Photo courtesy of MASDAR

VETIVER NEWSLETTER

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

LETTER FROM THE PUBLISHER

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

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

(continued on page 11)

FOR NEW READERS : WHAT IS A VEGETATIVE BARRIER ?

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

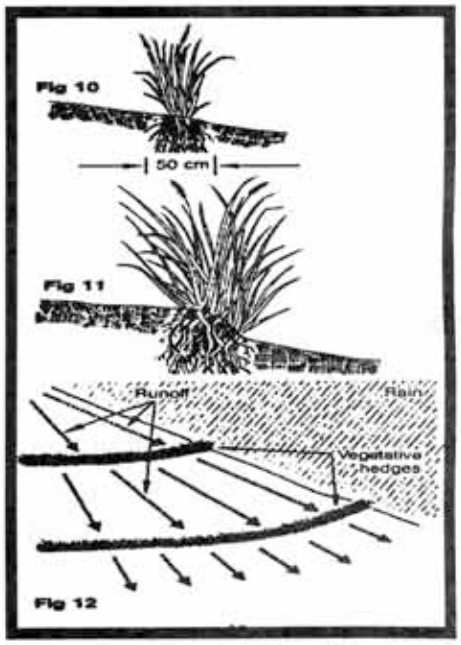


Illustration from Vetiver Handbook showing how the grass functions to trap silt and spread runoff

* - All correspondence to : Mr. R.G. Grimshaw, Division Chief, Asia Technical Dept., Agriculture Div. (ASTAG), World Bank, 1818 H Street NW, Washington, D.C., 20433 U.S.A. ; Tel. (202) 477-6227; Fax (202) 477-6391

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

ACQUIRING PLANTING MATERIAL

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

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

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

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

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

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

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

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

NURSERY MANAGEMENT

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

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

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

Alternative methods of vetiver propagation also exist :

- Stem and root cuttings of vetiver reportedly will sprout and

(continued on page 13)

Tillers should be pruned before transport to the field and outplanting

HEDGE ESTABLISHMENT AND MAINTENANCE

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

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

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

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

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

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

(continued on page 14)

PESTS AND DISEASES OF VETIVER

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

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

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

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

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

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

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

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

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

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

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

RESEARCH RESULTS

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

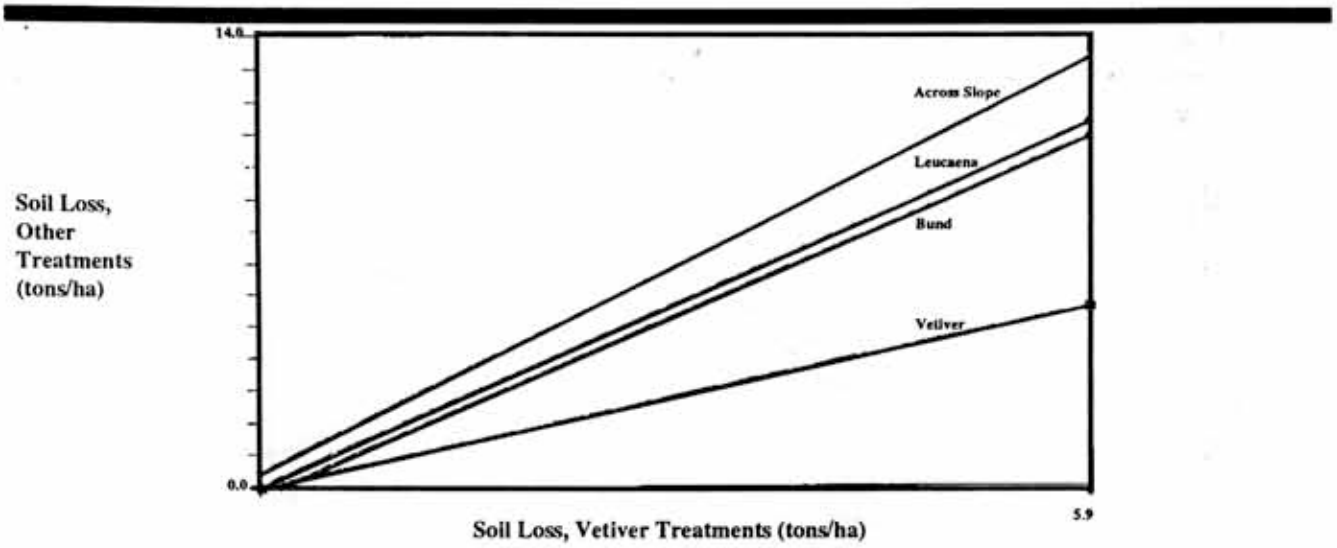


Figure 1. The Effects of Contour Planted Vetiver On Soil Losses Versus Other Treatments.

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

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

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

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

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

- **a 12% decrease** in average per storm soil loss from the contour cultivated (leucaena) plots versus the across slope cultivated plots;

- **little or no difference** in the average per storm soil loss from the contour cultivated plots and the contour cultivated with soil bunding plots;

- **a 56% decrease, a 51% decrease, and a 50% decrease** in the average per storm soil loss from the vetiver plots versus the across slope, contour cultivated, and contour cultivated with contour bunding plots, respectively.

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

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

An indication of the

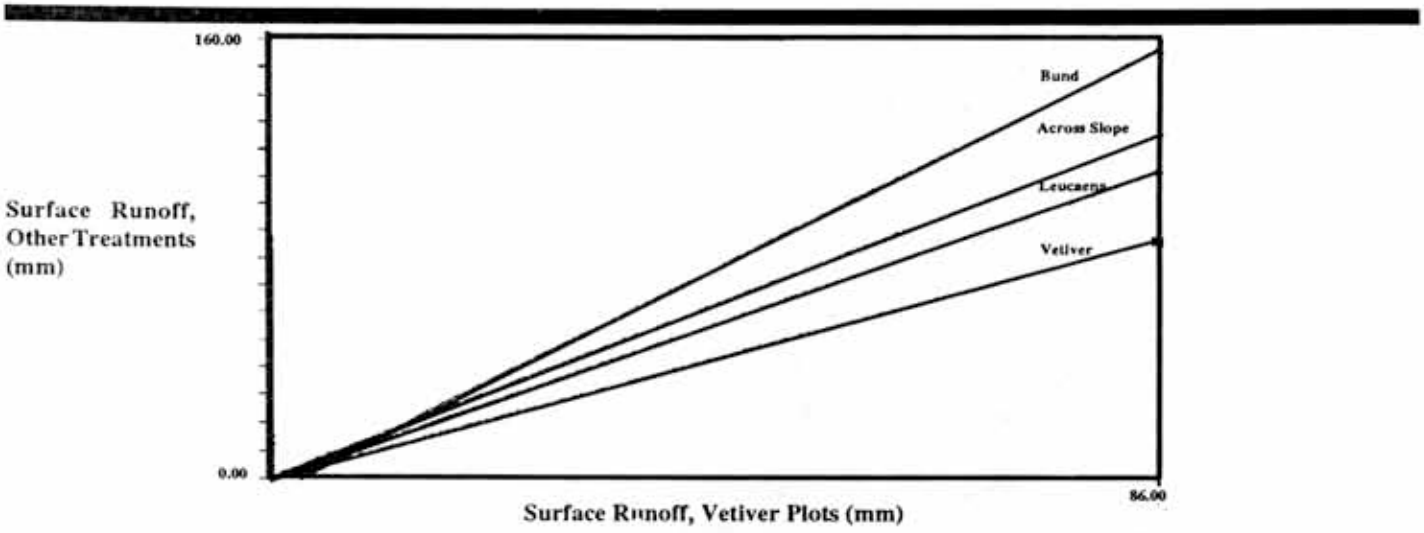


Figure 2. Effects of Contour Planted Vetiver On Runoff Versus Other Treatments

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

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

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

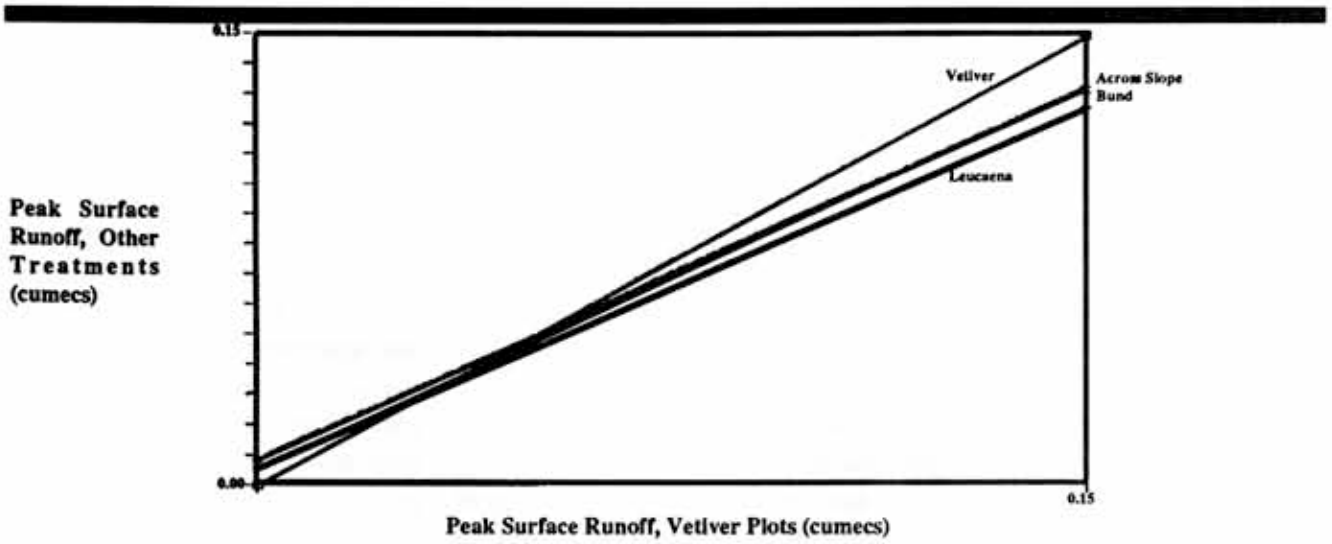


Figure 3. Effects of Contour Planted vetiver On Peak Surface Runoff Versus Other Treatments

the contour cultivated plots versus the across slope cultivated plots;

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

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

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

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

(continued on page 17)

VETIVER AROUND THE WORLD

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

VETIVER CATALOGUE

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

will cost US$ 60.00 each.

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

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

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

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

	PERCENT SLOPE CLASS												
DAILY LABOR RATE	0% - 1%	1% - 2%	2% - 5%	5% - 10%	10% - 15%	15% - 20%	20% - 30%	30% - 40%	40% - 50%	50% - 60%	60% - 70%	70% - 80%	80% - 90%	90% - 100%
US$ 0.50	2.43	7.29	17.02	36.46	60.77	85.08	121.54	170.15	218.77	267.38	316.00	364.61	413.22	461.84
US$ 1.00	3.44	10.32	24.08	51.60	86.00	120.40	172.01	240.81	309.61	378.41	447.22	516.02	584.82	653.62
US$ 1.50	4.45	13.35	31.15	66.74	111.24	155.73	222.48	311.47	400.46	489.45	578.44	667.43	756.42	845.41
US$ 2.00	5.46	16.38	38.21	81.88	136.47	191.06	272.95	382.12	491.30	600.48	709.66	818.84	928.02	1037.19
US$ 2.50	6.47	19.40	45.28	97.02	161.71	226.39	323.42	452.78	582.15	711.51	840.88	970.25	1099.61	1228.98
US$ 3.00	7.48	22.43	52.34	112.17	186.94	261.72	373.89	523.44	672.99	822.55	972.10	1121.66	1271.21	1420.77

LETTER FROM THE PUBLISHER (continued)

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

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

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

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

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

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

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

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

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

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

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

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

Dick Grimshaw • • • • • • • •

NURSERY MANAGEMENT (continued)

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

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

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

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

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

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

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

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

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

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

HEDGE ESTABLISHMENT AND MAINTENANCE (continued)

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

Photo Courtesy of MASDAR

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

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

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

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

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

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

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

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

Some effect on soil loss from hedges that have yet to

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

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

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

RESEARCH RESULTS (continued)

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

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

	OTHER TREATMENT	TOTAL RUNOFF (sowing to harvest)	TOTAL RUNOFF (first 4 weeks)	MAXIMUM 7 DAY RUNOFF	MAXIMUM 24 HOUR RUNOFF
1	ALONG SLOPE CULTIVATION	-45% (+/- 15%)	-52% (+/- 20%)	-35% (+/- 12%)	-24% (+/- 1%)
2	ACROSS SLOPE CULTIVATION	-40% (+/- 7%)	-39% (+/- 7%)	-42% (+/- 13%)	-37% (+/- 15%)
3	CONTOUR CULTIVATION	-20% (+/- 9%)	-11% (+/-1%)	-10% (+/- 2%)	-13% (+/- 1%)
4	CONTOUR CULTIVATION WITH LEUCAENA KEYLINE	-24% (+/- 10%)	-24% (+/- 21%)	-32% (+/- 15%)	-33% (+/- 16%)
5	CONTOUR CULTIVATION WITH GRADED BUND	-56%	-40% (+/- 3%)	-36% (+/- 3%)	-88%

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

ACKNOWLEDGEMENTS

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

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

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

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

ERRATA

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

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

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

.....

IMPORTANT NOTICE

Just after "press time" we received a sum of money to use as incentives for :

i) obtaining information on other plant species (not vetiver grass) that will perform the same soil and soil moisture conservation function over as wide a climatic and geographic range as will vetiver grass;

ii) obtaining information on management innovations and research results from users of vetiver grass.

The Vetiver Information Network will award **(i)** US$ 2,000 to any individual or agency that can show us another plant species as useful as vetiver grass and we will also award **(ii)** the seven top management and/or research results provided to us with US$3,000, US$2,000, US$1,000 and four awards of US$500, respectively. We will be accepting your letters detailing your suggestions and findings until March 15, 1991. At that time an independent, external panel will choose the awardees; all awards will be made by May 1, 1991. All valid information received on management, research and other species will be incorporated into a Newsletter for publication by June 1991.

The award for identification of another species suitable for use as a contour vegetative barrier for soil and soil moisture conservation, across the same range of conditions as vetiver grass, will be based upon the following criteria :

i) when planted correctly it will form a dense, permanent hedge capable of significantly slowing surface runoff and spreading it out;

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

iii) it is perennial and requires minimal maintenance;

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

VET USER	NAME	TITLE	COMPANY NAME	STREET ADDRESS	TOWN	STATE	COUNTRY
Y	Garrard		NSW Soil Conservation Service	P.O. Box 198	Chatswood	New South Wales	Australia
Y	Hassal	Managing Director	Hassal Associates		Canberra	ACT	Australia
Y	Truong	Dr. (PhD)	Soil Cons. Res. Branch-Dept. of Primary Indust.	Meiers Road, Indooroopilly	Brisbane	Queensland	Australia
Y	Ding Zemin	Director	Dept. of Rural Water Conservancy and Soil Cons.	P.O. Box 2905	Beijing		China
	Wang Xiuheo	General Manager	Jiangxi Agricultural Development Corporation	No. 75, Hongdu Street	Nanchang	Jiangxi	China
	Wang Xue-ming	Deputy Director	Jiangxi Prov. Bur. of Ag., Animal Husb. & Fisheries	Beijing Road	Nanchang	Jiangxi	China
	Wang Zi Song	Director	Ag. Foreign Capital Ofc. of Jian Yang Area Fujian Prov.	Huang Hua Shan	Tanchen	Fujian Province	China
Y	Yang Xing Zhong	Senior Agronomist	Jiangxi Provincial Red Soil Research Institute		Nanchang		China
	Zhang Feng-yu	Vice-Governor	Jiangxi Provincial People's Government	Beijing Road	Nanchang	Jiangxi	China
	Zhang Guang-ming	Agro-Economist	China Red Soils Development Project Joint Office	7 Building Bei Li-Baijia Zhuang	Beijing		China
Y	Zhang Xinbao	Associate Professor	Dir. Erosion Div.-Inst. of Mntn. Disaster&Environ.		Chengdu		China
	Laing	Deputy Director General	CIAT	AA67-13	Cali	Valle	Colombia
Y	Shimelis	Technical Manager	Coffee Plant. Dev. Corp., Min. of Coffee&Tea Dev.	P.O. Box 6	Gimira	Kaffa	Ethiopia
Y	Alexander	Agriculturist	World Bank Res. Mission	P.O. Box 416	New Delhi		India
Y	Bharad	Professor of Agronomy	PKV Agricultural University	PKV Agricultural University	Akola	Maharashtra	India
Y	des Bouvrie		World Bank Resident Mission	Po Box 416	New Delhi		India
Y	Fonseca	Village Animator	Delhi Jesuit Society, St. Xavier's	4, Raj Nivas Marg	New Delhi	Delhi	India
Y	Gopalakrishna	Joint Director of Agriculture	Dept. of Agriculture, Karnataka Government	1666, 9th Main Road, Wel III Stage	Bangalore	Karnataka	India
Y	Hegde	Professor Agronomy	Univ. of Agr. Sciences, College of Agr.	Univ. of Agr. Sciences, Hebbal	Bangalore		India
Y	Hussain		Andhra Seeds Corporation	P.O. Box 135	Hyderguda	Hyderabad	India
Y	Hussain		Plants Land	6-3 1104 Samajguda, Raj Bhavan	Hyderabad		India
	Jha			L/40, Road No. 20, Srikrishna Nagar	Patna	Bihar	India
	Kandaswamy	Dir., Water Technology Centre	Dir,, Water Tech. Centre, Tamil Nadu Ag. Univ.		Coimbatore	Tamil Nadu	India
Y	Krishneppa	Professor, ORP	University of Agricultural Sciences, GKVK	Univ. of Agr. Sciences, Hebbal	Bangalore	Karnataka	India
Y	Mashady	Divisional Forest Officer	Masheshwaram Project		Vidyanagar	Hyderabad	India
Y	Mutreja	Superintending Engineer	Civil Construction Circle	P.O. Box 16	Dehradun	Uttar Pradesh	India
Y	Naidu	Asst. Director of Agriculture	Maheswaram Watershed Development Project	Tukkuguda-I-Maheswaram Taluk	Rangareddi Dist.	Andhra Pradesh	India
	Naik			Water Works Road	Dist. Puri	Orissa	India
Y	Nigam	Team Leader	Govt. of Madhya Pradesh	Parvanala Watershed Dev. Proj.	Bhopal	Madhya Pradesh	India
Y	Patil	Manoli Watershed Team Leader	Rainfed Watershed, Project, Govt. of Maharashtra	Opp. Bank of Baharashtra	Jattar Peth	Akola	India
Y	Pereira			79 Carter Road	Bandra	Bombay	India
Y	Prasad			No. 24-84/56 Indiranagar Col. Lothmunta	Tirumalgiri-Secundarabad	Andra Pradesh	India
Y	Raju	Sr.Scientist, Maheshwaram Proj.	.	Andhra Pradesh Agricultural University	Pahadisharif	Andhra Pradesh	India
Y	Runeborg	Senior Programme Officer	SIDA , Swedish Embassy	Nyaya Marg, Chanakyapuri	New Delhi		India
Y	Sachdev	Additional Director (Rainfed)	Agriculture, Govt. of MP	Vindhyachal Bhavan	Bhopal		India
Y	Saran	Chief Scientist	R.A.K. College of Agriculture	R.A.K. College of Agriculture	Sehore	Madhya Pradesh	India
Y	Sastry	Act.State Coord.Watershed Dev.	Govt. of Karnataka, Podium Block	Visvesvaraya Centre, Dr. Ambedkar Rd.	Bangalore		India
Y	Shastri	Team Leader, Watershed Proj.	Government of Andhra Pradesh	2-3-1130/19-5 Vidyonagar	Hydersbad	Andhra Pradesh	India
	Shrotriya	Dry Manager (Agric. Services)	Indian Farmers Fertiliser Cooperative Limited	53-54 - Nehru Place	New Delhi		India
Y	Swindall	Director General	ICRISAT		Patancheru P.O.	Andhra Pradesh	India
Y	Verma	Chief Project Director	Govt. of Uttar Pradesh	151 Vasant Vihar-Indiranagar Forest Col.	Dehradun	Uttar Pradesh	India
Y	Yule	Principal Soil Scientist	ICRISAT		Patancheru P.O.	Andhra Pradesh	India
Y	Branscheid	Irrigation Engineer	Investment Center, FAO		Rome		Italy
	Carnelley		Fisherman's Camp	P.O. Box 79	Naivasha		Kenya
Y	Gibberd	E.M.I. Soil & Water Cons. Proj.	Min. of Ag., Provincial Agric. HQ, Eastern Prov.	P.O. Box 1199	Embu		Kenya
Y	Rao	Experimental Agronomist	ICRAF	P.O. Box 30677	Nairobi		Kenya
Y	Bredero	Senior Agriculturist	World Bank	Boite Postale 4140	Tananarive		Madagascar
Y	Kon	Group Leader, Weed Control	CIBA-GEIGY Agric. Experiment-Station Malaysia	Locked Bag, 71309 Rembau	Rembau	Negri Sembican	Malaysia
Y	Kong	Head-Plant Science Division	Rubber Research Institute of Malaysia	Experiment Station-47000 Sungei Buloh	Kuala Lumpur	Selangor	Malaysia
Y	Arens	South Asia Representative	World Neighbors	P.O. Box 918	Kathmandu		Nepal
Y	Deo	Senior Agric. Officer	Bhairawa Lumbini Groundwater Project	Amchalpur	Bhairawa	Lumbini Zone	Nepal

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

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

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

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

NOTES ON TABLE :

Assumptions :

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

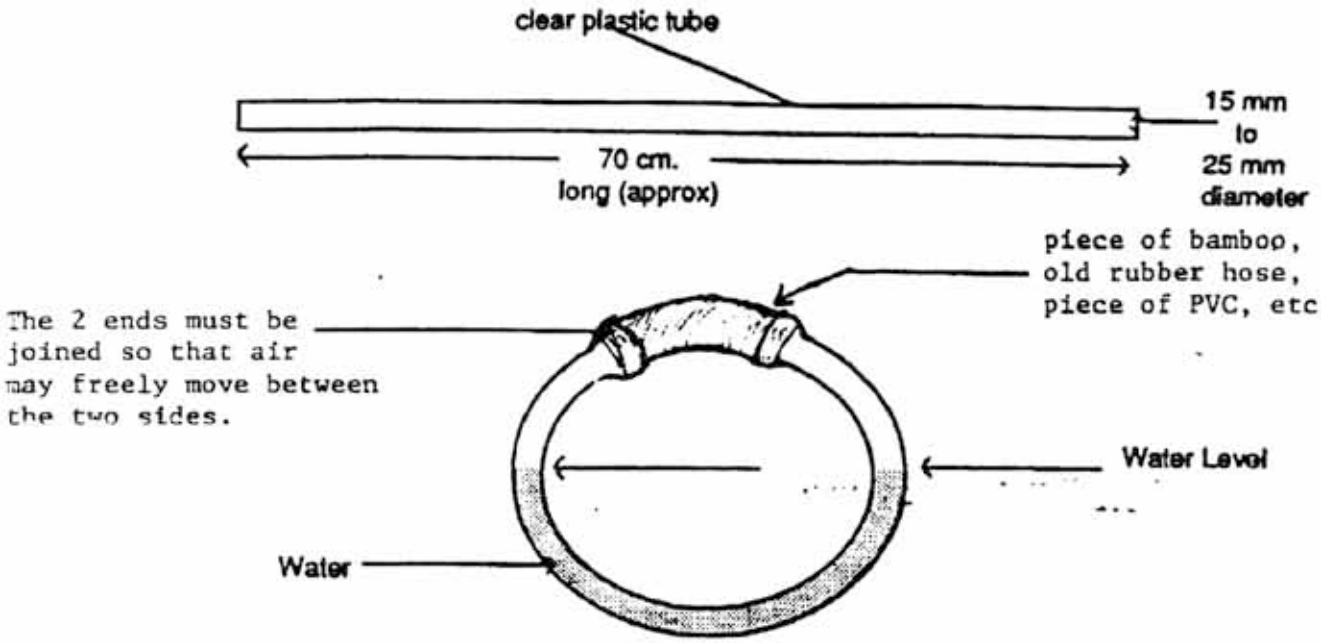
Varying Vertical Intervals :

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

Varying The Number Tillers Per Slip Planted :

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

HOME MADE HAND LEVEL



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