VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER INFORMATION NETWORK, AST*, WORLD BANK, NUMBER 10, OCTOBER 1993

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THE NEWSLETTER

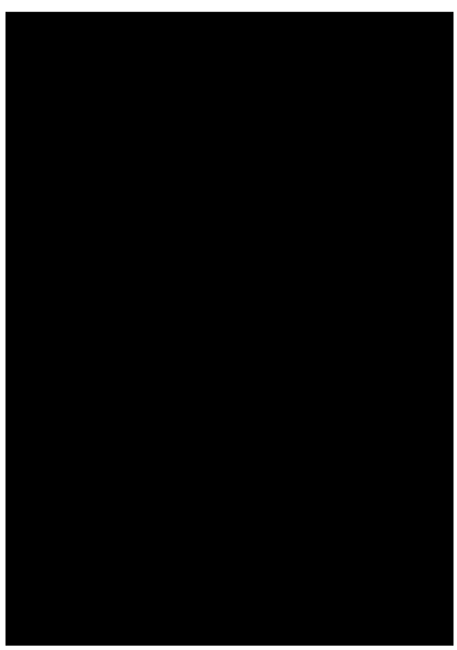
It has been almost one year since our last Newsletter. Our intention was to have this particular one in your hands by July, because this is a very important issue. In this Newsletter (#10) we announce the winners of the Vetiver Awards. However, an administrative restructuring and subsequent changes, including the termination of ASTAG as a division, has slowed us down a bit...but it has not in any way diminished our desire to get the word out on vetiver and to keep you up-to-date.

The majority of what you will read in this latest issue comes from the information that was sent in to us for the Awards competition. In the judging there was quite a bit of discussion over how to rank the entries. Last year the judges had two criteria : (i) the contribution made toward providing significant information about some aspect of vetiver as a species and/or its utilization and/or its impacts and (ii) the degree of personal initiative displayed in carrying out the work or providing the information. This latter criteria was and still is very important as the resources available to the individuals varied greatly. However, this year, because there were a number of instances where there were more deserving individuals than prizes, we came up with a third criteria to solve this dilemma. We also looked at the individual's contribution toward promoting the Vetiver Technology. That is, given the choice between two good pieces of work, the individual or individuals who were trying to apply their findings and/or who were working with users and actively promoting vetiver would be awarded the prize. The Network feels that it is important that these Awards be utilized to promote research and demonstration work that is practical. How can someone know if what they are doing is truly useful, truly practical unless they get out and work with the users ? So, first we would like to thank all of you who participated in this year's competition, especially those of you whose work did not receive an Award. Almost everything we received was good and represented excellent initiative. Secondly, we congratulate our Awardees for their fine work. And, lastly, we challenge you all to now get out and put your information to work. The Network is doing what it can to pass your ideas and recommendations on to others, but it is more effective if you, yourself extend it to those nearby who would benefit from your knowledge. Research is only the beginning.

All of those who receive an Award this year or who received an Award last year will be receiving a certificate within the next few months that notes their achievement. We are currently having the certificates designed and printed.

Photo 1. *His Majesty, King Bhumibhol Adulyadej of Thailand planting a vetiver grass hedge. His Majesty is heading a country-wide initiative on soil and water conservation with vetiver grass.*

Photo courtesy of Mr. T. Sumet.



Because of the length of many of the entries and the large numbers of photographs and figures which we received, it was not possible to include everything that we desired in the Newsletter. We have had to do some fairly heavy editing and as such some readers may wish to request unedited versions of some of the pieces. To do so, please write to either Dick Grimshaw or myself, Jim Smyle, at the address on the last page of this Newsletter.

As previously mentioned, the Vetiver Information Network is no longer a part of the Asia Technical Department, Agriculture Division (ASTAG) because that division has been eliminated. As a result, our Newsletters may not be coming out as often as they have

Photo courtesy of Dr. P.K. Yoon

Photo 2. *A comparison of root development at two weeks after transplanting between bare root and polybag vetiver planting material. From left to right, 3 tillers, bare root; >5 tillers, bare root; 1 tiller, 5"x7" polybag; 3 tillers, 5"x7" polybag.*

in the past, but be assured that they will be published as often as we can manage. Already we have enough information on "Non-Award" items to either double the size of this Newsletter or put out another one in the next couple of months. To those of you that have sent us pieces to put in the Newsletter and do not see it here, I assure you it will be in the next one which should be out after the first of the year. Keep up your good work and keep sending us information. We will always put it to good use.

The Awards

As you read down the list of Awardees, you inevitably will notice that one individual, **Dr. P.K. Yoon** of Malaysia, has managed to secure the bulk of the honors. This researcher, Head of Plant Sciences (now retired) at the Rubber Research Institute, early on recognized the potential of vetiver for Malaysian agriculture. Taking the initiative, he searched for months to find a few plants, raised funds entirely on his own from private sources and began the process leading to his highly successful research and field applications. This year the Vetiver Incentive Awards recognize the enormous influence that this one individual has had.

The King of Thailand Award of US$5,000 for overall excellence goes to Dr. P.K. Yoon of Malaysia for the tremendous body of analytically rigorous and eminently practical and useful work that he has done. The Network would like to recognize his achievement in single-handedly extending our knowledge of vetiver and its management so significantly across almost all aspects of interest to users. Congratulations, Dr. Yoon.

Research Awards

First Prize (US$2,500) : Dr. P.K. Yoon of Malaysia for his work on production of quality planting material, roots and root regeneration and response to management by different vetiver cultivars.

Second Prize (US$1,500) : Dr. Douglas Laing (ex- of CIAT), Mr. Martin Rupenthal and the University of Hohenheim/CIAT program on upland erosion control for their work in the study of roots, mycorrhiza and rooting patterns; digestibility/palatability of vetiver cultivars; and vetiver/legume plantings. *NOTE : This work is not published here, refer to Vetiver Newsletters 7 and 8.*

Third Prize (US$1,000) : Dr. Paul Truong of Australia for his work on vetiver's tolerance to extremes of pH.

Fourth Prize (US$500) : Mr. Mike Materne and Ms. Cindy Schexnayder of the United States for their work on stem measurements, stem mapping and other parameters for physical characterization of vetiver grass for use in identifying effectiveness and utility of other grasses for stiff grass hedges.

Fourth Prize (US$500) : Drs. Kresovich, Lamboy, Li , Ren, Szewc-McFadden and Bliek of the United States for their work on DNA fingerprinting of accessions and clones of vetiver grass.

Fourth Prize (US$500) : Drs. Xia Hanping and Chen Kai of the People's Republic of China will share this award for their separate works on vetiver's growth habits and interactions with orchard crops.

Fourth Prize (US$500) : Mr. Gregg Cook of Australia for his work in comparison of salinity tolerance in two accessions of vetiver with two native grasses.

Engineering Applications Awards

First Prize (US$ 2,000) : Dr. P.K. Yoon of Malaysia for his work on highway and road stabilization, stabilization of culverts and drains and stabilization of irrigation canals in Bangladesh.

Second Prize (US$1,500) : Mr. Anthony Tantum of South Africa for his work on highway stabilization.

Third Prize (US$1,000) : Drs. Sahu, Sharma and Nayak of India for their work on stabilizing small irrigation channels with vetiver grass.

Yolo County Flood Control and Water Conservation District Award (US$2,000) for vetiver use in storm and wastewater reclamation : No Awardee. Surprisingly, the Network received no submissions in this area. This is one area where vetiver is a natural as a biological filter!

Management Awards

First Prize (US$2,500) : Dr. P.K. Yoon of Malaysia for his work on establishment, management and maintenance of vetiver for a wide range of uses and conditions which has resulted in entirely new applications and approaches to utilization of vetiver grass.

Second Prize (US$1,500) : Messrs. Gueric and Victor Boucard for their work in mechanizing the production and planting of vetiver. Information on their work may be found in Vetiver Newsletter #9.

Third Prize (US$1,000) : Mr. Mike Materne for his work on propagation, establishment and demonstration of vetiver grass. Mr. Materne's work has been a turning point for focusing attention on the stiff grass hedge technology in the United States.

Fourth Prize (US$500) : Dr. R.D. Hill for his work on establishment of vetiver on difficult sites, the introduction of its use into Hong Kong and its fuel values. In addition, Dr. Hill's support of the Vetiver Network through his Newsletter "Asia Pacific Uplands" has been invaluable.

Fourth Prize (US$500) : Drs. Tiwari, Igbokwe, Burton and Waters for their work on the impacts of vetiver grass hedgerows for erosion control.

Fourth Prize (US$500) : Dr. Rao of India for his work on economic analysis of the impacts of vetiver grass on the farm and watershed levels.

Fourth Prize (US$500) : Drs. Sagare and Meshram of India for their evaluation of vetiver hedgerows compared to graded bunds and other vegetative hedgerows.

Promotional/Extension Work and Materials

Best Video Award

First Prize (US$1,150) : Dr. P.K. Yoon for his video record of the entire range of his accomplishments, demonstrations, trials and research.

No Second or Third Prizes are to be given as no other eligible videos were received.

Best Photograph, Poster or Drawings

First Prize (US$850) : Dr. P.K. Yoon for his photojournalism-approach to his work with vetiver and for the extension posters he creates.

Second Prize (US$400) : Mr. Mekonnen of Ethiopia for his photographic record of vetiver usage in Ethiopia.

Third Prize : Not given as no other eligible visual materials were received.

Extension/Technology Transfer

First Prize (US$500) : Messrs. Vietmeyer and Dafforn of the United States for their dedication in making sure that the "vetiver story" reached the widest possible audience worldwide.

Photo courtesy of Dr. P.K. Yoon

Photo 3. *Excavation reveals the quantity of soil trapped by this 24 month-old hedgerow in Malaysia. Approximately 55cm of soil have been deposited.*

Second Prize (US$300) : Dr. G.M. Bharad of India for extending his research work and practical experiences directly to farmers and other users.

Third Prize (US$200) : Mr. Maxime Robert of South Africa for the largest (known) individual plantings of vetiver hedges (146 ha). Mr. Robert began planting vetiver only in 1989. Since then, he has protected his sugarcane fields, stabilized culverts, drains and a river bank, and protected young trees. The demonstration effect from one motivated farmer, such as Mr. Robert, can be tremendous.

Fourth Prize (US $100) : Drs. Khandwe and Saran for their Hindi language extension leaflet on vetiver hedgerows for soil and moisture conservation.

Farmer Awards

First Prize (US$300) : Mr. Maxime Robert of South Africa

Second Prize (US$200) : Mr. Kulkarni of India

Third Prize (US$100) : Mr. Lebene of Ethiopia

Third Prize (US$100) : Mr. Sunday of Nigeria

Third Prize (US$100) : Mr. Ngwainmbi of Cameroon.

Third Prize (US$100) : Mr. Patil of India. The six additional third prizes were not awarded as no other eligible entries were received.

Letter from Dick Grimshaw

Let me first congratulate all the prize winners for this year's Awards. We have awarded $28,000 to more than 30 vetiver participants. Particular congratulations to **Dr. P.K. Yoon** of Malaysia who has won the **King of Thailand's Award** for overall excellence in furthering use and knowledge about vetiver. Also special mention should be made of **Noel Vietmeyer and Mark Dafforn**, both of the National

Photo courtesy of Dr. P.K. Yoon

Photo 4. *This 30 month-old hedgerow is farther downslope from the one shown in Photo #3. The wooden peg in the center of the hedge was placed at the time of planting, with the painted portion above the ground. Note the compactness of the hedge with many live culms; there is no dead center. It can be seen here how the crown of the vetiver climbs with the accumulation of trapped soil. The marks on the rulers are spaced 10cm apart.*

Academy of Science, who were responsible for the production of “The Thin Green Line”. Lastly, I thank people like **Alemu Mekonnen** of Ethiopia who sent me an excellent set of photographs of vetiver in Ethiopia, some of which were used in the recent publication “Agri Business, World Wide”, and farmers in Karnataka, India, who just write simple one sentence letters - “thank you, we read, we did and it works”. What more do we need?

Recently I visited six Central American countries (Panama, Costa Rica, Honduras, El Salvador, Nicaragua and Guatemala). Vetiver is known in all six countries, but is used most widely in Costa Rica, Honduras, and Guatemala. In Honduras the grass is known as “zacate violeta” and in Guatemala “"zacate valeriana". In Honduras it is used widely for medical purposes, and has special use (as a tea from the root) for curing hangovers, and calming the nerves of people and horses! In Costa Rica vetiver has been used for five or six years by coffee farmers in the southwest as a hedge against erosion, and with the arrival of a nasty fungal attack that is wiping out lemon grass, vetiver is expected to be used more widely in that country. It grew very well on most sites that I visited - some with over a 60% slope. Apart from farm use, it has great potential for checking the mass of widespread erosion point sources found along unprotected road sides and from hillside slumps.

In Honduras, LUPE, a USAID-supported conservation group, is very strongly promoting vetiver. In this country it is seen as the best grass for the creation of barrier hedges. **In Guatemala the NGO, SHARE**, is working with 20 other NGOs to establish vetiver in all the key highland zones of the country. SHARE reports that vetiver grows well at all its altitude testing sites including the highest at 2,800 meters. Some Guatemalan coffee plantations have used vetiver for at least 20 years to stabilize water ways, ditches, and road sides. The only constraints to widespread adoption of the technology are lack of farmer training, lack of information flow and planting material. All of which could be resolved given the necessary funds. I was pleased to see that in **Costa Rica** soil conservation is now a compulsory subject in the school curriculum, and that grass barriers with vetiver is one of the lessons.

In the Central American countries there is great awareness that more attention must be given to soil conservation. In these countries, with neither formal conservation agencies, nor available funds for conservation grants, their focus is on low cost biological systems. Vetiver fits their needs well and will do well throughout the region. One thought that struck me was that not only do the large farmers need to improve on-farm soil conservation, but those same farmers could do well by growing vetiver planting material for the smaller and poorer upland farmers. Often large and small farmers reside in the same watersheds, and it would be to the advantage of the large if they could provide planting material to the small - I would imagine it would also be good for community relations as well.

A couple of other snippets that might interest you. **Peter York from Zimbabwe** Tobacco Board writes to say that oven dried vetiver has a fuel energy of 17.5 MJ per kg. This is equivalent to about 56% of the energy value of coal. So maybe we have a small farmers fuel (Vetifuel) in vetiver to replace tree fuel, and if grown as a conservation hedge on the farm, perhaps rural women would love it. Anybody interested in researching what might be the the right sort of stove for vetiver and other phytomass fuels ? (S.O.S. to UK’s Intermediate Technology Group).

Ted Rice of the World Bank has a farm near Recife (northeast Brazil). When looking for vetiver to conserve his farm he found to his amazement (and shame!) that vetiver had been planted 30 years ago by the Federal Highways Authority to maintain the shoulders of the road adjacent to Ted’s farm, and he had never noticed - Ted is an economist so he has an excuse!

Colin McLoughlin of Vancouver called me the other day to say that he had planted vetiver (using some cold tolerance "snake oil" only known to Colin) at 59° North, and it is surviving. Has anybody else had success under such northerly or southerly conditions ?

Jano Labat of Zimbabwe writes to say that he thought that he had lost his 3 ha vetiver nursery to drought - it looked completely dead. In 1992 it received only 60 mm total rainfall, and of that 15 mm was a single occurrence. In mid-December, the rains broke and within two weeks his nursery was alive again. I get the impression that in Zimbabwe vetiver has a great potential, but is being held back by disinterest in some Government agencies. If any of you readers are cotton and tobacco growers, vetiver could provide the conservation technology that you are looking for.

Jef Embrechts from Belgium writes to say that following Dr. Yoon's visit to Bangladesh his company is testing out vetiver on the flood embankments that protect the land from sea surges. Vetiver is doing well, so he says, under quite saline conditions.

Harbans Singh from Haryana, India, tells me that he planted vetiver as a farm boundary hedge some four years ago. It grew well, and acts as a good stock fence. He tried Bougainvillea but found it difficult to manage. Four years later his neighbors have approached him for some vetiver planting material - a good example of how slow and cautious farmers are when adopting new technologies.

Following the current Mississippi flooding, perhaps the **United States Army Corps of Engineers** might care to take a hard look to see how vetiver could be used to stabilize flood levees along the southern reaches of the Mississippi.

Finally, from the **new Minister of Agriculture in Fiji, Mr V.F. Dreunimisimisi**, commenting on NAS's "The Thin Green Line" - *"I have a keen interest in this grass as I know what a friend it is to farmers. I was a Technical Field Officer with the South Pacific Sugar Mills and can vouch for all mentioned in the book."*

A Look See At Vetiver In Malaysia
A Second Progress Report
By Dr. P.K. Yoon

Dr. Yoon is now retired from the Rubber Research Institute of Malaysia and is pursuing his passion for vetiver grass on his own.

I met Vetiver grass on 12/14/89 and spent the rest of the year getting to know her. In 1990 some ad hoc trials were started. The First Progress Report summarizes the efforts up to February 1991 (See Newsletter # 6). After that Report was circulated by The World Bank I was honoured to be asked to organise the First International Vetiver Workshop in Kuala Lumpur. I have since been requested to carry out consultancies in Thailand and Bangladesh. In my own country, I was asked by the Public Works Department to assess the potential uses of vetiver as biological protection of highway embankments in Sabah and along the East-West Highway. In the local scene, I was invited to lecture to Members of the Institute of Engineers, Malaysia; The Director-General and staff of Malaysian Highway Authorities; Director and staff of the Institute of Highway Research, Malaysia; Site highway engineers in Sabah and site engineers of East-West Highway. In addition, I was visited by many interested parties, both locally and from overseas, and received much correspondence and feed-back from interested parties, especially from those in the Vetiver Network.

All the above interactions and activities serve to stimulate my interest and increases my awareness of the potentials of vetiver hedgerows. It also makes me conscious of the many problems and how little we know about the plant. From all these I was able to better target my simple investigations to solve specific needs or answer specific questions.

In the conduct of my trials, collection of quantitative data is difficult in many cases because of staff constraints and logistics problems. Also, much of vetiver's adaptive performance cannot be easily quantified. I have, therefore, resorted to sequential photography which can give a clear picture of the performance of vetiver under various conditions. Consequently, I have built up a large library of photographs on different aspects of vetiver hedgerow technology. However, such records, involving many photographs, would be too expensive to reproduce. Accordingly, I attempted to video-record the photographs. Originally, I was hoping that the video recording would serve as my Second Progress Report. But as this is the first time I am using a video camera, the quality of reproduction is rather poor, the colour is distorted and the definitions are not clear. Therefore, this hastily written report includes only certain selected photographs.

The First Progress Report summarizes mainly the efforts of 1989 and 1990. In the preparation of this Second Progress Report, which starts thereon, materials that were already in the First Progress Report are generally left out. However, those trials which were initiated as stated in that report will now be discussed in fuller detail as additional data are available.

This Second Progress Report concentrates on five main themes presented as 5 separate parts. They are :

1) Production of Quality Planting Materials
2) Establishment and Management of Quality Vetiver Hedgerows
3) Use of Vetiver Grass as Mulch in Rubber Plantings
4) Vetiver Uses - Case Studies
5) Observations to Show Special Characteristics of Vetiver Hedgerows

Readers may find that there is much emphasis on quality planting material and quality hedgerows. The quick establishment of quality hedgerows is critical under tropical conditions with heavy monsoon rain. It will be justifiable to use quality hedgerows for protection of expensive structures such as highway embankments, culverts, etc. Quality hedgerows will cost more, but they may not be necessary under many other circumstances. I am not after a perfect system, only aiming for a cost-effective system to suit prevailing needs.

Cultivar	Tillers Mean per Bag 3x5	4x6	5x7	6x9	Mean	Mean Dry Weight (g) Tops 3x5	4x6	5x7	6x9	Mean	Roots 3x5	4x6	5x7	6x9	Mean	Total 3x5	4x6	5x7	6x9	Mean
India	7.0	8.4	9.6	10.2	8.8	15.3	22.4	25.6	27.4	22.7a	5.1	5.1	7.0	7.1	6.1a	20.4	27.6	32.6	34.5	28.8a
Parit Buntar	5.0	3.8	5.4	6.8	5.3	13.4	13.5	21.5	27.9	19.1 b	3.0	2.7	4.1	7.9	4.4 b	16.3	16.2	25.7	35.8	23.5 b
Taiping	6.4	8.6	7.4	7.4	7.5	12.3	16.5	18.3	18.0	16.3 cd	3.0	5.6	6.1	7.0	5.4a	15.3	22.1	24.4	25.0	21.7 b
Sabah	5.4	5.8	8.8	9.6	7.4	11.0	12.0	21.5	27.2	17.9 bc	2.7	3.5	5.8	6.3	4.6 b	13.7	15.5	27.3	33.5	22.5 b
Sabak Bernam	5.8	6.6	7.2	9.2	7.2	10.7	14.6	22.9	23.3	17.9 bc	1.9	2.7	4.3	5.6	3.6 c	12.6	17.3	27.2	29.0	21.5 bc
Raub	6.0	5.6	7.0	7.2	6.5	10.9	11.8	19.3	20.1	15.5 d	2.1	2.7	3.5	5.1	3.3 c	13.0	14.5	22.8	25.2	18.9 c
						d	c	b	a		d	c	b	a		d	c	b	a	
Mean	5.9	6.5	7.6	8.4		12.3	15.2	21.5	24.0		3.0	3.7	5.1	6.5		15.2	18.9	26.7	30.5	

Means with the same subscript are not significantly different at P<0.05

Table 1. *Effect of cultivar and bag sizes (inches) on dry weight (g) of vetiver tops. Measurements taken at 15 weeks after planting.*

The readers will have to calculate the Benefit:Cost Ratio under their own respective requirements.

The results of the trials and other ad hoc observations carried out so far and the feed-back information have shown clearly that vetiver hedgerows have tremendous potential for many areas of human activities. In the next few years we should translate them to reality in practical applications. The trip has just begun, but we can see the ultimate glorious goal at the end of the journey!

Production of Quality Planting Materials

The quick establishment of good hedgerows is important for tropical conditions where heavy monsoonal rains will wipe away any poor planting. This is particularly critical for structural works such as highway embankments, road shoulders, bridge abutments, culverts, etc.

To be able to produce quality hedgerows, quality planting materials must be used. Good planting materials must still begin with young and active tillers. In the First Progress Report, I devoted a lot of attention to propagation techniques and also pointed out the effect of various tiller types on subsequent growth. Readers can refer to that for more information. This part concentrates on:

1) Root Regeneration
2) Effect of Age of Polybag Plants on Subsequent Growth
3) Effect of Tiller Numbers at Planting on Growth
4) Effect of Cultivar and Polybag Sizes on Growth
5) Raising Vetiver Plants in Biodegradable Containers

Root Regeneration

This section examines the regeneration of cut-roots in slips. The old roots do not regenerate. They do not even form any secondary roots. As the old roots do not regenerate, they are only useful for anchorage. New roots are only formed from the new tillers or from the nodes of the old culms. Therefore plantings using slips with cut roots would be very slow in establishment and growth relative to container raised slips whose roots have been regenerated before outplanting.

Effect of Age of Polybag Plants on Subsequent Growth

Early work has shown that plants at 4 months have a good root system for transplanting and will take off immediately to produce good hedgerows quickly. This section investigates the optimum duration for raising container plants in the nursery. Plants raised up to 11, 16, 23 and 51 weeks in polybags were transplanted into the ground. Weekly examination shows very good regeneration and early growth of the root system of 23 week and also 16 week plants. Plants raised for 11 weeks show early growth but were less vigorous. Growth of 51 week-old material was very poor. Previous experience has also shown that older (70 weeks) polybag plants perform even worse. The very old container plants are not good for subsequent growth in the field as the old roots are so bag-bound that they do not regenerate. The optimum duration seems to be about 23 weeks, but it may not be economically satisfactory to keep plants for such a long time in the nursery.

Effect of Tiller Numbers at Planting on Growth

The target is to improve materials for transplanting out earlier than 4 months in the nursery but still maintaining the same good root mass at the time of transplanting. This attempts to find out whether quality planting materials can be produced in a shorter time by using more tillers as starting material.

Trial 1 — This trial compares the use of 1, 3 or 5 tillers at the time of planting into polybags. Harvesting of plants were carried out at 4, 6, 8, 10 and 12 weeks after planting. On each occasion, 10 plants were randomly selected from each treatment, roots washed, photographed, the number of new tillers counted and the dry weights determined. Plants starting with 5 tillers have a lower number of new tillers compared with those started with 3 tillers or 1 tiller. It is difficult to get 5 tillers in a clump without resorting to usage of the more matured culms; and the older the materials, the slower they are at producing new growth. Therefore, to use 5 tillers will include using older culms which are not the best for use in the production of quality planting material. The usage of 5 tillers is also a

Bag Sizes (inches)	Gap (cm) At Months After Planting										
	1	2	3	4	5	6	7	8	9	10	12
6 x 13	8.2 b	6.7 b	5.8 bc	5.3 b	4.9 b	4.0 c	3.3 b	3.0 b	2.6a	1.3a	1.0a
6 x 9	8.5 b	6.7 b	5.6 c	5.1 b	4.8 b	4.0 c	3.3 b	2.9 b	2.5a	1.1a	0.3a
5 x 7	8.4 b	7.0 b	6.0 bc	5.4 b	5.0ab	4.3 bc	3.7 b	3.1 b	2.5a	1.2a	0.5a
4 x 7	9.7a	7.9a	6.6a	6.0a	5.4a	4.8a	4.2a	3.8a	3.0a	1.8a	1.3a
4 x 6	9.3a	7.6a	6.2ab	5.4 b	5.1ab	4.4ab	3.7ab	3.4ab	2.9a	1.5a	0.9a
s.e. (+/-)	0.20	0.17	0.15	0.14	0.15	0.14	0.15	0.17	0.23	0.25	0.21
LSD (P<0.05)	0.6	0.5	0.5	0.4	0.4	0.4	0.5	0.5	-	-	-

Means with the same subscript are not significantly different at P<0.05

Note : Data on 10 and 12 month are too variable and should not be used. It is presented here only for the record.

Table 2. *Effect of bag sizes on hedge closure. After three months, the size of the polybag used had no apparent effect on the rate of hedge closure. The data above shows the gaps between clumps (cm) over time (months) after planting.*

waste of materials with little advantage gained. Polybag plants with 1 tiller as starting material produced new tillers at the fastest rate. This supports my earlier work that we should use good young active tillers for early growth. The mass of roots produced by polybags that started with 3 tillers was greater after 8 weeks than that of 1 tiller after 10 or 12 weeks. Where the root system is concerned, 8 weeks with 3 tillers starting material can easily be substituted for 12 weeks with 1 tiller.

Trial 2 — Polybag plants produced from 1 tiller and 3 tillers were planted into the ground. There was not much difference in plants started with 1 tiller compared with those from 3 tillers. However, those plants started with 3 tillers were more uniform than plants started with 1 tiller. On that basis alone, it would be advisable to use 3 tillers as starting materials.

Trial 3 — This compares the performance of polybag plants with bare root slips (Photo 2). Those bare root slips with more than 5 tillers were faster growing than those with only 3 tillers, but even those started with more than 5 tillers had much less roots than container plants. For 15 week-old container plants there was not much difference in growth between those started with 3 tillers, compared with those started with 1 tiller. However, the nursery time for the 3 tiller material could have been only 8 weeks, in which case, it would have performed better than material started from 1 tiller (Photo 2).

Effect of Cultivar and Polybag Size on Growth

The cultivar used in all the earlier trials was collected from Taiping. Since then, we have made other collections. Those cultivars with enough materials for study and especially for destructive sampling, come from Parit Buntar, India, Sabak Bernam, Sabah and Raub. A trial was set up to study the different growth rates of these cultivars and how they are influenced by bag sizes. At 15 weeks, harvesting was carried out with 10 plants per treatment. Only the 4 smaller of the bag sizes were harvested then as the larger bag sizes of 6" x 13", 7" x 15" and 8" x 12" are considered too large for practical use. There was a decrease in the number of tillers and top dry weights production from the largest bag to the smallest bag. The results are summarised in Table 1. The Indian cultivar was the best performer. It is 30% better than the Taiping cultivar in the top dry weight, 13% higher in the root dry weight. Overall it was performing 33% better in dry matter production when compared with the Taiping cultivar. In the case of the Parit Buntar cultivar, it was 17% better for the tops. (**Note:** *Taxonomic studies have not been done to confirm that these are distinct cultivars.*) The topping of the materials for all 7 bag sizes at 40 weeks, suggests that there is not much difference in dry matter production between those raised in 5" x 7" polybags and those in the larger polybags nor with the smaller bag of 4" x 6". But the 3" x 5" polybag produced lesser tops. The Indian cultivar is 69% better and Parit Buntar 23% better than the Taiping cultivar. This is a preliminary trial. Even so, there are clear indications that cultivars like India and Parit Buntar may perform better than the Taiping cultivar.

Raising Vetiver Plants in Biodegradable Containers

All the container plants discussed so far use plastic bags which are not biodegradable and therefore not environmentally friendly. We therefore investigate other biodegradable containers to access whether they can be used as substitutes for polybags. Two types were tested: (i) paper pots imported from Japan, and (ii) bags made from old newspapers. At 6 weeks the growth of plants in newspaper bags was satisfactory. However, the newspaper bags had started breaking down and by the 12th week, most of the paper bags were broken. Therefore, we must find a system to prolong the life of newspaper bags or try other types of papers. This should be the subject of future investigation. Growth of plants in paper pots was very good if they were underlaid with a polythene sheet, but if they were not underlaid and left touching the ground, the growth was poor. Paper bags were also found to be satisfactory for continued growth up to 3 months at which time the plants were ready for field planting. However, they cost 10 times more than polybags and therefore are not economical to use.

EFFECT OF UNORTHODOX ROOTING-

Media on Vetiver Growth

Why this approach? The most important reason is the cost of transporting polybag materials. The use of polybags with good soil produces quality planting materials. However, unless the polybag plants can be raised on site, transporting of these planting materials tend to be very expensive. Because of that problem we tested other potting materials which are lighter and at the same time may perform better. Many materials were tested including saw dust, paddy husk, empty old palm bunches, etc. with generally disappointing results. So far, foam is the most promising unorthodox root-media.

We also investigated the influence of light conditions, testing growth under full sun and 65% daylight. The various durations under mist frame and irrigation sprinklers to produce the desired quality of the planting materials was also studied. Previously I have reported that vetiver is sensitive to shade, but nurseries are still set up underneath trees or by the side of houses, etc. where the light condition is not full daylight. In addition to the poor growth of the shaded nursery plants, the poorer quality appears to continue into the ground after transplanting; growth in the first 4 weeks was distinctly inferior to plants raised in full sun. Vetiver is shade sensitive, and nursery plants should never be raised under shade. Usage of the foam method ensures much better subsequent growth when compared with bare root tillers. In addition, the usage of the foam ensures easy and cheaper transportation costs and easy and cheaper distribution in the field. The development of the foam system (*) is most encouraging. More work will be carried out on more detailed comparative studies.

(*)Patent pending.

Establishment and Management of Quality Vetiver Hedgerows

It would be cheapest to plant vetiver slips directly into the ground. However, compared to containerized plants, such an approach can often require :

Photo courtesy of Dr. P.K. Yoon

Photo 5 . *Layering --attempting to protect a slope with a vetiver cover.The old culms are being pegged down using U-shaped steel wires. Where available, stones are used to hold the culms down.*

1) replacement of dead plants
2) filling of gaps of less vigorous growing slips
3) slower establishment
4) less uniform establishment

Under certain conditions, such as highway embankments, steep slopes in housing estates, etc., it would be more advantageous and possibly more cost-effective to use containerized plants. This ensures virtually 100% survival, fast establishment and good uniformity, producing the best hedgerows in the shortest time. In addition, to assess the Profitability Index or the Benefit:Cost Ratio, consideration must be given to the cost of repair of any failed structure and the inconvenience/cost of failure which disrupts other economic activities. For example, a failed road embankment could cut off transport affecting the economy of many activities.

The approaches affecting production of quality hedgerows are:

1) Effect of Bag Sizes on Establishment of Quality Vetiver Hedgerows
2) Effect of Spacing cum Fertilizer on Growth of Vetiver Hedgerows
3) Use of Selective Herbicides to Maintain Quality Vetiver Hedgerows

These are discussed in the following sections.

Effect of Bag Sizes on Establishment of Quality Vetiver Hedgerows

The total cost of establishing hedgerows using polybag plants will be greatly affected by bag size, in that these are reflected in the costs of : i) bags, ii) filling the bags, iii) transporting the bags, iv) digging the trench, and v) planting the polybag plants. A trial was therefore started to assess the practicality and cost-effective reduction in possible bag sizes without compromising the quality and speed of hedgerow formation.

Five bag sizes (4”x6”, 4”x7”, 6”x9”, 5”x7”, 6"x13") holding different weights of soil were used. The planting distance was kept at a constant 15cm between clumps. Fertilizer application was 1 Kokei (6g of 5-5-5-1(Mg)) per point at the time of planting and then 2 Kokei nuggets at 5, 8 and 11 months. Also at 11 months, 2 Field King Nuggets (15g) were applied. Good hedgerows formed after only 8 weeks growth.

The gaps in the hedgerow were measured at monthly intervals. It is interesting to note that the plot coefficient of variance (c.v.) increases with the months after planting. This should be expected as the error of measurement will increase as the absolute value becomes smaller. C.V.s of the first 6 months are readily acceptable while those of 7 - 9 months are tolerable. However, the data from 10 and 12

Photo courtesy of Dr. P.K. Yoon

Photo 6. *After 12 weeks, layering of culms had produced good results. The embankment seen in Photo 5 is now covered with vetiver.*

months are too variable. Thus the validity of the mean as an indicator is questionable and gap measurement for planting distance of 15cm should not be considered after 9 months.

At the beginning, the inter-clump gap size was determined by the different bag sizes since the planting distance was constant. Later, any change would be due to the different growth rates of plants from different polybag sizes.

Table 2 summarizes the gap reductions between measurements. Other than the period of 2-3 months after planting, they are not influenced by the original bag sizes used. This suggests that the clumps were growing (expanding) at the same rate, though they may have originated from different bag sizes.

The tops above 40cm were cut and the dry weight determined. For the first 10 months this was done monthly, thereafter, it was carried out at 2-monthly intervals until the trial stopped at 16 months. Other than the first month's measurements, the top dry weights from all bag sizes were not significantly different.

In using quality polybag plants, the transplanting success was 100%. However, the trial did not include a treatment of using slips of newly cut tillers. Another weakness in the trial is the absence of measurement of the dry weights of tops and roots of plants raised in different bag sizes before transplanting to the ground. These two points should be included in subsequent trials involving different cultivars. Despite the limitations in the trial, the results showed that plant growth in the smallest bag size treatment of 4" x 6" produced similar inter-clump gap size from the fourth month and similar dry matter production from the second month after planting. Thus, the conclusion is that the small bag size of 4" x 6" could be the most economical size for fast and good establishment of vetiver hedgerows.

My earliest work uses 6" x 9" bags holding 1,486g of soil per bag. This was later changed to 5" x 7", thus reducing the weight to 837g. Now the weight could be further reduced to 401g/bag. This weight decrease is substantial especially when plants have to be transported from central nurseries to field sites over long distances.

Effect of Spacing Cum Fertilizer on Growth Of Vetiver Hedgerows

(**Ed. Note** : *Only conclusions are presented from this particular piece of work. Those desiring the full text may write to the Network*)

Since this was only an observation trial for practical application the conclusions are tentative. More fertilizer treatments and wider range of spacing would be preferred. Additional fertilizer seemed to have an effect on dry matter production in the early months, but the higher level did not produce any increase later. Spacing plays a big role in dry matter production; the wider spacing produces significantly higher dry matter per clump. The reverse was noted in dry matter production per linear distance, reflecting the interaction of individual plant growth and the planting density. There is an apparent time x density interaction and 30cm spacing seems to have caught up with the 15cm spacing after 8 months. However, 60cm spacing stayed consistently lower. The dry matter studies, the measurement of inter-clump gaps and gap reduction, strongly indicate that close planting of 15cm is preferred for quick establishment of a functional hedgerow. Use of layering of culms to fill the gaps between wider spacing is of little value.

Use of Selective Herbicides To Maintain Quality Vetiver Hedgerows

Weed management is an important aspect in the maintenance of quality vetiver hedgerows. In Malaysia, weeds grow luxuriantly under high rainfall, humidity and temperature. These weeds compete with the vetiver directly for nutrients, water and light. The last factor is most important as vetiver is not shade tolerant. In a severe weed-infested situation, even an established vetiver hedgerow will weaken and be less effective for its intended purpose.

A weed is a plant growing where it is not desired. In vetiver hedgerow establishment and maintenance, the weeds are mainly grasses and broadleaves. The grasses are less important. The more damaging weeds are broadleaves such as *Asystasia intrusa, Chromolaena odorata* (Siam weed), *Mikania micrantha* and the leguminous creepers normally grown as covers in agricultural plantations. These latter are the most noxious because they swarm over, strangle and shade out the vetiver hedgerows.

Based on other ad hoc 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 (150g) or 2,4-D amine (1.5L) or Starane200 (1.25L)
Mikania micrantha — 2,4-D amine (1.0L) or Starane200 (0.5L)
Pueraria phaseoloides (legume) — Ally 20 DF (100g) or Starane200 (0.375L)

Use of Vetiver Grass as *In Situ* Mulch In Rubber Plantings

The good growth of vetiver, under many adverse conditions suggests it to be highly competitive. In a preliminary trial, vetiver without regular slashing, has been demonstrated to be competitive against Hevea (rubber); the diameter growth of young Hevea was depressed when vetiver was planted within 24". On the other hand, vetiver's growth characteristic can be exploited for various uses as in situ source for mulch when the tops are regularly slashed. Six experiments were set up to test this in three estates. The experimental details are:

Trial 1 — Alternate plots of linear planting of vetiver hedgerows and legume covers were replicated 3 times. This is a large scale observation area comparing the effect of mulching produced by the vetiver hedgerows with normal estate practice.

Trial 2 — The design is randomized blocks with 4 treatments x 6 replications. Treatments are : 1) control with legume covers; 2) linear planting of vetiver at 6" from trees; 3 & 4) circular plantings of vetiver at 18" and 24" from trees.

Trial 3 — This is sited on a steep slope. Vetiver is linear planted as hedgerows for mulch in a block flanked by commercial practice on either side.

Trial 4 — Trial layout is similar to that of Trial 1, but replicated 5 times.

Trial 5— Double grouping of treatments in a 5 x 5 Latin square was adopted for this trial sited on hilly terrain. The treatments are: 1) control - No vetiver; 2 &3) circular planting 24" from trees with 13 and 26 vetiver plants/tree; 4 & 5) circular planting 18" from trees with 10 and 20 vetiver plants/tree.

Trial 6 — This is sited on very steep land with very poor soil (Gajah Mati) in North Peninsular Malaysia where there is a very pronounced dry spell. The trial is a randomized block design of 7 treatments x 9 replications. Treatments are : 1) circular planting of vetiver at 18" from trees with 20 plants/tree; 2, 3 & 4) circular planting of vetiver at 24" from trees with 10, 13 and 26 plants/tree; 5 & 6) linear planting of vetiver, 6" and 12" away from trees; and 7) control with legume covers (estate practice).

The effect of vetiver as *in situ* mulches on the early Hevea growth over 1-2 years are rather disappointing. In 2 trials no effect was detected, while in another 3 trials, vetiver growing round a Hevea plant seem to be competitive and suppressing the growth and growth rate of Hevea. Linear planting of vetiver was beneficial for Hevea growth in two trials in the earliest girth measurements but thereafter is depressive though not as severe as circular plantings. All the above suggest that vetiver is competitive; this could be due to excessive number of vetiver plants used and the vigorous growth of vetiver. However, it should be noted that normally, in Hevea research the girth rates of the first 2 years are rarely used to assess the overall effect on the immaturity period of 4 - 5 years. We shall continue to monitor the results. Special attention will be paid to the effect of shading on the growth and competition of vetiver as the Hevea canopy close over.

Uses of Vetiver - Case Studies

This part of the report summarises the adaptive uses of vetiver on 3 commercial estates. More details are found in the video recordings which features the time sequence photos of specific sites of interest and the current situation existing as at March 1993. The following photo-essays attempt to highlight only the major points of interest.

(**Ed. Note :** *The Newsletter, unfortunately, cannot present this portion of the report to you as it utilizes about 90 photographs to tell its stories. We hope that in the coming year we will be able to find sufficient funds to allow the Network to edit Dr. Yoon's videos and add in these photos which we would then make available to Network members at cost. Any semi-professional editors out there who can volunteer to help us ?*)

Observations To Show Special Characteristics of Vetiver Hedgerows

This part examines certain special characteristics of vetiver hedgerows :

1) Resistance to Fire Damage :

A trial in ex-mining land was severely damaged by a fire. Sequential examination at weekly intervals showed fast and good recovery.

Vetiver hedgerows recovered rapidly from fire damage. The older and dry parts of the vetiver clumps were burnt, but culms which were green and active were only damaged in the upper portions. The lower parts, near the crown and partly buried in the sand, were not burnt. Similarly, there was little sign of damage to the massive root

Table 3. *Chemical analysis of soils used in Dr. Truong's experiment #1 on the impact of acidic conditions on vetiver.*

Soil pH (1:5 water)	: 3.65	Cu	: 0.1 mg/kg
EC	: 0.55 $mScm^{-1}$	Zn	: 4.0 mg/kg
Cl^-	: 358 mg/kg	Mn	: 2.0 mg/kg
NO_3^-	: 45 mg/kg	Fe	: 286 mg/kg
PO_4	: 115 mg/kg	Al (exch)	: 9.1 meq%
Ca	: 1.30 meq%	Ex Acid	: 10.30 meq%
Mg	: 1.95 meq%	Al saturation	: 62%
Na	: 1.65 meq%		
K	: 0.74 meq%		

system buried in the ground. Within a week, new tillers were produced from the unburnt portion of culms. By 4 weeks, all clumps have recovered, with vigorous new growth.

2) Growth in Highway Embankments with Difficult Soil Types:

A very difficult area on a highway embankment was used to test this. These trial results clearly show that the vetiver root system will seek out any weak point in a difficult soil structure.

A small stretch of the North-South Highway near Taiping, Perak Darul Ridzuan, was specially selected because the maintenance engineers had failed to establish any grass covers despite repeated attempts. Vetiver hedgerows, however, established well and showed good results. The tops of the vetiver hedgerows grew well. Excavation of the two difficult soil types in this small area showed that vetiver roots will seek out any weak spot in the soil. Despite the relatively poor root system that was able to develop on these difficult sites, the highway engineers were most impressed by the performance of these vetiver hedgerows to trap soil-wash and other debris from polluting the drain. Also, by slowing down the run-off, the hedgerows have allowed other grasses to grow where they were not able to earlier.

3) Excavation of Vetiver Hedges :

Excavations at various sites were done to study the soil trapped by vetiver hedgerows in cross-sectional soil profiles, the dynamics of the growth of vetiver hedgerows, and the root system. Photos 3 and 4 serve to highlight certain special features of the vetiver hedgerows.

4) Layering in Vetiver Hedgerows:

Vetiver was chosen for hedgerows because of its non-spreading characteristics. It is distinctive and compact and is an effective biological barrier for soil erosion and moisture conservation. However, under certain conditions it may be desirable to produce blanket cover for the whole area. By layering, new shoots are produced from the culms and we can make vetiver grass into a "runner" of sorts.

In the First Progress Report, it was pointed out that buds in the nodes of old culms can be induced to produce new plants. Layering of the culms, either detached or still attached to the mother clump, was used to produce culm branches for multiplication.

The same method of layering could be used to establish new plantings. A trial was carried out to determine the success of such an approach. 245 culms were pegged onto the ground by a U-shaped steel wire. Very good results of new plant production were obtained in the open (Photo 5). Only 14.1% of the culms failed to produce any plants. 27.3% of the culms produced 2 new plants each while 33.3% produce 3 - 5 new plants each. Beneath the canopy shade of the Hevea plants, the production of new plants was poorer with also less new plants per culm.

The distances where the new plants were produced on the culms were measured and partly mapped schematically. New plants were produced within 0.5m of the hedgerow and tended to be produced at the furthest end; the youngest portion of the culm. This could be partly due to the shade effect imposed by the overshadowing hedgerow. However, the more likely reason is the age of the buds on the culms; young buds tend to sprout faster.

A simple demonstration of the use of layering to protect the embankment was set up. A 15 month-old vetiver hedgerow at the crest of an embankment had its old culms pegged down by U-shaped steel wire or split bamboo. The results from this simple demonstration attracted a lot of attention during the First International Workshop in Kuala Lumpur 1992. The method using the split-bamboo did not give satisfactory result as the lower portions of the culms tend to curve up; few new plants were produced at those portions and those plants so produced, hanged in the air and did not take root. The culms pegged down by U-shape wire produced very good results and the slope on the embankment was soon covered by vetiver plants (Photo 6).

Biologically, vetiver is a clump grass of erect habit with no running rhizomes or stolons. However, this trial shows that vetiver can be converted into a runner, if necessary, by layering the culms.

THE EFFECTS OF EXTREME SOIL pH ON VETIVER GROWTH

BY DR. P.N.V. TROUNG

Dr. Truong is currently working with the Queensland Department of Primary Industries in natural resource management.

The main objective of this series of experiments was to study the effects of very low and very high soil pH levels and their associated nutritional problems on the growth of vetiver grass.

Table 4. *Sulphur and $CaCO_3$ rates used to modify pH levels in Dr. Truong's experiment #1. Basal dressing equivalent to 184 kg/ha of N, 144 kg/ha of K and micronutrients (Zn, Cu, Mn, Fe and B) and 50 kg/ha of Ca as $CaCl_2$*

Treatment	Fertilizer (t/ha)		
	Elemental S	$CaCO_3$	Basal Dressing
Control	0	0	No
1	5	0	Yes
2	2.5	0	Yes
3	0	0	Yes
4	0	0.25	Yes
5	0	0.50	Yes
6	0	1.00	Yes
7	0	2.50	Yes
8	0	5.00	Yes

TREATMENTS	PLANTING			HARVESTING		
	pH	Al*	Mn*	pH	Al*	Mn*
0	3.9	9.1	1.6	4.0	8.8	2.0
1	2.1	78.0	24.0	2.0	75.0	24.0
2	2.3	75.0	22.0	2.2	79.0	22.0
3	3.8	10.5	2.1	3.8	10.3	2.0
4	4.3	6.0	1.4	4.4	5.6	1.0
5	4.9	2.1	1.3	4.8	2.0	1.0
6	5.4	0.2	1.0	5.5	0.1	1.0
7	7.3	0.1	T	7.3	T	T
8	7.4	0.1	T	7.6	T	T

* in meq%; T = Trace

Table 5. *Soil pH, exchangeable Al and exchangeable Mn levels at planting and harvesting times.*

Acidic Conditions

A soil with extremely low pH which is known to cause Al toxicity in corn was used in this pot experiment. The very high level of exchangeable Al and relatively low exchangeable Mn concentration of this soil suggested Al toxicity rather than Mn toxicity would be the main problem of this extremely acid soil (Table 3). Eight levels of soil pH were obtained by applying varying quantities of elemental S and CaCO3 to the soil. All eight treatments also received a basal dressing of N,P,K, Ca and micro nutrients. In addition, a control treatment was also included where no S, CaCO3 or basal fertilizers were applied (Table 4).

The required quantities of S and CaCO3 were thoroughly mixed with the dry soil of each pot. Following the application of S and CaCO3, soil moisture was kept at field capacity level for two weeks before planting to allow for the stabilization of soil pH. Basal fertilizers were applied at planting. For watering, a closed system was used. Each pot was lined with two plastic bags to prevent leakage. Soil moisture during the trial was brought to field capacity by daily watering with deionized water. Plants were cut at crown level eight weeks after planting.

Table 5 indicates that the quantities of S and CaCO3 used provided a wide range of pH levels. Although both exchangeable Al and Mn concentrations were directly affected by soil pH, exchangeable Al had a larger response. Therefore the nutritional problem caused by the change of pH would be most likely due to the change of Al concentration rather than Mn. From other work it has been observed that in most cases, where both soil Al and Mn are high, plant growth reduction is due to Al not Mn toxicity.

Table 6 shows that when adequately supplied with essential nutrients, vetiver could produce excellent growth even under extremely acid conditions (pM = 3.8) and at very high level of soil Al saturation percentage (68%). However, vetiver could not survive at Al saturation level of 90%.

These results indicate that vetiver is highly tolerant to low pH and high Al saturation percentage in the soil, although these results did not show the critical toxic level of Al. Observation during the trial indicated that the critical Al toxic level for vetiver could be much higher than 68%. If the critical Al toxic level of vetiver was between 68% and 87%, then vetiver would be extremely tolerant to Al toxicity. At this level vetiver would be much more tolerant to Al toxicity than some of the most tolerant crop and pasture species. A relatively Al tolerant crop, would respond to liming when Al saturation percentage of the soil was at 15% or higher. This experiment shows that when essential nutrients are adequately supplied, vetiver growth was not improved by liming even when soil Al saturation percentage was as high as 68%.

It was also observed that proportionally more fine roots occurred under low pH and high Al saturation percentage than under low Al conditions.

The results of this experiment indicate that vetiver is extremely tolerant to high soil acidity and particularly Al toxicity. This high tolerance to Al toxicity may be traceable back to its natural habitat. Vetiver is commonly found in the tropical and sub tropical wetlands of Asia where acid sulphate soil with extremely high level of exchangeable Al in the dry season, commonly occurs.

Alkaline Conditions

An extremely alkaline and sodic soil was used in this experiment. The soil, an 18 month old spoil from an open cut coal mine, was highly erodible and very difficult to revegetate. Table 7 shows that this soil is extremely alka-

Table 6. *Dry matter yield of vetiver. These results indicate that vetiver is highly tolerant of low pH and high Al saturation.*

Treatment	D.M. Yield (g/pot)	Relative yield (%)
0	29.0	100
1	0	-
2	0	-
3	47.5	164
4	47.8	165
5	49.4	170
6	46.5	160
7	49.3	170
8	46.9	162

Photo courtesy of Dr. P. Truong

Photo 7. *Excellent growth of vetiver in a highly alkaline and sodic soil with adequate supply of N and P. 1 = Control, no fertilizer; 2 = Treatment 1, 100 kg/ha N and 110 kg/ha P.*

Photo courtesy of Dr. P. Truong

Photo 8. *Excellent response to N and P application. Vetiver did not respond to gypsum. 1 = Control, no fertilizer; 2 = 100 kg/ha N and 110 kg/ha P; 3 = 4 t/ha gypsum, 110 kg/ha N, 220 kg/ha P; 4 = 8 t/ha gypsum, 200 kg/ha N, 110 kg/ha P.*

line and sodic with high levels of Mg as well. The exchangeable sodium percentage (ESP) was 33%. It is also very low in N, P, Ca and S.

A pot experiment with four replicated and two levels each of fertilizer grade di-ammonium phosphate (DAP) and gypsum was carried out. For watering, the same system was used as for the previous experiment. All plants were harvested 10 weeks after planting.

Only a very small reduction in soil pH (from 9.6 to 9.0) occurred in treatments which had received fertilizer applications. At the end of 10 weeks, there was no difference in vetiver growth in all treatments receiving fertilizers (Photo 7). Vetiver grass has a moderately high level of tolerance to Na toxicity as it can be established and flourish at ESP level of 33%. The overall result is typified by the difference in vetiver growth between the control and treatment #1 which only had 100kg/ha of N and 110kg/ha of P but no gypsum (Photo 8). These results indicate that vetiver can be established on very alkaline and highly sodic soil with the application of 100 and 110kg/ha of N and P, respectively. This experiment shows that vetiver can be established and maintain good growth in very alkaline and sodic soil when N and P are adequately supplied.

Table 7. *Chemical analysis of soils used in Dr. Truong's experiment #2 on the impact of alkaline conditions on vetiver.*

Soil pH (1:5 water)		9. 5	Ca (Alc)	(meq %)	6.0
EC $mScm^{-1}$		0.36	Mg (Alc)	(meq %)	20.0
Cl^-	mg/kg	256	Na (Alc)	(meq %)	12.0
NO_3^-	mg/kg	1.3	K (Alc)	(meq %)	0.43
PO_4	mg/kg	13	CEC *	(meq %)	36
SO_4^-S	mg/kg	6.1			

(Alc) = Alcohol extract; * at pH = 8.5

Application of Molecular Diagnostics for Discrimination of Accessions and Clones of Vetiver Grass By Dr. S. Kresovich, et al

Drs. S. Kresovich, W.F. Lamboy, Li Rugang, Ren Jianping, A.K. Szewc-McFadden and S.M. Bliek are currently working with the USDA-ARS, Plant Genetic Resources Unit, Cornell University, Geneva, New York.

Because origins and genealogies of vetiver grass are poorly documented, and morphological uniformity and infrequent flowering precluded proper identification of selected clones, we employed molecular diagnostics linked with rigorous biometric analysis to :

1) establish if molecular diagnostics might be useful to resolve identity questions among vetiver grass accessions and clones;
2) implement a strategy, experimental protocol and analytical approach for the application of this approach toward broader issues in plant genetic resource conservation and use.

Accessions of vetiver grass were obtained from various sources. Tested were : 'Huffman' - an accession received as two clones of undetermined origin (*); 'Boucard' - an accession received as two clones from Jamaica and/or Guatemala; and PI196257 - an accession received as three clones of Indian origin.

DNA was extracted from young leaf tissue of each clone, amplified and analyzed.

The data support with a high degree of certainty (P>0.05) that the accession 'Huffman' and 'Boucard' were essentially the same genotype. The three clones of accession PI196257, on the other hand, were found to be genetically unique. A review of records (the accession was provided from a

	Total Stem Count	Sample Average	Stem Total Compared to Vetiver	% Compared to Vetiver	Total Area	Total Area Compared to Vetiver	% Area Compared to Vetiver
Vetiver	589	294.5	------	------	10,066 mm2	------	------
M. sinensis	629	314.5	+ 20	+ 6.8%	5,606 mm2	- 4,460 mm2	- 44.3%
M. zebrinus	1,455	413.0	+118.5	+ 40.2%	7,057 mm2	- 3,010 mm2	- 29.9%

Table 8. *A comparison of stem count and area occupied by stems for vetiver and two species of Miscanthus -- a clump grass under testing by the US Soil Conservation Service as a cold climate substitute for vetiver. Sampling consisted of measurements taken on two plants of each species; all plants were the same age.*

government plant materials center) show that this accession was introduced into the United States as a vegetative propagule, but seed was subsequently produced and collected domestically. Progeny of the seed increase were grown and then vegetatively propagated. On further investigation, one of the clones within this accession was found to have a mixture of genotypes among its individual culms, i.e. the plant was a mixture of genotypes. The mixture of genotypes among the three clones of accession PI196257 can be explained by its history of sexual rather than vegetative propagation. As to how an individual (supposedly) clone could be, rather, a mixture of genotypes is a matter of conjecture. One likely hypothesis is that unmonitored vegetative propagation occurred among accessions.

The work done here highlights how detection of genetic similarities and differences is important when classical morphological characterization information was of limited value. There are currently over 20 accessions of vetiver grass available for field trial in the United States. Serious consideration must be given to any planned introduction or improvement based on the characteristics of this genetic spectrum. More extensive surveys and/or acquisitions of material available globally would aid vetiver grass researchers as they attempt to resolve the chronic problem of soil erosion.

(*) **Ed. Note :** *Mr. Gueric Boucard believes that the clones designated 'Huffman' have their origins in Guatemala.*

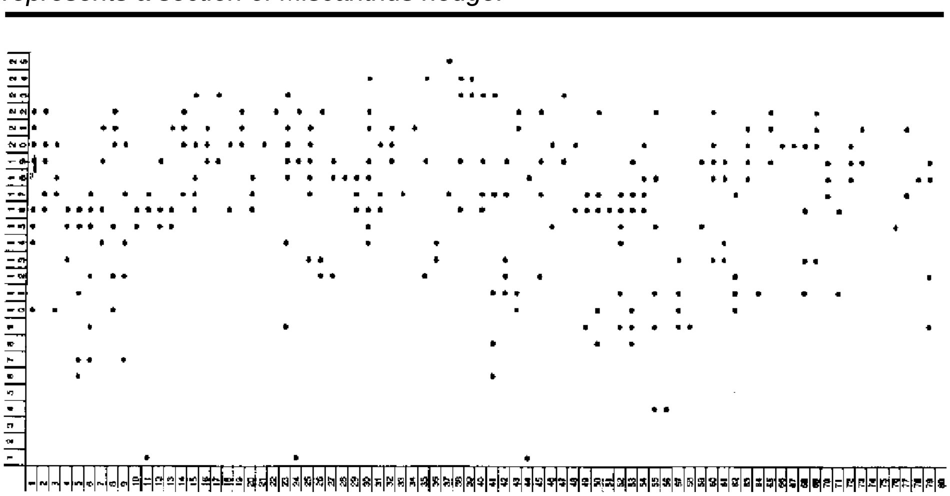
Comparative Measurements of Vetiver and Miscanthus By Mr. M. Materne and Ms. C. Schexnayder

Both Mr. Materne and Ms. Schexnayder currently work with the U.S. Soil Conservation Service in Baton Rouge, Louisiana.

The following are excerpts from Mr. Materne's December 1992 talk at the meeting in Oxford, Mississippi of the Work Group on Grass Hedges (cum Vegetative Barriers) For Erosion Control.

Some of these vegetative barriers (VBs) planted 30 months ago have now accumulated about two feet of sediment in front of them. Native plants which could not grow on the scoured hard beds of these wash areas prior to the vetiver hedge plantings are invading the accumulated sediments rapidly providing additional stability to these soils. The vetiver grass has sprouted from the nodes on portions of the stems buried by the sediment. The vetiver plants have adapted to the sediment deposition and are growing well. Extensive vetiver and miscanthus barriers planted about 18 months ago are all performing as barriers to water and sediment accumulations. The miscanthus begins growing about 6 weeks earlier than the vetiver (in the spring), but the extremely rapid summer growth of the vetiver produces more volume of stem growth and results in denser hedges (Table 8, Figures 1,2, and 3). Clipping hedges increased the stems per plant. Burning the hedges when they were dry increased mortality. Fertilization gave dramatic increases in growth rates of the VBs. Elevation profiles along the beds of the gullies across which hedges were planted in 1991 are showing significant depositions of sediment in front (upslope) of those hedges.

Figure 1. *A stem map of Miscanthus sinensis; each dot represents one stem. Marks on the scale are in centimeters. The area mapped is 25cm x 80cm, and represents a section of Miscanthus hedge.*



Effects of Shading and Cutting On the Growth of Vetiver By Dr. Xia Hanping

Dr. Xia is with the South China Institute of Botany in Guangzhou, PRC.

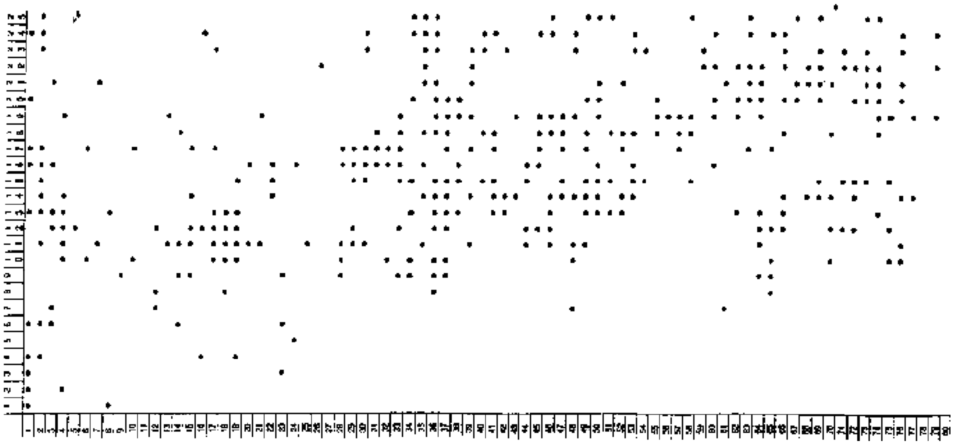


Figure 2. *A stem map of <u>Miscanthus zebrinus</u>; each dot represents one stem. Marks on the scale are in centimeters. The area mapped is 25cm x 80cm, and represents a section of Miscanthus hedge.*

Four treatments comprising two groups (shaded/non-shaded and pruned/non-pruned) were established in March of 1992. With the exception of the treatments themselves, all management was uniform across treatments (e.g. weeding, watering, fertilization). Beginning when the first new leaves appeared, the shade treatment was applied (75% shade) and maintained for 15 weeks (March 26 to July 9). Pruning treatments were applied three times (June 9, September 9 and December 8).

As expected, while under shade the rate of tiller formation was much lower than in the non-shaded plants. Upon removal of the shade, however, tillering rates were very close between the two treatments. We could conclude that shading only has a temporary effect on vetiver. However, the effect of shading on plant height and dry weight persisted. Height growth of the shaded treatment, measured by monthly net increments, was 85% of the non-shaded treatment in the four months following removal of the shading. Dry weights of the shaded vetiver were only 52% of the non-shaded. We conclude that when vetiver is planted in association with crops, it should be done at the same time or earlier than the crop and kept the maximum distance possible away from the crop.

Pruning of vetiver at 30cm was carried out three times. It is believed that pruning can enhance the rate of tillering. Our observations show that to do so, cutting must be timely and not too frequent or growth will be lost. Rates of tiller production between pruned and unpruned vetiver remained about equal until after the third pruning, when the rates of the pruned vetiver fell to 78% of the unpruned. With no further pruning, similar tillering rates were once again achieved. However, non-pruning of vetiver slows growth, that is, if allowed to grow into the reproductive stage growth rates will diminish. Therefore, it is suitable to prune vetiver twice annually. Once in February to March, and the second time in August to September. This will accelerate tiller formation relative to unpruned vetiver.

Effects of Vetiver Hedges and Mulch on Micro-Site Factors in a Citrus Orchard

By Dr. Chen Kai

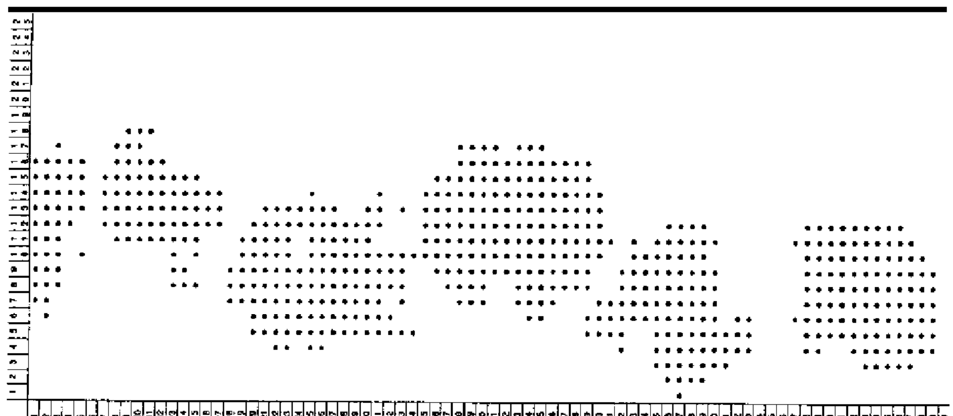
Dr. Chen is currently working with the Department of Horticulture at Nanjing Agricultural University in Jiangsu Province, PRC.

Based on 4 replicated trials in our department's orchards we have come to the preliminary conclusion that vetiver hedgerows and mulches have a significant, beneficial impact on a number of micro-site factors. We attribute its utility, and thus its beneficial impacts, to : i) its rapid growth and significant accumulation of annual biomass and ii) its excellent adaptability to the periods of extreme temperatures and water stress found in the eroded red soils regions of southern China.

Mulch production from vetiver hedgerows (in tons green weight per 100 m^2 of hedgerow) averaged 11.4, 14.7 and 17.8 in years 1, 2 and 3, respectively. (**Ed. Note:** *100 m^2 of hedgerow was equivalent to about 230 linear meters of hedge)*

Hedgerows, functioning i) as windbreaks, ii) to shade the soil, and iii) as a source of mulch provided a synergistic effect resulting in amelioration of the micro-climate. For example, on 22 August 1992 the differences between the controls and the vetiver treatments were measured. Air, soil surface and

Figure 3. *A stem map of <u>Vetiveria zizanioides</u>; each dot represents one stem. Marks on the scale are in centimeters. The area mapped is 25cm x 80cm, and represents a section of Vetiver hedge. Note the density of the vetiver hedge relative to the Miscanthus hedges.*



Treatment	Mean Daily Air Temp. (C)	Relative Humidity (%)	Soil Surface Temperature Mean Daily (C)	Soil Surface Temperature Max (C)	Soil Surface Temperature Min (C)	Soil Surface Temperature Fluctuation (C)	Rhizosphere Mean Daily (C)	Rhizosphere Soil Moisture
Control	29.3	59.2	33.8	58.6	22.5	36.1	29.2	17.4%
Vetiver	26.5	63.5	28.7	39.5	24.2	15.3	27.5	20.2%

Table 9. *Micro-climatic improvements associated with mulching and vetiver hedges combined.*

rhizosphere temperatures were all lower in the vetiver treatments. Also, in the vetiver treatments, relative humidities and soil moisture contents were higher; diurnal temperature fluctuations were less than half of the control's (Table 9).

Three years of mulching and erosion control with the vetiver hedges also significantly improved the orchard soil's physical and chemical properties (Table 10).

In view of our findings we have extended the use of vetiver throughout the orchards in our experiment station.

The Soil Salinity Tolerance of Vetiver Grass Species Compared with Two Native Australian Species

By Mr. G. Cook

Mr. Cook is a student at the University of New England in Australia.

This paper investigates 2 native species, *Vetiveria filipes* and *Lomandra longifolia* and compares their soil salt tolerance with that of *Vetiveria zizanioides* and *Vetiveria zizanioides* var Grafton. The objectives were :

- To set up a pot trial to test the salt tolerances of each species.
- To establish the relationships between soil ECse (Electrical Conductivity soil extract, a unit of measure to describe soil salinity) and the Relative Yields (increase in biomass) through statistical analysis.
- To determine the Lethal Dose 50%, or LD_{50}, for each species.
- To compare the results with Paul Truong's results (**Ed. Note**: *see Vetiver Newsletters #6 and #8*) and make comment on the differences.
- To make comment and recommendations on the potential of the various species.

The plant material was divided into individual culms (growth shoots), except for the *Lomandra longifolia*, which was trimmed so that the most dominant and central stem was the only one left. The leaves on all of the species were then trimmed to approximately 10cm and the roots were trimmed to a similar length. The soil used was supplied by the N.S.W. Soil Conservation Service/Kempsey Division. This soil was a free draining black coastal sand. The sets of culms were then planted into 17cm by 17cm black polyethylene pots. Each pot was fertilized with 5 grams of slow release fertilizer. (Total N - 18%, Total P - 2.6%, K - 10%, S - 4%, Ca - 0.6%). The plants were then watered daily for one week so as to give the plants time to acclimatize after transplant stress.

There were 5 salt concentrations used in the experiment by 4 species by 5 replicates per species. This pot trial set up was done in accordance with the methods laid out in the N.S.W. Soil Conservation Technical Handbook "Pot and Field Trials" (Anon. 1984). Each of the pots was free draining. Five NaCl salt solutions were made up daily. These concentrations were : 20 mS/cm, 15 mS/cm, 10 mS/cm, 5 mS/cm and 0 mS/cm. Degree of error = -0.1 mS/cm at 18.4 degrees C.

V. zizanioides tolerance to salt was high and even at the highest salt concentration there was still active growth in some of the culms. TheLD_{50} for shoot growth was calculated at 14.15 mS/cm while the LD_{50} for total growth was 14.75 mS/cm. This result compares well with Paul Truong's work (17.5 mS/cm). The accuracy of Truong's work is limited by the range over which the experimental Soil ECse was conducted. This experiment was conducted over a greater range of treatments. It can be confidently concluded that *Vetiveria zizanioides* has a very high tolerance to salt. *V. zizanioides* has a LD_{50} range of 13 - 17.5 mS/cm. Soil ECse at 16 mS/cm or higher are considered to be highly saline by the U.S. Salinity Laboratory.

Of the four types of grass tested., *V. zizanioides* shows the highest potential for the construction of hedgerows as a soil conservation measure in saline soil areas. It can be confidently concluded that it has a very high tolerance to salt. According to the U.S. Salinity Laboratory Soil ECse at 16 mS/cm or higher is considered to be highly saline. *Lomandra longifolia* exhibited greater salt tolerance (LD_{50}s = 23.2 mS/cm and 20.0 mS/cm, for shoot and total growth , respectively), but its open form and sexual reproduction make it less

Table 10. *Impact on soil properties of 3 years of mulch application and protection with vetiver hedges.*

Treatment	Bulk Density g/cm3	Porosity (%)	pH	Organic Matter	N	P	K	Ca	Mg	Zn	B
Control	1.35	48.6	4.7	1.03%	0.47%	0.07%	0.24%	2.52%	0.74%	0.01%	0.001%
Vetiver	1.26	52.4	5.4	1.49%	0.64%	0.09%	0.75%	5.26%	0.92%	0.03%	0.001%

desirable as a hedgerow species. It does, however, have a very dense and soil binding system of roots. *V. zizanioides* var Grafton appears to have a salt tolerance similar to that of *V. zizanioides.* This variety's ability to tolerate repotting stress and osmotic stress is, however, considerably lower than that of *V. zizanioides*. Additionally, it is known to set viable seed, from which it readily reproduces. *V. filipes* was found to have the lowest salt tolerance (LD_{50} = 11.1 and 10.9 mS/cm for shoot and total growth, respectively). Additionally, though it exhibited vigorous root growth, its roots did not form the type of dense mat desirable for soil conservation.

At this stage, the critical factor limiting *V. zizanioides* use in Australia is the evaluation of its weed potential.

Stabilization of Highway Roadcuts with Vetiver
By Mr. A. Tantum

Mr. Tantum operates his own consulting firm. One of his prime objectives is to demonstrate the value of vetiver grass in soil conservation and civil engineering in South Africa.

The face of a roadcut was gunited along its entire length in 1990/91. In addition, vetiver grass was planted above one section of the gunited road cut to observe its impact (if any). The lines of vetiver were planted and then left alone. No fertilizer or irrigation was applied. As there was no maintenance, vetiver slips which washed out prior to establishment were not replaced. Primarily, washouts occurred among the vetiver lines that were at the bottom (downhill side) of the planting. The top lines suffered little washout. The gunited surfaces below the vetiver hedges, in subsequent inspections, were found to be in good condition (Photo 9). In the areas with no vetiver hedges above to control runoff, the eroding of the gunite was well advanced (Photo 10). The non-protected areas will require re-guniting with in a short period.

Stability of Slopes of Vetiver Protected Irrigation Channels
By Dr. Sahu, et al.

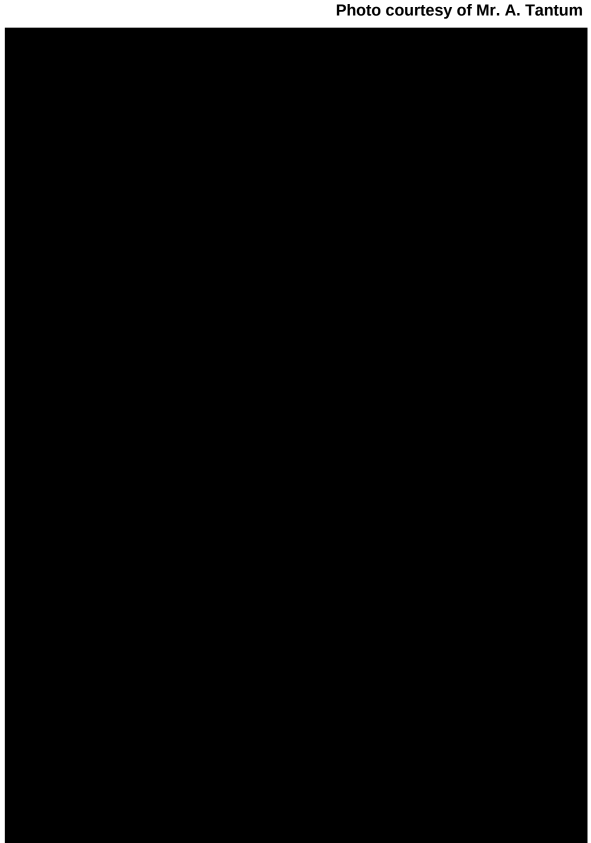
Drs. A.P. Sahu, S.D. Sharma and S.C. Nayak are working with the College of Agricultural Engineering and Technology, OUAT, Bhubaneswar, India.

Conveyance and distribution of water are integral parts of any irrigation project. Unlined earth channels are frequently used in the water conveyance systems. These channels are usually designed in trapezoidal sections. The flowing water in the earthen channels cause erosion and sloughing of side slopes. In the long run the side slopes become flatter and the channels take more or less parabolic shapes. The design capacity of the channel is, therefore, changed with the change of its cross-section.

Channel side slopes are determined principally by soil texture and stability. Earthen channels should be built with stable side slopes and with banks strong enough to carry the required flow of water safely. It has been recommended that the side slope of 3:1 (H:V) is suitable for channels constructed in sandy loam or porous clay soil and that permanent irrigation channels should not have side slopes steeper than 1.5 horizontal to 1 vertical. Where polyethylene has been used as a liner to prevent seepage, the protective soil cover placed over it also limits side slopes and permissible velocities. A 3:1 side slope has been recommended by some, though the National Committee on the use of Plastics in Agriculture (NCPA) recommends a minimum side slope of 2:1 where earth cover is used for LDPE film lining. But a flatter slope is required depending upon properties of the cover material. Using flatter slopes, as in LDPE film lining, larger areas will be lost by construction of channels.

Photo 9. *Vetiver demonstration plot, highway roadcut in South Africa. Hedges were planted to protect gunited surfaces from runoff.*

Photo courtesy of Mr. A. Tantum



As a potential solution to this problem, the ability of vetiver grass to protect side slopes from erosion and to stabilize the channel sections was tested. Whether or not it would be effective was assumed to be a function of the plant's root system, i.e. density or soil binding capability and depth of the effective root system.

Two rectangular field channels (one lined with LDPE and the other unlined) were laid out (20cm wide x 20cm deep, gradient = 0.1%, length = 19m) with vertical sides and vetiver grass was planted in lines 10cm back from the channel lips; a 10cm spacing between plants was utilized. Soils were a sandy loam with a maximum (dry) bulk density of 1.75gm/cm3.

After planting, the vetiver was allowed sufficient time to establish before water was run through the channel. Water flowing through a steep-sided (in this case, vertical) channel will erode the sides until such time as a stable condition is achieved. An average of 10 liters/second was run through each channel for one hour per day. Water was run through the unlined channel and the LDPE lined channel for a total of 9 and 6 hours, respectively. Table

Photo courtesy of Mr. A. Tantum

Photo 10. *Where no vetiver hedges were planted to control runoff, the gunite has begun to erode.*

11 shows the details.

The side slopes of the field channels planted with vetiver remained vertical in the lined channel and nearly so in the unlined channel. This indicates the high efficiency of the vetiver root system in binding and holding the soil together. It also suggests that in designing channels with vetiver grass, one can go for earthen channels with much steeper sides in sandy loam soil. Since the vetiver grass protected channels can maintain steeper sides, they occupy less space as compared with conventional earthen channels.

Vetiver in Hong Kong
By Dr. R.D. Hill

Dr. Hill works with the University of Hong Kong and is the editor of the Asia-Pacific Uplands Newsletter.

A number of experimental plantings for erosion control have been made since 1989, some of which have been previously reported in Vetiver Newsletters. One, a planting carried out in 1991 on eroding, decomposed granite of very low nutrient status at Jordan Valley is now flourishing. This planting was made at the beginning of the dry season to test survival of the tillers with the further object of seeing if vetiver planting might provide dry-season employment. However, the spring of 1992 was early and was very wet so that the high rate of survival (98%) that we observed may be atypical. By mid-1992 the plantings had hedged up, except in gully floors where wash-outs occurred, and adventitious plants had begun to cover the surface above the hedges. Soil formation has begun in the trapped sediment and this has been assisted by periodical cutting of the vetiver to 30cm and throwing the cut material upslope of the hedges to form a mulch. The mulch persists for up to a year and while adding nutrients also protects the soil surface from raindrop impact and reduces sediment mobilization. This planting was under government supervision and some objection on aesthetic grounds has, apparently, been made to using vetiver. Monitoring of the build-up of soil above the hedges has proved impossible in this public-access area as erosion-pins inserted for measurement purposes have been pulled out. This part of the experiment has therefore been abandoned.

A further, recent planting is part of a study to establish contour-planted hedges of two fodders - Stylosanthes for wet-season production and *Cajanus cajan* for dry-season production. Vetiver is first planted for erosion control in single contour rows at 10cm spacing on burnt-over grassland. We prefer to do this using soil augers as these disturb the soil much less than using conventional hoes or pick-axes. Once the vetiver is established Stylo and Cajanus are sown in contour furrows. This experiment has just begun and will continue in the 1993 planting season.

Our initial vetiver planting, on 18 January 1993, was less than successful. Slips were trimmed to 30cm of leaf before planting at 15cm depth. This proved to be too shallow, and of the 300 or so slips planted 18% were subsequently blown out and died. Several weeks of strong winds - the site is an exposed ridge -, temperatures below 15° and little rain also contributed to further losses, a further 39% had (apparently) not established when we surveyed the planting on 29 March 1993. The burnt area we are planting is the result of an uncontrolled fire which occurred in early November 1992. We wanted to plant the site immediately after the fire to protect it but we delayed the planting because we thought to be too late to rely on residual soil moisture as we had in the abovementioned Jordan Valley planting. It is hoped that a further planting in late March will be more successful since the spring flush of growth had by then begun. Further plantings at monthly intervals are planned.

In Hong Kong we prefer to use stiff, old tillers and new tillers planted together in the same hole. There are two reasons for this. Our 'mother stock' has been in the same plot for several years because high labour costs and limited demand for slips have made it uneconomic to divide and replant. More importantly it is desirable that the `comb-like' action of the vetiver in trapping sediment begins at once. If using young, green, relatively flaccid planting material there is a delay until it matures and stiffens up. On some sites pebbles and small boulders are mobile and by using stiff, mature material these are trapped even by very new plantings.

Vegetative Hedgerows for Erosion Control in Southwestern Mississippi By Dr. Tiwari, et al.

Drs. S.C. Tiwari, P.E. Igbokwe, J.L. Burton, and R.E. Waters, Jr. are all associated with Alcorn State University in Lorman, Mississippi, USA.

A field experiment was carried to investigate four vetiver grass accessions (Nos. 196257, 213902, 271633 and 302300) and a switch grass (*Panicum virgatum*) accession "Alamo" for sediment retention on an undulating field with a 6% slope. The study was conducted on a Memphis silt loam (Typic Hapludalf) soil. A randomized complete block design was used. Planting was done in single straight lines across the slope with four replications (blocks) per accession. Each block was 7.6m long and was planted with 10 plants from each of the five grass accessions planted 16cm apart. A 3.6m wide area immediately above each hedgerow was kept free of vegetation by constant cultivation to represent a farmland prone to soil movement due to tillage and absence of ground cover. A wire, 200mm above the ground level was stretched above the grass planting line, and used to determine changes in soil elevation. This field study, which began on May 5, 1991 (hedgerow planting date), was terminated June 30, 1993 after two growing seasons. At the end of the first growing season, all were pruned to 25cm. Every month, the rise in soil mass along the line beneath the 200mm wire was determined by five measurements at 5 randomly selected locations. Similarly, for each grass accession within each block, monthly measurements were taken to determine the rate at which the gaps between the clumps of grass were closing, i.e. rate of hedge formation. Data collected on soil elevation and gap closure during the two years of study were analyzed by the analysis of variance and means separated by the Duncan multiple range test.

There were no statistically significant differences between the different grasses tested and the rates of hedge formation or sediment accumulation (Table 12). However, soil elevation (sediment accumulation) was highest due to vetiver grass accession 271633, and least due to the vetiver accession 302300. The percent change in elevation was similarly highest due to vetiver grass accession 271633, and least due to the grass accession 302300.

The gap closure rate was highest due to vetiver grass accession 302300, and least due to the other vetivers and Alamo grass accessions. The percent gap closure was similarly highest for vetiver grass accession 302300.

Although all grass accessions showed potential for controlling sediment movement on a Memphis silt loam soil of Southwest Mississippi, it is observed that vetiver grass accession 271633 seems to have the greatest potential for the control of sediment movement even though vetiver grass accession 302300 seems to have faster rate of hedge formation than the other accessions in this study. After 13 months of growth in this area, for all accessions, the average rate of gap closure (lateral growth) was 124.2mm, and the average increase in soil elevation was 47.9mm.

These findings suggest that :

- These grass accessions are well adapted to the Memphis silt loam soil of Southwest Mississippi, and will slow runoff and cause the deposit of sediments when planted for use as vegetative barriers.
- Average slope between two hedgerows can be reduced significantly in only two growing seasons. In this trial, average slope was reduced by about 67%.

The authors wish to thank the United States Department of Energy and Mississippi Department of Energy and Transportation Division, Economic and Community Development for funding this project.

Table 11. *Effectiveness of vetiver in stabilizing irrigation channels. The sideslopes of the vetiver-protected irrigation channels remained nearly vertical, indicating the high efficiency of the root system in binding soil.*

Channel Description	Average Top Width, T (cm)	Average Bottom Width, B (cm)	Average Depth of Section D(cm)	Tan 0 = D / ((T - B)/2)	0 = Arctan D / ((T- B)/2)	Sideslope H:V
Unlined, vetiver protected	32.6	29.0	16.2	10.2	84.4 degrees	0.1 : 1.0
Lined (LDPE film), vetiver protected	22.2	22.2	17.2	infinity	90 degrees	0.0 : 1.0

Soil and Water Conservation A Dimension of Sustainability at the Watershed Level By Dr. D.V. Rao

Dr. Rao is working with the Institute of Economic Growth in New Delhi, India.

Our study pertains to the Maheswaram watershed development project in Ranga Reddy district of Andhra Pradesh. One of the outstanding features of this project is that the soil and moisture conservation encompass both engineering structures and vegetative barriers with khus (vetiver) grass hedges. A stratified random sample of 121 farms was surveyed during the year 1988-89 in the project area to analyze the relative merits of different conservation technologies and approaches adopted at the watershed level.

The conservation measures undertaken are expected to increase the yield and value of crops. An impact assessment shows that the yields of sorghum-pigeonpea and castor are 51.2% and 17.5% higher, respectively, on farms with engineering measures than that of those with no conservation. They are 74.2% and 32.6% higher, respectively, on farms with vegetative

Grass Accession	Soil Mass Elevation [Y] Soil Elevation (mm)	Elevation (%)	Lateral Plant Growth [X] Gap Filling (mm)	Gap Filling (%)
Switch "Almo"	47.78	23.89	122.70	86.17
Vetiver 196257	51.53	25.76	124.95	87.75
Vetiver 213902	44.20	22.11	122.83	86.25
Vetiver 271633	54.30	27.15	122.70	86.17
Vetiver 302300	41.08	20.54	127.58	89.59
Mean	47.78	23.89	124.15	87.19
CV, %	36.41	36.41	4.08	4.08

X - Based on the initial within row plant distance (152.4mm)
Y - Based on the initial height of stretched wire from soil level

Table 12. *Hedgerow effect on soil mass elevation, rate of gap filling.*

measures. Similarly, the incremental land values are 25% and 45% more with engineering and vegetative measures than that of lands with no such measures. These conservation measures need regular care and maintenance. For instance, the decrease in productivity and land values on farms with old bunds that were constructed 15-20 years ago indicates further degradation of dry lands. This suggests that stabilization of conservation structures is crucial.

The results of benefit cost analysis show that the annual incremental net benefit for sorghum-pigeonpea and castor are Rs. 300 and Rs. 291/hectare with engineering measures over that with no conservation measures at their market prices. The benefits are Rs. 453 and Rs. 480 for these crops with vegetative measures. Similarly the incremental net present values, NPVs, are higher for vegetative measures, i.e. Rs. 3045 and Rs. 2839/hectare for sorghum intercrop and castor, respectively. Whereas the NPVs are only Rs. 1101 and Rs. 586/hectare with engineering measures at 12% discount rate. However, the annual benefits and NPVs are much higher with castor with vegetative measures at their shadow prices as castor earns foreign exchange.

Optimal land use strategies suggest that within the available resource constraints, greater areas, as much as 80%, should be brought under vegetative measures of conservation to contain soil loss as a whole. Further, income can also be increased. Obviously, there is no conflict here between optimal land use with conservation and income maximization. To sum up, soil and water conservation programs are profitable if they are implemented on a watershed basis with regular care and maintenance. Vegetative barriers with khus hedges are found to be more profitable, even during the initial stages, due to their efficiency and low cost. Therefore the vegetative measures are expected to be in large areas in years to come by virtue of their replicability, efficiency and profitability.

Evaluation of Vetiver Hedgerows

Relative to Graded Bunds and Other Vegetative Hedgerows

By Drs. Sagare and Meshram

Drs. B.N. Sagare and S.S. Meshram are working with PKV University, Akola, Maharashtra, India.

During the period 1989 through 1991, data was collected to compare the impacts of vetiver hedgerows relative to graded bunds and other vegetative barriers of *Leucaena leucocephala* (Subabul), *Cymbopogon flexuosus* (Lemon grass) and *Chrysopogon martinii* (Tikhadi). The study areas receive about 840mm average annual rainfall.

Vetiver vs. Bunding

Experimental plots were located on shallow, relatively flat areas (22cm soil depth, 1.5% slope). The plot soils comprised Lithic Ustorthents with moisture holding capacity at -0.3 bar and -15 bar, 38% and 25%, respectively. Available water content was 170.3mm/m. Treatments comprised cultivation across the slope and along graded bunds with 0.2% grade at 1m VI (vertical interval) and contour cultivation along with vetiver hedgerows (0.5m VI). Subplot treatments included various cropping systems: sorghum, cotton and mungbean; sorghum + mungbean (2:1); and cotton + mungbean (1:1). Net plot sizes were 96.2m x 9.8m. Recommended rates of NPK were utilized for each crop.

Leaf area (LA) of functional leaves of representative plants was measured by automatic leaf area meter and leaf area indices were calculated. Periodic soil samples from 0 to 22cm depth were collected for gravimetric moisture determination and soil moisture storage calculations. Moisture Use Efficiency (MUE) was calculated on the basis of yield (kg/ha) divided by total moisture use by crop. Determination of NPK status of soil was carried out before and after the harvest of crops.

Maximum increases in LA was recorded with vetiver hedgerow treatments (with contour cultivation) as compared to cultivation across the slope and graded bunds at all the stages of crop growth. Average LA in vetiver hedgerow treatment was 20.6% and 12.5% greater than across the slope and graded bund treatments, respectively.

Maximum enhancement in yields of sorghum, cotton and mungbean was due to vetiver hedgerows followed by graded bunding and across the slope. Average increase in total productivity due to vetiver hedgerows was 17.1% and 32.3% as compared to cultivation along graded bunds and across the slope, respectively (Table 13).

The highest monetary returns was obtained with vetiver hedgerows followed by cultivation along graded bunds and across the slope. Vetiver hedgerows recorded maximum benefit:cost ratio followed by across the slope and graded bunding (Table 14).

Graded bunds and vetiver hedgerows were found comparable in respect of mean moisture use by various crops. However, MUE within the vetiver plots was 17.2% and 33.1% higher (i.e. greater production per unit of water) than that for graded bunding and across the slope treatments, respectively.

Residual soil nutrients consistently tended to be higher on the vetiver plots versus the others. N was 2.9% and 1.9% higher, P_2O_5 was 6.6% and 2.7% higher and K_2O was 11.5% and 7.7% higher in the vetiver plots versus the across slope and graded bund plots, respectively.

Vetiver vs. Other Vegetative Barriers

To assess vetiver hedgerows in relation to other vegetative barriers, a randomized block design experiment with three replicates was conducted during 1992 using cotton as a test crop. Plot soils comprised Typic Chromusterts of moderate depth on relatively flat areas (58cm soil depth and 2% slope). Moisture holding capacity at -0.3 bar and -15 bar were 40.4% and 19.4%, respectively. Treatments included across the slope cultivation and contour farming along with various vegetative hedgerows: *Vetiveria zizanioides* (vetiver or khus), *Leucaena leucocephala* (Subabul), *Cymbopogon flexuosus* (Lemon grass) and *Chrysopogon martinii* (Tikhadi) established at 0.5m vertical interval. Net size of plots was 98.2m x 14.8m. The recommended dose of NPK was applied to all the plots. Moisture use, MUE and soil nutrient status was estimated as per previously described.

Yield of seed cotton from vetiver with contour cultivation plots was 25.5% greater than that from across the slope cultivation without any hedgerows. Leucaena, lemon grass and chrysopogon treatments increased seed cotton yield by 24%, 15% and 11%, respectively, versus the across the slope cultivated plots.

Highest gross monetary return (Rs. 4734/ha) and benefit:cost ratio (1.55) were recorded due to vetiver barriers followed by leucaena and lemon grass barriers (Table 15).

Highest mean soil moisture percentage, profile and available moisture storage were recorded due to vetiver and leucaena hedgerows. Lemon grass and chrysopogon hedgerows recorded comparatively less available moisture than that of vetiver and leucaena barriers. This might be due to higher mortality rates in lemon grass and chrysopogon hedgerows, which resulted in decreasing intake of water and available soil moisture.

Maximum MUE (0.80 kg/ha/mm) was found with vetiver hedgerows followed by leucaena (0.75 kg/ha/mm), lemon grass (0.70 kg/ha/mm) and chrysopogon (0.69 kg/ha/mm). This indicated that growing of cotton along with vetiver hedgerows gave more yield of cotton per mm of water as compared to leucaena, lemon grass and chrysopogon hedgerows.

Experiences with Vetiver By Dr. G.M. Bharad

Dr. G.M. Bharad is working with PKV University, Akola, Maharashtra, India.

Dr. Bharad has been working with vetiver grass on, primarily, Black Cotton soils (vertisols) since 1987. His work has been covered in a number of previous Newsletters. In order to avoid redundancy, only a few excerpts from his paper, a compendium of his management and research experience, are published below.

Selection of non-flowering material : Variation in the flowering patterns of our vetiver stocks was observed. It was also seen that flower culms die in the next season and flowering diminishes plant vigor. Non-flowering clumps were identified, propagated and planted out in lines in 1991. Neither in 1991 or

Table 13. *Total productivity (q/ha) by treatment and by crop.*

Treatments	Sorghum	Cotton	Mung Bean	Sorghum + Mung Bean	Cotton + Mung Bean	Pooled Mean
Across the slope	18.10	7.83	1.89	19.67	8.09	11.12
Vetiver hedgerows	23.36	9.51	3.38	25.86	11.42	14.71
Graded bunds	19.38	9.02	2.49	21.08	10.84	12.56
Mean	20.28	8.79	2.59	22.20	10.12	

	SEm +/-	CD 5%
Main treatments	0.38	1.45
Sub treatments	0.31	0.89
Interaction effect	0.55	1.56

Treatments	Sorghum	Cotton	Mung Bean	Sorghum + Mung Bean	Cotton + Mung Bean	Pooled Mean
Across the slope	1.84	2.26	0.68	2.29	2.69	1.95
Vetiver hedgerows	2.48	2.76	1.22	3.41	3.79	2.73
Graded bunds	1.26	1.54	0.44	1.60	1.98	1.36
Mean	1.86	2.19	0.78	2.43	2.82	

Table 14. *Benefit : Cost Ratios by treatment and by crop.*

1992 did any of this material flower. The material from this line is being further tested and multiplied.

Selection and preparation of planting material : Old material with senescing or dead flower culms should be rejected. Prune shoots to 15-20cm and leave 5-7cm of roots to help anchor the slip. Treatment of stacked material with 25g/l of copper oxychloride is a good idea.

Planting : Be absolutely sure that the soil is well-compacted back around the slips when they are planted. Failure to do this is one of the major reasons for high mortality at planting.

Gapfilling : Vetiver normally establishes in within 2 to 3 weeks after planting. Gapfilling should be done 3 to 4 weeks after planting. Later than this, well-established, containerized plants should be used to fill gaps.

Maintenance : Pruning is essential and should be carried out 2 to 3 times during the rainy season; however, pruning should not be below 40 to 50cm or it will effect vigor and growth. When weeding the field NEVER throw the uprooted weeds into the hedgerows. Do not plow or cultivate within 20cm of the hedge until it is well-established. May burning of hedgerows helps to keep them termite-free.

Gully stabilization : Rows of vetiver planted at a 0.5m vertical interval appears to work well. Be sure to plant the vetiver in a V-shape, with the point of the V upstream. This lessens the chance for washouts. Where waterways or drains exit fields, two or three lines of vetiver planted across the waterway and tied into single lines of vetiver planted on the field boundary is effective to control runoff and scour.

The Largest (Known) Individual Planting of Vetiver Hedgerows By Mr. M. Robert

Mr. Robert is a private farmer in South Africa.

This letter has been written to inform the Network of the progress of vetiver planted on the sugarcane farms, Vallonia Estate. The total area of the farms is 300 hectares. Vetiver was introduced to this area from Mauritius about 70 years ago by my grandfather, the late Mr.Charles De Charmoy. The grass has been planted on the sides of roads on the above mentioned estates for the past 40 years.

The most common method of soil conservation on sugarcane farms in this area is to establish fields as strips aligned horizontally on the contour. The field boundaries are infield roads which are spaced according to slope and soil type.

On our existing fields, to change from our current practices to that presently applied was considered undesirable for a number of reasons, both economic and practical. In short, the current system would be too costly to apply, would take up land and restrict mobility. Through MASDAR I acquired a copy of your vetiver handbook, the concept made so much sense that I started implementing the hedgerow system right away and to date have planted 146 hectares to this system. I am now into the fourth growing season using the vetiver system and I am very pleased with it (Photo 11).

The vertical interval (VI) between hedgerows varies from between 3 to 7 meters. Vetiver grass can be planted in cane fields either during the planting operation or in a ratoon crop. Most important, the vetiver must never be cut back to promote tillering if the sugar cane is going to cause too much shading. Then when the sugar cane is cut, cut the vetiver back. In our area, the vetiver would be cut back once in every 12 to 18 months. The operation to promote tillering will cease once the desired hedge thickness has been achieved. Burning of vetiver also promotes tillering.

An effective planting approach for using vetiver in watercourse stabilization is shown in Figure 4. It is very important that the first line of grass is planted just above the base (line 1) and thereafter work your way up the slope (lines 2 and 3). The vetiver planted across the base (A) can be taken out once natural grasses are growing so as not to impede the flow of water. The lines 1, 2 and 3 will always remain.

Table 15. *Gross returns and benefit : cost ratios of vegetative treatments versus across the slope cultivation.*

Treatments	Gross Returns (Rs/ha)	B : C Ratio
Across the slope	3812	1.24
Vetiver	4734	1.55
Leucaena	4664	1.52
Cymbopogon	4336	1.42
Chrysopogon	4241	1.39

Photo courtesy of Mr. M. Robert

Photo 11. *Vetiver hedgerows on Mr. Robert's farm in South Africa (1991).*

Never plant just the one line on top (e.g. line 3) as you will get undermining in the waterway and eventually the bank will collapse.

When using vetiver in gully stabilization, where possible, shape the gully or bank before planting. Rows of vetiver planted half a meter apart will soon stabilize it.

We also stabilized a river flowing through the farm using vetiver in conjunction with indigenous trees.

Leechee trees were also planted together with vetiver. “Half-moons” of vetiver were planted on the downhill side of the tree to retain moisture. No young trees were lost in the 1992 drought even without irrigation.

All vetiver planting is done manually using between 3 and 5 slips, in clump form, which are dipped into water and planted 15cm apart. All the planting material is cut back to 200mm before planting. For maintenance, the vetiver is cut back periodically to 50cm in height to assist tillering. While young plants are growing, hand weeding is required; however, once mature chemical weedkillers can be used which do not affect the vetiver.

The use of the vetiver system has proved to me that in the long term it is the most effective and cheapest form of soil and moisture conservation. A lot of interest is being shown in vetiver and it is just a matter of time before more people start making use of it. In the short term I truly believe that one can expect an increase in crop yields. Some of my own experiments have proved this to be the case.

A Commercial Source For Vetiver Planting Material

One of the most common questions asked of the Network is *“Where can I obtain vetiver grass ?”*. Recently, a new source has come to the attention of the Network. **The American Vetivert Corporation, Inc.** has informed us that they now can offer vetiver planting material in commercial quantities through the mail. The material they offer comes in two forms :

1) Vetiver clumps of 15cm to 20cm diameter. Roughly, a 15cm clump comprises about 50 tillers. Leaves and roots are trimmed and it is treated with fungicide and packaged in 27.3 kg cartons for shipment. The cost (not including shipping from Dilley, Texas) is US$6/clump or about roughly US$300/27.3 kg carton.

2) Vetiver plantlets, comprised of about 3 or 4 tillers/plantlet. The plantlets are about 5cm in diameter at the base. Leaves and roots are trimmed and it is treated with fungicide and packaged in 27.3 kg cartons for shipment. The cost (not including shipping from Dilley, Texas) is US$2/plantlet or about roughly US$400/27.3 kg carton.

This material is the ‘Boucard’ clone that was DNA fingerprinted as related in the molecular diagnostics article in this Newsletter, and is genetically distinct from the ‘seedy’ vetivers.

For more information contact :

American Vetivert Corporation, Inc.
P.O. Box 166
Leakey, Texas 78873
Fax (210) 232-5716

Report On Mortality In Vetiver Hedgerows In India

Jim Smyle, editor of the Vetiver Newsletter, visited the Maheshwaram watershed in Andhra Pradesh, India. During the visit he investigated reports of dieback in established vetiver hedgerows. The following summarizes his findings.

I was able to observe a range of conditions under which older, established hedgerows of vetiver grass were intact and functional through to conditions where once functional hedgerows had virtually disappeared. These observations led to the formulation of the following **opinions** on the vetiver hedgerows and causes of the observed dieback.

No single cause of the die-back is apparent, rather it appears to be a combination of factors leading to loss of the hedges.

Vetiver is close to the edge of its range in terms of available moisture, with "available moisture" defined as a function of the combination of rainfall (semiarid zone with an average moisture deficit period of 9 to 10 months each year (*)), soil moisture holding capacity (low) and soil depth (shallow). It therefore is not as vigorous as it is under more humid conditions. However, it still is sufficiently adapted to the climate and soils in the Maheshwaram watershed to be useful so long as it is not subjected to prolonged periods of high stress.

To varying degrees — minimal in protected areas with some irrigation, to severe in rainfed areas under fallow — white ant (termite) nesting within vetiver clumps seems to be having the effect of

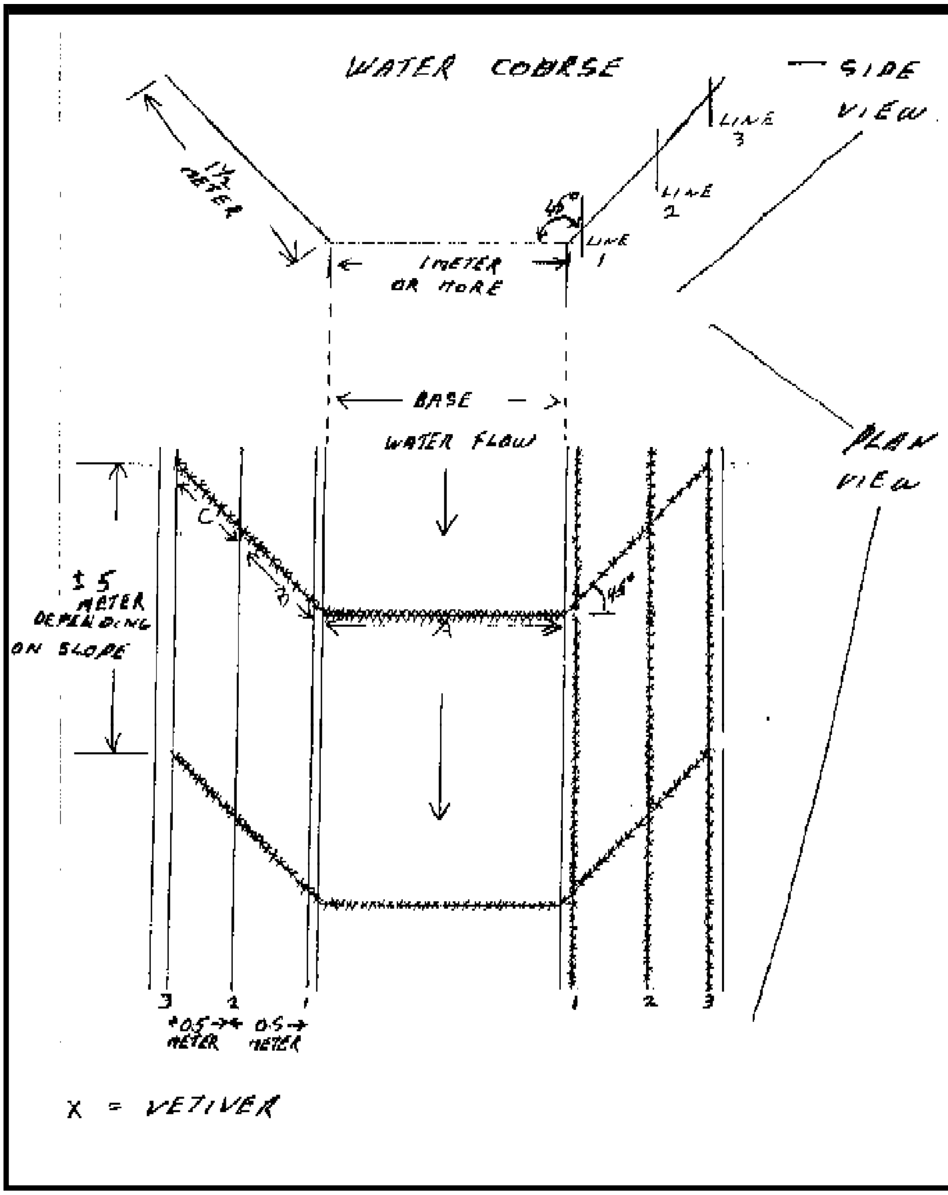


Figure 4. *Mr. Robert's approach for stabilizing watercourses. This is a method which Mr. Robert has used successfully on his own farm. Note the lines of vetiver running parallel to the direction of the flow.*

suppressing regrowth of new tillers within the centers of the clumps. The medium term effect is for the hedges to become hollowed out. The hollowing reportedly becomes noticeable about year 4 after planting.

With the hollowing of the clumps, the only new tillers are those which are coming out on the periphery. These young tillers are not protected by the presence of the older, woody growth. As a result, grazing commonly keeps the new tillers cut down near ground level.

Where fields are not cultivated for one to two seasons, unrelieved grazing pressure exhausts the roots and the clumps die and the hedges disappear. Where fields are cultivated, the plants are better able to persist. However, even under these conditions lack of regrowth in the centers and dry season grazing pressures are still causing loss of function and mortality such that the utility of the hedgerows for controlling runoff and sediment is being lost.

Under protected conditions — e.g. in irrigated horticultural plantings where increased soil moisture levels minimize the incidence of white ants — vetiver hedges are well-able to maintain themselves.

Under rainfed conditions where grazing does not occur, the vetiver hedges are in decline from (white ant-caused) lack of regrowth in their centers.

In summation, it appears that a hierarchy of problems exists. Firstly, the white ants suppress regrowth making the plants vulnerable to grazing. Secondly, grazing pressures keep the plants from maintaining themselves. Thirdly, under the prevailing climatic and edaphic conditions the plant is unable to overcome the stress.

Recommendations

The main concern at this point is to ascertain to what extent the causes of mortality in older hedges are amenable to management and under what circumstances such management practices would be practical. Since it appears that die-back in the older hedges is a function of white ant activities both suppressing regrowth in the hedges' centers and thus leaving the plants vulnerable to grazing, the first step is to target white ant control. Two strategies should be trialed by the project as a short term stop gap :

-- Annual burning of hedgerows in order to remove dead material upon which white ants feed. Hedgerows can be burned sometime in January through May within farmer's fields (**). With protection of the fields from grazing at onset of monsoons, the hedgerows could recover sufficiently to provide some runoff control by the time the more intense rains of late July and August occur. ICRISAT's runoff plot vetiver trials could include burning of vetiver as a treatment to verify the efficacy of this approach under local conditions.

-- Chemical control. The current practice of using BHC or Aldrin at time of planting gives only short term protection to the plants; also these chemicals are undesirable both from environmental and human health aspects. Any annual applications of insecticides are probably impractical and most chemicals capable of providing long term protection are highly toxic and environmentally unsafe. Some relatively new granular formulations recommended for forestry use may provide a solution; these are slow release, long acting (5 to 7 years) formulations that have low toxicity and are considered to be environmentally acceptable.

Concurrently, research support is needed to verify the cause of mortality. Studies which should be done could include :

-- Ascertain the impact, if any, of termite nesting on regrowth of the centers of vetiver. Possible mechanisms of suppression could be: (i) Mechanical: the walls of active termite nests as well as the material from abandoned termite nests which washes into the centers of the clumps appears to have a high bulk density. New, young tillers may be unable to push through this material and, then the covered portions would be shaded out; (ii) Chemical: there may be some allelopathic mechanism with termite castings which suppresses vetiver regrowth; (iii) Biological: increased humidity levels within termite nests could promote fungal, viral or bacterial activity inimicable to the growth of vetiver.

-- Verify that the fungi on older clumps is saprophytic, rather than pathogenic (i.e. causing mortality);

— Continue pruning studies to look at effects of long term, continuous grazing which keeps plants below 20cm in height; and

— Carry out accession trials to ascertain if any provenances or types of vetiver are better suited/more resistant to white ants, drought, etc. The traditional, so-called "farmer selected" vetiver from the Kabbalnala/ Gundalpet area should be tested immediately.

Other apparent causes of decline and mortality in hedgerows related to: (i) Farmers plowing through the hedges; (ii) Shading out of hedges as associated forestry species overtopped and closed canopies and; (iii) Farmers piling of weeds and other residues on hedgerows.

Hedgerow Management

Generally farmers (and often project staff) seem to be operating under the assumption that the vetiver hedges require no management. There are no systems which do not require management. For example, experience and experimental data indicate that, for example :

-- Some parts of the plant should be culled as they have low survival rates; culling, however, is not carried out;

-- Soil moisture levels are critical to vetiver establishment — however, planting reportedly continues almost irrespective of rainfall in order to meet targets. The example in Rajasthan of farmers carrying out their own planting appears to be the best solution here.

-- Planting depth and re-compaction of soil around slips is essential, yet one can commonly observe that these are not done correctly.

-- Any gapfilling should be done in the first year, yet gapfilling is not commonly carried out immediately or at all.

-- Pruning of hedgerows is beneficial to their growth and vigor; however, pruning below about 40cm stresses the plants. The majority of hedgerows observed were well below 40cm or, if above this height, were generally unpruned. The former situation is almost certainly detrimental to long term persistence when it becomes the norm and the plants are not allowed to recover.

— Repeated plowing operations immediately along the hedges damages plants and causes mortality. While such plowing is necessary to control hedge width, it probably is undesirable until the hedge attains a width of about 50cm.

Undoubtedly, greater levels of management inputs are needed in order to sustain the vetiver hedgerows, particularly under the semi-arid conditions in the Plains. This should not necessarily be a drawback. Narrow, stiff grass hedgerows as a technology for controlling surface runoff are likely to maintain a relative advantage in establishment and maintenance costs over structural and other vegetative (e.g. grass strips, woody perennial hedgerows) approaches.

<u>Footnotes</u>

(*) According to Nieuwolt, S., 1977, <u>Tropical Climatology</u>, John Wiley and Sons Ltd. London, England. pg. 191-92.

(**) There may be conflicting priorities in terms of when to burn. Intuitively it makes sense to burn the hedges as early as possible to remove the dry material before white ants nest. However, preliminary data from Maharashtra indicates that later burning (April) is preferred as early burning stimulates growth which is grazed or dries out in the dry season — this reduces plant vigor in the early monsoon season.