT VETIVER NETWORK NEWLSETTER PUBLICATIONS

Network	Title
Pacific Rim Vetiver Network	*Vetiverim 21* (July 2002)
Venezuela Vetiver Network	*Boletín Vetiver de Venezuela* (No. 1 - May 2002)
Southern Africa Vetiver Network	*Vetiver* (No. 10 - April 2002)
The European & Mediterranean Vetiver Network	*EMVN Newsletter* (No. 7 – June 2002)
Latin America Vetiver Network	*Boletin Vetiver* (No. 10 - May 2002)
Malawi Vetiver Network	*Malawi Vetiver Newsletter* (Volume 2, Issue 1 - June 2001)

Table 4. Some of the newsletters published in the last year by Regional and Country Vetiver Networks. All can be found on the TVN Homepage.

COUNTRY REPORTS

Vetiver Helps Protect Beach Erosion in Bali

By **David Booth**, Founder & Exec. Director, East Bali Poverty Project (EBPP), Denpasar, Bali - Indonesia

Since starting our first vetiver project to save our mountain village in March 2000, vetiver has also enabled us to develop organic gardens for the children's food and save many steep dirt tracks from complete collapse.

Now I'd be grateful for your urgent advice on a new vetiver project we have here for a client whose new house fronts the beach, with a river coming in from the east side to the sea. I am presently preparing a design, but am not sure how durable the vetiver will be when planted in "improved" sand when the high tides come next year. From experience, it seems that we have about seven months before the seaward side will be challenged. Below I will describe briefly the two situations.

The beach-front side: 8 days ago, we trial planted 10 vetiver polybags in the sand on the berm, in the following way: 1) excavated the sand to 20cm below polybag, and mixed a handful of organic worm fertilizer with the sand, 2) cut the bottom of the polybag and firmly placed polybag on mixture, and back filled with sand, 3) gave gardener instructions to water every evening after sunset, 4) checked 6 days later, and found roots had already extended by 5-7cm.

*[**Paul Truong** has responded: Why did you only take out the bottom of the polybags? I think you should take them out of the bags completely as on sandy soil we need the shallow as well as the deep roots to hold back the soil. In addition the water supply on sand is vital so you should expose as many roots to the moisture as possible.]*

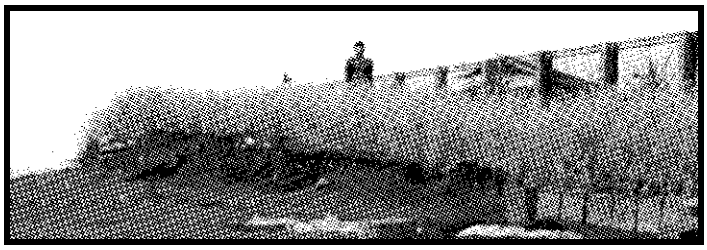

Photo 5 and 6. Photos taken less than 2 months after planting vetiver along a beach in Bali. "The power of vetiver is really showing itself after less than 2 months. We are all marvelling at the speed of growth and strength of the roots."
Photo credit: David Booth

River bank side: Here I plan to follow the design from the CD-ROM with the perpendicular rows: along the contours, about 1.5-2 metres apart up the slope, and vertical to slow the flow. It seems the flow will never be very fierce, so what spacing would you suggest?

*[**Paul Truong** has responded: How steep and how long is the slope? On very steep slopes, 1.5 horizontal to 1 vertical, you may need to plant them 1m apart. You have to design to take the flow at flood time or high flows, not normal flow, it is very difficult to advise you from here but off the top of my head, on good soil you can plant them 7-10m apart but on bends or erodible, sandy soil you must to go to 5m apart.]*

We introduced vetiver to Bali last May with our successful vetiver conference, thanks to **Ed Balbarino** [from the Philippines Vetiver Network], who was the key speaker. However, it is only in the last 8 months that we have had stock to sell… [and] every week we get new inquiries. We are now leading the way in Bali (and hopefully we can soon spread our knowledge throughout Indonesia and beyond) in advising and planting vetiver in a whole range of applications. However, we are also just learning, and whilst I think we are the only organization with sufficient experience, knowledge and vetiver stock, I am keen that we can achieve the optimum benefit for our existing and new clients, and hence I am appealing for advice from the experts in USA, Philippines, Australia and Thailand. You have all, at one time or another, been kind enough to advise us at the time of our first vetiver purchase in March 2000.

I would be most grateful for comments and advice from as many of you as possible, to help us spread the message, and hopefully pave the way for a much healthier and better land through vetiver solutions, from which many can benefit in a sustainable way. v

China Vetiver and Agroforestry Technology Project Launched on Dabie Mountain in China

By **Prof. Liyu Xu**, Coordinator, China Vetiver Network (CNVN), Nanjing - China

A two-year project started in October 2001 to run through October 2003 was initiated in the Dabie Mountain area of China (the boundary of three provinces: Anhui, Hubei, and Henan). Dabie Mountain is at 90 -1,700m above sea level with a total area near 100,000 km^2. The Dabie Mountain area forms one of the poorest regions of the country. In the recent years, increased interests in commercial

tree production has cleared vegetation, built earth terraces and planted tea, mulberry and chestnut trees, etc. on a large scale. This has lead to erosion and soil fertility problems and resulted in siltation of reservoirs and flooding. The project is:

- Introducing and raising awareness of soil and natural resources protection and the importance of VS in erosion control and sustainable agriculture, earth work stabilization, disaster prevention, sustainable farming, and other multiple uses among policy makers, farmers, extension workers and technicians in the Dabie Mountains;
- Introducing and extending proper agroforestry technology, such as hedgerow intercopping of vetiver-chestnut-wheat system; nitrogen-fixing trees, shrubs, and plants; contour planting technology, crop diversity for erosion control, etc.;
- Generating income by establishing high quality commercial trees and vegetables on terraces protected with vetiver, silkworm production, small animal husbandry, mushroom cultivation, and handicraft production, etc;
- Increasing food production by developing electrical pumping systems, intercropping of commercial tree with crops, reasonable application of fertilization based on soil and crop sample analysis;
- Helping women improve social and economic condition by training and demonstration on silkworm raising, tea production, and handicrafts production with vetiver pruning;

Extending the above technologies and experiences to the whole Dabie Mountain area through multiple activities. v

Project for Mountain Revegetation Launched in Nanjing, China

By **Prof. Liyu Xu**, Coordinator, China Vetiver Network (CNVN), Nanjing - China

To speed up the re-vegetation of Mofu Mountain with vetiver, a new project was launch in Nanjing, China. Situated in the northern part of Nanjing City, the mountain has an area of 7,040 km^2. The existing problems have been caused by quarrying. The mountain is covered by rock fragments, rubbish, and sediment that was excavated from a lake. Following the expansion of the city and economic development it is urgent to green up the disordered mountain. However, bad ecological conditions [make it difficult] for most of the plants to survive. The Vice Mayor asked the Mountain Landscape Management Office to contact the China Vetiver Network and plant vetiver. The project includes [treatment of]:

- fragments left by quarrying;
- sediments coming from [excavation of the] lake;
- rocky areas;
- parent rock.

For the fragments and sediments fill, bare-root vetiver was contour planted with a spacing one meter between rows. For the rocky and stony areas, vetiver in containers will be planted. For parent rock sites that contain neither soil nor rock fragments holes will be excavated and then container-raised vetiver planted into the holes. The basic soil and ecological properties will be studied and recorded. The project will last one year.

The present project attracts wide interest in correspondents and reporters. The project was shown in the newspaper such as Nanjing Daily and Jingling Evening. v

Swaziland Farmer Development Foundation Vetiver Demonstration Site

Review by **Rob Mackenzie,** Swaziland Farmer Development Foundation (SFDF), Manzini - Swaziland

Following is an edited version of the more interesting vetiver demonstration sites featured in an April 2002 review by the Swaziland Farmer Development Foundation.

Dvokodvweni Community Dam – Malindza

Project: Siltation control at a small community dam with a large catchment area and long steep stream. The planted areas are protected from cattle. Two double lines of vetiver were planted across the flow line on 7 Sept 2000.

Establishment was good, even in seasonally waterlogged areas. By mid October, vetiver growth was inhibited by weed growth and by late November weed growth was smothering the vetiver. In the main flow line, vetiver was buried and washed away. Canopy thinning of trees shading the lower vetiver lines was necessary. Weeding was very difficult once vetiver had been smothered, especially in waterlogged areas. The hedges responded well to weeding and canopy thinning in January.

The portions in the flow line, washed away or buried by storm flows, were replanted and a third hedge planted near the waterline in March. The flow lines were planted with vetiver in poly-bags and strips protected by sandbags. The sandbags were not adequately tied into the banks and flow from a late storm went around the protective sand bags washing out some vetiver.

The third hedge near the waterline …is not developing well because of competition, primarily from self-sown bulrush (*Typha latifolia*), which is well established in places.

On May 5, a 1.5m concrete sill was constructed to protect the flow line in the uppermost sill and vetiver strips planted behind.

By mid-August, the dam water levels were 1.5m below full supply level and with little winter rain, the area was very dry. There had been considerable grazing by livestock. The dam fencing had been damaged by storm flows early

last season but had only recently been repaired. All vetiver had survived. Later plantings were not thriving but will survive until the next rains.

Lubhuku Farmers Association (near Mpaka)

Project: Siltation Control and Land Rehabilitation in the catchment of a small community dam with a small catchment area and gentle flow line. The planted areas are protected from cattle.

On 26 October 2000, 3 hedges were planted across the flow line and protected with stones. Hedges were also planted across adjacent degraded areas into exposed subsoils. Further hedges were later planted by the community. Establishment was poor in the raised portions of the subsoil plantings with attack by termites common. Surprisingly even the growing leaves were attacked in places. Establishment was good in lower, wetter areas, initially with little loss from burial or dislodgement even though significant storm flows were experienced. Hedge development was however later restricted by burial under silt. Plantings of vetiver clumps, poly-bags and strips in March were quick to establish.

By mid August the vetiver was suffering severe water stress, with most of the foliage desiccated. Trampling and grazing by goats, which could pass through the barbed wire fence was severe in places. Little of the vetiver planted into the subsoil survived.

Mgampondo (Lavumisa area)

Project: Siltation control in community weir.

Vetiver hedges were planted above a stone check dam and gullies above the weir on 8 November 2000. Establishment was good though there was some damage by grazing goats, trampling by cattle and dislodgement in the main flow line. The damaged hedges were not protected by fencing. Hedges planted into shale were slow to develop. Vetiver planted into a partially shaded flow line, where the flow was often prolonged at times, developed well.

Mkhaya Community Dam (near Gilgal)

Project: Spillway Protection at a newly constructed community dam with a sandy spillway. The dam is fenced. The catchment is large. Approximately 12,000m^3 storage capacity with a catchment area over 5 km^2.

Four vetiver hedges, 50 to 75m long comprised of one double line and three single lines, were planted across the full width of the spillway on Nov 9. The vetiver was planted into germinated Rhodes grass (*Chloris gayana*) and self-sown species with minimum disturbance because of the vulnerability of the site. By early December competition from other grasses was affecting growth. There was no maintenance carried out by the community. Vetiver planted in late September, before the Rhodes grass was sown, did develop well.

During the heavy rains in February and March there was considerable flow down the spillway, which resulted in the formation of large gullies. Large sections of the vetiver hedges were washed away and the 1m deep sand/cement block sills were almost undercut at several points. Erosion on these highly erosive soils was made worse by the poorly leveled spillway and spillway sills. An effective hedge had not developed but there was evidence that flow had been channeled into gaps in the hedges, increasing localized erosion. Some erosion from turbulent flow through the hedges was also evident.

Note that vetiver hedges must not be planted within one vertical meter of the spillway mouth, as this will restrict flow and could contribute to the dam breaching.

Sithobela Dam

Project: Siltation control above a community dam with a medium sized catchment and gentle flow-line. The protective fencing is poorly maintained.

Vetiver hedges were planted above a stone check above the dam on 23 November 2000. A considerable number of gaps caused by trampling by livestock and people and grazing (the newly planted slips were pulled out) were replanted with pre-rooted vetiver on March 12. The established vetiver was developing well. By mid August all the vetiver had been grazed to near ground level (2-5cms) including most culms. Later plantings were surviving but seem particularly vulnerable to trampling.

Vuka Sidwashini F. A. near Buhleni.

Project: Embankment and gully stabilization at a Farmer Association Sugar Cane Scheme in association with SKPE.

On 11 Jan 2001, hedges were planted which was during a very hot dry spell. They were well watered by the members and survival was in excess of 80%. Most of the gaps in the hedges were filled by the community. Some damage was caused to hedges when a pump house was constructed.

Mgulube and Mkhuhlweni Community Dams

Project: Spillway protection at an established community dam to control erosion at the return to stream. The protective fencing is poorly maintained.

Mgulube Dam - Planted on 7 February 2001 into very wet soils, the survival was high but vetiver planted at the bottom of the small rills was washed away. During the winter of 2001, grazing by cattle was severe.

Mkhuhlweni Dam - The protective fencing is poorly maintained. On 15 March 2001 vetiver was planted into shallow flowing water at the end of the spillway. The area

was covered with bulrush (*Typha latifolia, T. capensis*), which had to be cleared to allow planting.

Asibemunye Farmers Association

Project: Vetiver nursery establishment, erosion control in an orchard in association with Vus'umnotfo and Swaziland Settlement. The orchard has steep slopes and is in a high rainfall area.

Planted on 22 March 2001, a row of vetiver was planted 2m above the top line of deciduous trees in an orchard and a small nursery established. The nursery was to provide planting material to plant further rows in the orchard 2m above and 2m below each line of trees which are planted roughly along the contour with 10m between lines.

Mortality was low and the nursery was well cared for, though growth has been retarded by livestock entering the garden and grazing the grass.

Ngwazini Orchard and Community School Nursery

Planted with assistance from DFID in December 2001. A small nursery was established for income generation, a community orchard planted for erosion control and mulching and an eroded area protected.

Highway Embankment Stabilization Mvutjini

Hydromulch (Pty) Ltd, a leading South African company, with the Ministry of Works established an embankment stabilization trial on the Manzini to Mbabane highway, 10km from Mbabane on 30 November 2000.

Vetiver in poly bags was planted and the area hydro-seeded using a mixture which appears to be dominated by *Eragrostis teff*. The vetiver has survived but not thrived. Starting in early winter 2001 the whole area has been mowed to ground level, showing the roads maintenance does not know the vetiver maintenance requirements. Vetiver should only be trimmed to knee height. All the plots, which include Kikuyu turf, Kikuyu turf strips, 2 types of mulching fabric and hydro-seeding alone, appear good especially when compared the bare control area. There was some rill formation in the hydro seeded plots, with or without vetiver. The vetiver was not planted closely enough (20cm between plants) and because of competition from the *E. teff* did not develop enough to have any effect. *E. teff* is an annual and the vetiver may develop in the coming seasons giving a more long-term effect.

Highway Embankment Stabilization Motjane

Puggs Landscaping of Nelspruit was contracted by the Ministry of Works to demonstrate embankment stabilization on the Mbabane Ngwenya highway near Motshane. A long steep embankment was planted to vetiver in March 2001. The distance between plants and rows was good. Bare root tillers were used (which we would not advise on a long steep embankment in a high rainfall area). There was adequate rainfall in the weeks following planting. The planting material was obviously dead when planted and there was 100% mortality.

Editor's Note: Rob's report strongly reminds us that while vetiver is a tough plant, it is still a plant. Like all plants, it needs suitable conditions to establish and maintain itself. As ***Aldo Miranda****, from NOBS in El Salvador told us, one of the keys to successful establishment in road stabilization projects in his country had been in first getting the community to understand why the plant was there and what the benefit was to them… this way, the communities themselves protected the plantings during the establishment phase and NOBS could concentrate on the technical factors.* v

CVN Earns 2002 Environmental Achievement Award

The China Vetiver Network/Institute of Soil Science was presented with the 2002 Environmental Achievement Award of Distinction from the International Erosion Control Association (IECA) at their annual conference in Orlando, FL. **Jim Smyle**, President of TVN, accepted the award on behalf of the CVN and **Liyu Xu**. The annual award is given to an outstanding project which demonstrates excellence in natural resource conservation and environmental protection through the use of effective erosion and sediment control policies, practices and/or public education. v

Guyana Sugar Corporation: Vetiver is Part of Company's Environmental Policy

From Guyana Sugar Corporation Website <www.GuySuCo.com>

The **Guyana Sugar Corp.** (GuySuCo) has a policy to implement an Environmental Management System that prevents pollution in the cultivation of sugar-cane and the manufacture of sugar and its by-products, both within the Corporation's boundaries and in adjacent communities. The system is compliant with national legislation and follows internationally acceptable standards. It is subject to continual review and improvement by management to ensure that environmental goals are achieved. The system is being developed in conformity with ISO 14001 standards.

The GuySuCo and the Guyana sugar industry are trying to improve their environmental management. To do so they are using vetiver grass to help prevent soil erosion by stabilizing soil (e.g. on drain sides and canal edges) and absorb and prevent the movement of contaminants (e.g. from land-fill sites and waste disposal ponds). Vetiver grass is also being evaluated as a natural insect repellent and a potential barrier to rat migrations into sugar cane. v

Investigations of Jiji Grass as an Alternative to Vetiver Grass for North China

By **Prof. Liyu Xu**, Coordinator, China Vetiver Network (CNVN), Nanjing - China

Under generous funding from **The Wallace Genetic Foundation**, a comprehensive research on Jiji grass (*Achnatherum splendens* (trin.) Nerski), a grass which can tolerate an extremely cold and dry climate, was implemented. The study included extensive field observation, laboratory analysis, greenhouse experiments, etc.

Distribution and major function

Multiple investigations before and during the project showed that although Jiji grass has a wide distribution, in general it can be found in 3 ecological zones: (a) Meadow Eocene - the grass was the main pasture component for livestock; (b) Semi-desert Eocene for anti-desertification and wind erosion control; (c) Serious eroded gully zone for soil erosion protection which was our main research topic.

Effect on soil properties

Based on the data and discussion, it is concluded that since Jiji grass had massive roots, >1 mm roots in particular, the number of soil pores, including capillary pores and non-capillary pores, were significantly increased. This decreased soil bulk density and increased soil water capacity, reduced runoff, and increased water penetration into soil. Jiji grass has great potential for soil physical property improvement, soil and water conservation, and crop production in Loess Plateau area.

With Jiji grass, soil nutrient properties were improved. Organic matter, nitrogen, phosphorus, potassium, pH value, and cation exchange capacity all improved.

Jiji grass has a high root density. The grass retained soil insitu and reduced scouring and erosion and therefore has high potential in soil erosion control and slope stabilization. Also, the grass improved other soil chemical, physical, and biological properties that are beneficial to crop production.

Jiji grass increases soil shear strength, with its strong and dense roots. Water erosion was controlled effectively. From earlier research we found that Jiji grass grew even better on the edges of eroded gullies, with roots length of one or two meters where the soil contained less water.

The strong root system of Jiji grass enabled the improvement of soil structure, porosity, and thus permeability, and therefore enabled more rainfall penetrating into soil and recharge to ground water during wet season, which not only reduced runoff and water erosion but also increased soil moisture for crop production.

Ecological tolerances

Based on field investigations which covered several provinces, in combination with laboratory analysis, it was confirmed that:

- Jiji grass can be tolerate temperatures from <-33Cº to > 38ºC.
- It is drought-tolerant. (it has been observed growing on earth walls in dry areas).
- It can tolerate saline soil containing salt (50% or more). In such areas, Jiji can tolerate submersion in saline water. Testing has indicated that certain salt contents may promote growth.
- The grass is tolerant of poor soils and has been found growing on stone walls with very low nutrient availability.
- Although Jiji grass requires light, it was observed to have better growth under the shade of trees possibly because of increased soil moisture.
- The most extraordinary property was that it was fond of growing on the edges of deeply eroded gullies or steep slopes where the soil had little moisture and higher capillarity.
- Like vetiver, Jiji grass can withstand fire. Although part of the old grass clumps, the central part in particular, may die-back, the clumps can stand several decades. Even if the clump looks almost dead the soil mound was still well fixed.
- Several tests showed that the grass does not grow well on acid soils (< pH 7.0) such as in south China.
- Although it can stand some grazing, long term overgrazing may cause the grass to degrade.

Main applications

For further applications, the first consideration is to plant the grass at edges of the eroded gullies to prevent further erosion in the Loess Plateau area.

Jiji grass can be used to stabilize new terraces. For sloping lands, Jiji grass should be planted along contours, 1-2 m vertical spacing.

Also, the grass can be planted for new construction protection, such as highways, railways, and dams.

Further study

Although preliminary test showed that the grass can be reproduced by both seeds and tillers, the survival rate was not as high as vetiver grass. Further study is needed mainly on the propagation and should include:

- Propagation: The tillers tested came from old plants, possibly a few decades old, and the survival rate was low. It may be much better to obtain tillers from nursery stock.
- The use of growth regulator for vegetative propagation.
- Propagation with seeds followed by transplanting

- Establishment of Jiji hedges (spacing, number of tillers/clump, etc.) and its effect on erosion and sediment control. v

Vetiver Propagation - Better Than Cow Tea, Faster Than a Speeding Bullet

By **Criss Juliard**, Vetiver Network Board Member, Dakar - Senegal

I stumbled on another, perhaps more rapid and less troublesome method to speed up the rooting process of vetiver shoots for more effective multiplication. I had some vetiver slips sent from a reputable South African supplier (thanks to **Duncan Hay** of the SAVN). Plants were packed bare-root in carton boxes that had been lined with black plastic, and water had been sprinkled on the tightly packed plants to keep them damp. The plants took about 8 days to arrive, between time packed to clearing customs and delivery. When I opened the cartons, nearly all the bare root slips had new white roots growing from the crowns, some measuring up to 3 cm, especially the carton that had been well sealed and had almost no chance for air or moisture to escape. There was lower growth in the box that did not have sufficient humidity. We immediately put the plants in damp soil, reducing to a minimum the amount of time roots were exposed to light, and put them in bunches of 25 to await dispatching. We had ordered 4,000 plants that had to go out to several districts in Senegal. Now some 4 weeks later, I have almost 100% growth, and very speedy retakes, faster than the cow-tea bath we often mentioned in multiplication efforts. When I dispatched the plants to other regions (some a week later, using the sealed, dampened cardboard box trick), we had similar results when unpacked in the field. Since then I have tried to replicate the method, and find that it works, although not as well as the plants that had an 8 hour airplane ride. In addition to roots, the stems began to grow out even though there was no light. When the plants were reintroduced to light (slowly going from shade to open sunlight over a period of 10 days), the plants developed at a faster rate than traditional methods of multiplication (no statistics, but confirmed observation).

I am looking for other experiences. I suspect the plants, under stress, liked the dark, the cold and the damp, and subsequently sprung roots in their effort to survive. Tell me if testing this method interests you, and if you can replicate. I would happy to hear the results of your efforts in your respective zones. Richard Grimshaw indicated he had a similar experience years back in India when he received a shipment of vetiver also sent by plane. We are not sure whether it is the plane ride or the dark, humid atmosphere, but perhaps this experience will lead you and others to experiment.

*[Note from **Paul Truong**: Very interesting, most plants tend to "grow" better in the dark, to be more precise they produce more roots and shoots but actually not growing as there is no photosynthesis. The trick therefore is to get them out to the sun as soon as possible to replenish their food reserve and continue to make the best of the new shoot and roots they produced before. Somehow vetiver seems to do very well under these conditons.]* v

Some Observations on Vetiver in the Mediterranean Region

By **Mike Pease**, EMVN, Algarve - Portugal

Dr. Vito Sardo, working in Catania, Sicily has drawn some valuable conclusions on the performance of vetiver under Mediterranean conditions. He writes:

"After six years with vetiver plants of the 'Monto' seedless variety, the following conclusions can be drawn:

- Vetiver grass in the Mediterranean environment can thrive satisfactorily as long as it is well irrigated.
- However, the growth rate is far lower than reported in the literature referring to tropical environments, the principal limitation depending on soil and atmosphere temperature - to initiate growth, in fact soil temperature must exceed 18º C.
- Vetiver grass can survive long periods (even months) of water submersion.
- Under the experimental conditions (37º latitude, sea level elevation, fully irrigated, loamy soil) the above-ground biomass production averaged about 20 Mg/ha dry matter/year.
- Root development was in all cases much less than reported in the literature, never exceeding 1m depth.
- Hedges formed to protect soils from run-off and erosion are efficient and reasonably fast to form (one season).
- While growing vigorously even under extremely high temperatures (46º C), vetiver grass can survive low temperatures (even lower than 0º C) but growth is arrested.
- No pest or disease was detected during the six years of observation.
- In no case did vetiver grass show the tendency to expand and become a weed; conversely, no weed could grow in the vetiver grass fields.
- Vetiver grass showed an appreciable efficiency in the depuration of urban wastes.
- Vetiver grass showed an unexpected tolerance to salinity."

[According to Mike Pease a number of questions arise from Vito Sardo's finding]:

Annual precipitation in Catania is normally about 600 mm but in recent years has been around 300 mm. Under these conditions leaf height varied between 1m and 1.5m.

In the Algarve, Portugal, various field applications of vetiver during the past 4 years have shown that, under irrigation and plant feeding, leaf growth will reach 2m or even exceed it. Root development has not been measured. It certainly does not reach the depths recorded in the literature for tropical

regions, i.e. 3-5m. However, it may exceed the 1m recorded scientifically by Dr. Sardo. Annual precipitation in those areas where vetiver is growing in the Algarve varies from say 400 - 800 mm per annum.

There is probably little question that, in those southern parts of the EMVN Region where climatic conditions permit the establishment of vetiver, plants will grow at a less rapid rate and reach a lower ultimate level of growth for both leaf height and root development.

This raises the question as to what are the critical leaf heights and root depths for effective hedgerow establishment to control erosion and water run-off.

I suggest that the critical height of dense, above-ground mass may be no more than 60-70 cm except where the purpose of the hedgerow is to act as a wind-break. If this surmise is correct, then it matters not if, under EMVN conditions, plants reach not much more than 1.5m. in leaf height.

Root depth and density is more critical. I am not aware of data that establishes the critical depth/density factors. However, it is probably reasonable to surmise, for the time being, that providing root depth is not less than say 1m and that root density is good, soil 'nailing', control of tunneling and overall surface and subterranean soil cohesion will be adequate. **Criss Juliard** comments that 'root mass' is more critical than 'root depth' in nailing the soil to prevent erosion. Incidentally, he has also found that pig manure is more effective in promoting extensive root growth than other manures.

In **Dick Grimshaw**'s report on his recent visit to China he mentions the desirability of removing 'dead woody stem material' (DWSM) from planting material. I think this merits discussion.

In has always been my practice to prepare really nice looking slips and this, of course, involves removal of the DWSM. It is unsightly, gets in the way and would not be viewed favourably by an agricultural inspector if the plants were for export. But, as far as I am aware, the DWSM harbours no pest or disease and causes no harm to the living plant. So, if it were not for the unsightliness the DWSM could be left on.

I have made a very approximate estimate of my work break-down for plant preparation. But my figures should be viewed in the light that my nursery is sited on heavy clay soil, whereas a good nursery site should be on light sandy soil. Also, a fully operational nursery would certainly have mother plants no older than 2 years, perhaps mostly one year. In my case the mother plants are 4 years old and have been trimmed back 4 times in their lives. So I have a lot more dwsm than one would expect in a commercial nursery.

- Digging out/removal of main clods - 10%
- Soaking/splitting into manageable chunks - 15%
- Trimming leaves to 20cm, roots to 10cm - 10%
- Washing - 5%
- Removal of DWSM and washing again - 50%
- Counting into bundles - 10%

Put a cost on the labour involved and the cost of removing the DWSM then becomes debatable. I would certainly never supply for sale plants that were not carefully selected and prepared with all DWSM removed. However, if I was dealing with thousands of plants rather than the few that I supply I would consider carefully whether it was worthwhile removing the DWSM, especially if the plants were destined for local use. v

Submergence Testing Vetiver Grass

Photo and Report by **Dr. Xia Hanping**, South China Institute of Botany, Chinese Academy of Sciences, Guangzhou - China

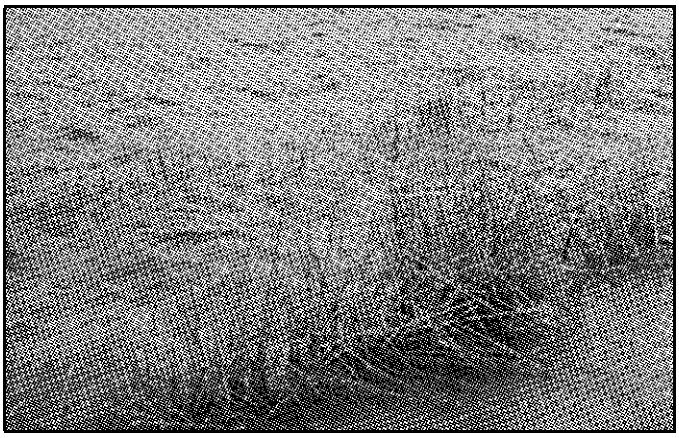

Photo 7. Taken Sept. 10, this vetiver hedge was completely submerged for 50 days (July 4th - August 24) and survived. A sixty day submergence trial is planned.

Photo credit: Xia Hanping

How Much Vetiver Do We Need?

By **John Dickinson**, PROSCARP, Lilongwe - Malawi (excerpt from the Malawi Vetiver Network Newsletter, Volume 2, Issue 1, June 2001)

How often have you been shown a newly established vetiver nursery by a justifiably proud village conservation committee or village headman? Much effort has been expended, money spent and resources utilised to establish the nursery. But how much land will this nursery protect once the grass is transplanted as countour hedgerows? Sadly, in the short-term, not as much as the farmers expect.

Let's look at the figures. But first some basic data and assumptions.

- On upland soils the recommended spacing for vetiver is 90 x 45cm givng a plant population of just under 25,000 clumps/ha.
  On dambo [good] soils the recommended spacing is 45x45 cm giving a plant population of nearly 50,000 clumps/ha.
- Under good management, between 10 and 40 splits can be obtained from one clump, hence 500,000 to 2 million splits from 1 ha. of dambo nursery.
- One split must be retained for replanting so 450,000 to 1.95 million splits can be obtained for hedgerow planting from 1 ha. of nursery.
- The recommendation for planting on the hedgerow is three splits every 10 cm or 30 splits per meter.

  So, under ideal conditions and good management, 1 ha of vetiver nursery will produce enough vetiver grass to plant between 15 and 65 km of hedgerow.

  On moderately sloping land, 15m spacing between hedgerows is recommended. Hence 1 km of hedgerow (1000m) will protect about 1.5 ha of land.

  1 hectare of nursery can therefore potentially protect 22.5 to 97.5 ha only

Of course management is rarely ideal, nurseries are often not established in dambos and villages able to provide and manage 1 ha of land for a nursery are the exception rather than the rule.

So, we have seen that under normal conditions a typical village vetiver nursery will, on an annual basis, provide only a fraction of the village's requirements for soil conservation. Even with a well established nursery, 8 years or more will be needed to protect all the land for an average Malawian village.

These figures should not be seen as discouraging. Rather, it is essential that from the outset of a vetiver program with any community, the long-term commitment required is clearly stated.

Many of the above figures are notional. We would be very happy to receive comments from others on their own experiences whether they appear to confirm or refute the above. v

Management Level	Dambo		Upland	
	Low	High	Low	High
Excellent	12	45	6	20
Good	8	30	4	15
Fair	4	15	2	7
Poor	2	7	1	0.5

Table 5. This table estimates the area of land that may be protected by a 0.5 ha nursery under different management conditions.

Road Works Stabilization …Your Problem?

The Problem

The Solution!

Soil stabilization is a critical issue to be addressed in road or railtrack engineering. This applies to cuttings, embankments, culverts and bridge abutments as examples. Often, a solution is sought by engineered means.
These can include gunite application, creation of gabion walls, biomatting or hydro-seeding as examples.
These solutions can be effective but they are generally costly or require costly maintenance. Mostly they are not aesthetically pleasing.

Vetiver Grass Hedgerows*

- Stabilize slopes cheaply, permanently and in an aesthetically pleasing manner.
- Restrain downward water flow by their density and height (up to 2m).
- Anchor and nail down the soil by using their unique, vertical and extremely strong rooting system (>3m deep and root tensile strength of 75 mpa).
- Resolve problems of gullying, rilling and tunneling that do not occur where a good system of Vetiver hedgerows has been established.

Practical Application and Economics

- Effective hedgerow establishment requires some attention initially. Thereafter, maintenance requirements are minimal and hedgerows will survive, even with annual precipitation as low as 300mm.
- Stabilization of engineered slopes using Vetiver hedgerows has been successfully demonstrated in such countries as: China, Malaysia, Thailand, Madagascar and El Salvador.
- The cost of soil stabilization using Vetiver hedgerows can be 60-90% of the cost using engineered methods, as demonstrated in Australia and China, dependent upon the nature of the works and labor costs.**

* **The Vetiver System (VS)** is a cheap, safe, proven and effective means of soil conservation and stabilization and has been extensively employed in many countries. Vetiver grass does not produce seed and stays where man plants it. So, it is not invasive. It is not affected to any significant extent by pests and diseases, nor does it act as a host for pests or diseases that might attack other plants. So, it is safe. The plant, emanating from India, has existed for centuries. But its extensive use for soil conservation, pollution control and bio-engineering only commenced in the 1980's. For more information contact The Vetiver Network www.vetiver.org.

** **Bracken & Truong**, 2000

Photo 8. Fact sheet developed by **Mike Pease** and **Harry Nijpels** of the EMVN. They would like to see the development of additional fact sheets with before and after photos would be used to "stimulate initial interest in VS" to then be followed up with additional information.

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