VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER NETWORK
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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

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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.

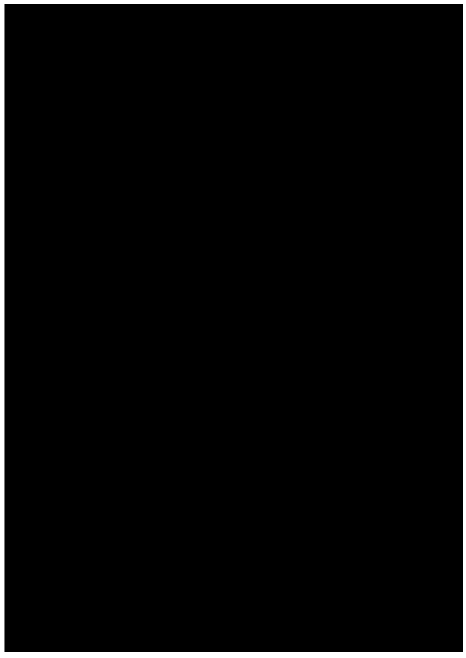

Photo 3. *Vetiver grass at 2,000 m asl in Nepal.* **Photo by S.P.Yadav**

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, QDPl 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.

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 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

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.

  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:

  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:

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).

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.

r o f

The largest Vetiver production area, approximately 250 hectares, is found in Garut District (West Java). It was not

- 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, Chromo!aena 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) CuIm-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. N*ortherly 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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