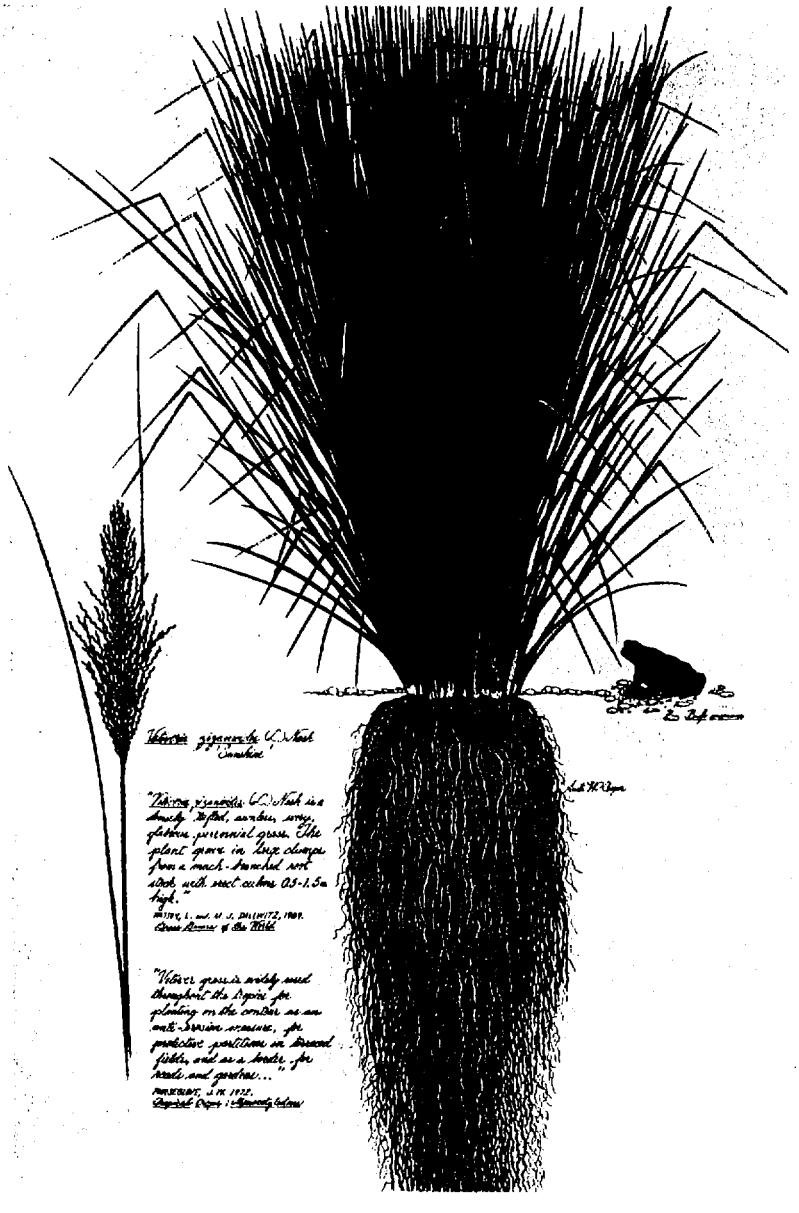
WORLD BANK TECHNICAL PAPER NUMBER 273

Vetiver Grass for Soil and Water Conservation, Land Rehabilitation, and Embankment Stabilization

A Collection of Papers and Newsletters Compiled by the Vetiver Network

Edited by Richard G. Grimshaw and Larisa Helfer



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The World Bank
Washington, D.C.

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When this paper was prepared Richard G. Grimshaw was the agricultural advisor in the Asia Technical Department of the World Bank. Larisa Helfer was a research assistant in the same department.

Since then, the Vetiver Network has been established as a formal nonprofit organization. For more information please contact the Vetiver Network, 15 Wirt Street, Leesburg, Virginia 22075, U.S.A. Telephone (703) 771–1942; fax (703) 771–8260; e-mail address **Grimshaw_R@vetiver.com**; Internet home page **www.vetiver.com.**

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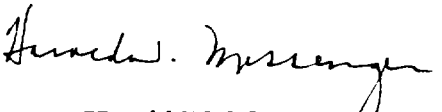
FOREWORD

This technical paper is a collection of some of the more important papers, newsletters, and references that have been published by the Vetiver Network since 1987 referencing the use of Vetiver Grass for soil and water conservation, land rehabilitation (degraded lands, mines, etc.), and embankment stabilization. It brings together under a general index most of the important information, research, and user feed back relating to Vetiver Grass. Its purpose is to provide readers throughout the world with a comprehensive collection of facts from which they can draw their own conclusions as to Vetiver's application and utility to their own needs.

At a time when there is a great concern about accelerating soil erosion, and the need to conserve, in-situ, rainfall, before it leaves the site of its initial impact, vetiver grass grown as contour barriers across sloping lands, provides a low cost and sustainable system that enables these needs to be met. It has been tested, and is now in use in practically every tropical and semi-tropical country of the world, and generally the "feed back" on its utility has been good. The potential for accelerating the adoption of the technology is enormous, and will depend on the development of effective user training and promotional programs, and the forcefulness and tenacity of government policy makers and managers in overseeing its introduction through as many channels as possible. A new use for Vetiver Grass is emerging for dealing with point source sites of sedimentation export, such as new highway embankments, mine dumps, quarries, etc. and for the remediation of polluted sites where the grass's ability to grow in areas containing high levels of toxic substances will prove important for the removal of heavy metals and other toxic materials.

This publication comes at a time of change in the World Bank when "sustainable environmental actions" are being given a high profile. It has been easy to identify problems, but much more difficult to find low cost and sustainable solutions. The Asia Technical Department is proud to have initiated and promoted the use of Vetiver Grass, as one of the solutions to dealing with a broad and ever increasing range of environmental problems. The Vetiver Network, for the last seven years, has been placing information in front of the highest policy makers in client countries, as well as to small and poor farmers, and it is gratifying to learn that the thousands of users have made use of the information provided, and have found it effective. A common response is "we read, we did, and it works." There are not many simple and low cost technologies that have such a wide adaptation and application in meeting environmental concerns; however, Vetiver Grass is one of them.

In putting this publication together we have to thank original authors such as John Greenfield, Dick Grimshaw, Jim Smyle, Bill Magrath and the scores of Vetiver Grass users (researchers, farmers, and engineers) who have contributed to the Vetiver Newsletters. We also have to thank Larisa Helfer for the tedious and sometimes painful task of editing and bringing this publication together.



Harold W. Messenger
Director
Asia Technical Department

Abstract

This technical paper is the result of seven years of research and development on the use of vetiver grass as a promising - and proven - agricultural technology to prevent soil erosion and conserve precious rainfall moisture. The information contained herein is intended for both present and potential users of vetiver, so that they might assess its usefulness and applicability. This technical paper includes the ten newsletters of the Vetiver Information Network; Vetiver Grass: The Hedge Against Erosion, the technically-oriented handbook providing step-by-step instructions as to the use of the technology; "Vetiver Grass: The Ideal Plant for Vegetative Soil and Moisture Conservation," a monograph by John Greenfield detailing the history and potential of vetiver grass; "The Role of Vetiver Grass in Sustaining Agricultural Productivity," a summary paper by Richard Grimshaw "debunking" some of the myths, and confirming others, commonly believed about vetiver; a detailed index; and a selected reading list on this topic by the National Research Council.

VETIVER GRASS
(Vetiveria spp.)
THE IDEAL PLANT FOR VEGETATIVE SOIL AND MOISTURE CONSERVATION

John C. Greenfield
World Bank
Washington, DC.
June 23, 1989

CONTENTS

Summary

• Few resource problems are so important and so little publicized, as the disappearance of soil. Each year billions of tons are washed away to the sea or carried away by the wind. There is no way we can replace this soil.

• The structural system of soil conservation has worked fairly well in developed countries, but has been a failure in developing countries. Constructed methods of soil conservation are unnatural interventions that alter the natural ways of draining the land.

• Although the value of contour banks in protecting arable lands from rill and gully erosion are well documented, the benefits of controlling sheet erosion on the land between the banks are not well understood.

• In Zimbabwe (150,803 square miles - six million inhabitants), they are losing a staggering $2.5 billion worth of nitrogen and phosphorus a year, along with 15.6 million tons of organic carbon, essential for soil fertility.

• Rainfall and nutrient losses can be reduced to negligible levels by plowing and planting on the contour following a vegetative guideline - called "The Vetiver System." This method depends on retaining the rainfall which would normally run off, and storing it in the furrows made by following a contour line.

• Structural solutions to soil erosion, are contrary to natural systems of drainage, they also intercept the runoff before it has a chance to infiltrate the soil, depriving the farmers of the full value of the rainfall.

• The public sector has failed to devise a better solution to erosion control, although the private sector has several times.

• The slope limits of arable land are restricted to the limits of the structural system. If vegetative measures are used, these limits could be safely quadrupled.

• The enormous productive potential of the Black Cotton soils (Vertisols) can be realized for the first time with vetiver hedges to control erosion.

• Vetiver hedges control roadside and bridge approach erosion.

• Vetiver hedges protect irrigation canals from erosion, dams from silting up, and produce better hillside orchards.

• Why vetiver grass ? Trials with other species, show no other plant is as effective for soil conservation.

• A list of essential criteria for a soil conservation plant.

• Constructed methods to prevent erosion pay little attention to the soil loss caused by sheet erosion.

• In contrast to constructed methods, vegetative hedges only filter runoff, and do not convey water,cutting down on the number needed for control.

• Vetiver hedges, unlike soil banks, can be safely breached to provide access for equipment. The special feature of soil conservation with vegetative hedges is that it filters runoff and retains soil.

• Vetiver grass nurseries are easily established and have a multiplication factor of 1:100.

• Vetiver grass covers an exceptionally wide range of soils and climates.

• Once established, vetiver hedges require no maintenance.

• Research data is needed to quantify field observations.

• The hectare budget shows the costs of developing the system.

• The history of Vetiver grass.

• Slope tables gives a guide to the degree of slope, percentage slope, gradient; and surface distance between vegetative hedges.

• What is an essential oil?

Conclusions And Recommendations

We have been able to demonstrate a better way to prevent erosion, by using vetiver grass in the form of a dense, permanent hedge. The grass opens up the opportunity of protecting the soil from being totally depleted.

Previous soil conservation methods, involving earthmoving, have been reasonably effective in developed nations but totally inappropriate in developing nations. These high cost structures were temporary and did not conform to the natural environment.

In the next five years, the vegetative system of soil and moisture conservation will demonstrate its effects sufficiently to leave no doubts that this is the system of the future. It is cheap to install, replicable, and sustainable.

The vetiver system developed by the World Bank's Asia region technical staff over the last four years shows the way to higher standards of living in rainfed areas. The changes in soil management reduce the serious effects of drought, increase the slope for successful and safe crop production, protect irrigated areas from the problems of silt and increase yields per hectare through better moisture conservation.

The recent work in India proves quite conclusively that the system not only prevents erosion, but, when used with contour plowing and planting, can go a long way towards improving agricultural production in areas afflicted by

drought.

INTRODUCTION

Degradation refers to the physical and biological processes that diminish the usefulness of land. Typical environmental effects are accelerated soil erosion, loss or degradation of vegetation, over-exploitation of groundwater, salinization of soils, waterlogging of irrigated land, and a deterioration in water quality. The physical environment is deteriorating. Per capita food grain production is falling. Population growth is uncontrolled. And international assistance in real terms is moving sharply downward. The grim warning in these facts is unavoidable. Further delays, in reforms, and a further weakening of external support will condemn entire continents to human misery. A similar warning in 1985 by Robert McNamara on sub-Saharan Africa, presented at the Sir John Crawford Memorial Lecture, is moretrue today than it was then. Still, in the international community, little is changing.

But there are a number of interesting technologies to stop land degradation, improve productivity, and reducethe risk to farmers by sustaining agricultural production. The most outstanding of these is the use of vegetative soil and moisture conservation measures that are cheap, replicable, sustainable, and fully effective in stopping erosive degradation and increasing crop yields. This is a system that meets the needs of the present without compromising the needs of future generations.

THE PROBLEM

Few resource problems are so important and so little publicized, as the disappearance of soil. Each year billions of tons are washed away to the sea or carried away with the wind.

There is no way we can replace this soil. If we wait for the natural processes to do the job, it would take centuries, if not millennia. The disappearance of soil threatens to undermine agriculture, and limit our ability to feed ourselves. Yet, because it is a silent problem, few give it the attention it deserves. It is not an issue that excites public opinion. Europe, the continent least affected by erosion, is estimated to be losing one billion tons of soil a year, while Asia, the worst affected, could be losing 25 billion tons. The United States loses well over one billion tons a year (net of natural replacement) from its grainlands - equivalent to more than 300,000 hectares of crop-growing potential.

BACKGROUND

Thirty years of testing Vetiver grass as a soil conservation measure and over 100 years of experience with the grass as a boundary hedge has shown it to be the ideal plant to prevent soil erosion, and rehabilitate eroded farmland.

In the 1930s technical and structural solutions were developed to cope with the devastating effects of the Tennessee valley's 'dust bowl.' These included a system of contour banks; diversion banks; absorption banks; grassed waterways and so on, to slow down the runoff, and divert it to a natural drainage outlet or a man-made waterway that would lead it to the natural drainage system or to a specially constructed dam. This system has worked well in developed countries where the farms are large, and where there is a strong element of grazing control, in particular, and landuse in general, where farmers are educated and have full access to resources, institutions and the law. But when studied closely, this system is not the answer for soil conservation. In reality it is an attempt at a 'quick fix' involving money, manpower and equipment to address a major agricultural problem. Using bulldozers in the West and a large labor force in the developing countries, engineers can construct diversionary earthworks in a matter of days. In the West these systems are generally monitored and maintained, but in the developing countries maintenance is seldom in the budget and is usually neglected; the system breaks down and often causes more erosion.

CONSTRUCTED SOIL CONSERVATION METHODS

Constructed methods of soil conservation are unnatural interventions that alter natural ways of draining the land. They are static measures trying to contain a dynamic system. The drainage system changes under the force of excessive storms; the watershed changes as the forces of nature act upon it ; denudation conveys more silt, ultimately filling the channels of the conservation banks, and destroying them, and finally silting up dams or rivers.

Diversion banks convey water from one micro watershed and concentrate it in another. In many cases this accelerates the erosion of the particular drainage line. Water is diverted away from its natural outlets before it has had a chance to soak into the ground because the constructed system is designed to move runoff rapidly and 'safely' to a disposal outlet. This can also interfere with the natural recharge of groundwater aquifers. Moreover the system does not address the massive loss of soil nutrients by sheet erosion. Soil conservation diversion banks are actually designed to move the runoff fast enough so that it will not silt up the channel - meaning they are actually designed to run the silt off the farm.

In Zimbabwe, H. A. Elwell, has been working on the problem at the Institute of Agricultural Engineering, Borrowdale, Harare. He states that "Although the value of contour banks in protecting arable lands from rill and gully erosion has been appreciated since the early 1930s, the benefits of controlling sheet erosion on the land between the contour banks are not well understood." New evidence in Zimbabwe (representative of most of the developing world but better documented), shows that sheet erosion has a major impact on soil fertility and fertilizer waste. The data show that large amounts of essential soil nutrients are carried away with eroded soil particles. It is now clear that erosion not only brings about longterm detrimental changes in the soil, such as a reduction in soil depth, but also has an immediate influence on soil fertility, productivity, and farming costs. Most farmers in rainfed areas are estimated to be losing the equivalent of more than half the fertilizers applied and, at the same time, are reducing the effectiveness of rainfall by at least a third by not making any attempt to conserve moisture. This is generally due to a lack of understanding by the farmers, and the absence of any reminder such as a contour guideline, that can be seen when plowing or planting.

In Zimbabwe, a country of 150,803 square miles, and only six million inhabitants, researchers have estimated that the country is losing, a staggering $2.5 billion worth of nitrogen and phosphorus a year , along with 15.6 million tons of organic carbon, essential for soil fertility, which cannot be directly costed or replaced. Yet, Zimbabwe has had one of the most active soil conservation programs in the developing world. This program, which dates from 1934, is based entirely upon traditional structural methods.

Elwell's analysis found that the loss of nutrients was not directly related to the type of crop nor the land slope, but was related to the rate of soil loss. The structural solutions do not address this soil loss which is directed instead as runoff. Elwell claims the loss of nitrogen, phosphorus, and organic carbon can be calculated (kg/ha/yr) by multiplying the estimated rate of soil loss (kg/ha/yr) by the appropriate factor.

	Well-drained sands	Other soils
Nitrogen	0.00097	0.0021
Phosphorus	0.000155	0.000155
Organic carbon	0.0107	0.0154

Multiply these factors by India's estimated six billion tons of annual soil loss to get some idea of the scale of the disaster in a densely populated country.

The study found a close correlation between soil loss and the amount of rainfall lost as surface runoff. The vegetative system, in contrast, by filtering the runoff, prevents almost all of the soil loss, and by slowing down and spreading out the runoff, improves rainfall infiltration over a much greater area. By plowing and planting parallel to the vegetative hedges (using them as contour guidelines) more precipitation is retained, and in moderate storms, runoff is prevented. If fertilizers are moved by runoff, they are filtered out by the vegetative hedges and not entirely lost to the farmer. Rainfall and nutrients are vitally important to crop growth. Nitrogen and phosphorus are the two most common nutrients purchased by farmers, and constitute the major costs of production. And it is quite evident that the yield of dryland crops is closely related to the proportion of rain absorbed by the soil. Obviously, the higher the runoff, the less is absorbed.

Unfortunately, the present system of structural soil conservation is not working. The problem is far greater in the developing world, where there is less control and supervision, and no maintenance. In India it is difficult to find a soil conservation bank that has been constructed along the contour, meaning that farmers are not aware of the sound benefits of contour cultivation.

Current levels of soil loss from small-scale farms in the communal areas of Zimbabwe have been estimated at 50 tons per hectares per year (Elwell 1985). At this rate about 30% of the available rainfall is also lost in the form of surface runoff. The effect of this loss is equivalent to moving the farm from a 650mm to a 455mm rainfall area, or from an area suitable for cropping to one unsuitable for most crops, including their staple: maize.

The real victim in this circumstance is the farmer who cannot afford to purchase fertilizer, and uses farmyard manure, which is excessively light and floats away at the first hint of runoff. This means that the nutrients are being drawn from the natural reservoir of nutrients every soil possesses, and that the inherent fertility of the soil will degrade very rapidly. Lands on which this has been happening soon become so infertile that they are of no use for cropping or grazing. They merely add to the growing pool of abandoned lands. When this point is reached, applied nutrients are proportionally less effective and amounts of inorganic fertilizer have to be increased just to keep yields static.

The prevention of these scenarios is one of the challenges facing researchers. We need a system that is literally foolproof. Experience with vegetative hedges over the past 30 years shows that bioengineering techniques are not only the latest advance in a long history of soil conservation measures but also, could consolidate productivity gains and provide sustainable growth. Rainfall and nutrient losses can be reduced to negligible levels by plowing and planting on the contour following a vegetative guideline - called here the vetiver system. This method depends on retaining the rainfall which would normally run off and storing it in the furrows made by following a contour line. Since the runoff is greatly reduced, other losses are also reduced. The vetiver grass hedge stabilizes the system, stops erosion, and makes yield increases sustainable.

In Zimbabwe, one of the few countries where reliable measurements have been made, some idea of the enormity of the problem can be demonstrated (despite years of intensive structural soil conservation interventions). Elwell 1988, states "The silt load carried daily by the Mazowe River from a predominantly cotton growing area has been measured during the early part of the growing season at 11,000 tons, which has been estimated to represent the equivalent of six to seven hectares of top soil being lost every day."

When soil erosion was first recognized as a national problem in the United States (circa

1930), only engineered methods of control were considered. In the developed world the system has done a reasonable job of slowing down erosion, but it cannot be said that it has done an effective job - soil loss has not been stopped, it has only been effectively slowed down.

The worst feature of man-made interventions is that they are only temporary, and unless properly surveyed and constructed, have a very short life. In India it has been calculated that to cover all the eroding areas with physical structures at the present speed of implementation would take 200 years and cost billions of dollars. And as fast as banks and waterways are constructed, they are destroyed by the forces of nature they are designed to resist. Conservation banks breach in storms, creating gullies; terraces collapse, causing a domino effect down the slope; waterways erode and cause gully erosion; all these structures deposit silt in dams or elsewhere. Sedimentation has a number of repercussions. The capacity of streams, channels and reservoirs is reduced, causing flooding, and destroying cropland. The deposits of sediment and other debris are expensive and veritably impossible to remove. Sediment also destroys fish spawning grounds by covering up the essential gravel beds. The present solution to this dilemma seems to be a bigger bank. This simply uses more precious top soil and takes more land out of production.

Structural solutions not only are contrary to natural systems of drainage, they also intercept the runoff before it has had a chance to infiltrate the soil. Thus the farmer is not getting the full value of the rainfall, and needs to build a variety of dams and water-harvesting structures.

Finally, the economics of the present method are difficult to justify. Because of the system's size and ramifications, other farmers in the area must cooperate for the system to work. They must agree to have banks constructed through their fields as part of the system linking them to a waterway running through their farm and other contiguous blocks on its way out. These systems cost more than the peasant farmer can afford. They involve a technology that the average farmer does not understand. Their construction requires labor or heavy equipment that is above the farmers' means. Ultimately, when they break down, the farmers cannot - or will not - repair them. This pattern can be seen in India where farmers never maintain soil conservation structures, because they can see no tangible benefit from the system.

Although a considerable amount is known about the physical causes of erosion little information is available on the important subject of how farming practices alter the natural resistance of soils to erosion. While this is obviously the case, rather than analyzing each scenario it is more useful to devise a system of managing all soils for maximum yields at minimum cost. This is the basis of the vegetative system.

THE VEGETATIVE SYSTEM

In nature, the undergrowth prevents erosion. If we create a system that behaves like undergrowth, will it give the protection constructed banks will not, and will it be permanent?

The sugar industry has used vetiver grass as a vegetative soil conservation measure in isolated parts of the world for the past 50 years, but it has gone unnoticed by government researchers, even in the same countries. It has been overlooked by lecturers and professors teaching soil conservation; it has even been ignored as a way to increase production by the International Agricultural Research Organizations. Strangely, it has never been the subject of any research. Yet for over 200 years, it has been used by more than 1,000 farmers in India as a permanent hedge. It has been free of problems and dense enough to effectively filter silt out of runoff. The sugar industry in the West Indies and the Fiji Islands has been using vetiver grass barriers for years.

THE ADVANTAGES OF VEGETATIVE HEDGES

Vegetative hedges have many advantages because they filter the soil and retain it, they build up natural terraces. If all cultivation and planting is parallel to the hedge and the hedge is placed at the correct vertical interval indicated by the point where rilling commences (and not by some theoretical formula), far more land on steep slopes can be safely brought under cultivation.

It is not possible to predict erosion based only on the incline and length of the slope. The concave or convex curvature of the slope must be kept in mind as well as the vegetation. The geological conditions, the texture and structure of both the top soil and subsoil, the type of soil, the intensity of rainfall, how the land is treated following clearing and other unknowns make it a meaningless exercise to use a simple formula.

In many countries, land scarcity and population pressure effect the slope that is considered acceptable for arable land. The maximum acceptable slope for cultivation in parts of central Africa is 12%, in the Philippines, 25% and in Israel, 35%. These limitations of slope are directly tied in to the structured system of soil conservation. The steeper the slope, the more complicated the engineering, and, consequently, the more difficult it is to build. Further, the structures have to occupy more land as the slope increases. Because of population pressure, however, cultivators take little notice of these slope limitations and most governments are either unable or reluctant to enforce them. The result is that government soil conservation measures stop at their slope limits, but cultivation does not, and erosion continues uncontrolled. If these areas were compulsorily planted by farmers with vetiver grass barriers, erosion would be controlled. Providing the cultivators follow the contour guideline, slope is not a constraint. This means that food crops can be grown safely on 50% slopes - in the Fiji Islands, sugarcane is grown on 100% slopes (45 degrees) without any erosion problems. In fact, over the 30 years the hedges have been in effect, they have built up almost level terraces, four meters high, behind the hedges.

In Ethiopia, the government has decided, because of the problems of erosion, to move all the farmers on slopes 30% and above. This means moving four million people. If vetiver grass hedges were established in this area, these farmers could become high producers without the threat of erosion! The Ethopian government made the decision because of the limits of the presently constructed erosion measures.

On Black Cotton soils (Vertisols), forming some of the world's most potentially productive plains, cultivation is severely restricted because of the effect of poor drainage. These montmorillonite clay soils swell when wet (and become impossibly sticky) and shrink when dry (becoming brick hard), and break into wide cracks that go down for meters. Because of these characteristics production is greatly restricted: earth structures cannot withstand the pressures, even concrete, brick and wood are torn to pieces, or swung about as the soil goes in to it's "Gilgai" undulations.

Soil conservation services around the world have been totally flummoxed by the behavior of these valuable soils; soil loss is massive no matter how flat the soils may appear. If large section contour banks hold up, they impede drainage. If this happens, the cotton crop these soils are so famous for will be drowned out because it cannot tolerate wet conditions. In India, black cotton soils, representing over 70 million hectares of potential production, are only cropped once annually during the dry season. With the introduction of vetiver hedges, however, it will be possible to double crop these soils for the first time. The vetiver grass is not affected by the movement of the soil, and works perfectly in spreading the runoff over the whole length of the vegetative barrier. This allows the

rainfall to spread out and infiltrate without creating a drainage problem. This means that vetiver grass hedges have given India another 40 million hectares of potentially productive land.

To plant vetiver grass in flat arid lands, it is necessary to construct a wide-section contour "V" ditch, with about 160 degree inside angle. At the beginning of the rains, the slips are immediately planted in the bottom of this ditch 10 cm apart. The idea is to harvest as much of the meagre runoff as possible (In Jordan we were able to capture sufficient water to establish olive trees without the usual initial irrigation in a 300mm rainfall area). A 6mm rainfall should put 20 cm of water in the ditch, meaning that the vetiver slips are receiving somewhere in the order of an equivalent 600 mm, more than enough for their establishment. Once the contour hedge is established it is self sustaining.

In an arid area, a hedge can extend for 10 or 100 km across the desert. As it does not carry water but filters it, there are no restrictions on its length. Cropping could commence on a one-meter-wide strip along the length of the hedge, taking full advantage of all the moisture and natural organic matter the hedge traps. As the hedge slowly builds up a terrace, the cropping strip could be widened by another meter.

There is now no question about the merits of using vegetative hedges despite the slope - and on flat land as well. In rainfed areas all land must be protected, right down to the river's edge. It is imperative to understand though that the land users will only voluntarily adopt conservation practices when these practices are perceived as being in their own best interests. Is conservation in the best interest of the land user? The constructed system of banks and waterways has caused many subsistence farmers problems. If you try to introduce a new system of soil conservation to such farmers, you will not gain their interest. But if you tell the farmer that you can increase his yields by at least 50%, (average increase in yields using the vetiver system have been over 100%) and that the cost is minimal, you will immediately get his attention.

The system can be introduced to farmers in the field. Show them the signs of sheet erosion, explain the vetiver system, take them to an area that has already been protected or show them the visual aids covering the system. Ask for volunteers to lay out the contour guideline with vetiver grass (or mark it with a 'dead furrow' if no grass is available), and show the farmer how to plow and plant parallel to the contour. It is a simple change of management. Do not introduce any other packages or practices at this time. When the farmer sees the increase in yields he gets, by retaining all the moisture and fertilizers, it is clear that the only explanation for these increases is plowing and planting on the contour. If you introduce a package of practices you confuse the farmer. If he cannot determine exactly what was responsible for the yield increase he is likely go back to the old ways of plowing up and down the slope.

Once the vetiver hedges have been established, the extension worker can show the farmer how the hedge is filtering out soil from the runoff and building up a terrace. Until the farmers actually see this, they have no concept of what they were losing to sheet erosion.

VEGETATIVE CONTROL OF ROADSIDE EROSION

Economic policy has often been accused of causing environmental damage. This is especially true in the case of the environmental damage associated with pioneering new roads. In the case of soil erosion, policies that disregard agriculture tend to cause land to be undervalued, and there is less incentive to husband it and to protect and raise its productivity. Such is often the case on the down hill slopes of a road. 'Cuts' are usually dumped without any discretion over the edge of the road to tumble down

the slope, establishing new areas of instability. Culverts are placed under the road to spill out on to the land below. Table drains run down to the bottom of the road gully before entering a culvert, at which stage they are often carrying far too much water, and cause considerable erosion. 'Fills' are made so that the soil finds its own angle of repose, but the the side-slopes remain exposed to rill erosion. The cost of treating these problems with engineering solutions would be prohibitive, and would possibly preclude the road's construction.

The solution which has been used very effectively in the West Indies, the Philippines, and in one site in Tanzania is to plant vetiver grass along the edge of the road. The results have been so impressive in Trinidad that officials are considering the possibility of designing road drainage around a vegetative system.

One option is to design the road with a slight fall to the outer edge, so that the runoff could be continually channeled to the vetiver hedge lining the road. Instead of a culvert, a small masonry apron 10 meters long would cross the road to the vetiver hedge. The water from the table drain at the base of the cut slope, could be conducted across the road at this apron and delivered straight to the hedge. The excess water would run down along the hedge until it filtered through. All 'fill slopes' would be stabilized with vetiver hedges.

All bridge wing-walls would also be stabilized with vetiver to prevent floods from damaging the approaches to the bridge. I observed this form of protection in Tanzania where it had been tried many years ago. Two opposing wing-walls of the bridge were planted with vetiver grass, and the other two wing-walls were made of concrete. By 1983, the concrete walls had long since fallen into the river, and the approaches they were supposed to protect were badly damaged by erosion but the two vetiver walls were in perfect shape. This experiment stood the test of time, but like so many natural phenomena, remained unnoticed and unrecognized. Protecting roads, from super highways to mere tracks can, in the tropics (where the need is the greatest), protect the area from erosion and maintain an all-weather road.

OTHER IMPORTANT USES FOR VETIVER GRASS

Irrigation: Vetiver grass has now been successfully used to prevent the erosion of canal banks. It can be planted along the top of the bank to protect the edges, or along the waterline, especially on curves of unlined canals. It will protect both the upper and lower slopes of secondary and tertiary canals as well as aqueducts leading back from the main canal, around the foothills to the upper reaches of the command area. It will protect the bunds of rice paddies, and should keep them free of rats, it may even rid them of crabs, though this is untested.

Dams and their approaches: Vetiver grass hedges around the perimeter of a dam will prevent silt from washing into the dam, and give the dam a much longer life. It should also be planted as hedges, one meter apart for several rows back, protecting the inlet to the dam and filtering the silt out of the water before it enters the dam. Such areas can be used for nurseries to supply planting material to local farmers. In China, a farmer is using it not only to stabilize the wall of his dam, but as a fence to keep his ducks from getting out of the dam. Traditionally, split bamboo pickets were driven into the ground, to contain the ducks although this was expensive and time-consuming. The grass has many other uses to stabilize soil. To the engineer, grasses are invaluable for stabilizing sand dunes, road verges, and other raw soil surfaces.

Orchards and tree crops on steep slopes: Orchards have shown remarkable response to being planted behind a vetiver hedge on very steep slopes (>100%). In Trinidad, on the university farm, mango trees planted behind the vetiver hedge have outgrown the trees planted away from it. We recommend that in rainfed

areas with steep slopes, all orchard planting follow the contour behind vetiver hedges. By filtering the runoff, the trees obtain the full benefit of runoff products. In this case, the trees can be planted closer together, and the rows farther apart. When the rains stop and the dry season sets in, the hedges can be cut to the ground and their leaves used as a mulch around the base of the trees. Vetiver mulch is very long lasting. The leaves also make an excellent thatch. In Fiji it is considered the best thatching material, and lasts for at least three years.

Plant protection: Vetiver grass in India and Zimbabwe is used to keep rhizomatous weeds out of fields. The rhizomes of *Cynodon dactylon* cannot penetrate the deep curtain of vetiver roots and farmers say that once all the rhizomes are dug out, they have no more problems. In Zimbabwe, it has been used to protect tobacco fields from couch grass.

WHY VETIVER GRASS ?

In their struggle for survival, certain plants and animals have evolved fantastic, sometimes unbelievable, adaptions. Vetiver grass is one such plant. It is a climax plant capable of growing over an extremely wide range of soils and climate. It meets all the criteria of a vegetative soil conservation plant. Vetiver grass is not just another grass, it is a special grass - like bamboo is a special grass. When people think of grass, they think of their lawns, or fodder grasses, or tall tussocks, pampas, etc., but none of these match up to vetiver for persistence and freedom from problems.

In the early 1950s, Fiji officials decided to expand the sugar industry to the hills to help meet the country's quota under the international sugar agreement. As soil erosion on the rolling country was already a problem, moving the industry up into the hills would certainly create major erosion problems that would be felt throughout the cane growing areas. Research agronomists at the Colonial Sugar Refining Company's agricultural experiment station were given the job of solving the problem. The first steps were the accepted methods - engineered contour banks, diversion banks leading to grassed waterways. Under tropical rainfall conditions these structures did not last a season. The search then turned to vegetative systems. Of all the plants tried, only vetiver grass was successful, and is still preventing erosion on slopes today.

Other species that have been tested include:

Cynodon dactylon
Saccharum Bengalense (munja)

Eragrostis curvula
Panicum clandestinum

Festuca arundinacea
Eulaliopsis binata

Leucaena spp.
Brachiaria brizantha

Paspalum notatum
Saccharum spontaneum

Paspalum vaginatum
Tripsacum laxum

Pennisetum clandestinum
Setaria sphacelata
Panicum maximum

Pennisetum purpureum
Cymbopogon nardus

None of the above grasses or shrubs proved effective for runoff. The majority of these plants were sown as seed. Cultivars grown from seed are individuals and will never join together to form a dense hedge, there will always be gaps between the individual plants. Even some species planted vegetatively will not grow together. Unless they form a dense hedge, the runoff channels between the individual plants

leaves them standing on a pedestal of their own roots. They will eventually be undercut and eroded out of the ground they were meant to protect. But this does not preclude other plants that we may not yet have found that could be as hardy, diverse, and useful as vetiver. One should never stop looking for a better plant, but until it has been found and tested we can only recommend vetiver grass.

CRITERIA FOR A VEGETATIVE SOIL CONSERVATION PLANT

For a plant to be useful in soil conservation it must have the following characteristics:

- It must be capable of forming a dense, permanent hedge, resistant to the harmful effects of overgrazing and fire. Only species planted as clones will grow in to each other to form such a hedge.
- It must be perennial and permanent, capable of surviving as a dense hedge for centuries
- Its crown must be below the surface, to protect it from fire and overgrazing.
- It must be sterile, also producing no stolons or rhizomes so it will not become a weed.
- It should repel rodents, snakes, and so on. The sharp leaves and aromatic roots of vetiver keep it free of vermin and other pests; and relatively unpalatable to livestock.
- It must be both a xerophyte and a hydrophyte if it is to survive the forces of nature. Vetiver grass, once established, is not affected by droughts or floods.
- It must have a deep penetrating root system, capable of withstanding tunneling and cracking characteristics of soils. Roots must penetrate to at least three meters.
- It must not compete with the crop plants it is protecting.
- It must be cheap and easy to establish as a hedge and easily maintained by the farmer. It must be easily removed if the farmer no longer wants it.
- It must be totally free of pests and diseases, and must not be an intermediate host for pests or diseases of any other plants.
- It must be capable of growing in all soil types, regardless of nutrient status, pH, or salinity. This includes sands, shales, gravels, and even aluminium toxic soils.
- It must be capable of growing in a wide range of climates - from 200 mm of rainfall to 6,000 mm - from temperatures of -9 degrees to more than 50 degrees C.

These characteristics describe *Vetiveria zizanioides*. It is a remarkable plant and no other is known to share its hardiness or diversity.

SOIL CONSERVATION WITH VEGETATIVE HEDGES

Soil erosion starts as sheet erosion. As the sheet of water moves down the slope gaining speed, it breaks up into individual streams or rills. If uncontrolled, the rills combine to form streams and cut out gullies. As the gullies are cut, their depth increases the slope and speed of the runoff, and these gullies go from the bottom to the top of the slope. Once they can go no further, they get deeper and create side gullies, until the whole dendritic pattern of erosion has developed.

On arable land, sheet erosion is the major problem, and the one least recognized. The present means of control is more oriented toward the secondary and tertiary stages of erosion: rilling and gullying. The silt load carried by the sheet erosion is merely diverted to drainage. If rills or gullies are obvious in an area, conservationists get concerned, but little attention seems to be paid to the irredeemable loss of topsoil and nutrients.

Vegetative hedges, on the other hand, form a protective barrier across the slope, which slows the sheet erosion and deposits the silt behind the vegetative barrier. The vetiver grass tillers growup through it, ready to filter the next

load, and so it goes on building up natural terraces and maintaining the fertility of the area.

Since the hedge only filters the runoff and does not convey it, there are no problems arising as to 'channel' design or capacity and far less of the hedges are required per hectare. Because they are natural, they do not necessarily comply with any formula; vertical intervals can be more accurately decided by observation. This is something the farmer can do if rills start to develop below or above the hedge -- another barrier can be planted to intercept them.

This feature makes the system very user friendly. One of the main complaints with the constructed system, whether it was in Australia or Zimbabwe, was, " how do I cross it with my tractor or oxen, combine or cultivator" as the banks could not be breached for temporary access. With the vetiver system, a track can be cut where you want it. Once planting is finished, the gap immediately grows back again from the grass root reserves. Even if it rains while the gap is open, there will be no erosion, as the runoff is not being moved sideways to pour through the gap.

This is a major advantage for the developed countries, especially on prairies, where vetiver grass can be established. On the black soil plains (the Vertisols) where high capacity equipment is essential to do the necessary cultivation before being 'rained-out,' many of the rigs are up to 20 m wide, which makes crossing the contour banks a constraint to production. But it is no problem to run a rotary slasher down the vegetative line and open up a 25 m gap that will re-grow just as soon as the equipment moves out.

In the watershed, the vegetative system is the ideal means of controlling erosion. Starting at the very top of the erosion gullies, single lines of vetiver grass can be planted at right angles to the gully starting at a level of two to four meters above the gully floor on one side, running down to the gully and up the other side to the same level with a single line hedge. In areas where the gullies have cut in deeply and there is little soil, it will be necessary to place a small masonry check to collect some silt to establish the vetiver grass. Under these conditions, it may be necessary to place some stones at the back of the planted slips, to protect them from a torrent and give them a chance to establish. Once they are established they will not be washed out.

Once these gully checks have been established, they need no maintenance except for an occasional inspection to ensure that they have not been damaged. They will filter all the silt out of the runoff year after year, building up terraces that never need increased capacity, as do masonry or brush wood gully checks.

The watershed can be divided into three levels of slope: steep, medium and the base slope, where the gully enters the natural stream. These slopes can be tackled one at a time, starting at the very top in the first year and planting the vetiver down to the middle level. After they are established in the first rains, it will be easier to establish the mid-level the following year, as there will be less runoff to cope with. Finally, in the third year, the most difficult lower slope will be more easily handled because the pressure from runoff will have been greatly reduced. At the same time, the two preceding years' work can be maintained. Watershed stabilization must always start from the top down.

ESTABLISHING A VETIVER GRASS NURSERY

To find a source of vetiver grass, first check with the local herbarium (located in the university, or botanical gardens, or agricultural department) to determine if it has any specimens of *Vetiveria zizanioides*. If they have, withdraw the specimen sheet, and in the bottom lefthand corner there should be a small map showing where this particular specimen was collected. This will show you what the plant looks like; give you the locality where it was found, and if

the collection was done correctly, it will tell you the local name of the plant. If the plant is unknown, contact a World Bank agricultural staff member for planting material

Assuming you have a source of planting material, dig out the clumps of vetiver, cutting the roots off about 20 cm below the surface. Cut off the leaves about 30 cm above the roots, and break the clump into planting pieces, or 'slips,'of about five tillers per slip, taking care to discard dead or seeded tillers. Single tillers will suffice if you are desperately short, but it is better to plant a small clump. The nursery is best located in an irrigated field,which will encourage the plants to grow very rapidly. Within six months you should have enough planting material to protect 100 ha of land (20 km of vetiver hedges).

Prepare the nursery bed as you would for any field crop: plow it, cultivate it, and get rid of the weeds. The seed bed need not be smooth, as the vetiver seedlings (slips) are extremely hardy. Irrigate the plot thoroughly, then transplant the slips as you would transplant rice, except the vetiver slips are spaced 40 cm apart. It does not matter if it rains after planting and inundates the slips. The plant will not be affected. This wide spacing gives each plant ample room to 'tiller,' or produce more planting material. There is no set planting distance and with experience you may develop a planting distance suited to local conditions. The planting material should be brought to the nursery at least six months before the planting season so that it is available at the beginning of the wet season.

Once all the slips have been planted in the nursery, fertilizer can be applied if necessary. Plants grow faster and produce more tillers in less time if they are fertilized. Generally we use phosphate fertilizers in combination with some form of nitrogen; for instance, sulphate of ammonia super phosphate, or urea super phosphate, or diammonium phosphate, whatever is available and cheap in the nitrogen-phosphate range. In India, farmers use manure on the nursery beds. The more optimum amounts of fertilizer applied according to the needs of the soil, the more planting material will be produced in six months.

In the first two months, when the plants are getting established, weed the beds to keep the weeds under control. Once the plants have started to grow vigorously, keep them trimmed to about 50cm, and use the cut leaves to mulch between the rows and keep the weeds down. Trimming encourages 'tillering' and produces more planting material in a shorter period. If the plants are allowed to flower, tillering is reduced.

After six months there should be between 80 and 100 tillers per plant, which can be used as planting material. Thoroughly soak the plants to make it easier to lift them out of the ground. Quite often, it takes a two-man team using a strong fork, or pick, or even a bar (crowbar) to remove the tillers from the ground. One man levers the plant out of the soil, the other pulls the top of the plant toward him. Once sufficient roots are exposed, they can be cut 20 cm below the surface, and pulled out by the other team member. Now the clump can be broken up into planting pieces for transport to the field.

When harvesting, leave three or four tillers in the ground from each clump to renew the planting material. Fertilize and irrigate the remaining plants, using all the trash from the harvest to mulch the beds. Succeeding harvests may be possible in four to five months.

Transporting the material to the field is no problem. Trim the slips as stated above - 30 cm of leaves/20 cm of roots, both trimmed with a machete - put them in grain bags or throw them in the back of a truck. The plants can stand a lot of rough handling, and can be left unattended for 10 days. It is always better if you can plant them the same day, but if they have to be transported over great distances or stored, the losses will be negligible. Planting should be done at the very beginning of the wet season.

In India, nurseries are now being contracted out to farmers with some spare irrigation land, that, while not being ideal for food cropping, is certainly good enough for the production of vetiver planting material.

SOILS AND CLIMATE

In India, vetiver is grown for its oil. Although the plant grows in all kinds of soil, a rich well-drained sandy loam is considered best for harvesting the roots. The grass grows luxuriantly in areas with an annual rainfall of 1,000 to 2000 mm at temperatures ranging from 21 degrees C to 44.5 degrees C (although it will grow at much higher and lower temperatures as noted above). Through recent efforts, a network has been established that offers better information about where the plant will grow, and updates previous references to the grass, which were limited to its usefulness in producing the essential oil.

Vetiveria zizanioides has been successfully established at 42 degrees N. Lat., north of Rome, where it has survived snow for 18 days, and -11 degrees C (including eight months when the minimum temperatures periodically dropped below freezing), at an altitude of 650 m with winter rainfalls of 1100+ mm. (Climatic Table for Cantalice, Italy. Rome-Ciampino 1946-1965). It has been successfully established at an altitude of 2,300 m in the Himalayas (Pauri. UP. India), where it not only withstood extreme cold, but survived heavy grazing by goats, deer and other livestock on poor, eroded mountain soils.

At ICRISAT, in Andhra Pradesh, a trial was established to test *V. zizanioides's* ability to survive under various treatments on red Alfisols. The treatments included
- cutting monthly to ground level
- leaving uncut
- irrigating
- not irrigating

as a randomized block design. Over the four seasons of the trial all the plants have survived, despite the worst three-year drought in many years. But more impressive, plant scientists planted a single line hedge of the grass on a soil (a substrate of mainly quartz gravel), where it could not possibly survive, to establish a datum point where it would not grow. This was on the inside excavated wall of a dry dam. Not only did the vetiver survive, but it formed a hedge and stopped the rill erosion, slowed the runoff, and in two seasons natural grasses and plants established behind it, rehabilitating wasteland at little or no cost.

Wherever *V. zizanioides* has been planted, it has grown. It had been thought that nothing would grow in aluminum toxic soils. The 'borrow pit' of a dam in the Kandy Hills of Sri Lanka was eroding into the dam and there seemed to be no way of stopping it. As a trial, vetiver grass was planted in the area, using crowbars to make the planting holes. The grass has not only survived but it is growing well.

Previous reference materials give vetiver grass a very narrow ecology. If grown for its essential oil, it is only suited to its natural habitat humid to sub-humid tropics, and alluvial or recent Andosols (volcanic ash soils that release the roots easily). By taking this plant from its natural habitat, where as a hydrophyte, it put all its energy into seed production and planting it from the semi-arid tropics to the temperate zone, it functions like a xerophyte, putting all its energy into its deep root system to survive.

In the watershed management program in Andhra Pradesh, India, we have planted a line of vetiver grass behind all the masonry gully checks. These will fill with silt and become redundant but the vetiver grass will continue to form terraces, trapping the silt and taking over from the static check as a permanent feature. The young hedges we established were completely submerged to a depth of over one meter for 45 days. When the water eventually drained away, the hedges grew again without any sign of

stress.

As for rainfall, from 300 mm to more than 6000 the grass has no problems. In fact, as it gets wetter, the plant grows faster and thicker. Below 300 mm it requires special treatment - it must be planted in the bottom of a two meter wide "V" ditch, having a 160 degree inside angle. This 'V' harvests the runoff needed to get the grass established. Once established, it will harvest its own runoff and nutrients.

PLANTING

All methods of planting in South India recommend prepared beds, to allow for harvesting the roots. In the most popular method, the land is laid out in beds 30 cm high, 68 cm wide, and 45 cm from edge to edge. The slips are planted in two rows 22 cm apart, leaving 22 cm on either side. Planting is usually done in the rainy season just before the monsoon, and should be completed by the end of August. The slips from harvested clumps of the preceding crop are used as planting material to keep the nursery viable. They are planted five to eight centimeters deep using a pointed stick. Two or three slips are planted in each hole to account for causalities and insure a thick stand. One hectare requires 150,000-225,000 slips for planting. Three or four weedings are necessary in the first year and two to three in the second year.

MAINTENANCE

Maintaining the hedge is simple and cheap. When the hedge is planted, any slips that have died or been washed out are simply replaced. In gully plugging, the new plantings are quite often washed out as they have not established a root system, so after each rainstorm it pays to check for gaps. Often, the material washed out can be retrieved and replanted. It is hardy, and if it has not been too damaged, it will grow. Once the hedge has been established and there are no gaps, it should be trimmed each year to keep it from flowering. This encourages the plants to tiller and thicken up the hedge. There is no harm in letting the plants flower as the seeds are sterile but trimmed hedges are more effective, especially on crop land, and reduce any shading of crops.

With mature, established hedges, there should be no need to fertilize as they filter nutrients from the field and seem to be capable of maintaining a high standard of vigor regardless of soil type. The same applies to water requirements; all the runoff water accumulates behind the hedge waiting to filter through, meaning that there is more water at the base of the hedge than the average amount of rain in the area, which is why the hedge is so drought-tolerant.

The thing to remember is that once the hedge is established, it is maintenance free. To keep the hedge from spreading laterally into the field, simply plow along the boundary of the field to remove any tillers that are encroaching. To remove the hedge just plow it out.

PROBLEMS WITH VETIVER.

In the literature and in discussions with farmers who have had vetiver on their farms for more than 100 years, the grass has never caused any problems. In a 1982 article by Iain Gordon and Patrick Duncan, however, "Pastures New for Conservation," they state:

"...in the Keoladeo National Park, a World Heritage Site at Bharatpur in India, the populations of water birds have suddenly declined. There are several reasons, but the removal of domestic livestock is probably the most important. In 1982 when Keoladeo was created, the park authorities banned grazing by cattle and domestic water buffalo because they thought that the area was overgrazed. A conflict broke out between the park authorities and the local graziers. At its climax, the Indian police arrived to evict the graziers; eight people died. In a recent report by the Bombay Natural History Society,

the late Salim Ali (founding father of natural history and conservation in India) documented the rashness of the decision to stop grazing by domestic stock, particularly buffalo. Since 1982, the park has been inundated with aquatic grasses favoured by buffalo and cattle. Two grasses, *Paspalum distichum*, and *Vetiveria zizanioides*, have spread most. The invasion of these grasses has reduced the area of open water and therefore, the submerged and floating vegetation that the water birds need. The fish that many of the birds eat have also declined in number..."

The only place that vetiver can survive without man's help is in natural swamps. The problem here developed as a result of government interference.

RESEARCH NEEDS

The vetiver system is a field-oriented technology developed specifically for farmers. The approach we use has been successful and is not misleading. Farmers that have volunteered to try the system, and their neighbors, who have observed the results, were amazed at the increased yields received by plowing and planting on the contour. The farmers that practice the vetiver system in India need no more convincing. It is a simple, cost effective, and sustainable method of increasing productivity. On Black Cotton soils, it is the only way the farmers can double-crop the land. There are many obvious advantages, including:

- Vetiver hedges filter the runoff, removing its silt load and building natural terraces.
- Because the runoff water is spread out over the length of the hedge while it is filtering through, the delay allows it to be absorbed into the soil. This improves ground water supplies, due to the system's wider exposure to aquifers.
- The hedge needs no maintenance, is permanent, and cannot be washed out, giving constant protection from erosion.
- Plowing and planting in furrows parallel to the vetiver contour guideline increases yields due to increased moisture conservation, virtually drought-proofing the crop, and making the rainfed farmer a better risk for credit.
- Vetiver acts as a barrier to the rhizomes of cultivation weeds, which cannot penetrate its root system.
- Vetiver hedges in wasteland watersheds not only prevent gully erosion, but increase infiltration, once again creating streams that had long since dried up and replenishing groundwater reserves.
- Vetiver hedges protect raw soil surfaces in dams, canals, road cuttings, and roadsides, thus increasing the life and usefulness of these structures.
- Vetiver hedges are cheaper, more permanent and far more effective than structural methods of erosion control.
- Vetiver hedges are easily controlled and only grow where planted. They make excellent permanent fences or boundary markers.

These are some of the features of the grass that can be easily observed in the field, but at this stage we have no scientific data supporting any of these observations. Data is essential to planners and policymakers that cannot get out to see the results in the field. Simple research trials, socio-economic field studies, soil loss and runoff trials, detailed studies of the plant, and documentation of yield results need to be collected now. Without data, the wider acceptance of this effective system will be unnecessarily delayed, and the soil will continue to be washed and blown off our farmlands, to be lost to the oceans, or to silt-up expensive dams. Research is essential to accord this new technology its rightful stamp of approval.

ECONOMIC ISSUES

Vetiver technology is a revolutionary system that will dramatically improve rainfed agriculture in developing countries. There is justification for work exploring its economic dimensions. Several topics seem particularly significant:

- Assessing the system's farm-level

private and social profitability.

- Predicting the rate, extent, and determinants of adoption.
- Program planning, including the optimal rate of nursery establishment and allocation of planting material.
- Assessing the regional and market impact of widespread adoption of vetiver hedging, especially as it applies to new crops made possible by better moisture conservation or double cropping.
- Exploring the consequences of rent-seeking on the choice of soil conservation technology.

Private and Social Profitability

This is essentially a straightforward benefit-cost question. Before much more work is justified on profitability, better physical impact data is a prerequisite. Otherwise, there is the potential that a great deal of poorly structured sensitivity analysis of quite limited utility will be undertaken.

At a more aggregate level, the impact of vetiver on district yields and income might be studied using Kabal Nala (Karnataka, India.), versus surrounding areas where vetiver has not been planted (providing those areas are representative of the vetiver areas in soil, climate, and cropping). If these conditions are met, and if the way in which vetiver is grown approaches the proposed system, there may be enough discernible differences in yields, fluctuations over time, and so on, to allow testing of some hypotheses about the profitability of the system.

Regional and Market Impacts:

Among the questions of interest are: what impact would greater yields and double cropping have on prices, quantities, and trade in oilseed crops? what will be the impact on demand for inputs, such as transport logistics, labor, and fertilizer?

Adoption:

Essentially all the work on adoption is ex-post. There is an enormous quantity of this literature, but it provides little guidance on the quantitative prediction of adoption rates. One generally presumes that existing patterns of adoption are based on farmers' perceptions of what is or is not profitable, or on some failure in the flow of information. The question is to try to identify which farmers adopt and which do not, and to see if there are instruments available to change nonadoptors to adoptors. Has the vetiver system been promoted long enough to show whether interest by farmers is a particular problem?

Program Planning:

An interesting economic characteristic of vetiver is that, much like trees, it is both capital and product at the same time. An individual slip can be allocated to the nursery where it will multiply fairly rapidly, or it can be allocated to a program of land treatment where it will start to generate direct benefits and multiply at a slower rate. There is an optimal policy to solve this allocation problem and it depends on time preference (discount rate), differential growth rates, cost of nursery management and planting out, and impact on farm profits. An extended formulation could take in to account the fact that farmers' demand for planting material is also partly a function of the area already treated (as they see their neighbors' benefit), and that as larger and larger areas are treated, the hedges can become a more significant source of planting material. This model might recommend more concentration in early years on nursery expansion, and eventual liquidation of nurseries as treated land becomes a main source of supply.

Rent-seeking:

A fancy term for corruption, analyzing rent-seeking as a factor distorting farmers'

choice of technology seems very relevant to the Bank's experience in many countries. If corruption accounts for the reluctance of institutions to promote vetiver because there is no 'money' in the system, compared with the amounts needed to implement constructed systems, it raises several questions. From the perspective of society, what is the cost of pursuing the constructed technology? It includes the costs of constructing and maintaining these works, less the "take" of corrupt officials. What would be the advantage of moving to a vetiver system? The savings to the government, plus any increase in farm profits, plus the reduction in decline of the resource base. Basically, if the benefit of moving to vetiver exceeds the value of rents transferred to officials under construction of contour banks then, aside from ethical considerations, there is justification for a policy to compensate them for the reduced value of their positions. In other words, does it make sense to pension off the old line soil conservation people in return for a stop to technological obstruction? If so, how can this be done?

Recommendations

A case can be made for proposing any one or a combination of these issues in a program of research on Vetiver grass. All need attention in some form or other and each could be tackled in one project if funds and time were not factors, assuming that a reasonable program of field trials can be designed to demonstrate the effects of vetiver on farmers' fields. Assessing the profitability of vetiver should receive first priority, but it should be done in the cheapest way possible, relying on an absolute minimum of survey work. It will be difficult to make a case for carrying out original expensive, time-consuming, and difficult survey work for this purpose. But the proof of the profitability of vetiver will be in the farmers' ultimate decisions. There is a need to design an optimal program, for if large sums are devoted to developing vetiver then some logic must be given to the establishment of nurseries and out-planting, to enable estimation of parameters, such as farm level profitability, costs, and so on.

Annex 1

HECTARE BUDGET FOR DEVELOPMENT OF VETIVER GRASS NURSERY, INDIA, 1988.

Labor/Machinery Costs	Units	Cost/Unit	No.Units	Total/ha
Plowing	Oxen	45	10	450
Breaking clods	Man/days	12	50	600
Spreading farmyard manure	Man/days	12	10	120
Forming ridges and furrows	Oxen	45	5	225
Loading /unloading slips	Man/days	12	10	120
Treatment/dressings	Man/days	12	15	180
Pruning and sorting slips	Man/days	12	20	240
Planting of slips	Man/days	12	75	900
Weeding	Oxen	45	15	675
Weeding and topping	Man/days	12	150	1,800
Uprooting clumps	Man/days	12	25	300
			Subtotal	Rs. 5,610
INPUT COSTS				
Purchase of slips	'000	10.0	62.5	625
Farmyard Manure	Tonnes	50.0	25.0	1250
Diammonium Phosphate (DAP)	kg	3.5	250.0	875
Urea	kg	2.6	375.0	975
Atrazine (ai)	kg	167.0	1.5	250
BHC (10%)	kg	2.0	25.0	50
Irrigation	Total			250
			Subtotal	Rs. 4,275
BASE COSTS				9,885
Contingencies/losses ..	%	25.0		2,471
TOTAL COSTS				12,356

Note: Based on the actual costs of a government nursery. A farmer could do the work much more cheaply, using less labor and inputs. These costs are for a commercial nursery, which will be 'harvested' (for slips) two to three times per year and possibly over several years. (Once farmers have planting material, they do not need the services of the nursery again.)

OUTPUT FROM THE NURSERY:

@ 20 slips/clump (at a planting rate of 62,500/ha) would yield 1,250,000 slips.
@ 30 slips/clump 1,875,000 "
@ 40 slips/clump 2,500,000 "
@ 60 slips/clump 3,750,000 "

ASSUMED SALE PRICE/SLIP = One paise/slip (1/1500 US$) therefore at 60 slips per clump the nursery farmer would make a return of $US 2,500/ha on each harvest.

NB. Cost in Rupees per hectare - 15 rupees = $1.00

FIELD COSTS FOR ESTABLISHING VETIVER HEDGES
(Indian Rupees)

Items:	Note	Units	Cost/Unit	No of Units Yr.1	No of Units Yr.2	Year of Establishment Year 1	Year 2.	Total
Labor:								
Opening furrows	1	2 oxen	45	0.5		22.5	0	22.5
Forming V ditch	2	M/days	12	5.0		60.0	0	60.0
Pruning/separating								
loading & unloading		M/days	12	2.0	0.4	24.0	4.8	28.8
Planting & fertilizing		M/days	12	4.0	0 8	48.0	9.6	57.6
Weeding		M/days	12	2.0		24.0	0	24.0
			Subtotal:-			178.5	14.4	192.9
Inputs:-								
Purchase cost of slips:-	3	'000	10.0	40.0	8.0	400.0	80.0	480.0
Transport of slips	4	%	10.0			40.0		40.0
DAP		kg	3.5	20.0		70.0		70.0
Urea (3 split dressings)	5	kg	2.5	60.0		150.0		150.0
BHC (10%)	6	kg	2.0	40.0	4.0	80.0	8.0	88.0
Contingencies		%	10.0	10.0		74.0	8.8	83.0
			Sub. Total			814.0	96.8	910.0
TOTAL (Rounded)						993.0	111.0	1100.0
TREATMENT (Cost per hectare.)								
Labor						44.6	3.6	48.2
Inputs						203.5	24.2	227.7
			Total (Rounded)			250.0	30.0	280.0

Notes:
1. Costs entered as Oxen-pair days.
2. Opening 'V' ditches, necessary in semi arid/arid areas to accumulate water to plant slips in to ensure their survival.
3. See nursery cost table.

4. From nursery to field site
5. Use of fertilizers is optional. Obviously the plants will form a hedge faster if fertilized, but it is not essential.
6. BHC was used to protect the young slips from white ant attack, but it is not essential.

These budgets are based on a 40 m Horizontal Interval (HI) between hedges, equivalent to 250 m of hedge per hectare. There are no hard and fast rules about horizontal intervals, this is a natural system and is not governed by formulae. The HI is determined by observation - the point where rilling would start again down from the protection of the hedge. As a guide to slope, vertical/ horizontal intervals and so on, see Annex 2.

CHINA
(1989)

Farmer-owned nursery
Cost of production of vetiver slips per Mu

			Yuan 6/day(1)	Yuan 3/day(2)
Labor	22 man days		132	66
Fertilizer	Urea 25 kg.@ Y1.4/kg		35	35
	Phosphate 25kg.@ Y0.4/kg		10	10
Water charges(3)			30	30
Planting material	4,000 slips(@1 Fen.)		40	40
Chemicals			20	20
Packing			100	50
	Total cost	Yuan	367	251
Average output(4) of slips per Mu(5) at 30 per clump = (30 x 3,900) = 117,000 @ 1 Fen/slip			1,170	1,170
	Gross margin	Yuan(6)	803	919

(1) Fujian labor rates.
(2) Jaingxi labor rates.
(3) Planted at 40 cm X 40 cm = equivalent to 3900 planting/growing clumps.
(4) Note it is possible to produce 60-100 tillers (slips per clump) resulting in significant profit increase.
(5) One Mu = 1/15 ha.
(6) There are 3.68 Yuan/US$ and 100 Fen to the Yuan.

Annex II

VETIVERIA ZIZANIOIDES (Stapf)

Synonyms

Andropogon zizanioides	(Linn.)
Andropogon squarrosus	(Hack)
Andropogon muricatus	(Retz.)
Andropogon nardus	(Blanco)
Andropogon nigritanus	(Stapf.)
Andropogon festucoides	(Presl.)
Andropogon echinulatum.	(Koenig)
Anatherum zizanioides	(Linn.)
Anatherum muricatum	(Beauv)
Agrostis verticillata	(Lam)
Phalaris zizanioides	(Linn.)

TAXONOMIC POSITION

Family	*Gramineae*
Subfamily	*Panicoidae*
Tribe	*Andropogoneae*

To find vetiver in a Herbarium collection it is necessary to check out previous given names. There has been a great deal of confusion over the naming of both the genus and the species. As of March 1987, there were currently 10 species of Vetiveria recognized at Kew, and distributed as follows.

Indochina: *V. nemoralis* (poorly known, sta tus doubtful)

India: *V. zizanioides., V. lawsonii.*

Australia: *V. elongata, V. filipes, V. intermedia, V. pauciflora.*

Madagascar: *V. arguta.*

Africa: *V. nigritana, V. fulvibarbis.*

There is an overall account of the genus at the Royal Botanic Gardens herbarium, Kew, England, where most of the species have been described in one flora or another. Unfortunately these descriptions are not strictly comparable, and it would take some research to construct a reliable diagnostic key.

I feel the specific name '*zizanioides*,' from what we know about the grass, is inappropriate. I can understand this name (meaning "by the river" - or "riverine") given by by the botanist who discovered the plant in India, where it was cultivated in the 'silty alluvium' of the river banks to make it easy to harvest the roots for oil. Two hundred years ago nobody considered it an ideal plant for soil conservation. I think a more appropriate name for the species would be *V. ubique* - but that is up to the botanists.

REFERENCE DATA ON VETIVERIA SPP

V. nigritana: Stapf = *Andropogon nigritanus*, Sahara, Sudan,. The scented roots are used locally for perfuming clothes.

V. odorata: *Virey* = *V. zizanioides*

V. zizanioides. Stapf. = *V. odorata* = *Andropogon muricatus*, (khus-khus, vetiver), Tropical Asia, especially India, Ceylon, and Burma. A heavy essential oil is distilled from the roots and is used in perfumery, mainly as a fixative. The roots are also used to make perfumed mats, baskets, fans. and so on. The plant is cultivated.

In Malaysia, D.H. Grist, writing in the Malayan Planting Manual No. 2, "An Outline of Malayan Agriculture," refers to *V. odorata* as

"A perennial grass, about four feet high (1.2 m.) with stiff erect leaves and aromatic roots. The essential oil is obtained from the roots by distillation and is used exclusively in perfumery on account of its fixed properties, as it prevents other essential oils from volatilizing too rapidly. This grass is propagated by divisions of the root, which are planted in rows three feet (0.91.m.) apart. The plants are ready for lifting after six to eight months, or just before flowering when the oil content is at its maximum.

"The yield of oil is highly variable and ranges from 0.5 to 3.3 % according to the condition of the roots when lifted. With two crops per annum, each yielding about 1,000 pounds (454 kg.) of dry roots per acre (0.4 ha), and with an oil content of 2%, the yield of oil approximates to 40 pounds per acre (45 kg/ha)."

"Owing to the ramifications of vetiver grass roots, it is an expensive crop to harvest and on this account it is very doubtful whether its cultivation with paid labour would be a profitable undertaking under local conditions. The grass is of value for the purpose of holding up silt-pit bunds on steep and undulating land. The root system is very vigorous and assists materially in forming a compact bank of soil (a natural terrace)."

" Wealth of India" states:

"*V. zizanioides*. A small genus of perennial grasses found in the tropics of the Old World. Two species are found in India, of which *V. zizanioides*, commonly known as Vetiver, is the source of the well-known Oil of Vetiver, which finds use in medicine and perfumery. Vetiver Oil was the original product making this an essential oil plant, but due to the extreme difficulty in digging up the roots, together with the cost of the operation, vetiver oil is not being produced in any quantity today."

World production was estimated at about 140 tonnes, with Haiti, Reunion Island, and Indonesia (Java) the principal producers. In general, the yield of oil is low, varying from 0.1% in India to a maximum of 2.0% in Indonesia. Interestingly, the oil (like the grass) is one of the most complex of the essential oils. Its chemistry is very complicated and not yet fully understood. Five kilograms of roots produce 25 to 50 grams of essential oil (Attar).

EARLY HISTORY

For over two hundred years there has been a controversy over both the naming of the genus and the species of this grass which has not been resolved. There is a need for more study before the species is sorted out, redefining the genus is academic. The following abstracts show centuries of trying to get this extraordinary grass into the right category.

From the The Royal Botanic Gardens, Kew's "Bulletin of Miscellaneous Information;" No.8; 1906.
XLVI.-THE OIL-GRASSES OF INDIA AND CEYLON.
(*Cymbopogon, Vetiveria, and Andropogon* spp.)
Otto Stapf.

"Around 1896, because of the confusion arising among manufacturers of volatile oils as to the type of oils; their volatility; what plants they actually came from etc., they commissioned Messrs E. Gildemeister, of Leipzig, and Fr. Hoffmann, of Berlin, to prepare a 'treatise on the entire subject of volatile oils.' The result was a volume of over 900 pages (with maps and numerous illustrations), under the title ""Die atherischen Ole." The work was considered "..a remarkable and unfortunately all too rare instance of cooperation between practical and scientific men." They found that there was an unsatisfactory state of knowledge of the botany of the grass oils. The 'Semi-Annual Reports' published by one of the big essential oil companies of the time, Schimmel & Co., contained direct and indirect references to the uncertainty of the taxonomy of the grasses involved.

In Schimmel & Co's April-May Report for 1903, p.23, two passages are worth quoting in order to shed a little light on the mixed taxonomic history of vetiver grass: "...It has repeatedly attracted our attention, that when it is a question of their origin, the Andropogon grasses are frequently confounded with each other...there are some exactly defined species indicated as the mother plants of oils which, according to our information, could not possibly be produced from them"; and again in the October-November Report for 1905, p.52, "On a previous occasion we have already pointed out that the Andropogon grasses, where their origin is mentioned, are frequently mistaken one for the other. This inconvenience is all the more felt as the uncertainty of the botanical nomenclature also exists in scientific work."

At Kew the experience has been the same. The incongruous application of the names '*Andropogon Schoenanthus*' and 'Lemon-grass' and the obscurity of De Candolle's *Andropogon citratus* have been among the principal sources of trouble. Even the 'composite' species. "Under the circumstances a thorough overhauling, from the taxonomic standpoint, of the grasses involved was essential in the interests of the grass oil industry." Otto Stapf goes on to say "[h]aving been intrusted with this task, I revised in the first place the material in the Kew Herbarium. Rich as it was in some respects, it was sadly lacking in others. A fine collection of oil-grasses made in Southern India at the instigation of Mr. C. A. Barber, Government Botanist at Madras, went a long way to fill the gaps, so far as the Madras Presidency and the Travancore were concerned, whilst Dr. Lotsy, of the Rijk's Herbarium at Leiden, and Dr. Treub of Buitenzorg, supplied useful material from Java. Convinced that no scientific problem should be approached without due consideration of its historical development, I have endeavored to get a good grasp of the history of the subject. This has entailed a great deal of library work and search for original specimens, as documentary evidence, in the older herbaria."

Finally, Stapf states that even after his efforts there could still be some confusion in the taxonomy of these grasses. "In this paper I have endeavored to embody the results of my researches into the history and taxonomic position of the oil - grasses of India and to introduce the necessary changes in to their nomenclature. I hope I have laid the foundation for a more satisfactory conception of those grasses as taxonomic units. At the same time I am well aware of the incompleteness of my work and the inevitable defects of research carried on to a great extent with material which has been collected casually or at least without consideration for the requirements of the problem as it presents itself today. Moreover, certain questions, some of them of great theoretical and practical importance, can, at the herbarium table, only be approached by a method of inference. The conclusions arrived at in this way will carry more, or less weight according to the number and precision of the data which the specimens present. I have in view, more particularly the question of 'variability' on which so much depends for the correct coordination and subordination of forms. The notes we have on this point from collectors and others who have had the opportunities of observing the oil - grasses in their natural stations or in cultivation are few and extremely meagre. Systematically conducted experiments there are none. (even today; 1989.) When this is the case the taxonomist has generally to fall back on his 'tact'; but valuable as this somewhat ill-definable quality in certain circumstances may be, conclusions based on it cannot be accepted as final so long as they have not been confirmed by extended and direct observation in the field, and by experiment. Work of this kind must therefore necessarily be more or less incomplete and preliminary."

So it is obvious that Stapf had plenty of problems sorting out the taxonomy of these grasses and was not at all convinced that he had really done a thorough job. That the cultivars of

vetiver found in other parts of the world were named individually by the different botanists that originally found them could have also lead to confusion. What is called *V. nigritana* in Nigeria, could in fact be *V. zizanioides*, and until we have some better means of distinguishing the species from each other, we would only be guessing.

If we admit certain deductions of the Sanscritists - and there is no objection to them from the botanist's point of view - this grass best known as 'Khas Khas' or "Vetiver," must have been popular with the peoples of Northern India for a very long time. W. Jones. [Jones in Asiat. Research. vol. iv, (1795), p. 306.] indentified the Urisa of Kalidasa with 'Khas Khas', and Hessler in 1850, did the same in his translation of the Ayurvedas, while the more recent interpreters of Sanskrit plant - Dutt (1900) - have come to the same conclusion. Other Sanscrit names which have been interpreted in the same sense are 'Virana, Lamajjaka, (or Lamaja) and 'Bala'. According to the "Pharmacographia Indica (vol. iii., p. 571), "In Vedic times the ancient Hindus were instructed to build their houses in a place where Virana and Kusa (*Desmostachya bipinnata*, Stapf) were abundant." Lamajjaka is in the same work (l.c.,p.562), referred to as 'Camel's Hay' (C. Schoenanthus) but the synonyms 'Dirgha-mulaka' (long rooted) and 'Jalasaya' (aquatic) with which Lamajjaka is connected in the Nighandas, are much more descriptive of Khas Khas and Heyne's (India,1814) and Elliot's (A.P India 1859) interpretation of the term as connoting the latter is therefore more plausible. Hessler also renders the 'Bala' of Susruta with *Andropogon muricatus*. According to Dutt, it stands for Pavonia odorata , another plant whose aromatic roots are frequently used in Hindu medicine. But the fact that 'Bala' in Hindi also denotes the roots of 'Khas Khas', and that the Bengali, Gujerati and Maharati synonyms 'Vala' and 'Valo' are applied in the same sense, supports Hessler's identification. In proof of the assumption that 'Khas Khas' was an article of some importance long ago the authors of the 'Pharmacographica Indica'(vol, iii., p. 572) also refer to the discovery of some other copper plates in the village of 'Basahi' in the district of Etawah, south east of Agra, it being stated that on these copper plates, which are dated A.D. 1103 and 1174, the grass is mentioned among the articles subject to royalties. The actual term used is 'turushka-danda', which Babu Rajendrala'la Mitra interprets as meaning 'aromatic reed' (turushka = aromatic substance, danda = stick), and hence also 'Khas Khas'. The latter term, now so commonly used, is supposed to be of Persian origin, but this appears to me very doubtful. It is mentioned in the Makhzan-el-Adwiyah, as a kind of 'Izkhir' used in India also known as 'Izkhir-i-Jami',(Izkhir-i-Ajami, foreign Izkhir), and called by the Persians 'bikh-i-wala' (wala = root).

The 'Khas Khas' was long ago equally well known to the Dravidic peoples of the South. Rheede (1703) described and figured the grass under the Malayalim name 'Ramacciam', which is still in use in Travancore (and still in use in Kerala in 1989) [Ramach-cham, Moodeen Sherif; Ramaccam, Stolz). He states that the roots, (but not the leaves) are fragrant and sold in the bazaars for medical purposes to prepare lotions, infusions and decoctions. It is, he remarks very common throughout Malabar and diligently cultivated by the natives, who propagate by dividing the tufts and planting them in loose soil. He further observes that the best 'Ramaccian' grows near Tutocorim, the port which in our own day is still the principal place of export of the roots of 'KhasKhas' or 'Vetiver'. Rheede's figure represents a leaf-tuft with the leaf tops cut off. Although somewhat crude, it is perfectly characteristic, and it is difficult to understand how the 'Ramaccian' of the 'Hortus Malabaricus' could ever have passed - as it so frequently has done - for the 'lemon grass'. Hermann (1672-1677) also found the roots in similar use at Colombo in Ceylon (Sri Lanka), where they were known as 'Lumbutschi-veru' (radix odorata) and the grass itself as

'Saewaendara', which name has survived to the present day. About 25 years later (in 1700), Dr. Bulkley sent it to Ch. Du Bois from Madras under the Tamil name "Vettyveer' (=Vetiver), the vernacular name by which the grass is best known in Europe. Petiver [Petiver, Mus. Petiv. (1699) p. 53, no. 559.] also received specimens of it from Samuel Browne of Madras at about the same time and announced them in his 'Museum' as 'Gramen Madraspatanum majus cujus locustae spinulis eleganter armatae sunt." Some of them he sent to Scheuchzer (1719) who from them drew up one of those classic descriptions which for completeness and accuracy remained long unequalled in agrostological literature.

FOUNDATION OF THE SPECIES - SYNONYMY.

No notice was taken of Scheuchzers description or of Petiver's and Du Bois's specimens, and when Linnaeus, circa 1770 [Linnaeus, Mant. Alt. (1771), p. 183.] received the grass from Koenig. He described it as something new under the name *Phalaris zizanioides*. Koenig, however, also sent specimens of the grass to Retzius, who published it as *Andropogon muricatus* in 1783. This name, which was suggested by Koenig himself, was subsequently adopted by Roxburgh and most other botanists. More recently, however, it has been replaced by *Andropogon squarrosus*, a name adopted by the younger Linnaeus in (1781) for a plant also communicated by Koenig, who found it "circa Zeylonam natans supra stagna profundiora," and entirely distinct from *Andropogon muricatus*. The specimen is still in Linnaeus' herbarium and was correctly identified by R. Brown (1810) with his *Panicum abortivum* that is *Chamaeraphis spinescens*, a characteristic floating grass of the Indo-Malayan region. Retzius (1789) himself is responsible for the erroneous reduction of Andropogon squarrosus to Andropogon muricatus, which recently has been revived, although Roxburgh (1820) long ago drew attention to the confusion. Zizanioides being the earliest specific epithet, it will have to be adopted or 'Khas Khas' so that its name under *Vetiveria* must be *V. zizanioides*."

Use of the Roots: The property of the Khas Khas roots emitting a pleasant odor as often as they are wetted, Staph states, was also mentioned by Jones in 1795. It has led from early times to their being woven into screens and mats (tatties) which are hung over doors or set in windows; in hot weather, when frequently sprinkled with water, they cool and perfume the air. The fans (Tamil, 'visri') mentioned by Koenig, act in the same way. The root in the powdered state, enters into the composition of an 'Abir' or perfumed powder used by the Hindus' at their 'Holi' festival. Such an Abir, Abir Izkhir, is already mentioned in the 'Ain-i-Akbari' (1904), the Annals of the Emperor Akbar, the appellation 'Izkhir', standing here for 'Izkhir-i-Ajami', that is 'Khas Khas'. The 'Schoenanthus' powder which Herbert de Jager (1732) found in use at Golconda in the second half of the 17th century was also most likely 'Khas Khas' powder. For what he says is this: "In Golconda, this 'Schoenanthus' is used in powder form for washing hands on account of the very pleasant odor it imparts very quickly to the water, but the odor ceases as soon as the hands are dry."

Stapf continues: "While the use of the roots of *Vetiveria zizanioides* for medicinal purposes and in perfumery has been universal in India for a very long period, I have failed to find, among the earlier writers, any definite and indisputable reference to the extraction of an oil from them. Indeed, the distillation of vetiver oil in India seems to be very limited and there is hardly any export (1905). The oil was mainly produced in European distilleries from the imported roots; but even the import of the roots as a regular article of commerce appears to be of comparatively recent date."

Natural Area and Cultivation: The natural area of *Andropogon muricatus* in India and Ceylon includes practically the whole country, in the North up to 600 m. Although common in

many parts of the country, particularly on the banks of rivers, and in rich marshy soil, it is also at present occasionally cultivated, as for instance in Rajputana and in Chutia Nagpur. Eastward, the area extends in to Burma. Throughout the Malayan region, it occurs only in the cultivated state. It has also been introduced into the Mascarenes, the West Indies, and Brazil, but it seems that in these countries oil is not distilled to any appreciable extent, except perhaps in Reunion. The grass here must have been in cultivation for at least 100 years, as the first sample of vetiver oil that was examined in 1809 came from here.

***V. zizanioides* : Early American History:**

Vetiver roots have been used in Louisiana since the state was settled, for perfumed sachets to be placed with stored clothing, thus protecting it from moths and other pests. Many years before the American civil war, planters in New Orleans imported it from India.

An old document from Louisiana states, "[t]here are many plants, minerals, and other nature products in this universe, that more or less protect the human race against the bothersome insects of life."

"It seems that the insect life has an absolute distaste for vetivert. We have found in the growing of this plant that no insects of any kind ever came it. We also find that in the powdered form the tops mixed with the residue of the oil repel any and all insects.

It is for that reason, so important that this plant be given every consideration and not be allowed to grow wild as heretofore has been the case in this country, It is as necessary to have vetivert as it is to have salt in your food."

"Strawberries that were grown in the Southland have been more or less contaminated by insects, and although pine needles and other things have been used in order to safeguard against these pests of nature, a great loss was wrought against the strawberry crop. We have found from experimental work that the tops, in the same formation of mixture with the residue of the roots, will make an absolute repellant for the insects that may hurt the crop"

In "A Dictionary of the Economic Products of the Malay Peninsula," by I.H. Burkill, (who was from 1912 to 1925) the Director of Gardens, Straits Settlement, and prior to that he the Officiating Reporter on Economic Products to the Government of India) stated that vetiver was,

"[a] very tough , wiry grass, found in a wild state across northern India and Indo-China, and now cultivated throughout the tropics. Its cultivation in India is very ancient, for apparently it was used in Sanskrit times as a perfume, and was known as 'usira', 'virana' and probably also 'bala'. "Bala" has given rise to a series of names now employed in India; but none of the three sanskritic names seem to be represented in Malay, though a series of Sumatran names - 'useur', and 'usa' extending as 'usar' in Sundanese, has a similarity to the Sanskrit 'usira'. The Malay name 'nara wastu', came to Malaya from Sumatra, and, in a variety of forms, it is met with through Java to Celebes.

There is in these names no clear indication of the introduction of the grass from India; yet it certainly was introduced from outside. It occurs wild near Batavia (Jakarta) and on the Kangean Islands; but there, as in other parts of the world, we must regard it as only run wild. In the Malay peninsula, it has been found in gardens for some time. It is clear that by the name *Andropogon echinulatum*, Koenig indicated it in the diary of his visit to Malaca in 1778. He recorded that the roots were used for making fans and the roofs of palanquins (see Fans. Jour.Roy As. Soc. Straits Branch, 26, 1894 p. 103). These uses had been borrowed from India, and just as the palanquin has gone out and with it a demand for the grass for its roof, so also, these

fans seem to have gone from Malaya, but fans are still made in the Philippine Islands. As the scent suggests, sandalwoods, fans, sent from the Philipine Islands to America nowadays, are offered as "sandalwood fans."

The Malays are not recorded as using the roots internally, but use them to give scent to a lotion and to powders applied moist to the body after childbirth (Ridley in Journ. Straits Med. Assoc 5, 1897 pp. 137 and 138).
Used internally in stomach complaints, the roots have but little power. However, Guerrero (Bull. 22 For. Philipp. 3, 1921 p. 170) calls the decoction of them an efficacious litho-triptic, used for breaking down stone in the bladder.

Distillation seems too have been first done in southern India, but it is not easy to do, and requires patience, so that it took little hold there. In 1893, it was tried on the 'Perseverance Estate' in Singapore and soon after this there was a demand for the grass by planters prepared to try it.

In 1908, a plot was grown experimentally at Kuala Lumpur (Agric. Bull. Straits and F.M.S. 7, 1908 p. 600), where the grass is easily raised. It is still grown, as at Serdang (Bunting and Milsum, Guide Gov. Exper. Plant. Serdang, 1931 p. 84), where it is used for holding up steep banks. It is well known to be good for this purpose.

Georgi (Mal. Agric. Jour. 12, 1924 p. 197) made an experimental distillation of roots grown at Serdang. He obtained 0.5 to 0.65% of oil from fresh air-dry roots, which, valued in London was regarded as of good quality, like Reunion oil and better than Indian oil. It is, however probable that the optimum climate for oil production is one that is drier and less forcing than that of Malaya, but data are wanting.

No oil industry was developed in the Straits after the 1893 trial, but in the mountains of Java success has been obtained. Vetiver oil is heavy, so distillation is slow; and, being heavy, its place in perfumery is to fix more volatile oils. Because it is heavy, it is easy to transport the roots without its loss, to distant stills; and dried roots were in the past, shipped as far as Europe. In distillation, specially designed separators have been used, as the viscous oil is difficult to manipulate with the usual apparatus. The demand is not great.

In the Philippine Islands, the flower stalks are made into hats. They are dipped into boiling water and dried in the sun, scrapped clean and woven. Brooms, also, are made from them (W.H. Brown in Bull. 22, Bur. For. Philipp. 1, 1920 p. 338). As a paper-plant, its leaves are second-class (Bull. Imp. Instit. 12, 1914 p. 136). Though cattle will eat the young leaves, when old they are too harsh to be used as fodder, but make litter for animals.

DISTRIBUTION OF *VETIVERIA ZIZANIOIDES*

India
Southeast Asia (Thailand, Malaysia, Philippines, Indonesia)
Pakistan
Polynesia (Samoa, New Caledonia, Fiji, Tonga.)
Nepal
Tropical Africa, as well as **South Africa**
Burma
Sri Lanka
Guyana
New Guinea
French Guyana
Argentina
West Indies (Haiti, Cuba, Jamaica, Puerto Rico, Antigua, St. Vincent, Martinique, Barbados, Trinidad)
Colombia (Santa Maria)
Brazil (Rio de Janeiro, Para, Bahia)
Paraguay (Central Paraguay)

NOTE: The above locations are noted from Kew Gardens Herbarium specimens. **China** (Fujian and Jiangxi provinces ; Hainan Island)

Zimbabwe: Introduced early 1960s from **Mauritius**. Now growing at Chiredzi, Chipinga, and Harare. Available from J.Logan, Coffee Growers, Association, Box 4382, Harare.
Kenya: Introduced to Kenya Nov. 1987. Available from P. Neylan, South Lake Rd., Naivasha, Box 356.
Somalia: Introduced to NWRADEP Hargeisa, April 1987.
Nigeria: Introduced to Kano October 1987. Now growing on Mambilla Plateau, and at Greenland Farm Kabba, also N.T.C. farm at Ilorin.
United Kingdom: Introduced Nov. 1988. Now under micro-propagation. Some plants established 'in the garden' at Wokingham and near Evesham, May 1989.

Near Jakarta and on Kangean Island, it is found growing wild at an altitude of 5-100 m ASL. in swampy terrain in the West Monsoon. The (seldom flowering) unawned species is found in Central Java up to an altitude of about 900 m, often along the edge of streams. In West Java, it is found along natural water courses where it has been planted to prevent scouring, and in tea gardens, it is used to protect the edges of terraces.

An article on page 816 of the 'Indische Mercuur', the grass 'Djokoet wangi' (the local name of vetiver grass) is strongly recommended for planting on steep slopes and along furrow edges, because of its easy cultivation and the formation of a dense hedge with a very extensive root system, which prevents breaking of the soil in the dry season and prevents erosion within the furrows. Due to the coarse nature of the grass, it is of little use as a fodder, according to Backer, the author of the article.

Concerning the use of the roots, this old article from the "Dutch East Indies," goes on to say: "Vorderman (Geneesmiddelen I.) mentions the roots as a pharmaceutical item of trade. V.D Burg mentions that they are used for the preparation of 'arak obat' (a local pharmaceutical) and that its concoction (brewed product) makes you feel 'hot and sweaty'. Oil distillation is not easy according to Schimmel's October news of 1913, and would almost always have to be done in Europe. Root export statistics (from Customs reports) indicate varying levels; from 2.3 tonnes in 1918, to almost 143 tonnes in 1925 (with most years less than 50 tonnes.). According to De Jong (Bericht No. 7 of the Colonial Institute p. 102.), oil cells are only found in the 'bark' of the roots and a special pretreatment is needed to obtain the highest extraction rate. He mentions a yield of 0.4 to 1.0% of the weight of the dry roots, sometimes increasing to 2.0% depending on the climate and the time of harvest.

The oil is used because of its low volatility as a fixative (in other old articles on the subject, especially those from Louisiana, they state that the oil was very volatile and therefore difficult to handle, who is correct? The consensus seems to be that of low volatility.) for the preparation of perfumes and is considered absolutely necessary for the preparation of fine soaps. The quality of the Indonesian vetiver oil has been found superior to that of other countries.

Common Names

INDIA

Sanskrit:- Abhaya; Amrinala; Avadaha; Bala; Dahaharana; Gandhadhya; Haripriya; Indragupta; Ishtakapatha; Jalamoda; Jalashaya; Jalavasa; Katayana; Laghubhaya; Lamajjaka; Nalada; Ranapriya; Rambhu; Reshira; Samagandhika; Sevya;Shishira; Shitamulaka; Sugandhimula; Ushira; Vira; Virabhadra; Virana; Virataru; Vitanamulaka
Hindi:- Bala; Balah; Bena; Ganrar; Khas; Onei; Panni
Urdu:- Khas
Bengalese:- Khas-Khas
Gujerati:- Valo

Marathi:- Vala; Khas-Khas
Mundari:- Birnijono, Sirum; Sirumjon
Oudh:- Tin
Punjab:- Panni
Sadani:- Birni
Santali:- Sirom; Telugu; Avurugaddiveru; Kuruveeru; Lamajjakamuveru Vattiveru; Vidavaliveru
Tamal:- Ilamichamver; Vettiver; Vilhalver; Viranam
Kanada:-Vattiveeru; Laamanche; Kaadu; Karidappasajje hallu
Malayalam:- Ramaccham; Ramachehamver Vettiveru

SRI LANKA
Sinhalese:- Saivandera; Savandramul

IRAN
Persian:- Bikhiwala; Khas

CHINA
Xiang-Geng-chao

MALAYSIA
Nara wastu; Nara setu; Naga setu; Akar wangi (fragrant root); Rumput wangi (fragrant grass); Kusu-Kusu

INDONESIA
Aga wangi; Larasetu; Larawestu; Raraweatu; Sundanese; Janur; Narawastu; Usar

PHILIPPINES
Ilib (Pamp.); Mora (Bik, Bis); Moras (Tag.,Bis.,Bi.); Moro (Tag,), Narawasta (Sul); Raiz de moras (Sp); Rimodas (P, Bis); Rimora (Sbl); Rimoras (Bik); Tres-moras (Bis) Vetiver (Eng.); Amoora (C. Bis); Amoras (Ilk); Anias de moras(Pamp); Giron(P. Bis); Muda (Cebu - Central Visayas).

LAOS and THAILAND
Faeg

SAHEL
Bamb:- babin, ngongon, ngoko ba
Sohghai:- diri
Ful:- kieli, dimi, pallol
Sarakole:- kamare
Mossi:- roudoum
Gourma:-kulkadere

SENEGAL
Wol:- sep, tiep
Falor:- toul
Tuk:- semban

GHANA
N. Terr. Dag; kulikarili

N. NIGERIA
Hausa:- jema
Ful:- so'dornde; so'mayo; chor'dor'de; ngongonari.; zemako

SIERRA LEONE
Me:-pindi
Susu:- barewali
Ti:- an-wunga ro-gban

DISEASES:- Vetiver has been reported to be attacked by, but not affected by, the following:

Fusarium spp. Particularly during the rains controlled with 0,1% Ceresan.

Curvularia trifolii . Has been reported attacking vetiver causing leaf blight, tan to dark spots which later turn black. Can be controlled by copper spray.

Gloeocercospora sorghi. This shows as diffuse brown spots with irregular margins.

Holotrichia serrata. These bugs have been found in the roots of vetiver.

DESCRIPTION OF SPECIES

V. zizanioides (L.) Nash

Distribution (in Africa): Gabon; Ghana; Liberia; Sierra Leone; Nigeria; Senegal; Congo; Central African Republic; Uganda; Tanzania; Zimbabwe; South Africa (Natal; Transvaal), and Tunisia.
Extracts from the bibliography, gives a brief description of past uses.

Uses: Holland, J.H. 1922. Known in Africa from the French Congo (Congo) and Belgium Congo (Zaire), further spread in to Nigeria. Known for its aromatic roots.

Raponda-Walker, A. Sillans, R. 1961. In Gabon it is planted along the ditches and roadsides to conserve the soil; de-limit field boundaries etc. The roots are used to perfume clothing/materials and preserve them from insect attack.

Dalziel, J.M. 1937. Cultivated in the tropics for its fragrant roots. In West Africa it is used as a border for roads, gardens and cultivated fields etc. to prevent the extension of 'Dub grass' (Indian Dhoub = Cynodon dactylon). Samples from Ghana yield a high percentage (2.25%) of volatile oil. The leaves are odorless and can be used in their young state for cattle fodder.

Hepper, F.N. (ed) 1968. Cultivated in West Africa for its aromatic roots, and sometimes maintained as an ornamental.

Meredith, D. (ed) 1955. Roots, source of vetiver oil for perfume.

Trochain, J. 1940. Introduced in to tropical and subtropical Tunisia by the Europeans (the essence vetiver used in perfume, is extracted from the roots) and is sometimes planted along tracks to conserve soils.

Kew Gardens; Herb. Coll.: Akpabla, G.K. 565. Ghana - common hedge plant.

Kew Herb. Coll. Irvine, F.R. 1638. Ghana - roots used commercially.

Kew Herb. Coll. Fay, J.M. 4494. Central African Republic - used for stuffing mattresses.

Kew Herb. Coll. Wingfield, R. 3394. Tanzania. Cultivated as a border hedge.

Kew Herb. Coll. Hill, W.G. 5901. Tanzania Contour plant and cattle fodder.

Kew Herb. Coll. Nicoll, W.D. 267119 Zimbabwe. Cultivated, possibly for use as a mulch in coffee plantations.

Kew Herb. Coll. Pollitt. 27962 Zimbabwe. Cultivated for its aromatic root.

Kew Herb. Coll. Pole-Evans, I.B. s.n. Natal. Cultivated extensively by Indians in Natal as a wind break.

Meredith, D. 1955. Cultivated to a limited extent in South Africa. The species does not, apparently, flower under cultivation.

Sect. Neurobiol. Behavior, Cornell Univ., Ithaca, N.Y. Insect Repellents From Vetiver Oil 1. Zizanal and Epi Zizanal: Jain, S.C.; Nowicki, S.; Eisner, T.; Meinwald, J.;Subfile BA (Biological Abstracts) On the basis of spectral data and partial syntheses, structures 1 and 2 are established for zizanal and epizizanal, 2 new insect-repelling aldehydes isolated from Javanese vetiver oil (*Vetiveria zizanioides*.)

V. nigratana (Benth.) Stapf.

Distribution: Senegal, Guinea Mauritania, Gambia, Guinea Bissau, Sierra Leone, Ivory Coast, Burkina Faso, Ghana, Togo Republic, Dahomey, Niger, Nigeria, Gabon, Benin, Cameroon, Central Africian Republic, Sudan, Zimbabwe, Zaire, Malawi, Tanzania, Mozambique, Botswana, Namibia, Angola.

Uses: Diarra, N. 1977. States that the roots ("gongo dili") are used to perfume drinking water, and that the stems are used to make "seccos" (large mats used to make enclosures or cover out-houses/sheds etc.).

Trochain, J. 1940. Used to perfume water in Senegal.

Adam, J.C. 1958. Mediocre forage species when young. Numerous domestic uses - mats, cabin/animal store roofs, enclosure walls and basketry. The roots are more or less aromatic, being used as a perfume by children and adults and for scenting garments. Also used to make necklaces. It is taken in infusions and used

in the treatment of certain animal diseases ("gorli" - Ghana). The plant is sometimes used as an ornamental.

Adam, J.C. 1958. Only grazed after bush fires. (the regrowth).

Innes, R.R. 1977. Much used by Farafara (Ghana) for weaving hats, baskets and mats for domestic use and the tourist trade.

Dalziel, J.M. 1937. Used for coarse matting and for plaited armlets and rings, toys, hats, baskets etc. The split stems are twisted into head bands and used by youths at marriage. Stems and leaves are also used for thatching. Roots are not often distinctly aromatic but probably vary according to habitat,. They are eaten by warthogs. Women use the roots like lavender, in sachets, or as a body perfume, or made in to necklaces. The fibrous roots sold in Salaga, Kumasi etc. under the name "Sansan" are used like loofah scrubbers. An infusion of the roots is taken as a beverage. In Ghana; it is a treatment of the cattle sickness "Gorli."

Holland, J.H. 1922. Used in Nigeria for thatch, hedges used as fences; plaited straw for armlets.

Raponder-Walker, A. Sillans, R. 1961. In Gabon the aromatic roots are sun dried, powdered and mixed "`a l'huile de toilette"(cosmetic oils). Roots also used to make infusions.

Baumer, M.C. 1975. States that in Kordofan, Sudan, it is eaten by all animals, but especially selected by cattle who do not hesitate to enter the waters during the rainy season to browse it. After a bush fire, the regrowth is rapid, and the fresh green parts are sought after by animals.

Rodin, R.J. 1985. Reports that the Kwanyama Ovambos cut the *aromatic stems*, in short sections which are strung as beads and worn around the neck. Furthermore, the powdered roots are boiled in water, cooled and then used as an enema for the treatment of gonorrhea, and also that the powdered roots are boiled in water, but the purpose, other than for "alimentary disorders" is not made clear - presumably for constipation.

Ferry, M.P. et al. state that the "Tenda" (Senegal/Guinea border) use the roots to perfume clothes Furthermore, the "Basari" also use it to perfume drinking water.

Kew Herb. Coll. de Lomos, F., Macuacua, L. 135. Mozambique. Used in hat making.

Kew Herb, Coll. Lawrence, E. 2. Nysaland (Malawi). Planted as a border fence (hedge) round fields. Also used to thatch huts.

Kew Herb, Coll. de Winter, B. , Wiss, H.J. 4125. Namibia "used in Okavango Native Territory for thatching".

Kew Herb Coll. Rodin, R.J. 9133. "...used for making hats."

Kew Herb Coll. Passett 50958 Zimbabwe. "Roots commercialized by natives as a scent."

Ecology:-

Adam, J.C. 1954. Tufted perennial grass to 2.5 m. Flowers August to January (Cap Vert, Senegal). Habitat - temporary inundated flood plains.

Meredith, D. 1955. Grows in water or in wet, usually swampy ground, especially on black turf soil (Vertisol).

Polhill, R.M. (ed.) 1982 Flood plains and other seasonally flooded places; 0-1100m.

Rattray, J.M. 1960. In the Sudan, *V. nigritana* occurs on edaphic grassland subject to various periods and depths of flooding. In Angola it is found in swampland and areas with impeded drainage. In Nigeria (ppt.< 750mm) it occurs naturally in swamp land.

Innes, R.R. 1977. Occurs on alluvial flood plains (in Ghana), extending along small seasonal streams and channels in marsh grass and tree savanna, also relict in wet spots in heavily farmed areas.

Trochain, J. 1940. Flourishes on wet soils. Tolerates, along with Sporobolus robustus, slightly saline soils.

V. fulvibarbis (Trin.) Stapf.

Distribution:- Senegal, Ghana, Togo Republic,

Mali, Nigeria, Cameroon

Uses:- Diarra, N. 1977. States that in Mali the roots are used for perfuming drinking water. The stems are used to make "seccos" (strong mats for walls).

Ecology:- Hepper, F.N. (ed) 1968. Robust perennial to 2 m. Occurs on flood plains.

Innes, L.R. 1977. Occurs on alluvial flood plains.

Rattray, J.M. 1960. In Ghana, *V fulvibarbis* forms a consociate on the huge area of black clay soils on the plains between Accra and the Volta river and is also dominant on many of the sandy soils in the same area. It is also an important constituent of the black clay (Vertisol) grasslands east of the Volta.

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Annex III

SOIL CONSERVATION TABLE:-

Degree of Slope: o	Percentage Slope: %	Gradient 1 in -	Surface run per metre V.I.
1degree	1.7 %	1 in 57.3	57.3 m.
2	3.5	1 " 28.6	28.7
3	5.3	1 " 19.1	19.1
4	7.0	1 " 14.3	14.3
5	8.8	1 " 11.4	11.5
6	10.5	1 " 9.5	9.6
7	12.3	1 " 8.1	8.2
8	14.0	1 " 7.1	7.2
9	16.0	1 " 6.3	6.4
10	17.6	1 " 5.7	5.8
11	19.4	1 " 5.1	5.2
12	21.3	1 " 4.7	4.8
13	23.1	1 " 4.3	4.5
14	25.0	1 " 4.0	4.1
15	27.0	1 " 3.7	4.0
16	28.7	1 " 3.5	3.6
17	30.6	1 " 3.3	3.4
18	32.5	1 " 3.1	3.2
19	34.4	1 " 3.0	3.3
20	36.4	1 " 2.8	3.0
21	38.4	1 " 2.6	2.8
22	40.4	1 " 2.5	2.7
23	42.5.	1 " 2.4	2.6
24	44.5	1 " 2.3	2.5
25	46.6	1 " 2.1	2.4
26	48.8	1 " 2.0	2.3
27	51.0	1 " 2.0	2.2
28	53.2	1 " 1.9	2.1
29	55.4	1 " 1.8	2.1
30	57.7	1 " 1.7	2.0
31	60.1	1 " 1.7	2.0
32	62.5	1 " 1.6	1.9
33	65.0	1 " 1.5	1.8
34	67.5	1 " 1.5	1.8
35	70.0	1 " 1.4	1.7
36	72.7	1 " 1.4	1.7
37	75.4	1 " 1.3	1.7
38	78.1	1 " 1.3	1.6
39	80.1	1 " 1.2	1.6
40	84.0	1 " 1.2	1.6
41	87.0	1 " 1.2	1.5
42	90.0	1 " 1.1	1.5
43	93.3	1 " 1.1	1.5
44	96.6	1 " 1.0	1.4
45	100.0	1 " 1.0	1.4

(* these figures are for a one meter vertical interval V.I. therefore
multiply the surface run by the VI eg. 3 m VI on a 70% slope the
distance between vegetative barriers = 3 x 1.7 = 5.1m

WHAT ARE ESSENTIAL OILS?

There seems to be some confusion about the term 'essential oil.' It applies to a volatile substance, an essence or constituent of a perfume, and not to essence, something that exists or is essential to life. Essential oils are also called 'volatile oils.' These volatile, odoriferous substances are widely distributed through the plant kingdom. These oils are distinguished from fatty oils by the fact that they evaporate or volatilize on contact with air. They occur in some 60 plant families. They are typical liquids, and have a pleasant taste and strong odor. Almost any organ of the plant may the the source of the oil: flowers (rose), fruits (orange), leaves (eucalyptus), bark (cinnamon), root (vetiver), wood (sandal), or seeds (cardamom). The amount of oil ranges from a minute trace to as much as one or two percent, or even more.

The utility of essential oils to the plant itself is obscure. They appear largely to be by-products of carbohydrate and fat metabolism. They occur as a rule in small concentrations in special cells, glands or ducts, either in one particular organ of the plant or distributed over many parts. The common essential oils are:

Turpentine, Eucalyptus, Lemon-grass, Cinnamon, Sandalwood, Ginger-grass*, Palmarosa, Citronella**, Vetiver, Peppermint, Ginger, Geranium, Clove, Camphor, Cedarwood, Keora*** (*Ginger-grass oil is Cymbopogon martini; **Citronella comes from Cymbopogon nardus; and ***Keora oil from Pandanus tectorius)

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 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 follow-

*Asia Technical Department Agriculture Division

ing 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 technol-

ogy 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 * * * * * * *

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 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 suffiçient 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

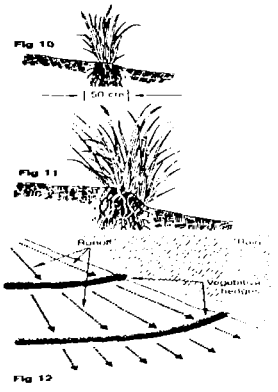


Illustration from Vetiver Handbook showing how the grass functions to trap silt and spread runoff

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.

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.

the plant is unknown, check either with the Vetiver Information Network, the Royal Botanical Gardens at Kew in London, or with a World Bank agricultural staff member to

locate material.

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

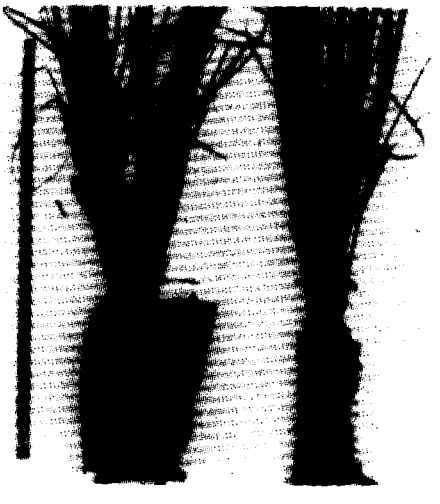
NURSERY MANAGEMENT

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 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 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.

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



- 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

Tillers should be pruned before transport to the field and outplanting

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

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

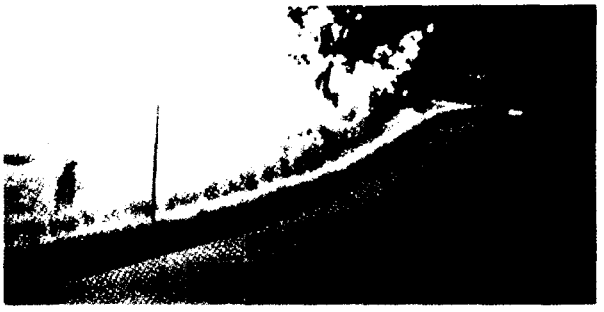
out on vetiver grass (Dr. A.P. Raju, Andhra Pradesh Ag. Univ.) showed no difference in growth response between fertilized (40 kg/ha N and 40 kg/ha P) and unfertilized vetiver in one plot (at 70 days) and no response until about week 8 in a second plot. Vetiver has also been reported by the same source 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

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 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



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

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 that you wish to wait for hedge establishment. In the long term, if the 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. 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 160O 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 de-

crease 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

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 regression 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 :

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

where, X = soil loss or runoff from the vetiver treatment plots, Yi = 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 r2 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% decreas** 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 "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 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, 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 results 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 out-planting. 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 surfacerunoff 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 Table1, 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 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 :

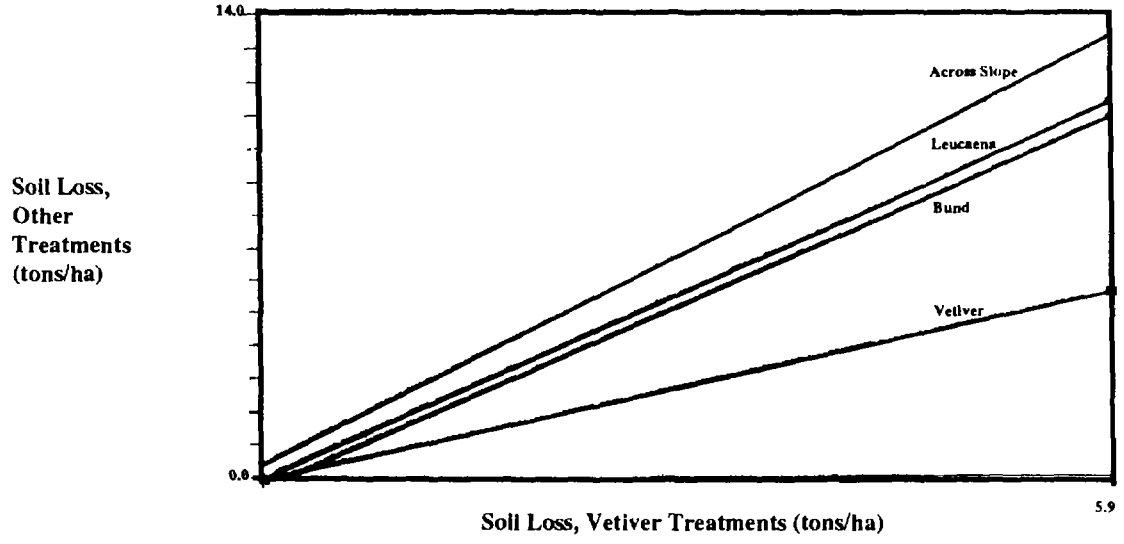
- **Drs. S. Subramanian and S. Senthhil**, Tamil Nadu Agricultural University, monitored soil moisture over 18 weeks on similar plots with and without vetiver hedging on a Vertisol with 1.2% slopes in Coimbatore, India. Over the 18 weeks, which began on October 27, 1988, the vetiver plot had an average 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**, in Akola, 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



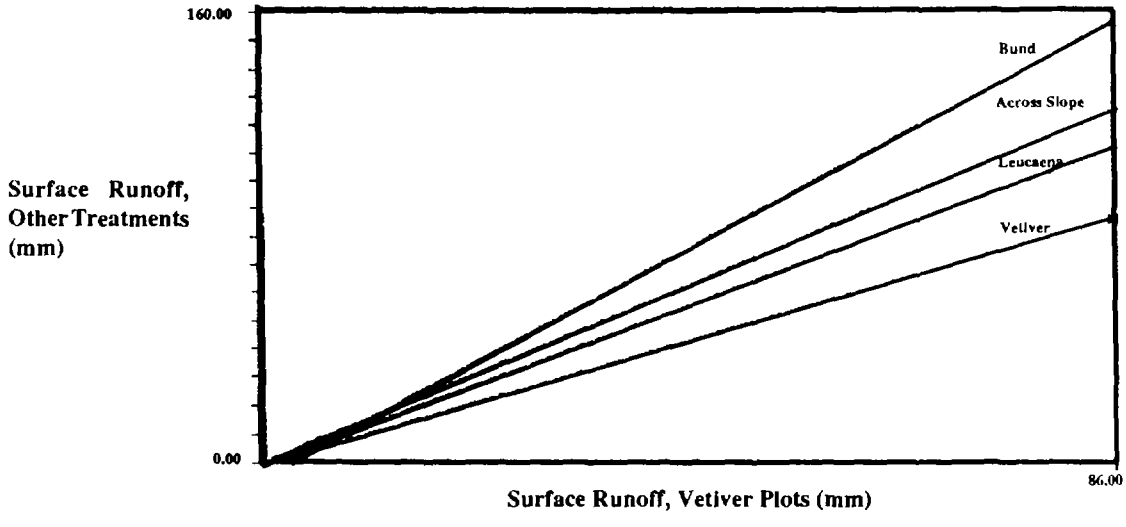


Figure 1. The Effects of Contour Planted Vetiver on Soil Losses Versus Other Treatments (top)
Figure 2. Effects of Contour Planted Vetiver on Runoff Versus Other Treatments (bottom)

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.*****

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

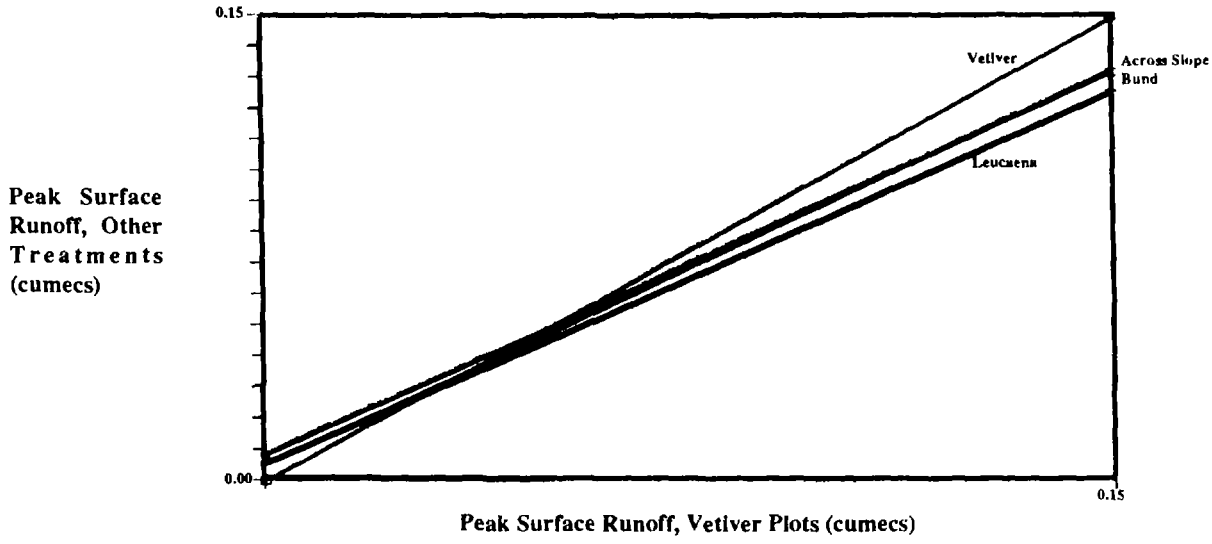


Figure 3. Effects of Contour Planted Vetiver on Peak Surface Runoff Versus Other Treatments

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.********

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 in this newsletter.**********

ACKNOWLEDGEMENTS

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

- Figures1,2 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 Management 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 ignore 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.

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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 $2000 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 $3000, US $2000, US $1000 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 over-grazing;

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 propogation (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 characteristics 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.

VETIVER NEWSLETTER

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

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Letter From Dick Grimshaw

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

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

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

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

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

— Dick Grimshaw

The Newsletter

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

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

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

*Asia Technical Department Agriculture Division

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

Vetiver Grass Seminars and Training

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

Vetiver Awards

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

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

If you or your organization wishes to participate, please keep in mind the March 15, 1991 deadline for presentation of your work. At present we are uncertain of the number of people who will competing for these awards. It

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

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

would be helpful if you could send a note notifying us of your intentions with a short description of your work.

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

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

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

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

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

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

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

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

References To Vetiver Grass

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

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

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

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

SECONDARY USES OF VETIVER

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

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

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

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

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

Some points of interest from the paper where :

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

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

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

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

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

How Far Apart Should Hedges Be Planted?

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

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

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

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

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

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

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

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

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

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

FODDER VALUE OF VETIVER GRASS

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

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

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

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

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

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

RESEARCH UPDATE

More data has been received from Drs. G.M. Bharad (Professor of Agronomy and Director of Research, PKV University, Akola, Maharashtra, India) and A.M. Krishnappa (Operational Research Project, Kabbalnala Watershed Project). Since 1987 a number of research station and farmer's field trials have been carried out to compare the impacts of vetiver hedgerows on surface runoff, soil losses and crop yields. In total the information given below represent 27 plot years of data from two areas (Akola and Kabbalnala) and two soil groups (Vertisols and Alfisols). The data is as yet preliminary, and is not statistically significant. Table

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

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

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

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

IV provides a summary of all the available research data on surface runoff, soil losses and crop yields from India between the years of 1987 - 1990.

Surface Runoff

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

Sediment Yields

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

Crop Yields

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

Crop Competition Effects

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

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

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

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

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

Letters From Correspondents

India

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

China

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

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

Philippines

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

Sri Lanka

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

Malaysia

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

Japan

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

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

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

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

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

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

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

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

Vetiver Bibliography - A listing of some of the literature

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VETIVER NEWSLETTER

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

TABLE OF CONTENTS

THE NEWSLETTER

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

VETIVER AWARDS

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

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

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

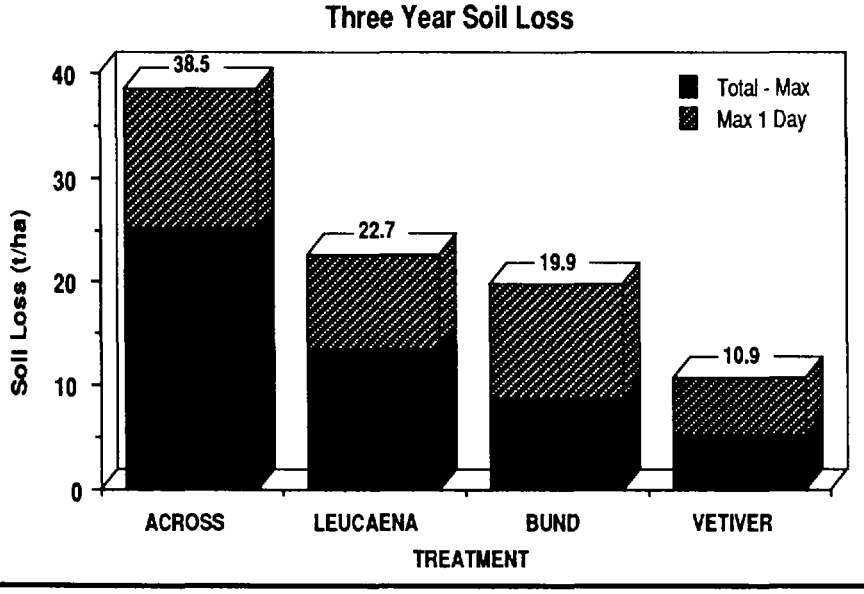


Figure 1. Three year total soil loss from runoff plots in Akola, India. Treatments are Across slope cultivation, contour hedges of Leucaena, graded earthen bund (0.2% slope) and contour hedges of Vetiver grass. Numbers on top are total soil loss (t/ha), lighter areas represent the maximum one day soil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

*ASIA TECHNICAL DEPARTMENT AGRICULTURE DIVISION

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

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

Dr. Yoon's report provides information on:

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

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

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

Diseases

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

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

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

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

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

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

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

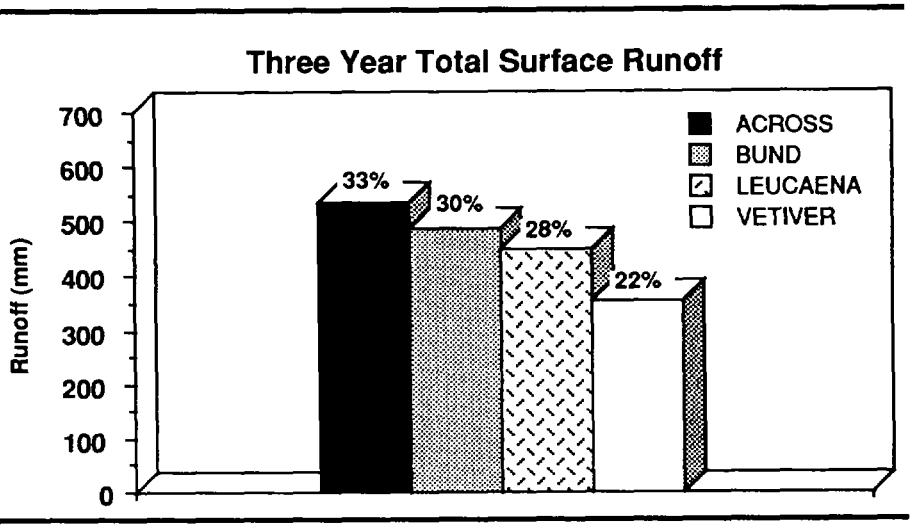


Figure 2. Three year total surface runoff from runoff plots in Akola, India. Percentages on top express total runoff as a percentage of rainfall occurring in those storm events which resulted in surface runoff. The difference between the Vetiver and the Across slope cultivated plots amounts to almost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

Update On Vetiver Research In Akola, India - Synopsis of three years data

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

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

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

Figure 2 shows the total amount of surface runoff from all treatments. comment made above regarding performance of conservation treatments during the extreme events. This figure represents the data from the top 10% largest storms over the three years. These storms also represent the events which resulted in the greatest volumes of surface runoff. The figure shows soil losses and surface runoff from the leucaena, bunded and vetiver plots as a percentage of losses from the across-slope "control" plot; the absolute amounts of soil loss and surface runoff for each treatment are given on top of the histograms. Across all three treatments, it was in this 10 percentile of storm events that one-half to two-thirds of the three year total soil loss occurred and about 50% of the total volume of surface runoff.

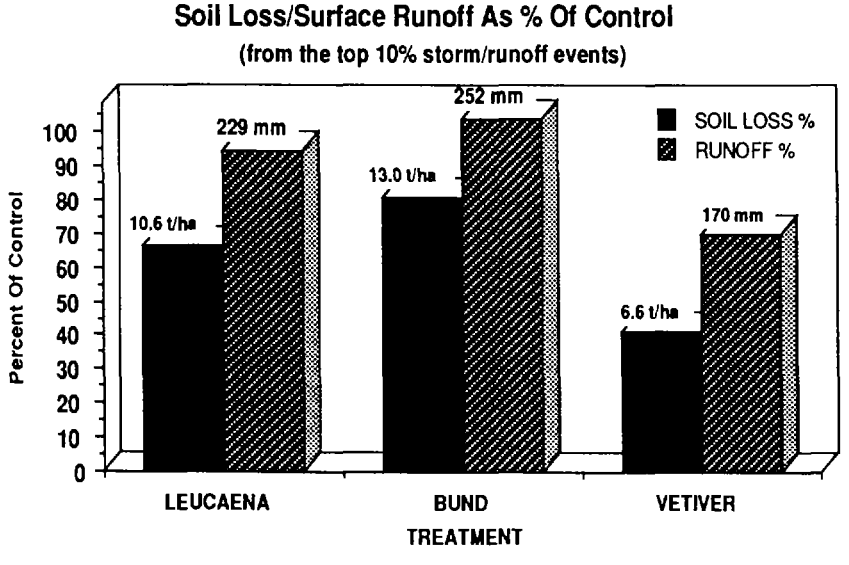


Figure 3. Soilloss and surface runoff from the largest 10 percentile of storm events occurring over the three years of observation on runoff plots in Akola, India. The great majority of soil losses and runoff damages are incurred during the "non-average" storm events; conservation treatments must be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

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

Figure 3 is a followup on the

On-contour Vetiver Grass Hedge For Conserving Soil and Water, and Enhancing Crop Productivity On Sloping Lands

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

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

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

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

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

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

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

[a]Vertical Interval

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

Conclusions

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

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

Vetiver Research In Malaysia - Some preliminary results on soil loss, runoff and yield

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

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

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

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

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

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

production indicated that vetiver grass competed with maize, and yield reduction was about 10% (Table 2)."

CONCLUSIONS

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

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

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

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

HEDGEROW ESTABLISHMENT - PLANT SPACING & DENSITY

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

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

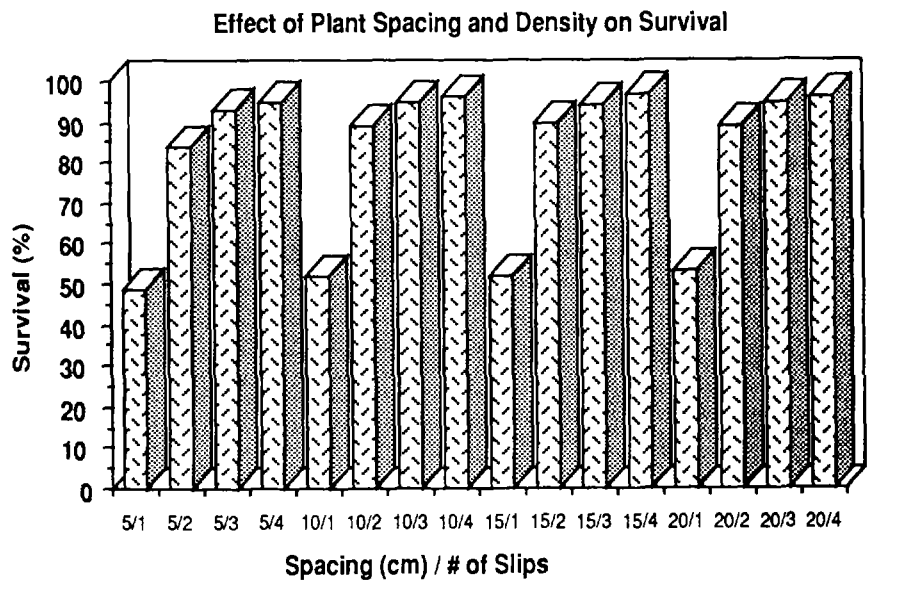
The differences between these recommendations probably results from differences in the planting materials, the soils, the climate and to a lesser extent, the planting techniques. What this shows is that the question of optimal practice for hedgerow establishment in a given location is going to be a location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

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

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

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

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



one wishes to form a hedgerow, the closer together one should plant the slips.

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

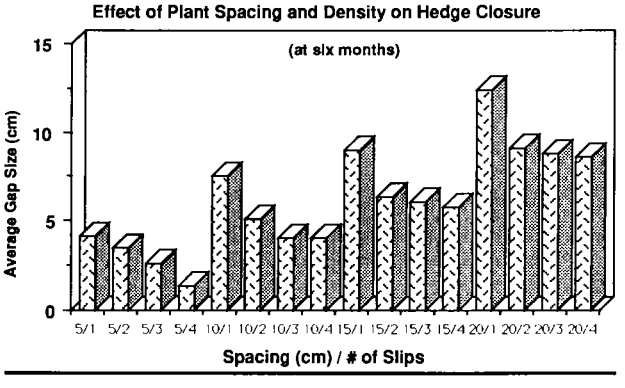
Estimated Rate of Closure. Using Figures 4 & 5, there are four possible approaches : every 5 cm planting 4 slips; every 10 cm planting 3 slips; every 15 cm planting 2 slips; and every 20 cm planting 2 slips. Comparing the 4 planting strategies, we could calculate that hedgerow closure with:

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

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

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

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



Research On Vegetative Hedges at Regional Research Station in Tamil Nadu

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

Stemborers In Vetiver Grass - Chinese Research Results

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

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

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

United States Department Of Agriculture's Soil Conservation Service Workshop On The Use Of Grass Hedges For Erosion Control

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

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

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

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

Notes & Letters From Correspondents

Australia

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

China

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

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

Costa Rica

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

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

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

Hong Kong

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

Kenya

- Mr. V. Gibberd of the Ministry of Agriculture's E.M.I. Soil & Water Conservation Project writes that trial work has begun on vetiver grass in the more arid (<800 mm/yr) zones of Kenya. So far early trial results indicate that the vetiver grass is out-performing the other species in their trials (*Panicum maximum* , *Sehima nervosum*, and the officially recommended *Panicum makarikariense*) — "*It certainly established better and puts on far more impressive vegetative growth*". The trials were started in an attempt to find an alternative for fanyaa juu terracing as its adoption is reported to be constrained by its high labor requirements for construction and maintenance, shortage of tools to construct them, that the preferred season for construction work is the dry season when soils are hard, construction costs are relatively high, loss of land from production, and that the terraces require precision design and checking by competent people to assure that there are no low spots.
Mr. Gibberd also reports that he has found vetiver established on terraces in coffee country in the Machakos District where it was probably planted in the early 1960's, and even earlier than that (date unknown) are splits of vetiver that are thought to have been brought from the United States and used to protect a dam wall on a farm near Thika. He says they "*are still effectively protecting (the) dam wall*".

Lao, PDR

- Mr. J.P.Evenson, Chief Technical Adviser UNDP/DTCD, Nabong Agriculture School Project writes that his school is interested in vetiver for soil conservation in orchards and upland cropping areas. He discovered that the Lao he spoke with were very familiar with its common name (*Faek* or *Faek hom*); vetiver is reported to have medicinal uses in Lao PDR. As part of the school's program for making students aware of the importance and diversity of useful native plants they will launch a search for it in the vicinity of the school. Mr. Evenson also carried out a literature search where he found a reference in Vidal's 1960 publication on "The Vegetation of Laos" where it states that vetiver is :
Found in periodically inundated marshlands which are characterized by having a woody overstory and a perennial herbaceous layer (number of grass species limited to three). Places observed: Houey Kao Canal, near Vientiane.; Nong Bo Canal, north of Vientiane draining to the Mekhong via the Nam Pak Sa; Nong Thevada close to Vientiane and bordering the Mekhong; Nong Na Seng close to Thadeua, east of Vientiane; Than Tha Ngon some 28km to the north of Vientiane; Nam Khem north of Vientiane; Marshes around Pakse;Shallow pools near Paklung close to Louang Prabang.
- Mr. Somphong Pradichit from the Northern Regional Office of Environmental Protection, Ministry of Agriculture and Forestry, Luang Prabang writes that the Vetiver Handbook has been translated into Lao and the script for the Vetiver Slide Show is currently being translated. Also, a vetiver nursery has been established in Xieng Moak where some local varieties of vetiver are being compared with an Indian variety. He reports that the local varieties seem to be doing better at this time.

Philippines

- From Richard Grimshaw, Chief of Asia Technical Department, Agriculture Division, World Bank:

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

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

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

USA

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

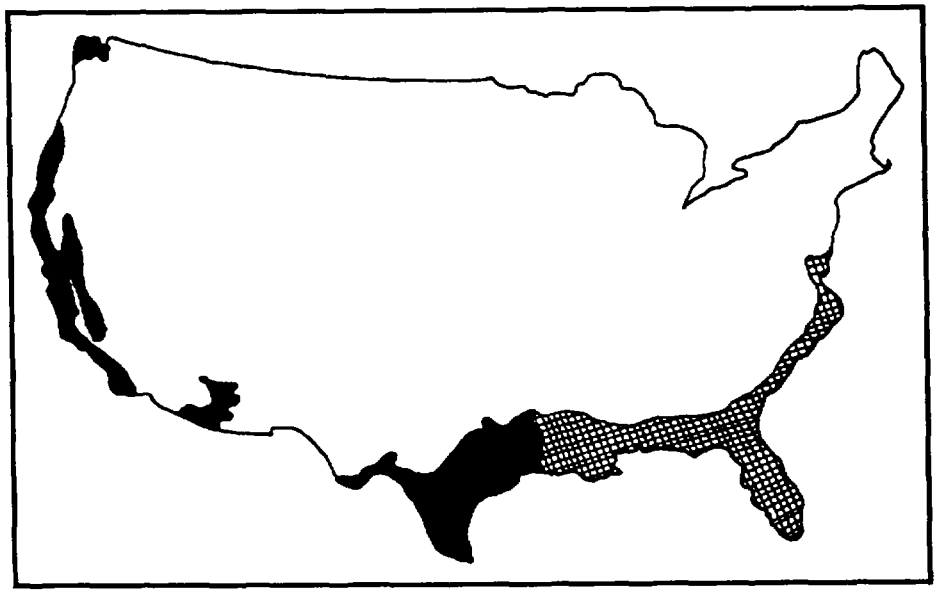


Figure 6. Shaded areas represent those parts of the United States where Vetiver grass may potentially be planted for soil and soil moisture conservation.

Excerpts From the All China Vetiver News Network Newsletters

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

Survival

"At the end of March this year, the Soil and Moisture Conservation Office of Sichuan Province and the Hilly Area Development Office of Chengdu introduced 12 tons of Vetiver slips from the Jingyang Prefecture of Fujian Province. These slips have been planted experimentally.... Since June, some of the experimental locations have sent us growth condition reports and observation records. According to the Pingshan SM Office: Vetiver was planted on March 29, established itself in 25 days,

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

Growth

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

Vetiver For Soil And Moisture Conservation

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

An Insect Pest On Vetiver

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

Potential Availability Of Funds For NGO Trial/Demonstration Work With Vetiver Grass

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

This next year, there is a good possibility that the Vetiver Network/ASTAG will have another grant with which it will be able to repeat the funding of another four or five NGOs in each of four or five countries. We would be interested to hear from any NGO groups who are currently involved with agriculture/natural resource management cooperatively with small farmers and who

Photo 3. Vetiver grass thatching in South Africa

Photo Courtesy of Mr. Anthony Tantum

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

Where Vetiver Grass Is Not.... Known to Be

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

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

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

Institutions Currently Carrying Out Research On Vetiver Grass For Soil/Soil Moisture Conservation

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

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

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

Fiji
University of the South Pacific, Suva

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

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

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

Nepal
Central Animal Nutrition Division, Khumaltar

Nigeria
IITA, Ibadan, Nigeria

Papua New Guinea
Lowlands Agricultural Experimentation Station

Philippines
IRRI, Los Baños

South Africa
King Williamstown College

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

Non-Governmental Organizations Involvement With World Bank

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

Operational Summary" to NGOs that request it. For further information or to order these items contact :

Mr. Chris Hennin or Mr. Art Thomas EXTIE/World Bank NGO Information Service; Room T8102, 1818 H St., NW; Washington, D.C. USA 20433.

The Vetiver Information Network

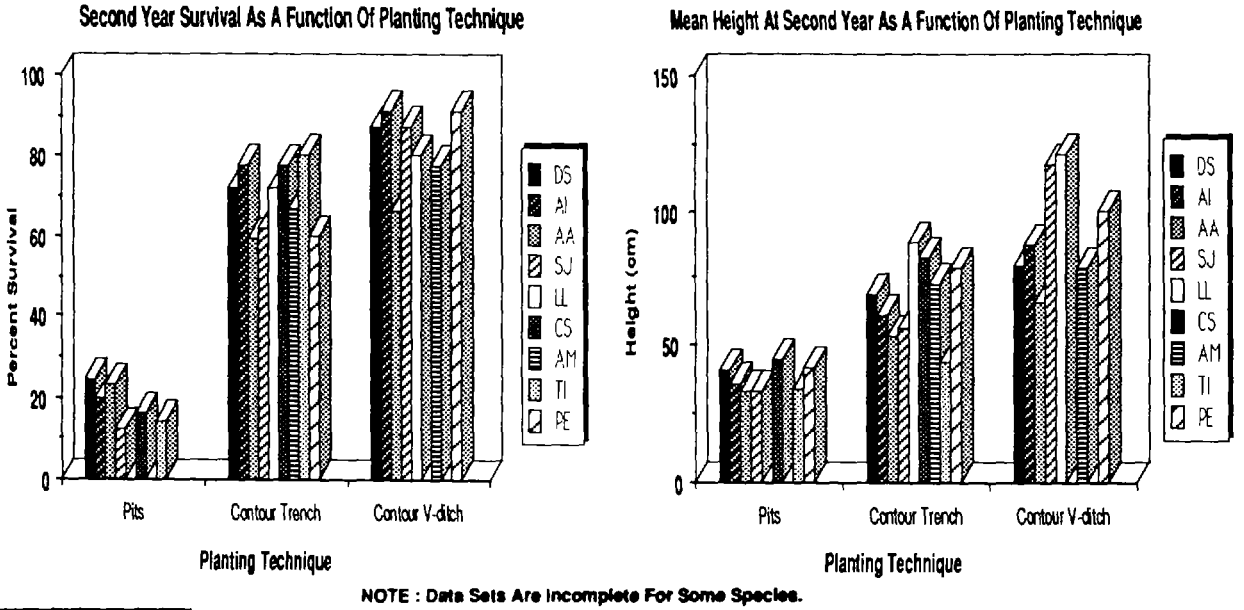
The purpose of the Network is to provide a central point where information on the use of contour vegetative barriers of Vetiver grass may be compiled and disseminated to all interested individuals free of charge. If you wish to join the Network, request further information or supply information to other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

Vetiver Information Network; c/o Mr. J. Smyle, ASTAG; Rm. F 3027; 1818 H St. NW, Washington, D.C., 20433; USA; Tel. (202) 458-2274; Fax (202) 477-1865

Alternative Technologies

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

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

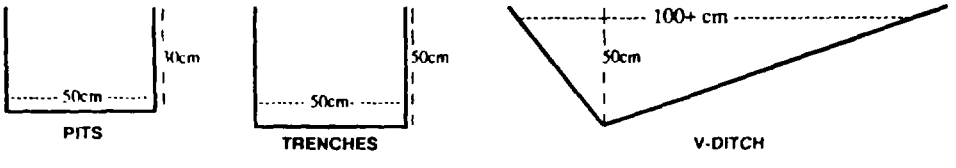


NOTE : Data Sets Are Incomplete For Some Species.

LEGEND

DS = Dalbergia sissoo
AI = Azadirachta indica
AA = Acacia auriculiformis
SJ = Syzgium jambolana
LL = Leucaena leucocephala
CS = Cassia siamea
AM = Aegle marmelos
TI = Tamarindus indica
PE = Phyllanthus emblica

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



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

SPECIAL ISSUE

VETIVER NEWSLETTER

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

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

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THE NEWSLETTER

Vetiver Awards

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

Reader Participation

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

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

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

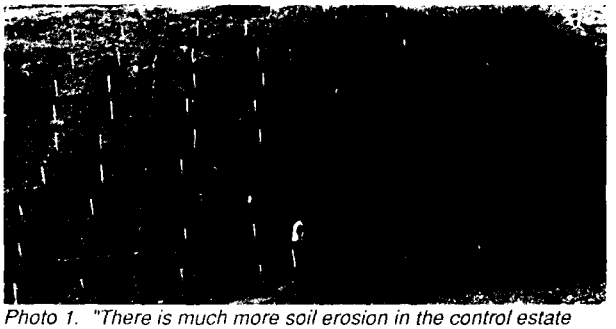


Photo 1. "There is much more soil erosion in the control estate plot." One of Dr. P.K. Yoon's vetiver trials in Malaysia.

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

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

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

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

Dick Grimshaw

The Vetiver Awards

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

The Awardees, selected by the panel, are :

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

Second Place (US$ 2000) - **Dr. G.M. Bharad** from PKV University in Akola, Maharashtra, India for the consistently excellent research work he has carried out over the last four years on measuring the on-farm impacts of contour vegetative barriers of vetiver grass and leucaena, of graded earthen bunds and of farming with no conservation measures. Dr. Bharad was one of the people who early on grasped the importance of vetiver grass and the opportunities it opened up in conservation farming;

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

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

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

The Network would like to

thank all of those who took the initiative to participate in the Vetiver Awards and to congratulate those whose work was singled out by the panel for awards. For those whose work was not awarded, a special thanks is in order and please be assured that the Network values the information that you provided and intends to disseminate it widely.

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

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

1989 was the time to get to know the plant and to multiply it for distribution. 1990 was the main period for distribution, start some ad hoc trials and set the stage for 'proper' trials in co-operating estates. This report summarizes mainly efforts of 1989 and 1990 . 1991 should see better progress.

Whereas, Vetiver is promoted by the World Bank as a low-cost hedgerow system for controlling soil-loss and improving soil moisture, this may be true only for the poorer developing countries. Malaysia is well developed agriculturally and money is readily available for any cost-effective technologies. My research targets assess the potential values of Vetiver from both ends of the economic spectrum and, therefore, the early results and discussions presented could be easily adapted to suit different input requirements.

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

A. Multiplication Of Vetiver

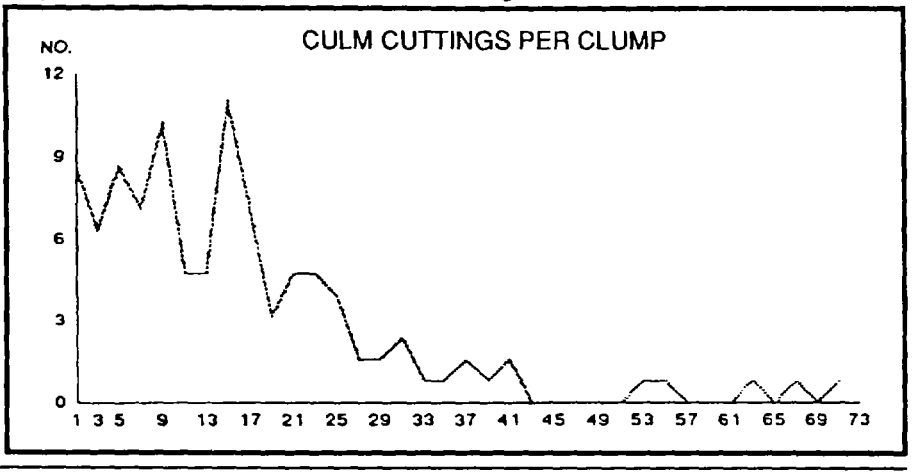
I. Multiplication using tillers

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

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

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

Figure 1. The number of culm cuttings obtained from vetiver



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

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

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

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

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

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

II. Multiplication by culm-branches

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

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

Dr. P.K.Yoon

III. Multiplication by culm-cuttings

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

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

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

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

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

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

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

Conclusion

Vetiver is easy to multiply at low cost. Under normal conditions, multiplication by planting with tillers will give satisfactory results. However, refined methods of vegetative propagation by culm branches and culm cuttings may be considered from 2 view points: (1) They will be of little value in mass vegetative propa-

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

B. Growth Of Vetiver

I. Effect of shade on growth of vetiver

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

(i) Trial 1

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

Results

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

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

(ii). Trial 2

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

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

(iii). Trial 3

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

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

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

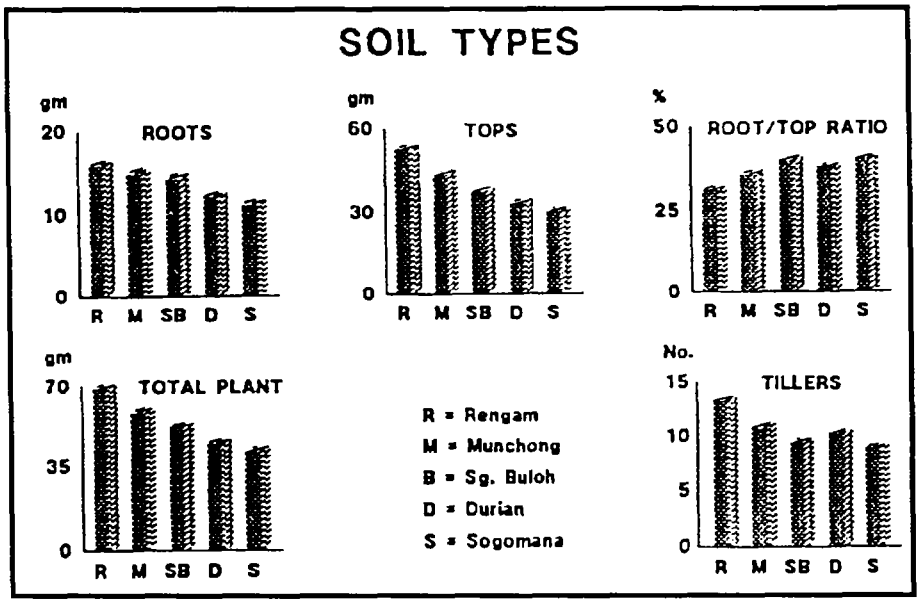


Figure 2. Effect of soil types on the growth of vetiver.

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

Conclusion

The following points should be noted:

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

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

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

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

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

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

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

II. Effect of soil types on growth of vetiver

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

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

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

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

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

III. Effect of bag sizes on growth of vetiver hedgerows

While it would be cheapest to plant Vetiver slips directly, such

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

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

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

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

IV. Effect of fertilizer on growth of vetiver

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

(i) Trial 1

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

: (i) Fertilizer aids in dry matter production and tiller production; (ii) even without fertilizer application, the plants grow and multiply; (iii) increasing fertilizer application rates did not increase growth and multiplication rates significantly, suggesting that the cheapest application rate of one Kokei nugget is sufficient.

(ii) Trial 2

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

Conclusion

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

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

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

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

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

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

(i) Different tiller types

Preliminary observations have suggested that each clump of Vetiver produces different types of tillers; thus their growth and tiller formation would be quite different. This would lead to high variations in response of experimental treatments where assessment is by tiller formation and dry matter production. This could be one of the causes of non-significant effect of fertilizer, soil types, etc. previously reported. The experimental error may be higher than the treatment effect. To overcome this, the tiller types must be sorted out and the within-population studied before planning any experiment. The starting material must be the same tiller type and fine-tuned to minimize experimental errors. The 4 major types are :

Type A - the most mature

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

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

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

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

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

(ii) Different culm-branches

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

D. Effect Of Vetiver On Soil Erosion

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

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

II. Growth of vetiver and its effect on filled earth

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

(i) Trial 1

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

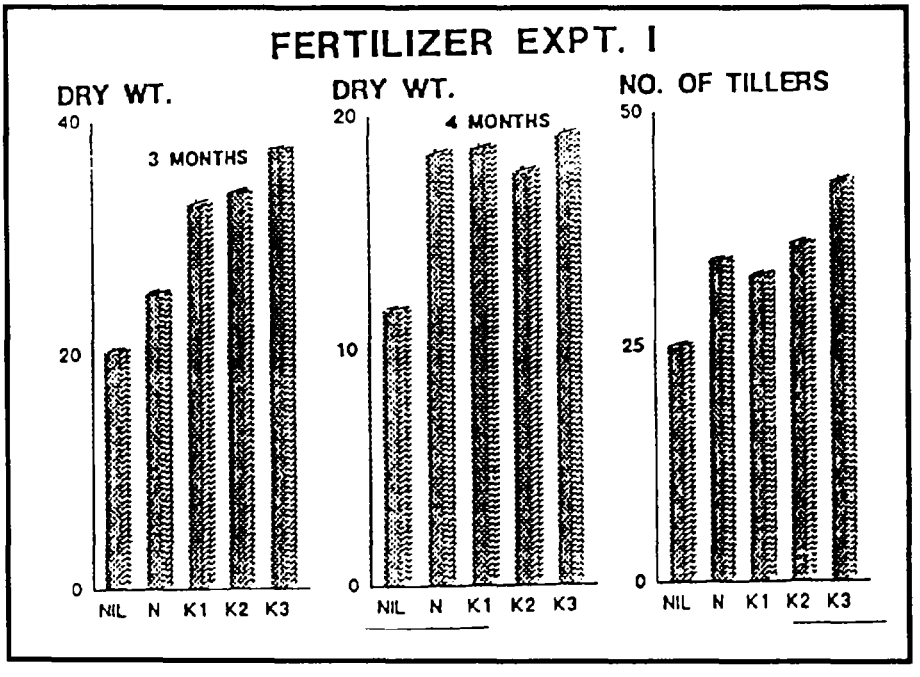


Figure 3. Effect of fertilizer on multiplication and growth of vetiver.

(ii)Trial 2

This trial was on bunds where filled earth had been in place for about a month prior to

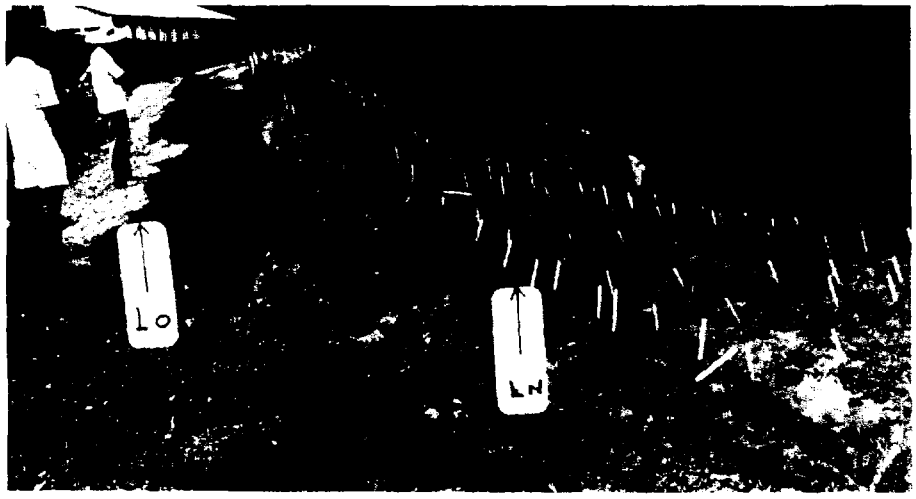


Photo 2. The subsoil has collapsed. The Vetiver plots had slipped 4 to 5 meters from the original level (L_O) to the new lower level (L_N).

the filled earth bunds being planted with vetiver immediately upon construction.

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

Conclusion

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

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

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

E. Diseases

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

Results

In the period under observation, fungal attack was observed and identified as: *Nigrospora spp., Curvularia spp., Helminthosporium spp.* With the help of a mycologist, we isolated the inocula involved. We then tried to inoculate new emergent leaves. Our

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

Conclusion

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

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

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

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

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

Photo 3. General view of the experimental sites

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

F. Adaptive Use Of Vetiver By End-Users

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

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

I. Production of planting materials.

Based on early experience gained, 2 methods were used: (1) Polybag nursery producing about 30,000 bags of 6" x 9" polybag plants under a Sumisansui irrigation (drip-type) system and fertilizer applied at 1 Kokei (6 gm) per bag. The polybag plants were ready for use in 2-3 months. (2) Ground nursery. Raised beds were prepared mechanically; each bed was 3 $^{1}/_{2}$ feet x 50 meters with 3 feet spacing in-between. Planting distance of the tillers were 6" x 6" with each bed producing 1800 clumps. At the initial phase, 6 beds were planted to produce 10,800 clumps. With the Sumisansui irrigation system and liberal use of dried chicken dung, the plants were ready for use in the field after 2 months. However, for multiplication, the

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

plants were left to grow longer. It was estimated that these beds produced more than 150,000 tillers after the first 3 months. Currently (October 1990), the estate has 12 such beds.

II. Ponding

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

III. Erosion control in irrigation piping

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

IV. To protect terracing

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

V. Erosion control and moisture conservation.

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

G. Ad Hoc Notes

I. Labor

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

II. Weather conditions

The high intensity rainfall in Malaysia dictates that the hedgerows must be established fast in order to be effective. For highway construction, the contract of establishment of cover on embankment to control erosion runs into $100 millions and therefore cost of establishment is not prohibitive. What is expensive is

the following "repair" work, if there were any failure. Therefore, the main target is to establish the good uniformed hedgerows fast. The same also applies to land fills in ponding, irrigation canals, housing estates, etc.

III. Fodder production

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

IV. Vetiver as a mulch

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

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

Dr. P.K. Yoon

V. Tolerance to contact weedicide spray drift

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

VI. Effect of vetiver on growth of Hevea

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

VII. Competition with other weeds

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

H. Trials Being Initiated

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

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

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

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

I. The future of vetiver in Malaysia

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

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

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

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

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

Materials and Methods

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

Results and Discussion

1. Productivity

1.1 Shallow Soils (Model Watershed,University farm)

Mean productivity of crops viz.green gram + Pigeon Pea-Saffower (1987-88), Pearlmillet-Safflower (1988-89) and pearlmillet (1989-90) grown on shallow soils was seen to be favorably influenced by contour cultivation. The average productivity recorded by contour cultivation was highest for contour cultivation along vetiver, followed by leucaena and across the slope (Table 4)

1.2 Medium Deep Soils (Model Watershed, University farm)

Productivity of sorghum hybrid CS11-9 (1988-89) with contour cultivation along vetiver key line was highest. Grain yield

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

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

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

1.3 Very Shallow Soils (Manoli Project Area)

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

2. Surface Runoff

2.1 Shallow Soils (Model Watershed, University Farm)

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

2.2 Medium Deep Soils (Model watershed University farm)

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

2.3 Very Shallow Soils (Manoli Project Area)

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

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

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

3. Soil Loss

3.1 Shallow Soil (Model Watershed, University Farm)

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

3.2 Medium Deep Soil (Model Watershed,University Farm)

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

Conclusions

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

The graded bund system was found to enhance runoff and soil loss and in high rainfall situations the productivity was lower than even the across the slope sowing plots. The vetiver barriers functioned both in low and high rainfall situations and did not effect the crop in any way. In view of the above results, it could be inferred that the contour cultivation along vetiver key lines for raising crops is necessary to

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

T_1 = Across Slope Cultivation ; T_2 = Contour Cultivation Along Leucaena ; T_3 = Contour Cultivation Along Vetiver

** Figures in parenthesis indicate percent surface runoff

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

improve productivity and *in situ* conservation of soil and moisture in rainfed farming.

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

Introduction

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

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

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

- To determine the salt tolerance of Vetiver grass in comparison with some well known pasture grasses.
- To determine the effects of shallow saline groundwater on Vetiver growth.
- To determine the soil salinity level and plant chloride con-

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

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

T_1 = Across Slope Cultivation ; T_2 = Contour Cultivation Along Leucaena ; T_3 = Contour Cultivation Along Vetiver ; T_4 = Cultivation Along Graded Bund

· Data from July & August 1989 only

** Figures in parenthesis indicate percent surface runoff

*** Not comparable with other figures, as data set not complete

tent of Vetiver grass at which toxic symptoms appear and to describe these symptoms.

Experimental Design

An integrated series of pot, column and field experiments were carried out to achieve the objectives mentioned above. Three pot experiments were conducted. Experiment 1 compared the salt tolerance of Vetiver with *Chloris gayana* (c.v. Pioneer) (Pioneer Rhodes grass) and *Paspalum dilatatium* (Paspalum). Rhodes was the most salt tolerant and Paspalum the second most sensitive species among the ten tropical grasses evaluated by Russell (1976). Experiment 2 investigated the effects of osmotic stress, caused by high soil salinity level, on mature plants of the three grasses. Experiment 3 determined the soil salinity level at which yield was reduced by 50%. The column experiment was set up to determine the effect of shallow saline watertable on Vetiver and Paspalum. A field trial was also established to correlate the results of pot and column experiments to field conditions.

Methods

I. Soil salinity levels of the pot experiments

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

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

All EC in $mScm^{-1}$

Cl^- in mg/L

Na^+ (exchangeable) in mequiv/100g

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

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

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

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

II. Column Experiment

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

III. Field experiment

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

IV. Harvest

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

Materials

I. Soils

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

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

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

* Mean values for 0-12 cm depth

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

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

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

with 25% clay in the top 10cm and 50% at 30cm depth.

II. Saline water

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

III. Planting materials

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

IV. Containers

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

V. Fertilizers

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

Results And Discussion

I. Soil Salinity Levels

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

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

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

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

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

In the pot experiments a wide range of soil EC_{se} was obtained by watering the pots with the treatment solution as described in Section 3.1. The EC_{se} recorded for experiment 1 ranged from 0.96 to 42.89 $mScm^{-1}$, for experiment 2 from 23.88 to 73.44 $mScm^{-1}$ and for experiment 3 from 3.39 to 20.92 $mScm^{-1}$. The values for the column experiment were from 2.63 to 52.26 $mScm^{-1}$. These

values cover a wide range of soil salinity levels, ranging from non toxic to highly toxic concentrations.

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

II. Salt tolerance of Vetiver grass

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

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

III. Effects of shallow saline groundwater

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

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

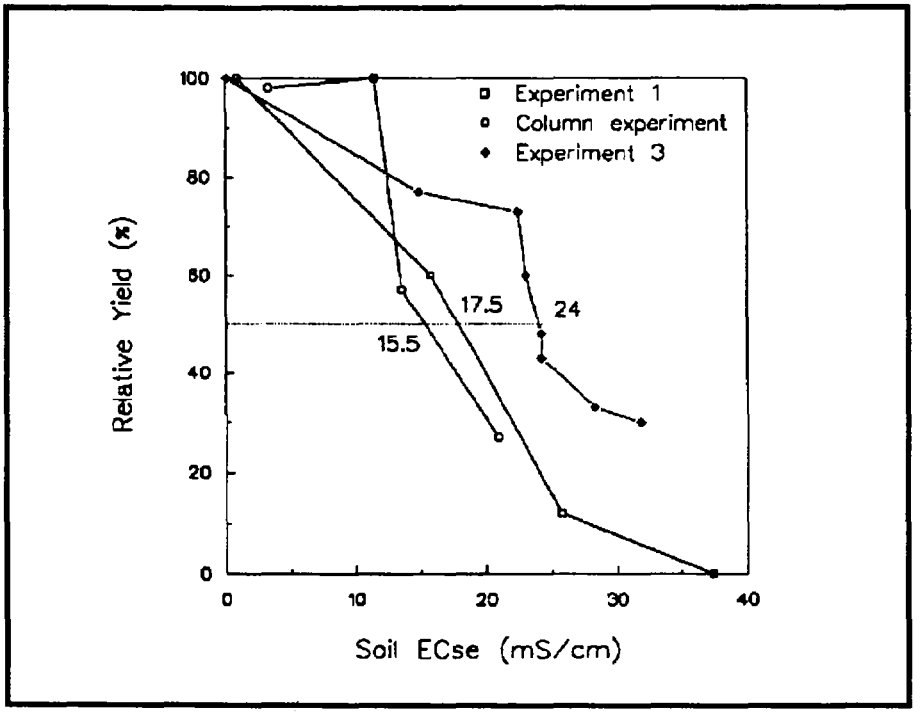


Figure 4. Soil ECse values for a 50% Vetiver yield reduction in pot and column experiments.

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

IV. Effects of saline water on mature Vetiver

In experiment 2, well established plants, which had been grown under non-saline condi-

tions for five weeks, were watered with saline solutions to examine the adaption of mature plants to saline water.

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

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

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

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

VI. Recovery after rain

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

VII. Soil salinity level for 50% yield reduction

Dry matter yield of Vetiver grass from experiment 3 is much higher than that from experiment 1 over the six week period. This higher yield can be attributed largely to warmer growing conditions and better planting materials used in this experiment. While the temperature ranged between 12°C and 28°C (spring) for experiment 1, the range was be-

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

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

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

* Mean values for 0-50 cm depth

** Relative yield expressed as percentage of highest yield

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

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

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

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

tween 22°C and 38°C (summer) for experiment 3. Faster growth and higher temperatures required more water, and led to higher soil salinity levels. As a consequence, for a 50% reduction in growth, soil EC_{se} needs to be at approximately 24 $mScm^{-1}$ (Figure 4).

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

VIII. Plant Chloride concentration

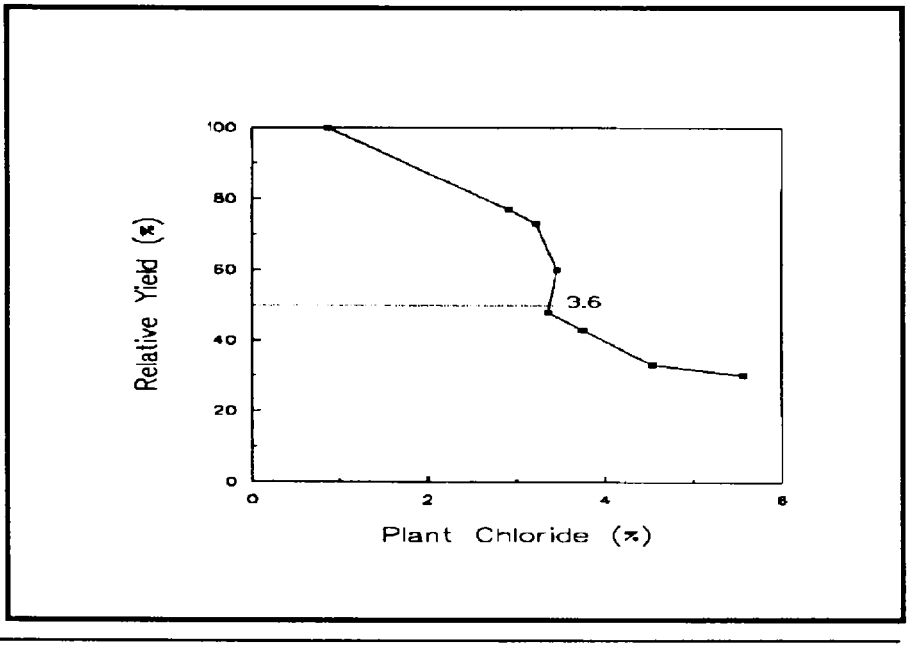
In general, the chloride concentration of Vetiver leaves increases as the soil salinity level increases. Figure 5 shows that a leaf chloride concentration of approximately 3.6%, is associated with a yield reduction of 50%. However this chloride concentration cannot be considered as the critical level,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

IX. Symptoms of saline toxicity

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

Under field conditions, older leaves first turned light purple in color and dried up from the tip. In more severe cases the whole shoot became chlorotic and dried up. The chlorotic leaves in the field were not as bleached as those in the glasshouse.

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



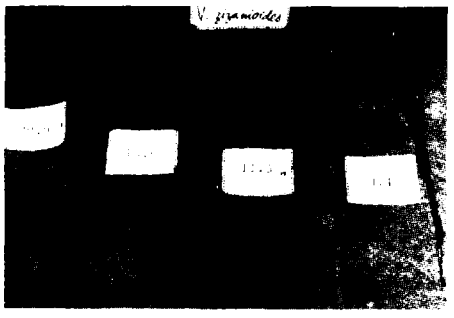


Photo 5. Root distribution pattern of Vetiver grass at varying salt concentrations

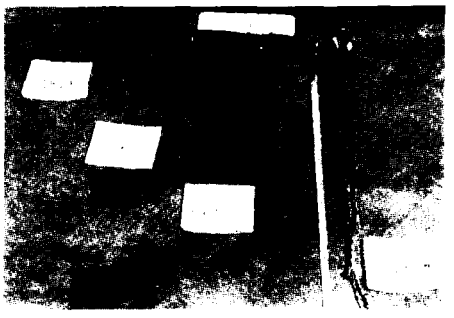


Photo 6. Root distribution pattern of Paspalum at varying salt concentrations

Conclusion

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

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

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

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

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

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

n.i. not implemented

n.s. non significant at 5% level

* Dry matter yield g/pot

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

Treatment	Depth of Roots (cm)	Width of Roots (cm)	Roots in 6.25m² profile	Number of roots at depths 0-20cm	20-40cm	40-60cm
Oil Seed Cake	55	42	165	120	30	15
Lime	35	35	41	32	9	0
CaMg Phosphate	40	40	55	28	27	0
Pig Manure	46	36	78	45	28	5
Control	50	35	50	20	20	10

Table 13. Root development under different manure treatments.

Utilizing Local Vetiver Grass

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

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

I. Local vetiver grass growth

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

Nursery Establishment

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

Research

I. Effects of different base fertilizers

A 5x3 fertilizer trial (12 plants/replicate) was carried out to compare applications of oil seed cake (10 g/plant), lime (42 g/plant), calcium magnesium phosphate (17 g/plant), pig manure (42 g/plant), and no fertilizer; though quantities differ, costs for each treatment is the same. The trial was carried out in a red soil (*ed. note* : red soils = Udults; acidic; high Al saturation). Table 13 shows the results on the plant root growth. Oil seed cake promoted the best root growth followed by pig manure. Table 14 shows that oil seed cake and pig manure's effects were about the same in aboveground biomass production. Oil seed cake manure than is the most effective for establishing vetiver grass in the marginal red soils, followed by pig manure. The effectiveness of lime and calcium magnesium phosphate was not very outstanding; though height and tillering under

these treatments was better than in the control, the plants were slender and aboveground biomass reduced. This may have been a function of treatment-related change in pH and a decrease in available nitrogen.

II. Vetiver growth on barren lands

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

III. Cold tolerance of vetiver

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

IV. Effect of varied planting densities

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

V. Experiment of combining different hedge plants

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

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

Table 14. Treatment effects on aboveground biomass

VI. Experiment of different planting places

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

VII. Experiment with vetiver as a contour vegetative barrier

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

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

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

IX. Stemborers

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

Benefits Of Vetiver Planting

I. Preventing walls and ridges of terraces from collapsing

The cost of protecting terraces with stone walls is Yuan 22,500/ha whereas protecting with vetiver costs only Yuan 1,900.

Also, according to multi-site experimental data the soil and water losses in some tea farms is serious and the terrace walls collapse easily without protection with vetiver. Terracing alone reduces soil losses on the average of 63%; terraces with vetiver plantings reduce soil losses 87%.

II. Preventing drought, decreasing temperature and storing water

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

Excerpts From The All-China Vetiver Newsletter; No. 6 February 1991.

Vetiver Grass News from Jiangxi Province

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

V-grass do not produce seeds, it can only be reproduced by vegetative propagation. In India, where V-grass is very popular it is propagated mainly by splitting young shoots from the plants. On the average, such method reproduces 12 young shoots per year. This rate of reproduction is very slow, and it requires digging into the original clumps. In order to promote reproduction, and not to dig into the V-grass clumps, we tried planting from culms. Basically, we have succeed. In August 10, 1990, we did an experiment. The experiment contained 4 sets, 3 applied different treatments, and 1 acted as a control without applying external treatments. 30 culms were planted in every set of the experiment. In about 7-10 days, new buds appeared on the branches, in 10-15 days, new roots begin to emerge. By September, the number of young shoots to appear in each set of the experiment are as follows: Set A: 23 tillers, 77% success; Set B: 20 tillers, 67% success; Set C: 2 tillers, 7% success; Set D (control) : 1 tiller, 3% success. It is seen that without any external treatment, the success rate is very low. Sets A & B have a high percentage; planting culms has a practical value. On August 24, we tried the experiment for a second time, we repeated the experiment with Sets A & B and we obtained results which were close to the first one. Set A: planted 30 culms with 22 successfully establishing and Set B: planted 30, culms with 19 successfully establishing. Overall, planting of culms to reproduce V-grass is successful. This requires no digging, it makes use of the

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

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

Table 16. Site effects on vetiver grass

Location	Year Planted	Org. Matter (%)	Avail. N (ppm)	Avail. P (ppm)	Avail. K (ppm)	# of Tillers	Sum of Leaf Length (cm)	Root[1] Area (cm^2)	Weight (kg)	Weight (kg)
1	90	0.60	23.8	1.8	0.30	3.5	122	110 x 10	0.17	0.09
2	90	1.19	32.2	2.5	0.36	6	360	20 x 20	0.17	0.09
3	90	1.37	32.7	3.0	0.65	8	880	50 x 30	0.58	0.33
4	90	1.48	42.9	2.3	0.30	12	1080	50 x 35	1.28	0.68
5	89	1.60	48.1	2.6	0.26	18	1620	50 x 40	1.43	0.83
6	89	1.99	57.4	2.7	0.36	41	6150	100 x 58	5.8	3.34

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

cut-offs of the V-grass shoots to grow the plant. This method of reproduction is very fast. This experiment was carried out during a dry and hot season which affects budding and growth of V-grass. If the experiment were carried out in a warm and humid spring weather, it is expected that V-grass would have a higher growth rate.

Vetiver Grass News from Hunan Province

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

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

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

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

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

Vetiver Grass News from Sichuan Province

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

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

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

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

Excerpts From *A Preliminary Study On Vetiver (Vetiveria zizanioides) For Utilization In The Fight Against Erosion* By Dr. Françoise Dinger

Propagation Of Vetiver

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

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

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

CEMAGREF Tests

I. Cold tolerance

The vetiver plants were placed in containers filled with a potting mixture ($^1/_2$ sand and $1/_2$ compost) on 20 July and grown until 10 October, providing material for testing. The first trials were to determine vetiver's cold tolerance, trials were carried out concurrently in Draix (Haute-Provence Alps) and in Grenoble (Isère).

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

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

Research work was also carried out in the center at Ecully on both the Indian (LV and SV) and New Caledonian vetiver. The objective was to look at vegetative multiplication in consideration of light and temperature. Plants were placed in pots at four different dates and grown for ten weeks. Fertilization was every 15 days. Pots were placed outside to test cold tolerance and within a greenhouse where they were exposed to natural light conditions and extended (16 hours/day light using a mercury vapor lamp) light conditions. At the end of ten weeks note was taken of the growth. Results showed that the Indian plants were very sensitive to the cold though the winter of 89/90 was not severe (min. temp. - 6° C). Tillering rate was low in the winter period and no significant influence on tillering was observed as a result of differing photoperiod length; though the plants with the greater amount of light exhibited a greater degree of homogeneity in growth rates and had better root growth. The New

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

Dr. Françoise Dinger

Caledonian plants, which were observed under greenhouse conditions only, appeared to respond to the longer photoperiod with greater tillering. We concluded that the Indian vetiver is freeze-constrained under a temperate European climate and that photoperiod seems to influence growth and rhizogenesis but this conclusion requires further confirmation.

II. Tissue culture

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

III. Conclusions

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

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

IV. Field Testing

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

Hedge	October	November	December	January	February
Vetiver	12.8	12.3	10.4	8.6	7.6
Cenchrus	11.1	11.5	10 9	9.4	8.4
Subabul	12.9	9.2	6.7	7.2	5.2
Desmanthus	11.4	11.1	10.2	9.0	7.9

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

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

For sustained agriculture, conservation of agricultural assets are essential. This is more true in dryland agriculture. Land and water are the two major natural resources which need efficient management to ward against degradation of the environment and of agricultural productivity. Various soil conservation measures have been attempted and contour bunding had been accepted in India on slopes up to 6%. The system is effective, however, it is not without difficulties. (In) deep vertisols, where shrinking and swelling results in cracks up to one meter in depth, contour bunds get destabilized and become ineffective. Also saturation of soils and waterlogging behind the bund result in poor crop stand and growth. Another difficulty is that landholdings in India are small and this type of bunding requires co-op-

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

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

erative efforts to achieve safe disposal of surplus water; in practice this cooperation is only achieved in stray instances. These factors necessitate new thinking on contour bunding, especially for deep vertisols; vegetative hedges seem to offer an advantage.

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

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

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

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

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

The Vetiver Information Network

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

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

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

VETIVER NEWSLETTER

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

TABLE OF CONTENTS

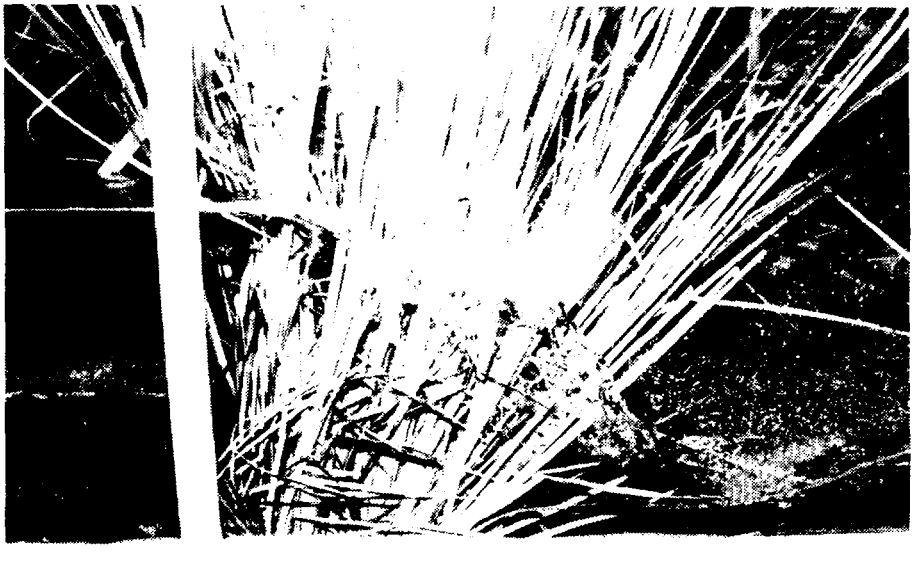
THE NEWSLETTER

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

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

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

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



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

CORRECTION ON VETIVER AWARDEES

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

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

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

*ASIA TECHNICAL DEPARTMENT AGRICULTURE DIVISION

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

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

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

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

Seeds Of Change In Soil Conservation

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

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

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

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

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

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

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

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

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

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

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

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

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

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

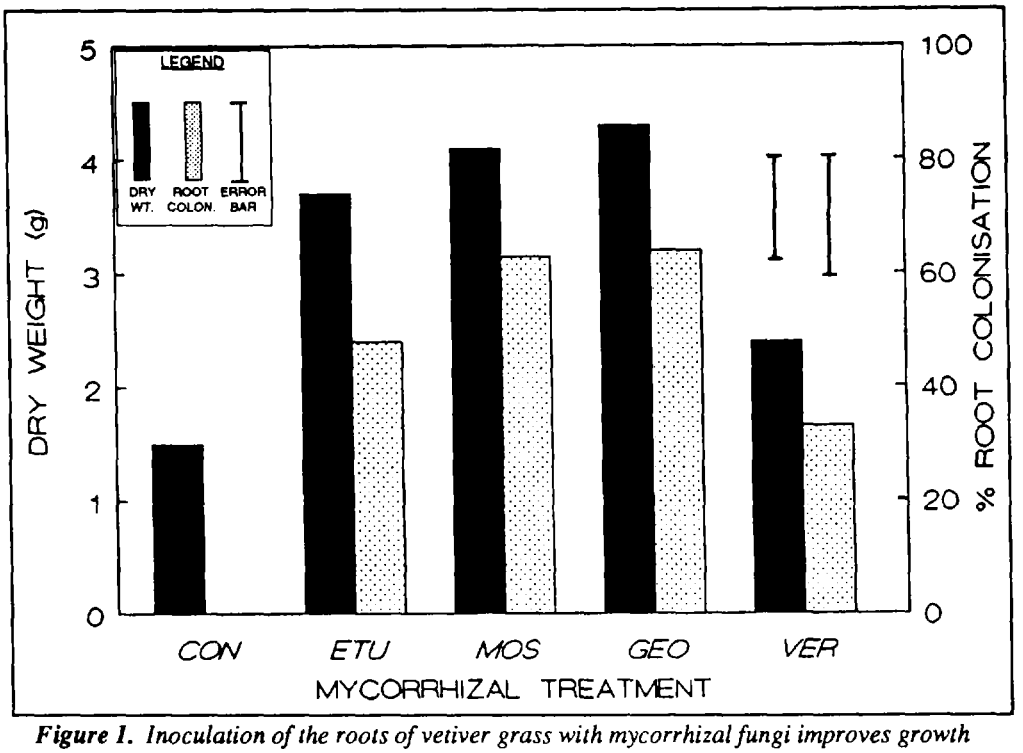


Figure 1. *Inoculation of the roots of vetiver grass with mycorrhizal fungi improves growth significantly. Note that while some of the fungi were better than others in promoting biomass production, even the least successful of the fungi still improved the average biomass production by over 50% compared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

Mycorrhiza and Vetiver - Rehabilitating Degraded Lands

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

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

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

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

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

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

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

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

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

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

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

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

[Y] Survival after initial transplanting of 7 plants per accession.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Philippines - The Introduction of Vetiver Grass to Improve An Indigenous Technology for Soil and Water Conservation.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Photo courtesy of CIAT, Cali, Colombia

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

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

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

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

"As of June 1991, one farmer has already expanded the planting of Mura in another parcel of his farm and there are six who are planning to do the same when the rains come. Some of them have cited insufficient planting materials, at; present, as a constraint for expansion. The comments of farmers who have planted Mura suggest that they are optimistic about its performance as hedgerows in the uplands."

Concluding Statement.

"After a year 17 upland farmers have tested and adopted Vetiver grass for soil and water conservation. Indications are that the technology will be spread and be sustained even if the project no longer exists. A main ingredient leading to such a good adoption rate in a short period of time appears to be the following: learning from farmers first before attempting to introduce technological improvements. In the long run the simple grass (Vetiver) strips will not remain simple. They provide foundation for subsequent diversification into more labor-intensive hedgerow enterprises. This diversification is being looked into by the project."

"Based on the Project's experiences and reinforced by recent literature on the use of Vetiver grass for soil and water conservation around the world, the Project has prepared and pretested a leaflet written in Cebuano for distribution to all farmers covered by the Project. However, it should also be useful for other upland farmers in Region VIII."

From The International Center For Tropical Agriculture (CIAT)

Dr. **Douglas R. Laing**, Deputy Director General of CIAT in Cali, Colombia writes :

"I enclose for your information some photographs taken recently in Mondomo Cauca, Colombia showing vetiver with *Arachis pintoi*. I believe this is a first. The results seem to be shaping up quite well from various viewpoints. The final results at the end of the first year and particularly after 2 or 3 years will really tell. At the moment erosion is at a minimum in the vetiver plots and cassava seems to be growing well without competitive effects close to the barriers."

"The idea of the Arachis association is to provide a source of nitrogen for the system as a whole. Arachis is shade tolerant and fixes nitrogen quite well in acid soils at intermediate altitudes, i.e. where most of the erosion seems to take place in the tropics. Over time there could be a reasonable contribution of nitrogen provided from this association. The Arachis could also be cut for fodder without endangering the vetiver as a hedge against erosion. This would reduce one of the main constraints in the use of vetiver per se, i.e. its low acceptability to bovines."

"The experiment is the work of Mr. **Martin Ruppenthal** from the University of Hohenheim,working at CIAT in a collaborative project funded by the BMZ. We will keep you posted on the outcome."

An Update From Karnataka, India On The Effects of Vegetative Barriers On Crop Yield and Soil Loss

Dr. **B.R. Hedge** from the University of Agricultural Sciences in Bangalore (who has been carrying out research involving vetiver hedges for over 4 years now) has provided the Network with some information from the 90-91 Annual Report of the AICRP for Dryland Agriculture. In comparing a control plot (no hedgerows, graded bunds at top and bottom of plot), a plot with a vetiver hedgerow (in plot center, graded bunds at top and bottom of plot) and a plot with a *Pennisetum hohenackeri* hedgerow (in plot center, graded bunds at top and bottom of plot), he reports that there was no influence of the vegetative hedgerows on overall yield of millet. This is significant as the crop rows adjacent to the hedgerows exhibited some competition effects. Yields in the adjacent two or three rows (editor : these would be located within about 30cm to 50cm of the hedgerow) were reduced from, in one case 0% (row 3) upto a maximum of 52% (row 1) in another case. This suggests that yield increases in the interior rows would have had to occur in order to offset the losses due to competition at the hedge. Soil losses in the three plots during that year were very low due to rainfall charecteristics; losses were .49, .51, and .54 t/ha for the vetiver, pennisetum, and control plots, respectively.

A Preliminary Study on Vetiver Grass Mulch Effect On White Ant (Termite) Attack In Horticultural Plantings

From the **Staff of the Watershed Technology Development Center** in Solo, Central Java, Indonesia :

"The objective of the study is to determine the usefulness of vetiver leaf for preventing white ant attack of horticultural plants. The study is executed in an area of marginal and shallow soils at Gunungsari, Sub-district of Wonosegoro, Boyolali."

"Table 5 shows the number of trees observed, the intensity of the white ant attacks and the percentage of the trees killed by white ant attack. From the data it can be seen that there is a significant difference between the three mulches used — cuttings from the wild grasses, banana stems and vetiver grass cuttings. The use of banana stems or vetiver grass as mulch decreased the intensity of white ant attack and the percentage of trees killed by white ant. That vetiver is as effective as banana stems is important as it is impossible to fulfill the need for mulch with banana stems. It is suggested that further more detailed research should be carried out to test the usefulness of vetiver mulch in preventing white ant attack on horticultural plants."

No.	Combination of mulch type and horticultural plant type	Number of trees observed	Number of trees attack by white ant	Number of trees killed by white ant
1.	Mulch of wild grass manure in coconut trees	5	4 (80%)	1 (20%)
2.	Mulch of wild grass manure in mango trees	5	5 (100%)	2 (40%)
3.	Mulch of banana's stem in cocoonut trees	5	0 (0 %)	0 (0 %)
4.	Mulch of vetiver manure in coconut trees	5	0 (0 %)	0 (0 %)
5.	Mulch of vetiver manure in mango trees	5	0 (0 %)	0 (0 %)

Table 5. Effects of mulching with native grasses (wild grass, banana stems and vetiver grass on white ant (termite) attacks and mortality in some horticultural crops.

Letters From Vetiver Network Correspondents

Australia -

The Network has received information through Dr. **Noel Vietmeyer** at the United States National Academy of Science, that, according to Mr. **R.S. Junor**, Commissioner, Soil Conservation Service, New South Wales, the Australian Soil Conservation Service's "interest in Vetiver has been reawakened and currently we are undertaking a major project to evaluate vetiver in four states of Australia. The project is coordinated through our Plant Materials Centre and the officer responsible is Mr. **Ken Reynolds**..... Over the next three years vetiver will be evaluated at a wide range of sites, in various environments and for different uses. Throughout the duration of the project, results will be distributed through the Vetiver Newsletter."

Dr. Paul Truong, the recipient of one of the Vetiver Awards for his work on saline tolerance in vetiver, writes that he is continuing his salinity work and, in addition, hopes to set up trials to evaluate the effectiveness of vetiver in stabilising coal mine overburdens. He writes : "If this trial is successful, Vetiver will provide our mining industry with a low cost and effective means of reclaiming mine wastes."

Bhutan -

Possible First Vetiver Planting in Bhutan

Mr. **P.G. Harrison** writes from the Department of Primary Industries

Photo 4. Digging Vetiveria in the Benue Floodplain near Demsa, Nigeria

and Fisheries in Australia that he believes that, what may be the first vetiver plantings in Bhutan, have been put in at Pemagatshel this last February. Mr. Harrison informs the network that planting material was obtained through World Bank staff from Kathmandu and that they had excellent establishment with new tillers appearing only 10 days after transplanting. They planned to try and distribute vetiver to farmers this last July or August.

Bolivia

Mr. **Mathieu Kuipers**, Project Coordinator of a cooperative program between the Ministry of Agriculture and Campesinos (MACA), the Corporation for the Development of Cochabamba (*CORDECO*) and the United Nations informs the Network that they are beginning to develop a program to assess and utilize vetiver grass hedgerows. Mr. Kuipers has also provided us with Ing. **Alfredo Ballerstaedt's** (MACA) translation of the Vetiver Handbook as well as an introduction that Ing. Ballerstaedt has written on the vetiver system for Bolivia.

Cape Verde

Vetiver Introduced To "New" Country

Ms. **Frances Harris**, a Plant Scientist with the Henry Doubleday Research Association who is working in a collaborative project with the Instituto Nacional De Investigação Agrária on agricultural and forestry research, writes that their project has introduced vetiver to Santiago Island :

"A supply of the grass was brought out from England in February 1991 and is now growing well in a nursery. When the rains start, these plants will be divided and should provide enough material to plant a demonstration trial on a steeply sloping site. Survival and growth of vetiver grass will be monitored and its effects on soil erosion and crop yield will be observed."

"Cape Verde foresters, soil conservationists and agriculturalists are very interested in vetiver. They have been very helpful with respect to allowing it to enter the country and providing materials necessary to build an enclosed nursery. Many Cape Verdians have requested planting material and are very curious to see if it will grow successfully here. If it does, it is likely that the National Soil Conservation Service will use it regularly in their campaign to control soil erosion."

"Vetiver grass has also been introduced to the second-largest island, Santo Antao, by a Dutch agricultural project. Unfortunately, I have been unable to contact them. If any groups from Cape Verde have responded to your (Network), I would like to know of them."

Costa Rica

Six Years of Vetiver Use

Dr. **C. Bufford Briscoe** writes that he now has about six years experience with hedgerows of vetiver, lemongrass (*Cymbopogon citratus*), and citronella (*C. naudus*) on his farm in a humid zone ("Ten days without rain is rare") receiving about 2400 mm/yr rainfall. He reports that there had been no apparent differences between the hedgerows until 1990, when, more than 90% of his lemongrass (apparently) died of a root rot. Other than this, he tells us that there are no visually obvious differences in the densities of the three hedgerow types, nor has he observed any die out in the centers of any of the hedgerow species....which he suggests may be due to annual trimming. He reports that flowering in the plants is rare to nonexistent. Dr. Briscoe also states that on a consultancy to St. Vincent, West Indies this year, he found that lemongrass is considered to be an important pest...."it flowers and seeds abundantly, and has spread over considerable areas".

Hong Kong

A Perspective On "Good" vs "Bad" Fodder Grasses For Erosion Control

In the May 1991 edition of *Asia-Pacific Uplands - A Newsletter for Scientists*, Dr. **R.D. Hill** of the Department of Geography & Geology, University of Hong Kong writes about upland development in Guizhou Province, P.R.C. :

"For higher more temperate areas pampas grass (*Cortaderia argentea*) may offer possibilities and for lower more tropical areas Vetiver may be suitable for erosion control. Neither is good quality fodder. This is important since good-quality fodders are likely to be environmentally-sensitive, or require significant inputs (which no farmer can afford and would not use anyway on public-access grazing lands). More importantly, vigorous low-quality fodder is likely to suffer less cutting or grazing pressure and thus continue to be effective in erosion control, especially if planted, as recommended, in a double-row hedge along the contour."

Dr. Hill is publishing this news-

letter for the Pacific Science Association as a medium for the sharing of news and views, for the informal publication (in brief) of research reports and for documentation on management systems which are economically and environmentally sustainable for the utilization of the **Asia-Pacific uplands. If you are interested in joining this network, contact Dr. Hill at the University of Hong Kong.**

(**Editors note** : *there are two points in Dr. Hill's article on which we would like to comment. The first is to note that in some areas pampas grass is considered to be a serious weed, and the second is to state that the Network does not recommend double rows of vetiver in areas where control of sheet and rill erosion are desired. Double rows may, however, be desirable or necessary in situations where runoff is concentrated, for example, stream banks and active cutting areas in gullies.)*

Photo courtesy of R.S. Patil

Photo 5. *Mr. Patil's vetiver about 90 days after planting from single tillers.*

India

Letter From A Karnataka Farmer

Mr. **R.S. Patil** of Hombal, Gadag, Dharwad writes to the Network that :

"I am happy to give you my feedback from my last 6 months of work. During the summer I found our Forest Department's vetiver nursery and requested a supply.....I was able to make vetiver bunds (hedges) on 8 acres of Black-cotton soil land (**ed. note**. *high shrink/swell clay soils subject to deep cracking when they dry - Vertisols*). This land has been planted on all boundaries....(and) divided into two equal parts with khus (vetiver) planted across the waterway. A total of 67 acres (drains) through this land to another farmer's land. Another farm of my own has also been planted....there I have planted khus on 3 boundaries (of a) 7.5 acre land (and have) made 16 parts. Everywhere I have used single rootlets (plants)."

We are encouraging farmers to make vetiver nurseries on their own land through a small group, a farmer to farmer association called 'DHARLTRI'. Already four small nurseries have been established....We are promoting Permaculture, organic farming, vetiver importance in soil erosion and other related methods of sustainable Agrimethods in our area."

Mauritius

More Evidence That Vetiver Grass Hedges Stop Encroachment of Weeds Into Farmer's Fields

The following information was sent to the Network by Dr. Noel Vietmeyer and comes from a communication by Dr. **Jean-Claude Autrey**, Head of the Plant Pathology Division of the Mauritius Sugar Industry Research Institute.

"Any sugar cane grower in Mauritius will tell you that vetiver is used both for erosion control as well as some sort of barrier to prevent noxious weeds such as Cynodon dactylon to penetrate fields from roads. The abundant root system of vetiver is ideal for this purpose."

People's Republic of China

Plantings Expanding in Jiangxi

Mr. **Zhang Guangming**, a regular contributor to the Newsletter and one of the individuals who has been instrumental in promotion of vetiver grass in China, writes : "Under the influence of vetiver establishment in the Red Soils project area, Jiangxi Is now expanding its planting area. By the end of 1990, we had established a protection area of 5,000 mu (332 ha), nurseries of 100 mu (6.7 ha) with six million planting slips. Vetiver is not only planted in the Phase I Red Soil project area. In mid-March, 1,500 county government staff and farmers were organized to plant 30,000 meters (protection area 1,000 mu) of vetiver strips with 700,000 slips in proposed phase II project area. In Xinfeng county, 100,000 slips (protection area 100 mu) have been planted at the edges of level trenches, in the soil plugs of gullies and around the slopes of hills on the contour. Priority will be continuously given to planting material and planting quality."

"Recently a training course was sponsored in Nanchang for an environmental protection forestry project. Participants from 16 provinces discussed vetiver establishment. Special funds have been allocated to Jiangxi and Guangdong provinces for trial planting. Mr. Liao Baowen, from the Tropical Forest Institute of the China Academy of Forestry came to Jiangxi ADC on April 14 for information and handbooks

on vetiver. He says that the Institute, which is near the South China Botanical Garden where three people have started research on vetiver, and the Forest Bureau of Yangxi county in Guangdong province will plant a 150 mu (10 ha) vetiver demonstration for a forestry project."

In Fujian province, the Network is informed that under the direction of the Water and Soil Conservancy, two more counties (Anxi and Jianyang) will put in vetiver trials on about 255 mu (17 ha). The trials will consist of hedges on sloping agricultural fields, in gully control, to stabilize collapsed slopes, to stabilize fruit/tea terraces, to protect ponds, and along roadsides. The trials will monitor impacts of vetiver on erosion, runoff, soil nutrients and work at enhancing management techniques.

Rates Of Tillering Significantly Increased By Pruning

According to work carried out by Mr. **Chen Cayang** and Mr. **Cheng Hong** of the Department of Water and Soil Conservation, Nanchang Water Resources and Hydropower Academy in Nanchang, Jiangxi, the rate at which tillering occurred in vetiver was definitely affected by pruning. In their trials, pruning of vetiver in late August had increased the rate of tiller formation by 71% at the end of one month and by 83% at the end of the second month; they conclude that pruning should be carried out prior to flowering, but after growth has begun to slow so as to maintain the maximum photosynthetic surface during the period of optimal growth. The authors carried out their work in six locations, between latitudes N18°10' and N36°33' (rainfall 706 to 2,000 mm/yr; lowest temperature -9°C; soil pH = 4.5 to 5.6) and make the observation that based on the first year's data, so far vetiver appears to be sufficiently adapted to this climatic range for use as a soil and water conservation species. They will continue monitoring.

In Zhejiang, Vetiver Grows In Cold Uplands

Mr. **Qiu Jiye** of Zhejiang has written to the network to inform us that vetiver grass has been planted in the Province since 1971. It has been planted as clumps, not as hedgerows, primarily for stabilizing soil, for pickling spice (from the root), and for fuel from the stalk. Mr. Qiu notes that vetiver has a large range of adaptability from acid soils (pH = 4.5) to alkaline soils (pH = 8.5) and from mountainous uplands (mean winter temp 7°C; min = -7°C; 35 frost days; 10-15 snow days) down to sea-level.

Vetiver Is A "Delicious" Spice

Mr. **Gao Weisin** of the Institute of Mountain Disasters and Environment in Chengdu informs the Network that new economic uses for vetiver grass are being found in China. He tells us that vetiver is being found useful to feed fish and also "Another use of V. grass is to be used as a spice, especially with meat. These dishes are very delicious."

Republic of South Africa

Private Firm Stabilizes Difficult Sites

Mr. Anthony Tantum has been working with vetiver grass since 1966, when he first saw the Mauritians using vetiver grass hedgerows to stabilize drains on a sugar estate in the Lower Shire Valley; today he has a private company which specializes in land stabilization with vetiver grass hedgerows. In a recent letter to Dr. Noel Vietmeyer at the United States National Academy of Science, Mr. Tantum recounts the following :

"In 1990, **Nells Carsten** of the Roads Department (Cape Provincial Administration) asked (me) if vetiver could solve a serious erosion problem at the Stellenbosch flyover (Exit 22 of Hwy N2 to Cape Town). The embankment was very steep; the "soil" pure white sand. Vetiver was planted in April 1990, closely spaced and without fertilizer. Virtually all plants survived, and their growth was good. Natural terracing was already visible before the end of the year."

"In another trial in the Stellenbosch area (on the R44 road to Paarl), a steep road bank with very poor subsoil was planted. Nothing grew in the white clays with red patches until vetiver was put in April 1990. Today the grass is growing and tillering well, and the bottom hedge, for example, had built up between 70 and 100 mm of soil in just the first 7 months !

Another remarkable approach in South Africa has been achieved by the Institute of Commercial Forestry Research. Vetiver has now been accepted by the forestry industry on fire breaks; which have been a major source of erosion up until the introduction of the vetiver hedges. The insurers of this industry have accepted the concept of vetiver hedges, on fire breaks, not being a potential fire hazard. In June of each year, the hedges are herbicided with Gramoxone and burnt a week later. Within two weeks the hedges come back as green belts across the fire breaks."

Thailand

'Faek' Well-known in Thailand

The following are some excerpts from two articles passed on to the Newsletter. The first is by Dr. **Weeachai Na-nakorn**, who is the Coordinator of the recently established Thai Vetiver Network, written in response to some question arising from a seminar on Vetiver grass given in Thailand last May. The second is from **Richard Grimshaw**, Chief of the World Bank's Asia Technical Department, Agriculture Division and gives some of his impressions from his May trip to Thailand to speak at the seminar on Vetiver.

Those interested in joining the Thai Vetiver Network can contact Dr. Nanakorn at The Forest Herbarium, Royal Forest Department, Phaholyothin Road, Bangkok 10900.

"According to interviews with the Department of Biology, Faculty of Science, Chiang Mai University, and reference to the Royal Forestry Department's Directory of Plants in Thailand, vetiver grass, known in the scientific name as *Vetiveria zizanioides*, is a plant under "Faek" family in Thailand. The new generation who are not familiar with rural life may wonder as to what is Faek. "Faek" is well known among Thai people in many provinces because it can be used for house and

Photo courtesy of the USDA/ARS Sedimentation Laboratory, Oxford, Mississippi.

Photo 6. Water is ponded to the depth of 30 cm during a test run at the Agricultural Research Service's Sedimentation Laboratory in Oxford, Mississippi, USA.

farmhouse roofing. However, according to people in the countryside, natural Faek is now becoming scarce. People have begun using Imperata cylindrica for roofing instead. In their opinion, roofing made from Imperata cylindrica is not as effective as that made from Faek because Faek leaves, when assembled into a band, can aggregate themselves tightly due to the characteristics of the bottom end of its leaf. As a result, rain water does not hold on nor leak. Due to its more durability, its price is higher than roofing made from Imperata cylindrica."

Where Can Faek Be Found In Thailand? "Faek is commonly found in the low plateau lands of the Nakhon Sawan and Uthai Thani provinces; where it grows along the edge of swamps and roads. The specimens in the collection of the Botanical Center, Royal Forestry Department, come from areas of 250 metres MSL in Nakhon Patchasima province, 400 metres MSL in Phayao province and 800 metres MSL in Mount Phu Kradung in Loei province. Since natural Faek can be found thriving in different environments, it can be said that Faek can endure occasional floods, droughts and low-quality soil."

Faek and Soil and Moisture Conservation. "According to a World Bank report, Faek which was burnt in dry season could thrive on again during the following rainy season. This qualification means that it is likely to be suitable for use as a plant for soil and moisture conservation because there are often fires on upland crops during the dry season. It is under an experimentation as to how quick native Faek in Thailand can thrive on in time in rainy season for effective soil and moisture conservation."

From Richard Grimshaw's Trip to Thailand

"During the month of May (May 21 to May 24) I visited Mae Hong Song Province in Northern Thailand. Specifically I visited the Royal Project (near Chiang Mai) and the Thai-Australian Project at Mae Ho (near Mae Sa-reang) and the Thai-German Project at Nam Lang in Pang Ma Pha District. I was impressed by the efforts being made to help the Hill Tribes and by the indigenous farming practices by these Hill farmers. Clearly bush fallow/crop rotations are being reduced in duration and soil fertility is declining. Soil loss due to erosion is extremely high - sometimes more than 100 tons/ha per annum."

"Experimental work by the Thai-Australian, and Thai-German projects confirm that vegetative systems of soil and moisture conservation are significantly superior to engineered/structural systems. Not only are they cheaper but also require less maintenance. The two most commonly used conservation hedges were *Leuceana spp.* (a Shrub hedge) and grass strips of various species."

"Vetiver may well prove to be readily adoptable by the local farmers. Presently, they are showing increasing interest in grass strip conservation - even on the steepest slopes (over 50% slope). The main problem with the grasses being used are their spreading habits and limited longevity."

USA

Vetiver hedgerows have been established by the Soil Conservation Service in and near Baton Rouge, Louisiana under the initiative of Mr. **Mike Materne** of the SCS with the aid of Dr. **Kitty Derstine** and Ms. **Cindy Shexnayder**. In one particularly impressive trial, the SCS has planted vetiver hedges to test their ability to control gullies and arrest sediment flows in a military tank testing ground at Ft. Polk, La. Planted in May 1990, the hedgerows have established well and begun to trap sediments. During 1991, Louisiana has had record rainfall (it is their wettest year on record) and under these extreme conditions the structural integrity of the vetiver hedges in the active drainageways has not been compromised — more than 50 cm of sediments have built up behind the hedges despite their not being fully closed yet.

Vetiver Barriers Pond Water

Further evidence of the structural strength of vetiver hedgerows has been provided to the Network by Drs. **S. Dabney** and **G. Dunn** at the United States Department of Agriculture's Agricultural Research Service Sedimentation Laboratory in Oxford, Mississippi. In a flume study, water flowing at 28 liters/sec (flume width 61 cm) was ponded to a depth of about 30 cm behind a vetiver hedge; gravity head loss through the hedge was about 23 cm; it can be seen that leakage between the glass and the hedge contributes to reduced effectiveness in ponding the water. Photos 1 & 5 show that the vetiver hedge is only slightly deflected by the flow.

More On Drought and Cold Tolerance

Two areas of concern are vetiver's ability to establish under difficult, particularly drought, conditions and its ability to withstand cold. The following letter from **James E. Eagan** of Esparto, California provides the Network with some information of interest :

".....An associate of mine visited Sunshine, Louisiana and made arrangements to ship 3 square feet of Vetiver grass root to me in Woodland, California. We started propagating the Vetiver from tillers in about 200 pots in my small backyard in Woodland. During July of 1989, I was forced to separate and transplant the tillers under very hot and adverse conditions. Water was a serious problem due to Californias drought conditions. As a result irrigations were sparse and the tillers were severely stressed. Quite frankly, I expected a near zero survival rate. I was surprised that I lost less than 10% of the materials. However, due to the stress the plants were very slow to develop and averaged about one foot of height during the next six months. In December of 1990 the hardest freeze in at least 50 years struck our area. Night time temperatures stayed between 10 and 20 Fahrenheit (-12C to -7C) for approximately 17 to 20 days. At the end of this time all of the plants were brown and wilted right to ground level. There was only a hint of green remaining on a few of the plants. I again expected nearly a 100% loss. Amazingly enough all but a few plants showed signs of new growth in about 6 or 7 weeks. The actual rate of loss was 2% or less."

"One fact that I should have mentioned earlier is that the original root stock that was obtained from Louisiana was air freighted to me in California in burlap sacks. The roots were kept moist in a wheel barrow for 2 weeks and covered with newspapers until my associate and I had time to separate and plant the tillers. (Other plants which are now growing very well) were literally started from scraps that I had discarded as meaningless during the initial planting. Obviously, I am impressed with the durability of Vetiver grass."

Editors Note: *We have seen repeatedly that vetiver grass is capable of surviving under some fairly rough conditions and handling;that is one of the reasons why it is well adapted for use as a soil conservation species. It is not, however, a very good idea to take the approach that vetiver does not need any care in order to establish and grow. All plants benefit from careful handling and good planting practices. Better mangement means greater survival, faster establishment, better growth, and overall better results. Poor management and careless planting, particularly under dry conditions, can result in failure with vetiver as it can with any plant.*

Zimbabwe

Protecting Valuable Irrigation Works

The following excerpts are from a letter written by Mr. **Alan Norton**, Project Manager of the Rupike Irrigation Scheme.

"I am currently installing the Rupike Irrigation Scheme on behalf of the Rio Tinto Foundation. My interest in Vetiver grass started because of my concern at the large areas of denuded borrow pit (approx. 15 ha) left by the contractors who constructed the dam. The borrow pits are within the immediate dam basin, largely on slopes greater than 5% and on highly erodible granite-derived soils. Already there has been much visible soil wash into the dam from the pits in addition to the considerable amounts from farther up the catchment. The installation of the dam, irrigation facilities and associated infrastructure represents a large investment and we do not want the life of the project shortened unnecessarily by siltation of the dam. We have attempted to plant Vetiver on the contour in the borrow pits in order to check the erosion. Much of the grass is on decomposing granite with thus very little soil for root development. Also the cattle and goats in this area are so desperate for food that they feed on the grass not only when it is young and palatable, but also when it is dry and/or fully grown in its coarse state. However, despite these set backs and a long dry season, the grass is surviving in most places. We have started a vetiver grass nursery in order to bulk up to plant in other places especially on the waterways in the fields."

Notes From A Long Time Vetiver User.

The Network received this letter (excerpts from it are given below) from Mr. **Jano Labat**, who has known of vetiver for some years, but, only recently had become aware of its use for soil and water conservation. Since then, through his own efforts, Mr. Labat has written a small pamphlet on vetiver grass to pass out to his fellow farmers and within which he has offered to help them with more information or planting material. The Network would like to recognize Mr. Labats initiative and commend him for his activist approach toward providing solutions to problems — in this case, the use of vetiver to control soil loss.

"I must say that, although I have been associated with Vetiver for quite a number of years, I was not aware of its many uses until February (1990, when I saw) your booklet and newsletters and (Tony Tantum from Howick, Republic of South Africa) told me of his programme. Needless to say I am an addict of Vetiver since. Recently I have been see Tony and see first hand all his work. I was most impressed."

"I have already established a nursery of 3.2 ha. on my farm. The grass was planted on 15 March 1991 under flood irrigation. You might be interested to know that to control weeds I have sprayed the Vetiver with herbicide three days after planting, at a concentration of 3 litres/ha. The herbicide used was ATRAZINE 500 FW (47% atrazine, 3% active triazines, 50% inerts). There were no ill effects to the Vetiver."

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER INFORMATION NETWORK, ASTAG*, WORLD BANK, NUMBER 8, JUNE 1992

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THE NEWSLETTER

Quite a bit has taken place in the few months since our last Newsletter, amongst which is that Dick Grimshaw, the division chief of ASTAG, has been able to raise $32,000 for this next year's **Vetiver Incentive Awards**. An article in this issue gives further information. Additionally, the first International Vetiver Technology Workshop, sponsored jointly by the Rubber Research Institute of Malaysia and the World Bank was held in Malaysia in April. Also in that month, the second Ethiopian vetiver grass workshop was held in Addis Ababa, this workshop was jointly sponsored by Ministry of Agriculture and Environmental Protection and Development (MOAEPD) and the World Bank and brought together those in Ethiopia either working with vetiver or interested in its use. Both workshops were given excellent reviews by the participants and in the Ethiopian workshop **Dr. Mesfin Abebe**, Vice Minister, MOAEPD promised the support of his Ministry in seeing the vetiver technology demonstrated and extended in that country. We have more on the Malaysian workshop in this Newsletter.

On the subject of the Vetiver Incentive Awards, the Network wishes to thank those who provided funds for the awards. In particular we would like to thank **His Majesty, The King of Thailand**. His Majesty had previously expressed a very keen interest in the vetiver technology; one of the King's special interests being the development of the tribal people in the hills of North East Thailand, where deforestation is accelerating, where soil erosion rates are very high, and where there is a need to diversify away from growing poppies. The King had been quick to see the value of Vetiver grass for soil and moisture conservation and he started a testing program in 1991. Soon after that, Dick Grimshaw was asked to meet with him and discuss the Thailand program further. During the audience The King expressed his belief that Vetiver could well be the answer to stabilizing Thailand's fast eroding lands while reducing excess runoff and the problems that excess causes. The King then gave a generous gift of US$ 10,000 to be used to promote research with vetiver through the Network's Vetiver Incentive Awards program.

Photo 1. A well-established vetiver hedge along a roadside in Malaysia not only stabilized the road's edges, but also stopped and held a boulder rolling down the slope. Photo taken at one of Dr. Yoon's demonstration areas. Photo by James Smyle

In the last Newsletter (#7) we published a questionnaire on Network participants experiences, needs and suggestions regarding the propagation of vetiver grass. Due to the unexpectedly large response, we are delaying the publication of our "Propagation Newsletter" issue to the next one after this one. As yet we have not had the time to put together all of the responses so it will be late August or early September before that issue will come out.

In the last few weeks, Dick Grimshaw returned from China

and had a few observations to pass along to the Network :

"China's Ministry of Agriculture (MOA) is well convinced on the use of Vetiver on slopes of less than 15 degrees (30% slopes). They still have some doubts as to its effectiveness on steeper slopes, particularly where soils are very shallow. They also worry that farmers do not see any direct economic value to Vetiver — in other words it has no value for paper, etc. — making its extension difficult. My view is that there are direct economic benefits, such as forage, thatch, and mulch, but these are not immediately perceived by the farmers. MOA will be taking steps to improve its information campaign for Vetiver as well as for other promising technologies such as grain amaranth for fodder."

"Another point of interest from my trip is that I have for the first time seen quite well established 'living walls' (cattle proof hedges) in China. They (many kilometers of them) are located alongside the main road from Beijing to Mutianyu (Great Wall) some 36 km from the Great Wall Hotel, at a place called Niulanshan (Cowshed Hill). These livestock proof hedges are protecting large orchids of peaches, and consist entirely of Black Locust (Robinia pseudoacacia). With a little better planting (a double row, and closer interline spacing), and improved management (specifically the cutting and maintenance) Black Locust should make a very robust and effective hedge, as well as producing wood for fuel and poles."

"Recently, the Chinese have translated from English to Chinese the excellent report done for the GTZ by Dr. Guido Kuchelmeister entitled Hedges for Resource-poor Land Users in Developing Countries. The report, published in 1989 is a comprehensive detailing of

(Continued on page 18, see Grimshaw's Remarks)

Vetiver Awards To Be Given In June 1993
King of Thailand Contributes To Award Fund

Once again Dick Grimshaw has persevered in finding funds which can be utilized to recognize those 'jobs well done' by both individuals and groups in promoting, managing and researching the use of vetiver grass for contour vegetative barriers. This time the Network has a total of **$32,000 to award**. The Network wishes to thank His Majesty, The King of Thailand for his support and contribution to the award fund. The Network would also like to thank **Messrs. Kajl and Wood**, respectively the World Bank Vice-Presidents for East Asia & Pacific and for South Asia, **Mr. James Eagan** of the Yolo County Flood Control and Water Conservation District in California, USA, and **Mr. Reginal Pollack** of Washington, DC for their contributions to the Award fund.

Below are the categories within which the awards will be given. The Network has split the awards in order to encourage a number of different, valuable areas. Please note that "work of interest" is indicative only, we do not want these categories to limit anyone, on the contrary we encourage any useful and practical work outside these areas as well. Be assured that any one sharing information on an area not contained below will have their work treated equally with that which does fall under the categories set out below. Wherever appropriate and possible, costs or cost estimates for implementation of recommendations should be included in order to allow potential users to fully weigh the utility of the recommendation for their situations.

The Network will be accepting your 'entries' until April 15, 1993. At that time an independent, external panel will choose the awardees (with the exception of the Yolo County Award, see below); all awards will be made by June 1, 1993. All materials received should be sent with the understanding that they will not be returned and that

Photo 2. *Assistant Professor Zheng Songfa making observations on the growth of a vetiver hedge in a runoff plot where vetiver hedges are being tested for their impacts on soil loss and runoff control in eucalyptus plantations. The research is being carried out at the Research Institute of Tropical Forestry in Longdong, Guangzhou, P.R. China*

Photo courtesy of Drs. Zheng D., Zheng S. and Liao B.

they will become public information and shared with the Vetiver Network. All relevant information received will be incorporated into a Newsletter (or Newsletters if warranted) for publication by July 1993.

The Awards

The King of Thailand Vetiver Research Award.

His Majesty, The King of Thailand has offered $10,000 in awards to promote the dissemination of useful and practical information on vetiver grass. One-half of these funds ($5,000) will be awarded seperately to the individual contributing the most significant piece of research work.

Research Awards

The Plant

Work of interest on : Vetiver taxonomy , eg species/varieties/types, their identification & comparison of characteristics in : growth and/or management needs and/or palatability/non-palatability and/or applications based on differences and/or pollen, flower, seed fertility/sterility by type; effectiveness as soil/water conservation species as a function of its roots, strength of tops and hedge-forming ability; pest repellency effects by type; allelopathy; cold or drought tolerances; pests and/or diseases; mycorrhiza and vetiver; pH-related questions (eg. absolute tolerances, Al toxicity, P deficiency); and other physiological characteristics. **Awards = 1st - $2,500; 2nd - $1,500; 3rd - 1,000; 4th - 4 awards of $500 each.**

Engineering Applications

Yolo County Flood Control and Water Conservation District Award for most comprehensive and/or unique viable applications for vetiver in stormwater and wastewater reclamation. The winner of this award will be determined jointly by Mr. James Eagan, General Manager of the Yolo County Flood Control and Water Conservation District and Mr. R.G. Grimshaw, Chief, ASTAG/World Bank. **Award = $2,000;**

Other work of interest on : stabilization of cuts and fills, protection of infrastructure from run-on and sedimentation, stabilization of the infrastructure:soil interface, stabilization of canals and ponds, groundwater recharge. **Awards = 1st - $2,000; 2nd - $1,500; 3rd - 1,000.**

Management

Work of interest on : pests, their importance/significance and management (insects and/or weeds); "how-to" guides for most efficient propagation and/or viable, alternative propagation methods (eg. layering); "how-to" guides for most efficient establishment of hedgerows (be specific about soils, climates and land use conditions); establishment and management system costs under varying conditions; "how-to" guides on mycorrhizal inoculation of vetiver; management of vetiver hedgerows for secondary benefits; economic analysis of the benefits of vetiver hedgerows relative to other approaches; impacts on soil loss, runoff/soil moisture and crop yields on steep slopes. **Awards = 1st - $2,500; 2nd - $1,500; 3rd - 1,000; 4th - 4 awards of $500 each.**

Promotional/Extension Work and/or Materials

Best Video Awards = 1st - $1,150 and a painting contributed by Mr. Reginald Pollack, a renowned contemporary artist, 2nd - $600, 3rd - $250; please include an english-language script if there is any untranslated speech in the video. Note that while the quality of the video, editing, etc is appreciated, the content of the video will be more important. Do not worry if your video is not a 'professional' production.

Best Photograph, Poster, or Drawings. Awards = 1st - $850, 2nd - $400, 3rd - $250.

Please include any necessary descriptions, explanations or translations with the submitted material. Materials do not have to be in english, but a translation is required on a separate piece of paper.

Photo 3. Roadside stabilization with vetiver grass includes protecting culverts from scouring. Photo taken at one of Dr. Yoon's demonstration areas.

Photo by James Smyle

Best Proven Approaches for Extension/Technology Transfer. Awards = 1st - $500, 2nd - $300, 3rd - $200, 4th - 5 awards of $100 each.

Tell us your story of how you have been successful in promoting and extending the use of contour barriers of vetiver grass so that we can pass it on to other extensionists. Please include photgraphic evidence and testimonials from farmers/users in your area.

Farmer Awards

These awards will be given out to farmers who are using vetiver grass hedges and have sufficient experience to be able to discuss what they are doing, tell how they work with other farmers and/or report other farmer's opinions of what they are doing, give their honest opinions of vetiver's strengths and weaknesses, and recommend to us what we should be telling other farmer to convince them to give it a try. The form provided on the back page of the Newsletter may be used and/or a voice recording of the farmers with an english translation; photographic evidence should, if at all possible, be included. **Awards = 1st - $300, 2nd - $200, 3rd - 10 awards of $100 each.**

First International Vetiver Workshop

A jointly sponsored Rubber Research Institute of Malaysia (RRIM) / World Bank workshop was held between April 13 and April 16, 1992 in Malaysia at the RRIM Experiment Station at Selangor Darul Ehsan near Kuala Lumpur. Some 85 persons from nine countries — Australia, China, India, Malaysia, New Zealand, Sri Lanka, Thailand, the USA and Viet Nam - representing government, public and private research institutions, development agencies, and field practitioners attended. Only 5 formal papers were presented at the Workshop with most of the time devoted to field visits showing the practical applications of vetiver grass for soil and moisture conservation. Dr. P.K. Yoon of RRIM, who should be familiar to Network participants as the person whose work received the first place Vetiver Award last year, personally organized the workshop.

The main presenters - **Drs. G.M. Bharad (India), M. Materne (USA), P. Truong (Australia), P.K. Yoon (Malaysia) and Zhang Xinbao (China)** - paper's are excerpted in this Newsletter where appropriate. Newsletter #6, in which the work of the recipients of the Vetiver Awards was published, contains either all or part of some of the presentations, therefore only that information not to be found in #6 is presented here.

In addition to the main presenters short talks were also given by a representative of the **Golden Hope Plantations/Malaysia, Mr. John Greenfield** (the initiator of the vetiver system), **Mr. Richard Grimshaw** (Chief, Asia Technical Agriculture, World Bank), and **Dr. S.L. Seth** (Additional Commissioner Watersheds/ Ministry of Agriculture, India).

Ad Hoc Trials On Vetiver - Presented at Vetiver Workshop

The following article contains excerpts from the paper pre-

Table 1. Effect of fertilizer and spacing on vetiver -- Tops (gm, dry wt.) per 10m of hedgerow

Spacing (cm)	Month after treatment 1	2	3	5	6	7	8	10	12	13	15
15	176a	449a	475a	370a	745a	855a	666a	1568a	2285a	1777a	2021a
30	90b	238b	282b	312a	598b	742b	663a	1481b	1889b	1594a	1967a
60	42c	130c	180c	191b	388c	472c	438b	911b	1261c	1136b	1438b
s.e. (+)	6.93	17.5	21.7	23.5	41.7	37.3	36.7	82.0	100.6	105.9	116.8
LSD(P<0.05)	21	53	65	71	126	112	111	247	303	319	352
Fertilizer											
F1	94	221b	257b	254b	498b	622b	561a	1318a	1735a	1465a	1747a
F2	111	324a	368a	327a	656a	758a	616a	1322a	1889a	1540a	1870a
s.e. (+)	5.7	14.3	17.7	19.2	34.0	30.5	29.9	66.9	82.1	86.5	95.3
LSD(P<0.05)	-	4.3	53	58	103	92	-	-	-	-	-

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

Treatments	Gap distance (cm) 10 mths	12 mths	13 mths	Gap reduction (cm) 10-12 mths	12-13 mths
30 cm F1	16.8 b	16.2 b	15.3 b	0.6 b	0.9 b
30 cm F2	15.7 b	15.1 b	14.3 b	0.7 b	0.8 b
60 cm F1	44.3a	42.8a	41.3a	1.5a	1.5a
60 cm F2	43.6a	42.2a	40.7a	1.4a	1.5a
se (+)	0.50	0.44	0.39	0.12	0.15
LSD (P<0.05)	1.6	1.4	1.2	0.4	0.5

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

Table 2. *Effect of fertilizer and spacing on vetiver - interclump gaps.*

sented by **Dr. P.K. Yoon** from the Rubber Research Institute of Malaysia at the recent Vetiver Conference in Malaysia. A more complete presentation of Dr. Yoon's work was printed in Vetiver Newsletter #6 in "Excerpts From A Look-See At Vetiver Grass In Malaysia - First Progress Report". The following presents only the information not found in Newsletter #6.

The Effects of Spacing Cum Fertilizer On Growth Of Vetiver Hedgerows

Treatments testing three spacings (15cm, 30cm, and 60cm) x two levels of fertilization (F1 - one 6 gm Kokei fertilizer nugget at 0, 4, and 8 months, followed by one 15 gm Field King fertilizer nugget at 12 and 15 months; F2 - same as F1 except three Kokei nuggets used at 0, 4 and 8 months and two Field King at 12 months and three Field King at 15 months). Assessments of dry matter were based on production from tops cut above 40 cm Table 1), gap measurements (Table 2) were begun at month 10 (due to staff constraints) at which point it was not possible to measure the gaps in the 15 cm treatments as the error in measurement would have been too great.

Results and Conclusions

This exercise was not designed as a proper trial and therefore the conclusions are tentative. Additional fertilizer seemed to have an effect on dry matter production in the early months, but the higher level did not produce any increase later. Spacing plays a bigger role in dry matter production; the wider spacing produces significantly higher dry matter per clump. The reverse was noted in dry matter production per linear distance reflecting the interaction of individual plant growth and the planting density. There is a time x density change which will only be apparent if the trials are carried out over a long period with time sequence studies. Time x density changes and dry matter yield will be affected by the vigour of planting materials. This information is useful in the establishment of Vetiver for : i) production of fodder and ii) production of source materials for paper pulp.

Competitive Effects of Vetiver and Other Weed Species on Rubber

In rubber plantings much effort and cost have been expended to control weeds. This study attempts to quantify the depressive effect of weeds if they were left unattended.

Trial 1

A trial was conducted on the competitive effects of vetiver and other weed species on the growth of rubber clone RRIM 901 at the Rubber Research Institute Experiment Station, Sungei Buloh, Malaysia. The rubber plants and weed species were planted in perforated polythene bags, 95 x 150 cm filled with 256 kg of Sungai Buloh series soil which is sandy in texture. Of the grasses tested, all effected both the growth (girth) and dry matter production. Reductions in girth, compared to the control, ranged from 8.2% with *Imperata cylindrica* to 26% with *Pennisetum polystachion*; vetiver reduced girth by 14.9%. Other species tested were mixes of *Eleusine indica + Paspalum conjugatum* (12.4% reduction) and *Ottochloa nodosa + Ischaemum muticum* (18.1% reduction). Dry matter reductions, compared to the control, ranged from 27.2% with *Imperata cylindrica* to 53.2% with *Pennisetum polystachion*; vetiver reduced dry matter by 37.7%%. The other species reduced dry matter by 28.5% and 44.4% for *Eleusine indica + Paspalum conjugatum* and *Ottochloa nodosa + Ischaemum muticum*, respectively. This severe reduction in growth of rubber was due to the competitive effect of the roots of weeds which were confined within the limited area of the polythene bag.

Trial 2

In the field trial at Sungei Chinoh Estate, Perak, Malaysia, vetiver was planted around 2 whorl rubber buddings of clone RRIM 937. The results showed at 6 months that vetiver reduced the girth of rubber 14.2%. This could be due to the massive roots, and the erect and tall Vetiver which shaded the rubber plants. Further recordings were taken at 14 months. During this period from 6 to 14 months, the

vetiver was slashed three times at 50 cm height and the leaves were used as mulch. At 14 months, Vetiver was less competitive and rubber girth was reduced by only 8%.

In these two experiments, the competitiveness of vetiver to rubber was more severe in the polythene bags than in the field because of the confinement of roots within the polythene bags. In the field, the rubber roots will outgrown the root zone of the Vetiver. Manuring will be difficult if the Vetiver are planted too close to the rubber plants. Slashing of Vetiver to prevent shading of young rubber and mulching will benefit the growth of rubber.

Use of Vetiver Grass As In Situ Mulch In Rubber Plantings

Trial 1

Alternate plots of (linear) plantings of vetiver hedgerows and a leguminous ground cover were planted in early 1991 on a large scale (with 3 replicates) to compare mulching with vetiver grass to normal estate practices. The vetiver was slashed twice to provide mulch, viz. July and October 1991. To date, data analysis suggests that there are no significant differences between a vetiver mulch and a leguminous ground cover on rubber growth at 5 months. At 11 months, in one of the three blocks, the mulching showed effects on average tree girth (a 9.1% increase) and tree girth increment (a 22% increase). The trial is continuing.

Trial 2

A randomized block experiment with 4 treatments x six replicates of :

T1 - Control, normal estate practice with leguminous ground covers

T2 - Vetiver hedgerow, 15cm spacing

T3 - Circular planting of vetiver around trees, 61cm radius

T4 - Circular planting of vetiver around trees, 46 cm radius

After the 6 months growth, the girth measurements of rubber showed that producing mulch from the hedgerow (linear) planting of Vetiver resulted an increase in the mean tree girth by 5.8%, 10.1% and 14.7%, respectively, compared to T1, T3 and T4. Mean girth increment was increased 14.3%, 24.4% and 30.2% by mulching from the hedgerows versus T1, T3 and T4, respectively. The 46cm radius planting seemed to be growth depressive. These results are only tentative at this early stage. This trial continues.

Diseases of Vetiver

In Newsletter #6, it was reported that a fungus, *Helminthosporium sp.*, had been found on vetiver, since then that fungus has been reclassified as a *Bipolaris sp.* or, specifically, *Bipolaris maydis* (Nisikado and Miyalce) Shoem. In Malaysia this fungus is not considered an important plant pathogen; though it is recorded on maize, which is not a major Malaysian crop. Additional observations on the (previously reported) *Curvularia sp.* and *Nigrospora sp.* (not common) infections have shown that the fungi occur only in wounded portions (cut ends, pinpricks, etc), therefore they are considered as secondary invaders.

In February 1992, the leaves of some vetiver plants in a crowded nursery were observed to be covered with dark powdery fungal colonies which could be easily peeled off. This fungus has been identified as *Meliola sp.* a fungus belonging to a group commonly known as sooty molds. Meliola species are described as common in the tropics, generally occurring in the crowded and shady conditions where the plants are found. Severe attacks can be detrimental through covering over the leaf surfaces and thus reducing photosynthesis.

Control of Noxious Weeds In Vetiver Hedgerows

Weeds grow luxuriantly under Malaysia's high rainfall, temperature and humidity, making their control necessary in situations where severe infestations would result in poor vetiver hedgerow establishment. Based on ad hoc experiments in the establishment of Vetiver hedgerow, the various

Table 3. *Herbicides and rates of application for control of some weed species in vetiver hedgerows.*

Weeds	Herbicides	Rates
Chromolaena odorata (Siam weed)	Ally 20 DF	150 g/ha
	2,4-D Amine	1.50 l/ha
	Starane 200	1.25 l/ha
Mikania micrantha	2,4-D Amine	1.00 l/ha
	Starane 200	0.50 l/ha
Pueraria phaseoloides	Ally 20 DF	100 g/ha
	Starane 200	0.375 l/ha
Asystasia intrusa	2,4-D Amine	0.50 and 1.50 l/ha
	Starane 200	0.3 l/ha

herbicides and rates recommended to control various common weeds are shown in Table 3.

Qualitative Experience With Vetiver In Louisiana - Presented at the Vetiver Workshop

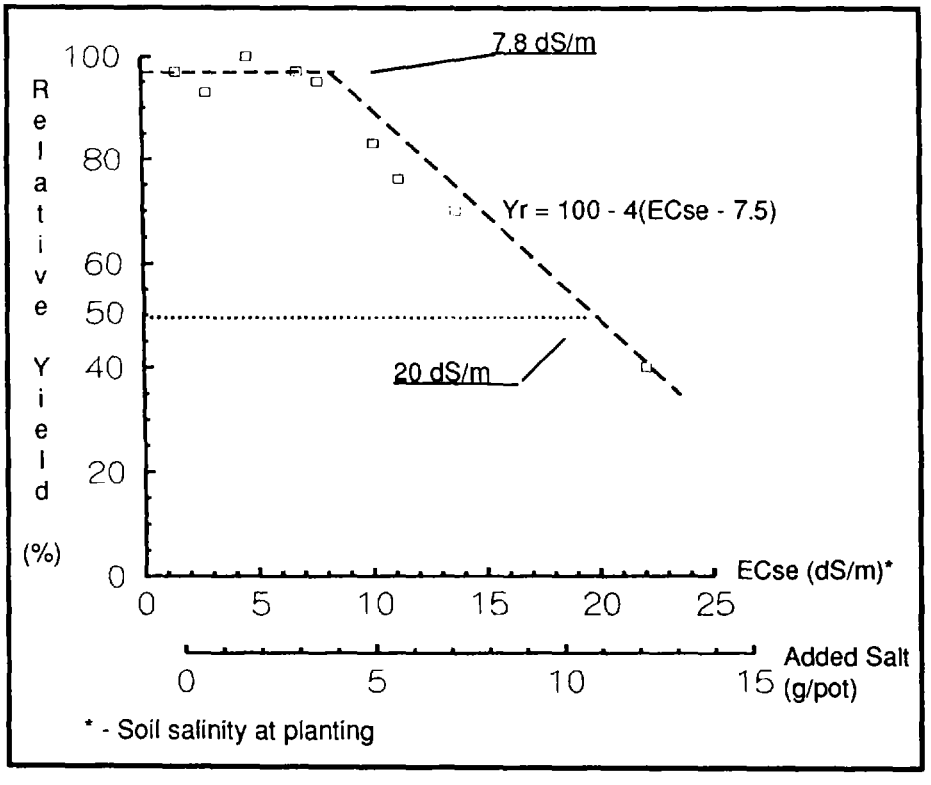
The following article is a summation of **Mr. Mike Materne's** presentation at the recent Vetiver Conference in Malaysia. Mr. Materne is with the United States Department of Agriculture's Soil Conservation Service in Baton Rouge, Louisiana.

"Though vetiver grass has been in Louisiana for over 100 years, it is just in the last 3 years that we have begun to look at it as a soil conservation species for what we refer to as "stiff grass" hedgerows. Our early field trials were conducted to look at vetiver grass' environmental tolerances — its water, nutrient and soil needs, primarily. Though we have had access to a number of vetiver accessions from India through the Soil Conservation Service's Plant Materials Centers, the accession which we have been using in our field trials is the "Sunshine" vetiver from Sunshine, Louisiana. This particular accession was obtained from **Mr. Eugene LeBlanc** whose family has grown vetiver for generations."

"Our field testing of vetiver hedgerows has been mostly carried out with the military. Vetiver hedgerows have been established by the SCS to test their ability to control gullies and arrest sediment flows in a tank testing ground at Ft. Polk, La. Planted in May 1990, the hedgerows have established well and begun to trap sediments. During 1991 we had record rainfall (wettest year on record) and under these extreme conditions the structural integrity of the vetiver hedges in the active drainageways has not been compromised — more than 50 cm of sediments have built up behind the hedges despite their not being fully closed yet. Based on our three years experience we can say that vetiver grass has performed well up to our expectations."

"We can definitely say that vetiver grass is hydrophytic, but also grows well under the extremes of dry conditions found in Louisiana. Vetiver's main drawback is that it is not sufficiently cold tolerant to be useful across Louisiana, or the majority of the United States. Based on work by **Dr. Gill Lovell** at the Agricultural Research Service, the threshold value for vetiver appears to be a soil temperature of 5°F (-15°C)."

Figure 1. Salinity response for Vetiver grass.



Salt Tolerance of Vetiver - Presented at the Vetiver Workshop

The following article contains excerpts from the paper presented by **Dr. Paul Truong** at the recent Vetiver Conference in Malaysia. Dr. Truong is from the Queensland, Australia's Government Department of Primary Industries. The piece below is a summary of Dr. Truong's latest efforts on the saline tolerance levels of vetiver. A presentation of his earlier work was printed in Vetiver Newsletter #6 in "Excerpts From Effects of Soil Salinity On the Establishment and Growth of Vetiveria zizanioides". The following presents only the information not found in Newsletter #6.

Background and Method

In the previous series of trials, the effects of soil salinity on Vetiver were studied under an open system where water with various saline concentrations was used to irrigate the plants and excess water was drained off. Although weekly flooding was carried out to minimize salt accumulation in the soil, there were some doubts as to the critical saline values obtained from the trials.

This series of experiments was carried out under a close sys-

tem to overcome those doubts. The same soil and the same saline water were used and the range of soil saline levels were obtained by adding appropriate quantities of saline water to the soil. After drying out the soil was thoroughly mixed, fertilizer added, repotted in a strong plastic bag, and brought to approximately field capacity soil moisture levels before planting. The pots were weighed and brought back to field capacity soil moisture levels daily using de-ionized water. After 12 weeks of growth, plant tops were harvested.

Results

Figure 1 shows the relationship between relative yield and soil saline level at planting. The critical level was approximately 8 dS/m and the 50% yield reduction level was at 20 dS/m which is within the range obtained by the last series (15.5 to 24 dS/m). This trial confirms the findings of the previous series and using the US Saline Laboratory standards, Vetiver can be used on moderately saline (4-8 dS/m) and very saline (8-16 dS/m) soils.

In another trial where saline water was added to fully established plants results indicate that Vetiver growth was not significantly affected within the range of soil saline levels between 4.6 and 10.5 dS/m. This again confirms the results of the last trial.

Vetiver Grass In P.R. China - Presented at the Vetiver Workshop

The following article was presented by **Dr. Zhang Xinbao** at the recent Vetiver Conference in Malaysia. Dr. Zhang, of the Chengdu Institute of Mountain Disasters and Environment of the Academica Sinica and Ministry of Water Conservancy, heads China's Vetiver Information Network.

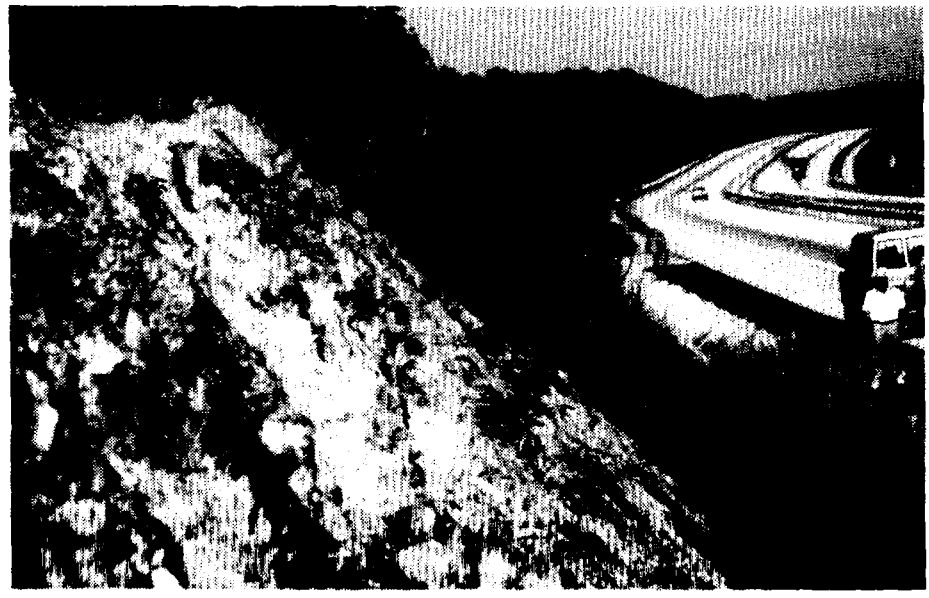


Photo 4. *Along the North-South Highway in Malaysia, Dr. Yoon is carrying out trials on the use of vetiver hedges to stabilize road cuts. In this area high rainfall results in soil "blow outs". The control area in the foreground of the photo is rapidly degrading while the vetiver plot on the far side remains stable.*

China has 22% of the world's population, but only 7% of the world's arable land. Not only the flat Valley plains, but also many hill slopes have been exploited for cultivation in upland regions in China. The extensive cultivation brings about severe soil erosion problems; a considerable amount of cultivated slope land has been degraded into bare rock slopes. Protecting cultivated slope land has priority over other aspects of soil conservation in China and traditional terraces are still the principal practice against soil erosion. Terraces require heavy labour and are very costly to build. For steep slopes (>20°), farmers do not like to adopt terraces because the terrace walls will occupy too much land; they are anxious to seek other cheap and reliable techniques to protect cultivated slope land against soil erosion.

Many thanks to Mr. Richard Grimshaw, who introduced the Vetiver Grass hedge technique into China in 1988 and promoted the technique to farmers and officers at all levels. Since then, the technique has been spread over 8 provinces in Southern China. Here, I briefly describe the application and dissemination of the Vetiver Grass hedge technique in China.

Biological Behavior

Temperature. Vetiver Grass has been planted experimentally in 9 provinces of Southern China and in 4 provinces of Northern China. The grass grew well during the summers in both Southern and Northern China, but it could not survive the cold winters in Northern China. Observations show that the grass sprouted when mean daily temperature was >12° C, grew normally at >17° C, and grew fast at >25° C. The grass could survive slight frosts and snows, but it died out whenever the soils froze. The subtropical climate of southern China up to the Yangtze River is favourable, but the temperate climate of Northern China is not.

Soil The grass has grown normally on various soils and with pH ranges from 5.0 to 8.5 — such as red soil, yellow soil, paddy soil, alluvial soil, and lithological soils. Fertile loams and sandy soils are the most favourable. Where soils are sticky or shallow and underlain by

hard bedrock, the grass grows slowly in the first year as the root development is difficult under those conditions; but it grows much better in the second year. Soil fertility has a great effect on the grass growth. For example, after one years growth a clump of vetiver grass had 30 to 50 tillers (on a lithological soil of weathered granite in Fujian) with fertilization, but only 10 to 15 tillers without fertilization.

Moisture Vetiver grass persists well under very dry soil conditions. The grass survived dry seasons without watering during 1990 and 1991 in the dry and hot valley of Yuanmou in Yunnan Province. The annual precipitation and average temperature there are 613.0 mm and 21.9 °C, respectively, and only 14% of annual precipitation occurs during the dry season (from November to May). The grass also grew well under very wet soil conditions based on observations in a vetiver grass nursery located on very wet land and surrounded by rice fields in Dujiangyan City, Sichuan.

Pests and Diseases Paddy borers were reported in all planting places in Southern China. In the worst case, about 39% of the grass was effected by the borer. In the drier and hotter valley regions of Yuannan, the borer problem was not severe. Armyworm has been reported to occur in the humid and mild springs of Kuizhou and Sichuan. Both problems were controlled by using pesticides. A smut was found growing on vetiver this autumn in the garden of the Chengdu Institute of Mountain Disasters and Environment.

Photo by James Smyle

Photo 5. *A hillside road in Malaysia stabilized by vetiver hedges. The hedge, in controlling runoff over road's edge, has protected the entire surface to the extent that native grasses are establishing themselves evenly across the road. Photo taken at one of Dr. Yoon's demonstration areas.*

Nursery Practices

Nurseries are usually set up on fertile land of sandy soil or loam with reliable irrigation. Manure is commonly used as a base fertilizer. Slips with 2-3 tillers are planted in a ploughed furrow that is 15-20 cm deep. Planting density is 30x40 cm or 30x30 cm. One mu (.067 ha) of nursery needs about 250 kg of planting material. After the planted slips begin to turn green, human waste or nitrogenous fertilizers are used as top dressing. Survival rates varied from 45-95% in 1990, mainly depending on temperature and soil moisture conditions. Analyses of observational data from various places showed that vetiver grass should be planted when the mean daily temperatures are higher than 15° C. In 1991, the survival rates of vetiver in most nurseries was higher than 90%. In Deyang, Sichuan vetiver was split and replanted 4 times in 1990. The original 2 mu (.13 ha) nursery was enlarged to 10 mu (.67 ha) and 15 tons of planting material was produced from 250 kg. The nursery reported that, once established and growing vigorously, the grass was kept pruned back to 50 cm to promote tillering. In Chongren, Jiangxi Mr. Zhou has successfully used stem cuttings to multiply vetiver grass.

Application and Dissemination

Vetiver Grass was first introduced into Hainan Island from India as a perfume oil plant in the 1950's. It subsequently was planted in Fujian, Guangdong and Zhejiang provinces for this purpose, however, farmer interest declined as root prices were low. Since 1988 the technique of using vetiver for soil conservation has spread over the 8 provinces of Southern China, with support from the World Bank, Water Conservancy Ministry, Agriculture Ministry and local governments. The first field workshop of Vetiver Grass in China was held in Saowu, Fujian, in October 1989. In the workshop, two Ministries decided to set up a 'Vetiver Grass Network" based at the Chengdu Institute of Mountain Disasters and Environment. The Network has 150 members now, and has edited and published 9 newsletters.

Vetiver In Fujian and Jiangxi

In Fujian and Jiangxi, under the World Bank-financed Red Soils Project about 1000 hectares of arable land, mainly valuable tea and orchard terrace land, have been protected by using vetiver grass hedges; scarcity of planting material has constrained

Water (%)	Ash (%)	Raw Fat (%)	Raw Protein (%)	Raw Fibre (%)	Other (%)
78.7	1.8	0.4	3.3	7.1	8.8

Table 4. Nutritional analysis of vetiver grass from P.R. China.

this effort. The grass has mainly been planted on terrace edges to strengthen earth banks. Farmers have used grass cuttings as a mulch in their orchards. Vetiver grass hedges have also been successfully used to control slope failures in weathered granite hills (a mixture of water erosion and gravitational erosion) in Xingao County, Jiangxi. Contour hedges were planted on bare slopes of the loose weathered granite as a pioneer species to provide stability. Afterward, trees were planted on the accumulated soils captured by the hedges and by year 3 the previously bare slope was totally covered with young pine trees, various shrubs and grasses. Farmers have also successfully used vetiver hedges to protect canal banks.

Vetiver In Sichuan Province

In 1989 Sichuan Province received 20 kg of vetiver grass from Jiangxi. It was experimentally planted In four counties and grew well. In 1990, 12 tons of planting material obtained from Fujian was planted in 6 nurseries across the province and 200 tons of planting material were produced by spring of 1991. In April of 1991 a Vetiver Grass workshop was held in Sichuan. At the workshop, the Provincial Soil Conservation Department decided to set up twenty mu (1.33 ha) of trials in the hill and mountain areas of eastern Sichuan. Most of the vetiver grass hedges were planted on terrace edges to protect them; cuttings from trial areas are now being used to feed cows and fish. Additionally, vetiver grass hedges have been successfully used to stabilize roadsides and irrigation ditch banks.

Vetiver In Yunnan Province

In Yunnan province, vetiver grass was experimentally planted in the dry and hot valleys of Yuanmou and Dongchuan in 1990. It tolerates the dry climate well. Two nurseries of 10 mu (.67 ha) were set up in 1991 and trails on protecting cultivated slope land without terrace and of controlling severe soil erosion on bare rocky slopes in debris flow gullies will be initiated in 1992.

Vetiver In Hunan, Guizhou, Zhejiang and Guangdong Provinces

In Hunan, Guizhou, Zhejiang and Guangdong, vetiver grass has been experimentally planted and growing well since 1990. Nurseries to multiply the plant for trial plantings have also been set up in each. In Hunan, a trial was set up to use vetiver hedges to control severe soil erosion in tea oil (camellia) orchards.

Ecological & Economic Benefits

In Jianyang, Fujian two runoff plots were set up on cultivated land with a slope of 30° to test soil and water conservation benefits of vetiver grass hedges. The experiment ran from May 1990 to September 1990. The treatments were cultivation up and down slope with a sweet potato crop and the same treatment, but with three across slope vetiver hedges. Each plot was 20m in length and 5m in width. Data showed that water and soil losses decreased 56% and 95%, respectively, from the vetiver.

In Anqi, Fujian, vetiver grass hedges were planted in April 1990 on 2 ha of nearly bare slopes of weathered granite to control severe sheet and rill erosion. The vertical interval between adjacent hedges was 2 m, slopes were 10°. Two years later, comparing data from the two runoff plots (1 control plot, 1 vetiver plot) showed that water and soil losses decreased 25% and 70% from the vetiver grass plots.

Cost data from Sichuan shows that the cost of terracing cultivated slope land is about 300 Yuan per mu (about US$ 825/ha). It is only about 60 Yuan per mu (about US$ 165/ha) using vetiver grass hedges.

Direct economic benefits from Vetiver grass may the crucial factor of whether farmers adopt the grass hedge technique for soil conservation in China. Young cuttings of Vetiver grass have been used to feed cows, goats, pigs and fish in China. Nutrition analyses show that the cuttings are good livestock fodder (Table 4). In 1990, the Pinshan Soil Conservation Station, Pinshan, Sichuan, used Vetiver grass cuttings as fish fodder and produced 1396 kg of fish with 5 tons of vetiver grass and 2 tons of rye grass. In 1989, fish production of the station was 1156 with 6.5 tons of rye grass. The Vetiver grass nursery in Deyang, Sichuan sold young cuttings of vetiver grass to a milk cow farm in 1990. The price was 0.1 Yuan per kg (US$ 18.4/ton) of young cuttings. It is estimated that the vetiver grass hedges in 1 mu (.067 ha) of cultivated slope land (about 200 m in length) can produce 500 to 1000 kg of young

cuttings. It means that farmers can get 50-100 Yuan per mu (US$ 9.2 to 18.4) from vetiver grass hedges. It was reported from the Red Soil Project that Vetiver grass cuttings were used as a mulch material instead of rice straw in orange orchards; this would equal a saving of about 100 Yuan material costs per mu for the orchards (US$ 275/ha) if vetiver hedges planted in the orchards supplied the mulch instead.

Discussion

From present experience, the following points can be made regarding vetiver use and adoptability by farmers. First, the problems with adoptability are that the farmers are not yet very interested in Vetiver Grass hedges in some areas because : i) vetiver grass is not a high value plant and land for cultivation is very limited; and ii) crop yield does not appear to increase in the first year, though it will apparently increase from second year.

Second, I think that without subsidies the technique would be mainly applicable to : i) protection of cultivated slope lands in remote mountain regions where cultivable land resources are not too limited; ii) to control severe soil erosion in areas too difficult for other soil conservation practices, such as the granite mountain and hill regions in Southern China and the dry and hot valley regions in southeastern China; and iii) to protect banks of canals, ditches, roads, highways and railways as a bio-engineering method.

Finally, I think that Vetiver grass hedges can be considered as part of an ecological agriculture system in the mountain and hill regions of southern China. The hedges can protect cultivation land, the young cuttings of vetiver grass and crop straws are used as livestock fodder/bedding, and the livestock manure is returned to cultivation land. I propose to set up an experimental vetiver grass eco-agriculture demonstration farm. If it succeeds, vetiver grass hedges will have a bright future for protecting cultivated slope land in most of the mountain and hill regions in China.

Golden Hope Plantation's Vetiver Experience - Malaysia - Presented at the Vetiver Workshop

The following article by **Drs. Khairudin Hashim, C.H. Teoh and Ismail Hamzah** was presented at the recent Vetiver Conference in Malaysia.

This paper reports early experiences on the utilization of vetiver for erosion control in Golden Hope plantations. Our interest in vetiver grass was aroused by the World Bank's handbook: "Vetiver Grass - The Hedge Against Erosion". Planting materials were obtained locally from Ciba-Geigy and the Malaysian Agricultural Research and Development Institute (MARDI). Slips in small polybags were obtained from Ciba-Geigy (4 slips total) in December 1989 and MARDI (12 slips total) in May 1990. These 16 pieces of materials were multiplied by conventional and micropropagation techniques for planting on our estates for erosion control. In September 1990, 2 slips of vetiver from India referred to here "India grass" were received from Mr. R.G. Grimshaw of the World Bank; they are currently under multiplication. If our work confirms vetiver to be cost-effective, commercial scale planting could be considered in estates where soil erosion is likely to be a problem

Early experience with conventional propagation revealed that vetiver from CIBA-GEIGY and MARDI multiplied at about similar rates as shown in Table 5. The materials were raised in cylindrical plastic containers 27.5 cm in diameter and 30.0 cm in height. For the low moisture regime, two holes were made at the bottom of the containers while for the high moisture regime the two holes were located on the sides at 10 cm from the bottom of the containers. The soils used were Munchong series and the vetiver plants were fertilized once with Nitrophoska Yellow (15:15:6:4) fertilizer at 5g/container two weeks after planting. There were no differences in multiplication rates of vetiver grown between different moisture regimes or the two sources. This was not unexpected as Ciba-Geigy materials suppos-

Table 5. Multiplication rates of vetiver from two different sources in Malaysia

Source	Moisture Regime	No. of tillers 21 days	47 days	101 days
Ciba-Geigy	Low	3.8	11.7	32.7
	High	4.4	10.7	30.6
MARDI	Low	2.7	8.2	27.3
	High	3.3	11.2	30.3

Soil Condition	No. of tillers 5 months	8 months
Subsoil	4.8	7.6
Topsoil	4	29.1

Table 6. Multiplication rates of vetiver under two soil conditions.

edly originated from MARDI.

No direct comparison was yet been made between MARDI and India grass as the latter was acquired much later. We were more interested in multiplying them to serve as stock materials. After one year, the two slips have been multiplied to 1,134 slips and outplanted in the ground. India grass was observed to be very vigorous, it also has several different characteristics from the MARDI vetiver. Its leaves are bluish green and it readily produces culms (ed. note: culm = a stem with joints) whereas the MARDI vetiver possesses green leaves and does not produce culms as readily.

As we are using vetiver solely for erosion control we have resorted to minimum inputs in our approach to establishing vetiver hedges. A comparison of the multiplication rates of vetiver under two soil conditions viz. subsoil by the edge of a road and on a topsoil as a fence around a nursery, are recorded in Table 6.

Initial growth was slow in both soil conditions, however, the rate of tillering increased markedly at the eighth month in the vetiver grown on top soil as compared to that grown on sub-soil. It was seen that our planting of single slips at 50 cm proved too far apart to form a rapid continuous hedge. From this, it is obvious that the planting interval of 10 - 15 cm recommended by the World Bank would be more appropriate to achieve quick hedge formation. The closer planting intervals should be considered for sub-soils or poorer soils. Use of multiple slips could ensure even more rapid closure of the hedge.

In establishing a vetiver nursery using slips, weeds were seen to overwhelm the grass. As manual weeding is both laborious and expensive, a trial was undertaken to determine six herbicides for eradication of broadleaf weeds (*Mimosa invisa* and *Boreria latifolia*) and grasses (*Paspalum conjugatum* and *Axonopus compressus*) growing among vetiver. Herbicides were applied using a knapsack sprayer at an equivalent 400 litres of spray solution/ha. Metsulfuron-methyl provided the best control of broadleaf weeds with no effect on vetiver and grasses. Acceptable kill of *B. latifolia* was obtained with bentazon, 2,4-D amine and fluroxypyr, however, they were ineffective on *M. invisa* and grasses. Glyphosate was effective on grasses while fluazifop-butyl was only effective on *P. conjugatum*. Unfortunately, both were phytotoxic to vetiver, particularly glyphosate. It is of interest to note that in the treatments where glyphosate was applied immediately after trimming of the vetiver good control of the other grasses was achieved with minimal scorching effect on vetiver.

Using the micropropagation technique, vetiver was multiplied and supplied to 12 Golden Hope estates in peninsular Malaysia and Sabah. The significant advantage of the micropropagation technique is that large numbers of plantlets could be obtained within a short time and furthermore, production of plantlets may be regulated or programmed according to demand. Using internodal stem cuttings of matured tillers, the rate of multiplication is from 8 to 16 fold within four weeks. Thus, if one begins with 1,000 shoots initially, within four weeks the total number of shoots available would he between 8,000 to 16,000 shoots. Once the base number of shoots for subculturing is available, it would be a matter of growth room space and demand that would determine the volume of production necessary for a particular month.

Although vetiver could be propagated from stem nodal cuttings by conventional means the rate of lateral shoot development is slow compared with micropropagation. The percentage of lateral shoots from such cuttings after four weeks is about 70%, and root formation is sparse. By the in vitro method roots are usually readily formed within two weeks after the multiple shoots have been transferred from the multiplication stage to the rooting medium. Once they are removed from the rooting medium and transferred into polybags vigorous growth occurs and the survival rate is almost 100%.

For long distance transportation vetiver plantlets are sent out as bare rooted material from the production centre to the site of nursery establishment. The shoots are usually removed from the rooting medium and wrapped with moist paper towels. So far we have successfully established vetiver grass on estates in Sabah via this method. The establishment success was reported to be almost 100%.

To date, more than 14 km of vetiver hedge have been established for erosion control. Growth of vetiver has been satisfactory and they are performing as expected. The labour cost for field planting of

Using internodal stem cuttings of matured tillers, the rate of multiplication is from 8 to 16 fold within four weeks. Thus, if one begins with 1,000 shoots initially, within four weeks the total number of shoots available would be between 8,000 to 16,000.....

vetiver in small polybags into the field was about $99 per 100m of hedge (about US$40). However, using bare root slips from established stocks, the field extraction and planting costs was $47.50 per 100m of hedge (about US$19).

Acknowledgement

The authors would like to thank Golden Hope Plantations Berhad for permission to present this paper. We would like to record our appreciation to **Mr. K.H. Yeow** of World Bank for introducing us to vetiver and **Ciba-Geigy, MARDI** and **Mr. R.G. Grimshaw** [World Bank) for providing our initial vetiver stock material.

From the International Center for Tropical Agriculture (CIAT), Cali, Columbia

Dr. Douglas Laing, Deputy Director General of CIAT writes :

In Newsletter #7 of November 1991 I promised to bring the Network members up-to-date on the research conducted at CIAT on erosion control in cassava production systems. We at CIAT have been researching this subject for many years. Recently, various initiatives have come together in a series of experiments being conducted in a collaborative project between CIAT and the University of Hohenheim. The results reported here are the work of **Mr. Martin Ruppenthal** who is about to leave CIAT to finish writing his PhD thesis in Germany.

The long-term treatments at two locations involve a series of cultural options that we have developed over the years, compared two cassava treatments viz: the system used by farmers in the region (treatment #2 -planting cassava at about 10,000 plants/ha in rows 1m apart, no other cultural practices). The other treatment (#3) is cassava planted on (about) 30 cm high contour ridges; involving a considerable amount of manual labor. Treatments 4, 5 and 6 were designed to study cover species (Zornia, Centrosema and kudzu) underplanted beneath the cassava to provide not only groundcover but soil improvement possibilities. Treatment 7 is cassava planted on the flat with elephant grass (*Pennisetum purpureum*) living barrier strips where the grass occupies about 25% of the total plot area. The advantage of this system would be that elephant grass could be used for fodder.

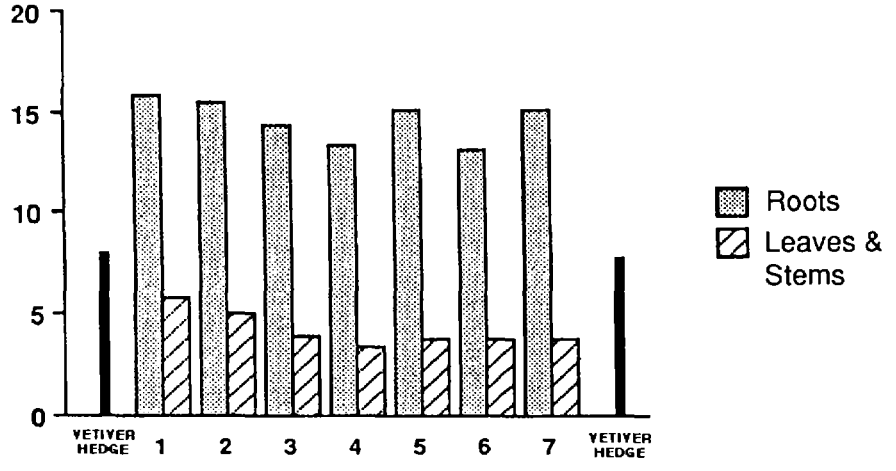
Treatment 8 is cassava planted on the flat with vetiver grass barriers occupying about 12.5% of the plot area. The vetiver grass, not the cassava, is underplanted (at the same time as the planting of the cassava) with the forage legume *Arachis pintoi*. All these treatments are compared to a clean weeded, bare fallow (treatment #1) where the soil is allowed to erode in accordance with the rainfall received.

Table 7. *Cassava and forage productivity, soil loss and runoff data for a range of cassava production systems compared to bare fallow on an Oxic Dystropept[1] at CIAT's Santander de Quilichao Station, Colombia (1,000m altitude; growing season rainfall, 10 months 1240mm)*

System	Cassava Fresh Root Yield, t/ha /2	Forage Yield t/ha	Runoff mm (10 months)	Runoff % Rainfall	Soil Loss t/ha (11 months)
1. Bare Fallow	na	na	144.0	11.6	142.0
2. Cassava on Flat Cultivation	35.7	na	46.0	3.7	8.3
3. Cassava on Contour Ridges	35 6	na	44.0	3.5	3.1
4. Cassava Underplanted with Zornia	27.2	3.4	80.0	6.5	27.4
5. Cassava Underplanted with Centrosema acutifolium	31.8	3.4	38.0	3.1	12 8
6. Cassava underplanted with kudzu	20 7	2.9	43.0	3.5	15.4
7. Cassava on Flat with Elephant Grass Strips /3	23 6	5.3	50.0	4.0	4.0
8. Cassava on Flat wilh Vetiver Grass Hedges /4	34.0	1.1	45.0	3.6	1.3

1 - Acid soil (pH 4.2), Al saturation 50-85%, low nutrient status in shallow A horizon (15-25cm); average slope 0-15%.
2 - Cassava yields for 11 months (1990-91); Vetiver plots planted one month after other treatments thus cassava yield for treatment 8 was adjusted to an 11 month basis using growth in root yield per day data available from a similar experiment on the same station in the same year.
3 - Area occupied by elepahant grass is 25% of the plot.
4 - Area occupied by vetiver grass is 12.5% of plot area; Vetiveria zizanioides was transplanted and under planted (only under grass barrier) with Arachis pintoi at time of planting cassava.

Figure 2. Cassava/Vetiver -- Contourbarrier; Yields per row (each row contains six plants) in kg of fresh roots and leaves and stems.



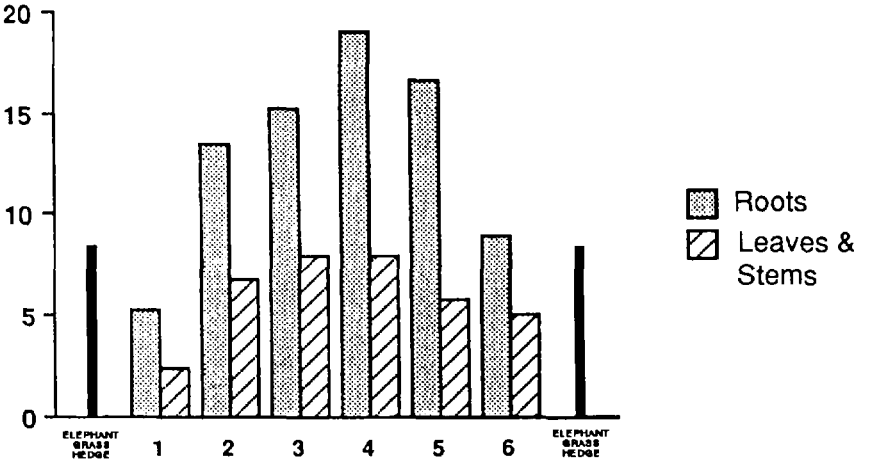
The data in Table 7 shows the final results from the first year at one site in terms of fresh cassava root yield, forage yield from the associated legume or grass species, runoff (and runoff as percentage of rainfall) and soil loss in tons of dry soil/ha over an 11-month period. The data clearly supports the view that vetiver grass is by far the best living barrier that CIAT has evaluated in the sense that the yield of cassava has not been affected, i.e. considering that 12.5% of the plot area is occupied by the grass strips, and given that the vetiver grass was only established at the same time as the cassava.

Runoff in the vetiver grass plots was extremely low representing only 3.6% of the total rainfall received and the soil loss was an insignificant 1.3 tons/ha compared with 142 tons/ha in the bare fallow plot. These results are extraordinary considering that the vetiver was only established at the same time as the cassava was planted whereas the elephant grass had been pre-established long before the planting of the cassava. The *Arachis pintoi* is now well established forming a dense mat under the vetiver grass hedge and is helping to stop erosion and presumably is providing nitrogen to the vetiver grass. As the soil and nutrients accumulate on the uphill side of the vetiver it is expected the Arachis will produce more fodder in coming years.

In Figures 2 and 3 we show the competitive effects of the two grass species on cassava in terms of per row yields at various distances from the grass strips. You can see that cassava growth was not affected by the vetiver grass whereas the elephant grass had severe competitive effects (probably root zone competition) on cassava.

We have studied the rooting pattern of the vetiver grass on an acid oxisol soil (**ed. note** - *oxisol = ferralsol in FAO taxonomy*) at the CIAT-Quilichao station. It is clear that the species has a cone-shaped root system where the major roots penetrate more or less vertically and then fan out slightly at deeper depths — in these highly aluminum toxicity-affected subsoils. Analysis of the vetiver grass roots have shown it to be extremely mycorrhizal with three fungal species identified on the same roots providing colonization levels greater than 80%. The demonstrated vigor of vetiver on very poor soils is clearly related to this phenomenon.

Figure 3. Cassava/Elephant Grass Contour barrier; Yields per row (each row contains six plants) in kg of fresh roots and leaves and stems.



The one major doubt we have with respect to vetiver is related to its palatability and digestibility for bovines. If adoption is to be successful in the region we have to find an economic use for the grass strips. We are carrying out digestibility studies (in-vitro and in-vivo) to find how vetiver grass compares with other tropical grass species in terms of some critical parameters.

Once again we have proved that there is nothing new in the world. In our on-farm research with vetiver and limoncillo we have uncovered the fact that vetiver grass

"We are convinced at CIAT, both in our on-station and on-farm research with farmers in the mid-altitude acid soil tropics, that vetiver grass is probably the best living barrier one could possibly ask for in terms of its low competitivity with the associated crop and its extremely effective erosion control ....."

(known as 'Tiva' to the local people) has been growing in the region for many years. We visited a farmer near Jamundi Valle (1000m altitude) who has planted vetiver grass around his house to stop the land from slipping away, thus stabilizing the foundation. Unfortunately, he had not planted the grass in his cassava field which is eroding very heavily nearby. Tiva has been grown in the Valle del Cauca for many years and one of the reasons it has not spread is probably because of its apparently low palatability to bovines.

In response to this we have made a small collection of some of the local vetiver grass materials that have been planted by farmers and found some variation among accessions in leaf 'softness'. Included in the above studies on digestibility is one of these 'softer' selections. If any members of the Network have comments to make on this issue we would be delighted to receive them. The accession originally obtained by CIAT for our work was found growing in the botanical garden at the National University in Palmira. CIAT now has small quantities of sexual seed of this accession if Network members are interested they should contact **Dr. M. Iwanga** (see editor's note below). Obviously we will continue to look for more such variation including material for high elevations in the tropics.

The above discussion on palatability for bovines and the possibility that there is variation within vetiver grass points to the urgent need for a breeding program devoted to this activity somewhere in the world. I would urge members of the Network to think about this and to contribute accessions from various sources to somebody who could begin a breeding program. This program would have to be associated with scientists who can measure palatability and digestibility (in-vitro and in-vivo) so that we can see if we can come up with a fodder grass which is more acceptable to animals and without losing vetiver's superb features as a hedge against erosion.

We are convinced at CIAT, both in our on-station and on-farm research with farmers in the mid-altitude acid soil tropics, that vetiver grass is probably the best living barrier one could possibly ask for in terms of its low competitivity with the associated crop and its extremely effective erosion control characteristics. Terraces are already forming behind the vetiver grass and the second year's harvest seems to be pointing toward longer term benefits. We will keep the members of the network posted on these results as they come to hand. Contacts with CIAT for the immediate future should be made through **Dr. Karl Mueller-Saaman or Dr. Mabrouk El-Sharkawy** in the Cassava Program.

Editor's Note : *The Network urges extreme caution when dealing with vetiver propagation with seed. One of the most important characteristics of vetiver grass is the fact that it can be introduced with little or no fear that it will become a weed. However, if one begins selecting for plants which are more easily established from seed, a problem may be created where one did not exist before.*

Herbicides for Vetiver Grass Control

P.E. Igbokwe. S.C. Tiwari, J.L. Burton and R.E. Waters, Jr., Alcorn State University, Larman, Mississippi.

This study investigated the efficacy of glyphosate, sethoxidim and fluazifop-p-butyl in controlling vetiver grass accession 271633 at 3 different stages of its growth in greenhouse ground-beds and in field plots.

Materials and Methods

Both greenhouse and field-experiments were used to evaluate 3 postemergence herbicides for vetiver grass control at Alcorn State University. The study investigated the effect of postemergence applications of 6.32 kg active ingredient (ai)/ha of glyphosate (N[Phosphonomethyl] glycine), 0.52 kg ai/ha Fluazifop-p-butyl ([R1-2-[4-[[5-[trifluoro- methyl]-2-pyridinyl]-oxy]phenoxyl] propanoic acid), and 1.04 kg ai/ha sethoxydim ([2]1[ethoxy-imino] butyl]-5-[2-ethylthiol propyll]-3-hydroxy-2-cyclohexen-l-one) on vetiver grass control. A completely randomized experiment design was used in this study. Herbicide treatments were either applied at one, two or three, months after the transplanting date to represent the immature, mature without seedheads, and mature with seedhead growth stages, respectively. Treatments were made with a backpack knapsack sprayer at 20 psi. Also, Ortho X-77 was used at the rate of 14.79 ml per 3.67l of solution as a surfactant for each of the herbicide treatments.

Greenhouse Experiment:

On March 25, 1991 seeds of vetiver accession 271633 were seeded in inserts containing Pro Mix BX® as a growing medium and placed on a greenhouse bench. On April 25, seedlings were transplanted into the greenhouse groundbeds with pH of 6.5. Plants, which were at 5-leaf stage with an average height of 12.7 cm, were spaced 20.3 cm within each row. Fertilization with Ca[NO3]2 was at the rate of 112.1 kg N/ha and irrigation was as needed. Visual ratings were used to determine herbicide effects on vetiver grass at one week, one month and two months after each application was made. The rating of 10 signifies complete control by herbicide,whereas 0 signifies no control.

Field Experiment

On July 29, 1991 seeds of vetiver accession 271633 were seeded as for the greenhouse study. Plots were disked, harrowed and made weed free before seedlings were transplanted one month from seeding. Transplants, which were at 5-leaf stage with an average height of 12.7 cm, were spaced 60cm x 90cm. Soil pH was 5.3. Fertilization with NH4NO3 at the rate of 293 kg/ha was based on soil test results. Moisture was limited to hand watering with can immediately after transplanting plus natural rainfall. Visual ratings were as in the greenhouse study.

Results and Discussion

For the greenhouse experiment Vetiver grass control due to herbicides applied either one, two or three months from the date of transplanting is reported in Table 8. For herbicides applied one month after grass transplanting, sethoxidim had the highest initial grass control rating of 7.9 after seven days of application. A perfect [100%] control of vetiver grass was observed for all herbicide treatments after thirty days of applications. For herbicides applied two months after grass transplanting, glyphosate had the highest control rating of 5.2, 9.9 and 10.0 after seven, thirty and sixty days of application, respectively. Such values were significantly different from values due to other treatments and the control. For herbicides applied three months after grass transplanting, glyphosate had the highest control ratings of 3.2, 9.2 and 9.9 after seven, thirty and sixty days of application. The values were significantly different from values due to other treatments and the control.

For the field experiment (Table 9), herbicides applied one week after grass transplanting, sethoxidim and glyphosate had perfect control of vetiver grass after

Table 8. *Herbicide control of vetiver grass in the greenhouse.*

Herbicide	Rate Kg ai/ha	Herbicides Applied One Month After Transplanting — Weed Control Visual Rating Periods (Days From Herbicide Applications) 7[Y]	30[X]	60
Control	0.00	0.0	NIL	NIL
Glyphosate	6.32	6.5	Perfect	Perfect
Fluazifop-p-butyl	0.52	2.1	Perfect	Perfect
Sethoxidim	1.04	7.9	Perfect	Perfect
LSD, 5%	--	0.5	--	--
C.V., %	--	8.7	--	--
		Herbicides Applied Two Months After Transplanting		
Control	0.00	0.0	0.0	0.0
Glyphosate	6.32	5.2	9.9	10.0
Fluazifop-p-butyl	0.52	2.2	8.7	8.9
Sethoxidim	1.04	1.4	8.4	8.7
LSD, 5%	--	0.9	0.6	0.7
C.V., %	--	29.6	6.8	7.3
		Herbicides Applied Three Months After Transplanting		
Control	0.00	0.0	0.0	0.0
Glyphosate	6.32	3.2	9.2	9.9
Fluazifop-p-butyl	0.52	0.6	2.6	2.8
Sethoxidim	1.04	1.6	2.6	2.8
LSD, 5%	--	0.7	2.4	0.8
C.V., %	--	36.3	48.7	15.6

[X] NIL indicates no control; Perfect indicates complete control.

[Y] Based on a scale of 0 to 10, where 0 signifies no control, and 10 signifies complete control.

Table 9. Herbicide control of field-grown vetiver grass.

Herbicide	Rate Kg ai/ha	Herbicides Applied One Week After Transplanting — Weed Control Visual Rating Periods (Days From Herbicide Applications) 7[Y]	30[X]	60
Control	0.00	0.0	0.0	NIL
Glyphosate	6.32	10.0	10.0	Perfect
Fluazifop-p-butyl	0.52	7.6	9.0	Perfect
Sethoxidim	1.04	10.0	10.0	Perfect
LSD, 5%	--	0.4	0.9	--
C.V.,%	--	6.8	3.3	--
		Herbicide Applied One Month After Transplanting		
Control	0.00	0.0	0.0	--[Z]
Glyphosate	6.32	10.0	10.0	--
Fluazifop-p-butyl	0.52	2.0	10.0	--
Sethoxidim	1.04	2.8	9.4	--
LSD, 5%	--	0.4	0.4	--
C.V.,%	--	6.8	3.3	--
		Herbicide Applied Two Months After Transplanting		
Control	0.00	--[Z]	--	--
Glyphosate	6.32	--	--	--
Fluazifop-p-butyl	0.52	--	--	--
Sethoxidim	1.04	--	--	--
LSD, 5%	--	--	--	--
C.V., %	--	--	--	--

[X] NIL indicates no control; Perfect indicates complete control.

[Y] Based on a scale of 0 to 10, where 0 signifies no control, and 10 signifies complete control.

Plants were killed by freezing temperature, hence no data collected.

one week of spray. These effects were significantly better than those due to fluazifop-p-butyl application and the control. However, control of vetiver after one month of application was not different for treated rows. All treated rows had perfect control due to herbicide applications after two months. For herbicides applied one month after transplanting, glyphosate had a perfect control after one week of application. This effect was significantly better than fluazifop-p-butyl, sethoxidim and control. After one month of herbicide application, grass control was also perfect for fluazifop-p-butyl and was significantly better than sethoxidim effect and the control. No data was collected two months after herbicide application since all plants were killed by freezing temperature. For the same reason, no data was reported for herbicides applied two months after transplanting, and no herbicide application was made three months after transplanting.

Conclusions

Findings suggest that glyphosate, fluazifop-p-butyl and sethoxidim will effectively control or surpress the growth of vetiver grass in greenhouse ground-beds and in field plots. Glyphosate which had a near complete control of mature vetiver grass with seedheads in the greenhouse is considered superior to fluazifop-p-butyl and sethoxidim at the rates of their applications in this study. A perfect control of vetiver grass can best be achieved by the application of these herbicides one month from grass emergence or earlier.

Acknowledgment

The authors wish to thank the **United States Department of Energy** and **Mississippi Department of Energy and Transportation Division, Economic and Community Development** for funding this project. Special appreciations to **Dr. Doral Kemper**, ARS National Program Leader, Soil Science, Beltsville, Maryland, and **Southern Regional Plant Introduction Station**, Griffin. Georgia for providing seeds and seedlings used to initiate this study; **Dr. Seth Dabney**, Agronomist, ARS Sedimentation Laboratory, Oxford, Mississippi, and **Mr. Thomas Collins**, Soil Conservationist and SCS Liaison to ASU for their valuable suggestions and assistance with materials for literature search: **Drs. Samuel Donald, Johnnie Collins**

and **Charles J.D. Tilman** for their encouragements: **Ms. Janice Carter** for typing the manuscript.

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Grimshaw's Remarks

(Continued from page 2)

the state of knowledge on hedgerows. The Chinese translation was done by the Middle-Reach Bureau of the Yellow River Conservancy Commission and interested individuals should contact them directly to arrange for copies."

"One last issue that I would like to bring up in this Newsletter is about where we stand today on the usage of vetiver grass. As a technology, contour barriers of vetiver grass for control of soil and runoff in farmer's fields have matured rapidly in the last few years. No longer should planners and field people who are proposing and promoting soil conservation technologies view vetiver grass as an "exception rather than a rule". Vetiver hedgerows are a proven technology that should be considered by all soil conservation agencies and agricultural projects. Where we need to get on with business is in the engineering areas — for example, stabilization of roadsides and ponds. With vetiver now engineers could construct effluent ponds on hillsides, something which has not been possible before. Another area of unexplored potential is the use of vetiver hedgerows to reduce non-point source pollution from agriculture and for the hedges themselves to help renovate runoff waters contaminated with agro-chemical residues. Preliminary work — such as that by ***Dr. Miyamoto*** *in Texas who found that vetiver, when planted in stormwater detention ponds, was a very efficient scavenger of the lead contained in urban runoff — points out that this remarkable plant has tremendous potential beyond that which we currently are trying to exploit. Let us get on with the needed work."*

"No longer should (people) view vetiver grass as an 'exception rather than a rule'. Vetiver hedgerows are a proven technology that should be considered by all...."

Letters From Vetiver Network Correspondents

HONG KONG -

Calorimetric Value of Vetiver - Dr. R.D.Hill, University of Hong Kong

From the viewpoint of farmers in developing countries, one of the objections to the use of Vetiver is that it gives limited direct return, especially from plantings for erosion control. As is well-known, vetiver is of indifferent quality as fodder for animals, fortunately so, in fact, since it proves to be remarkably persistent in the face of heavy grazing and, providing a fair stubble (20-30 cm) survives, its sediment-trapping abilities are substantially unimpaired by grazing or by cutting.

A possible alternative use of vetver is as fuel where quick heat is required, as in the traditional Chinese cooking method employing a stove fueled by dried plant materials and hemispherical iron pan (wok). Over very large areas of southern China wood, grass, fern and herbs are cut, sorted and dried for fuel; an activity that essentially maintains the vegetation as scrub and grass or fern land. In monsoonal ctimates, vetiver growth tends to slow or cease during the dry season. At this stage, when the grass becomes tough and unpalatable to animals, it is useful as a bedding material or as a mulch for crops; vetiver mulch breaks down rather slowly under dry conditions. Use as fuel is thus an alternative. This was investigated at Kadoorie Agricultural Research Centre, University of Hong Kong, employing a standard semi-micro method of analysis by bomb calorimeter. In February 1992 (dry season) samples were analysed in field condition i.e. without prior drying. The average moisture content (eight samples) was determined to be 11 per cent. Calorimetric analysis of the eight samples showed a mean gross heat of combustion of 18.6 KJ/g with a range from 19.1 to 17.8 KJ/g.

These results fall within the range of calorific values for grass, fern and herb species commonly used for fuel in southern China reported for oven-dried samples by Chen (in litt.) i.e. 21.5 to 16.5 KJ/g, with a mean of 19.3 KJ/g.

Future work will focus upon the nutrient-value of residues after

Vetiver Variety	Water (%)	Crude Protein (%)	Crude Ash (%)	Crude Fiber (%)	Ca (%)	P (%)
Fujian	43.2	0.44	4.5	22.2	0.22	0.076
Indian	39.5	0.68	4.4	20	0.18	0.068

Table 10. *Nutrition analysis of two different accessions of (dry) vetiver in China.*

burning. It should be noted also that Vetiver may be of some value as feed for grass-eating freshwater fish such as grass carp. Trials will begin shortly at the South China Agricultural University.

Acknowledgements

Calorimetric determinations for Vetiver were made by **Ms. Dorothy Yu at the** Kadoorie Agricultural Research Centre, University of Hong Kong (**Prof. D.K.O. Chan**, Director) where also the comparative determinations were made by **Mr. Chen Rongjun**.

NIGERIA -

The following contribution to the Newsletter was received from **Mr. H.S. Randev**, a Forestry Specialist now living in the United States, who worked for a number of years with the Federal Agricultural Coordinating Unit (FACU) in Kaduna, Nigeria.

Vetiver Grass Technology In Nigeria

Vetiver grass, locally named 'Jemma' grass in the Northern states, grows naturally along the rivers Niger, Benue and their tributaries especially in fadama lands which are characterized by deep heavy soils with favorable moisture conditions. In its wild state the grass grows gregariously, but is localized, in the lowlands of Bauchi, Sokoto, Gongola, Borno, Kano, Plateau, Niger and Kwara states. Recognizing its usefulness and adaptability under varied savannah agro-climatic conditions, progressive farmers in Kano, Katsina, Sokoto and Bauchi states had planted Jemma grass over the decades for boundary demarcation, not realizing that it also possesses soil and moisture conservation uses. Under semiarid and sub-humid climatic conditions, clumps sprout and attain 1-2 meters height during the rainy season spanning over 3-5 months. The vegetative growth provides animal fodder either cut and carried or grazed in the open after the agricultural crops have been harvested. During the dry season green parts are relished by cattle. When protected, they flower and form panicles 15-70 cms long which are generally sterile.

Photo 6. *A coffee plantation protected by vetiver hedges in Indonesia.* Photo Courtesy of P.C. Romkes

FACU, in cooperation with Agricultural Development Units (ADPs) initiated vetiver pilot activities in 1987. The first materials came from the Plant Introduction Bureau of the Indian Agricultural Research Institute in New Delhi. In1988, Mr. R.G. Grimshaw of the World Bank identified the local Jemma grass as *Vetiveria nigritana* which could serve equally effectively as the Indian *Vetiveria zizanioides*. During 1989 the first pilot plantings were made in farmers fields to test the effectiveness of Jemma for arresting soil erosion. To date, activities are confined to demonstrations, though farmers in the Mambilla Plateau adopted vetiver planting on a large scale. In this latter case, NGOs (mostly farmers clubs) were provided input and technical support including training in multiplication of vetiver stock for Sokoto state in 1990. As part of FACU support, information from

the Vetiver Network was summarized in the form of technical notes and distributed to ADPs for dissemination to farmers. In addition, FACU compiled a technical note on Irrigated Nursery Techniques for Vetiver Grass Multiplication.

Vetiver grass multiplication and its use in land management forms an important component under the new National Agricultural Technology Support Project", which is currently in the negotiation stage. If funded, this project would have the capacity to provide about 24 million slips for farmers field over a 5 year period in the states of Kano, Bauchi and Sokoto.

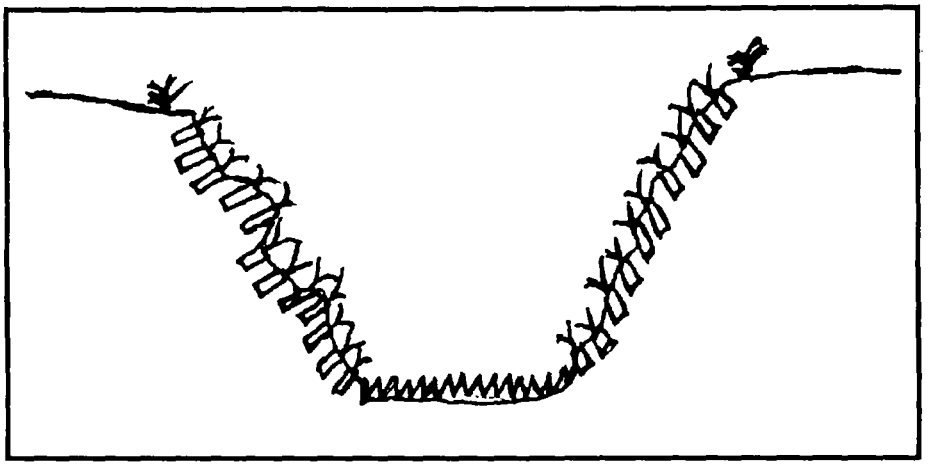

Figure 4. Mr. Jano Labat suggests that vetiver slips be plugged in to gully banks rather than trench planted. He reports that with this method there is less chance of the slips washing out before they take root.

P. R. CHINA -

Mr. Liu Zhou Lin from the Jiangxi Agricultural Development Corporation sends the Network the following information on the fodder value of vetiver grass :

"We ... collected 5 kg of leaves from each of the Indian (vetiver) variety (ed. note : this is the farmer selected variety from south India which is commonly used as a fodder grass) and the Fujian variety. We noted at the plot that the Indian vetiver is much shorter and darker green than the Fujian variety, which is tall and light green. After taking the cuttings we immediately drove to a dairy farm where we divided four dairy cows into two groups. We feed one group with the Indian and the other with the Fujian vetiver. To our surprise it seemed that the cows liked to eat it and there was no obvious difference between the cows eating of the two varieties; they ate all of both. We tried again on another farm with small amounts of vetiver given to 8 cows, only one cow refused it. I also sent samples of the two varieties to a lab for a nutrition analysis, the results are presented in Table 10."

SOUTH AFRICA -

Mr. Martin Bothe wrote to the Network to describe a unique application for vetiver grass, one which readers should note :

"I planted Vetiver right across the lowest spots within the low-lying places on my land. It was not long after that vetiver "dams" popped up and collected a lot of other grass, debris, mud, etcetera. The water which, after it works itself through the vetiver is now almost 100% clear. I also planted vetiver all across between my dykes. In such places it holds the water back long enough so that it soaks into the ground between the dykes. As a result, the water level rose in the boreholes which were drilled alongside the dykes. If people, governments, municipalities, mining companies, farmers etc. plant Vetiver my way then floods all over the world will be somewhat reduced and even avoided in many places."

Mr. Bothe included a hand drawing with his letter which shows his planting configuration, with the rows of vetiver planted across the low spots and up to higher ground so that flow will not bypass the hedges. He writes :

"When the lowest areas fill up, then such areas can be used to plant things such as creeping grasses."

TANZANIA -

Mr. Poul Richardt Jensen, Agriculture Adviser, HIMA-DANIDA, Iringa writes :

"We are just about to finish distributing about 50,000 splits of vetiver to farmers in the project area. Agreed, it is not very much but this is what we can handle this season. We will try to increase our nursery production to 100,000+ this year but at the same time we try to advocate the farmers own multiplication. Mostly because it seems as if the use of vetiver is ever going to reach anywhere then we will have to operate in numbers of many million splits and not just in numbers of thousands as today. And that will be difficult to manage in central nurseries."

ZIMBABWE -

Mr. Jano Labat, the Director of Vetiver Grass Stabilization (Pvt) Ltd. writes :

"...Right now we are going through one of the worst droughts we have ever had. For the last four years we have received below 50% of normal rainfall and this year, so far, we are 20% below. We need a

miracle to come through, otherwise the sugar industry will collapse."

"Another sad part of it is, that no rain means no vetiver to go out planting in the lands for another year, and another year means tons and tons of soil will be washed away with any little amount of rainfall that we might receive. I have written, I have travelled, I have shown the vetiver slides to many people; to Government officials, to farmers, to peasants. Everybody is impressed, you leave the meeting feeling good and expect a positive reaction, but in vain. I would like to send extracts from the Newsletter to our farming magazine, The Farmer, that I might reach more people. The only positive attitude I have received so far comes from G.T.Z., the German aid mission, but there again the drought is not helping."

"As a matter of interest I send you the best way that I have seen to plant vetiver in gullies : Plant the vetiver slips across the gully. When going up the banks, instead of making a trench, use an augur to drill holes at a 45 angle into which the slip is inserted. Caution must be taken that the roots do not end in a J at the bottom of the hole. To avoid J-rooting, once the slip is in the hole, ram the soil back lightly and pull the slip up slightly, and then ram the soil in firmly. By doing so the soil is hardly disturbed and remains firm in between the slips with less chance of the soil and the slips being washed away (see figure 4). If this idea is helpful to someone I will be happy.

Editors Note : *Mr. Labat's letter points out the need for not only for perseverance in introducing new technologies, such as vetiver, but also the critical need for good extension materials that can be self-explanatory, eye-catching or interest inspiring, practical and effective. Please, if you have any ideas, work on them, test them, refine them and then, let us pass them along to others. Remember to look at the article in this Newsletter on the latest round of Vetiver Awards where extension-oriented work is being emphasized.*

ADDENDUM

Just before we went to the print shop, Dr. Laing sent the Network the resullts from CIAT's second year of vetiver research (the first year's results are contained in this Newsletter). The results speak for themselves.

CIAT (International Center for Tropical Agriculture) reports on the second year's results in cassava systems with living barriers of Vetiver Grass and Elephant Grass.

Dr. Douglas Laing, Deputy Director General, writes as follows:

The results of the second harvest (1991-1992) are now available. The data on cassava yields, forage yields, soil loss and run-off are similar to the 1990-1991 cropping year (Table 11). The cassava crop in 1991-1992 was harvested at 11 months.

The data are remarkable. Cassava with vetiver barriers in 1991-1992 yielded higher than the traditional cassava system even though the vetiver grass occupied 12.5% of the plot area. The elephant grass and the other legume-based treatments reduced whole plot cassava yields significantly as was the case in 1990-1991. The yields on the actual area cropped to cassava was 26t/ha suggesting that the vetiver barriers are having a strong positive influence through factors such as soil fertility maintenance (i.e. reducing nutrient loss in run-off water or in eroded soil) or in water availability (i.e. by slowing down rate of run-off and conserving water for longer periods in the subsoil). This year the vetiver has had competitive effects on cassava yield in the first row next to the grass barrier but this was compensated for by the higher yields in the intermediate rows, i.e. giving a net positive effect on cassava yields for the whole plot area. It will be interesting to see the competitive effects of vetiver in the third cropping year which is now planted. The forage yields obtained are to be expected given the difference in plot area occupied by the elephant grass in relation to the vetiver barrier. Clearly the forage quality of elephant grass is superior to vetiver grass. The importance of breeding or selection to improve forage quality of vetiver without losing its superior qualities in soil and water conservation cannot be overemphasized.

On another matter we have had a response from **Dr. N. Vietmeyer** of the National Research Council (BOSTID) with respect to the advisability of exchanging sexual seed of vetiver grass. The concern was expressed that vetiver accessions with sexual seeding capacity could increase the potential of the species to become a weed. We at CIAT fully agree that this species is too valuable for human kind and the above outcome should be avoided at all cost. On the other hand, we feel that researchers will need fertile accessions for breeding to improve such characters as forage quality. we will definitely hold any shipments of vetiver sexual seed until this matter is clarified. It would be useful to have opinions from other members of the network. CIAT has oniy one accession which has actually produced any seed so far. The amount of seed produced is extremely low compared to most of the other tropical grasses with which we are working. Exchange of seed only between breeders could be an environmentally acceptable solution to this very real problem.

The University of Hohenheim-CIAT project has now taken vetiver and other grasses and legumes into on-farm conservation research in the Cauca Department of Colombia.

Farmer resistance to vetiver seems evident because of the lower forage quality of the species. This will be my last communication on this project. In future all enquiries should be addressed to **Dr. Karl Mueller Saemann, Dr. Mabrouk El-Sharkawy** or to **Dr. Masaru Iwanaga** (Genetic Resources Unit/CIAT). The latter will be handling the matter of seed exchange (or not). It has been a pleasure to participate in this very exciting global effort on this excellent species.

Table 11. *Cassava and forage productivity, soil loss and runoff data for a range of cassava production systems for 1991-1992 harvest compared to bare fallow on an Oxic Dystropept[1] at CIAT's Santander de Quilichao Station in Colombia (1000m altitude, rainfall 1625 mm (11 months).*

System	Cassava Fresh Root[2] Yield, t/ha (11 months)	Forage Yield t/ha (11 months)	Run Off mm (12 months)	Run Off % Rainfall	Soil Loss t/ha (12 months)
1. Bare Fallow	-	-	195	12	210
2. Cassava on Flat Cultivation	22.7	-	81	5.1	4.6
3. Cassava on Contour Ridges	23.3	-	63	3.9	3.8
4. Cassava underplanted with Zornia	12.9	2.4	119	7.4	0.9
5. Cassava underplanted with Centrosema acutifolium	13.2	3.5	91	5.7	1.2
6. Cassava underplanted with Kudzu	16.0	1.9	91	5.7	4.0
7. Cassava on flat with Elephant grass strips[3]	16.2	4.6	93	5.8	3.5
8. Cassava on flat with Vetiver grass strips[4]	23.5	2.4	81	5.1	1.2

1 Acid soil (pH 4.2), Al saturation 50%-85%, low nutrient status in shallow A horizon (15-25cm); avg. slope 15%.
2 Cassava yields for 11 months; Vetiver barriers planted 12 months earlier.
3 Area occupied by Elephant grass is 25% of plot area.
4 Area occupied by Vetiver is 12.5% of plot area; *Vetiveria zizanioides* underplanted with *Arachis pintoi.*

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER INFORMATION NETWORK, ASTAG*, WORLD BANK, NUMBER 9, NOVEMBER 1992

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THE NEWSLETTER

In Newsletter #7 (11/91) the Network sent out a questionnaire on the subject of the propagation of vetiver. Part of our concern in sending this out was to get at the question of how demand for vegetative material might be met on a large scale. In the questionnaire we asked for information from people and also requested them to tell us what information they needed. This Newsletter is in response to what people have told us and what they have told us they would like to know. Our intention is to provide information for each level of vetiver production from small-scale to large-scale; we also hope that this may provoke some further response on questions regarding propagation.

Questionnaire Results

In total we received 148 responses, of which 115 came from people who have vetiver. Out of those with vetiver, 89 see no problems with propagating sufficient material to meet future demand for establishing vetiver hedgerows, whereas 17 respondents did feel that there would be some problems. The rest either did not comment or were not sure. There were no apparent regional or climatic trends amongst those who responded in the negative.

Among the 17 who felt that future demand could not or would not be possible to meet, 6 reported poor nursery production rates and 3 responded that lack of funding and/or government support was the main constraint to meeting demand for planting material. The remaining individuals did not specify why they felt that future demand would not be possible to meet.

Of the 89 persons responding in the affirmative to the question about being able to propagate sufficient vetiver, nursery production rates were high for 18, moderate for 23, low for 10, and 5 relied on native grass populations; 2 respondents relied on containerized plant production using polybags. Those with high nursery production rates tended to be in tropical climates, about evenly humid and semi-arid; those with moderate rates tended to be in humid areas, and about evenly distributed between tropical and subtropical areas.

Photo 1. Vetiver's massive root system. Photo courtesy of Dr. P.K. Yoon

Proposed Strategies To Meet Propagation Needs

Those who responded to the survey generally did not seem to be concerned about meeting centralized targets or the size of areas that potentially could be covered. Their answers reflected an attitude that small-scale propagation by a large number of farmers, NGOs, locally-based projects, etc will solve the problem. Almost 80% of the respondents indicated that the long-term needs must be met through such a de-centralized approach. Other recommendations included micropropagation (tissue culture), containerized propagation, and large-scale government or commercial nurseries. Discussion of all of the above techniques are contained in this Newsletter.

Absolutely DO NOT Plant Vetiver Seed

Several respondents to the vetiver propagation questionnaire recommended using seed and this is something that we feel is an extremely dangerous idea. One of the

*ASIA TECHNICAL DEPARTMENT, AGRICULTURE DIVISION

greatest advantages of vetiver is that it has not spread as a weed from seed and become a pest. The northern Indian-types of vetiver, however, which flower and seed freely do produce some seed which is viable and will germinate — usually only under a fairly narrow range of conditions such as are not normally found in agricultural areas (rainfed or irrigated). However, a program of propagation through seed would result in selection for plants with a greater potential for becoming invasive. In this fashion we could create our own weed problem. The Network requests that vetiver users take the responsibility to not begin, or, if already propagating from seed, to halt all seed-based propagation. Please be aware that it may only take one incidence of vetiver spreading from plants selected for their ability to sexually reproduce to cast suspicion on vetiver's use. We have a good technology, let us not lose it intentionally.

Obtaining Vetiver For The Nursery

Do Not Use Seeds ! The Network very strongly urges all people who are working with and selecting vetiver to avoid the use of seeds. Throughout the history of vetiver's movement around the world, up to today when it is found in almost every country on earth, we do not have any reports of vetiver's spreading as a weed from seed. Yet we know that there are accessions which flower and seed freely and whose seed can be brought to germinate. We consider that vetiver seed is not good for two reasons : 1) vetiver seed, when viable germinate under a fairly narrow range of conditions - conditions which are not normally found in agricultural areas (rainfed or irrigated). We consider this to be advantageous as then the plants do not spread and become pests and 2) plants from seed display a high degree of heterogeneity whereas clonal material is uniform; in a hedgerow a high degree of uniformity is desirable. Therefore, the Network urges extreme caution when dealing with vetiver propagation with seed. One of the most important characteristics of vetiver grass is the fact that it can be introduced with little or no fear that it will become a weed. However, if one begins selecting for plants which are more easily established from seed, a problem may potentially be created where one did not exist before. Select, collect, and use vegetative material, NOT SEED !

When collecting material bear in mind that there may be more than one cultivar of *Vetiveria zizanioides* available to you. It would be wise to put out trials in your area using as many different provenances of vetiver as possible. This is not to say that a start cannot be made with the planting materials on hand, rather that for long term promotion of vetiver as a conservation species it would be prudent to ensure having the best material possible for your area and conditions. Finally, when planting the collected material in your nursery, throw away older plant parts that have flowered or seeded. Once having flowered and gone to seed, vetiver (and all other plants) will exhibit reduced vigor and decreased growth rates. Use young, vigorous plant material both in planting the nursery and in establishing hedges.

Photo courtesy of Dr. P.K. Yoon

Photo 2. Vetiver protecting a paddy field along a river in Bangladesh.

Using Native Populations Of Vetiver

The following is abstracted from a recent report by **Dr. P.K. Yoon** from Bangladesh :

With the ready availability of Vetiver growing wild in the country, the first reaction was that nurseries would be redundant. When needed, Vetiver could be collected and transported back for planting. However, the above assumption may be affected by : i) transport and collection costs and logistics; ii) adverse weather condition, e.g. the project team was supposed to collect the plant materials for planting in early July, but the collection was not carried out because of flood; iii) some of the Vetiver plants in the

field may be weakened by overgrazing.

In addition to the concerns that Dr. Yoon raises above, again, with collection from native populations there is the question of selecting types which reproduce more readily from seed. One must consider carefully the circumstances under which one finds the wild vetiver. If plants are non-uniformly spread along a waterway or within a flood plain or wetland, this would suggest that this particular type was not readily establishing from seed. If, however, there are large, uniform patches or areas of vetiver this may indicate a potentially weedy type. Even in this first case, caution is urged. Perform a few tests yourself on the germination rate of the seeds. If the seed readily germinates under controlled conditions, look for other sources of planting material where this is not a problem.

Different Cultivars of Vetiver : Their Specific Attributes and Superior Germplasm

This is an area where we are sorely lacking in information and it is becoming more and more critical. We know that there are differences between various accessions of vetiver and this is repeatedly borne out whenever comparisons are made between gross morphology and biomass production. We have strong evidence to suggest that vetiver from north India represents a different type than vetiver from south India. What we lack is specific knowledge that lends itself to improved management and plant selection. Any ideas out there how we can solve this problem? Any volunteers? This is perhaps the priority area for vetiver research at this time.

Nursery Management

How Long Should Vetiver Be Grown In The Nursery ?

Nursery establishment should take place sufficiently in advance of the optimal time for hedgerow planting in order that an adequate supply of material is assured. "Sufficiently in advance" will be determined primarily by management inputs and climate. Analysis of the information that came in on the propagation questionnaires showed no correlation between rainfall, minimum temperatures, or length of growing season and months in the nursery

Months In Nursery	Number of Slips High Yield	Average Yield
3	22	14
4	29	17
5	37	20
6	44	23
7	51	26
8	59	30
9	66	33
10	73	36
11	81	39
12	88	43
24	176	81

Table 1. Nursery production rates as estimated from information provided by respondent to the vetiver propagation questionnaire.

or yield of planting material from the nursery. Even the amount of time over which vetiver was grown in the nursery was not a particularly good measure of how much planting material might be produced. This suggests that the most important variable is the management which is put into nurserying....the better the management, the faster the plants grow and the higher the production. Good management equals good yield.

Undoubtedly climate does affect growth and even the best management cannot overcome all climatic constraints. In looking at the propagation questionnaires, the worst nursery production rates tended to be in colder locations. However, notice the word "tended", about one-third of the locations in which the best production rates occurred were colder and about one-third of the worst production rates came from nurseries in the warmer locations. Vetiver is a tropical plant. It prefers a warmer climate. It is also a C_4 plant, that means that as temperature rises, vetiver will continue to grow faster and faster as long as it is not constrained by moisture and lack of nutrients. Therefore, in areas where temperature is a constraint to nursery growth, the strategy should be to have the vetiver as well established as possible coming into the warmer months. Best estimates suggest that minimum soil temperatures above about15°C are necessary for growth to begin. Locate nurseries where soils warm the fastest in the spring, be sure that cold air drainage is good. Moist soils heat up and maintain heat better than drier soils. If possible, mulch the nursery with the vetiver cuttings going into the cold period. Produce strong plants, they resist cold better and grow faster — irrigate, fertilize and weed the nursery! Another suggestion from **Mr. Gueric Boucard** of Leakey, Texas is to burn back the vetiver if its leaves are killed by a frost. He says if you wait for it to dry out after the frost, then burn it, it will come back earlier and more rapidly in the next growing season.

In answer to "How Long Should Vetiver Be Grown In The Nursery?", we cannot answer that for you. Since it will depend on your local conditions, use your own judgement and experience ask the opinions of others who are good with plants and know your area. Manage your nursery so as to get the best production possible. What the Network can tell you is the average

Photo 3. Roadside stabilization with vetiver in Malaysia. Plantings were established from vetiver nurseried in polybags.

nursery yields that were reported to us in the propagation questionnaires and they are reported to you in Table 1.

Nursery Soils

Sandier textured soils are preferred as this makes it much easier to lift the vetiver clumps at harvest. However, sandy soils are drought prone soils. It is by far the best practice to irrigate your nursery; in sandy soils it is an absolute necessity if you wish to achieve even average production rates. Network correspondents generally recommend sandy to loam soils. These types of soils can be identified by simple means. Moisten the soil and squeeze it in the hand - sands will stick together in a clump, but the clump will easily crumble when touched and handled. A sandy loam, will bear careful handling without breaking. A loam soil can be handled freely without breaking.

It is strongly recommended to avoid clayey soils for nurseries. To identify these soils, again, moisten the soil and squeeze it between your thumb and forefinger. If you can form "ribbons" with the soil it is clayey. If the ribbon breaks easily it is a clay loam. If the ribbon does not and is flexible, it is a clay. Neither of these two are recommended.

Reportedly, vetiver grows better under slightly acid soil conditions.

Nursery Preparation

Land should be prepared as would be done for any crop to provide a well-aerated rooting zone, clods broken up, etc. If available, it is always good to incorporate farm yard manure, animal manure (pig manure seems best), green manure, and/or oil seed cake during land preparation.

Planting of Vetiver

Irrigate the soils or wait until soil moisture levels are good, prior to transplanting into the nursery. Plow a shallow furrow to accomodate slips such that not more than 2 cm of the tops would be buried in the furrow. Do not worry about the amount of root on the slips, vetiver will establish without roots. Some persons with practical experience in growong vetiver report that residual roots on the slips serve no purpose at all. They contend that vetiver slips only grow after they put out new roots. Plant 2-3 tillers every 15cm to 40cm depending on the level of inputs and time in the nursery. Nurseries where little fertilization and/or little or no irrigation is available should be spaced farther apart. Longer nurserying periods mandate wider spacings as well. Between rows, a spacing of 15cm to 40cm is also appropriate.

Fertilization

If possible, soil testing should be done to ascertain the levels of available soil nutrients and aid in deciding the nursery's fertilizer regime. Optimum levels of fertilization are not known at this time, however the benefits of fertilization to nursery production are certain. Work in the United States has shown an increase in tiller production of 56% one year and 183% the next year between unfertilized and fertilized vetiver (**Igbokwe, et al**, Vetiver Newsletter #7). This particular experiment was conducted using 241 kg/ha of 13-13-13 — 31 kg/ha total N, 14 kg/ha available P, and 25 kg/ha water soluble K — in soils with extractable nutrient levels of 68 kg/ha (moderate) and 216 kg/ha (low) of P and K, respectively. In India 250 kg/ha of di-ammonium phosphate is recommended. This is the equivalent of 53 kg/ha of N and 58/ha of P. **Mr. John Greenfield** had earlier noted that use of phosphate and nitrogen together was beneficial. It is also reported from India that split doses of urea at 45, 75, and 105 days after planting is beneficial. Doses of urea at 50-125 kg/ha — 21 kg/ha to 58 kg/ha N — were reported.

Irrigation

Irrigation is absolutely essential to good production rates in the nursery. The purpose of nurserying is to provide optimum conditions for the plant in order to maximize pro-

duction. Dryland nurserying of course can be done, but it simply will not produce the amounts of material that irrigated nurseries can. Irrigation, in combination with good management practices, can more than pay for itself by reducing the unit cost of planting material to insignificant sums. Without irrigation and management, labor costs will keep the unit cost of planting material high as production will be low. The only good alternatives to irrigation are nursery establishment in landscape positions which maintain adequate levels of soil moisture throughout the nurserying period (e.g. bottoms of gullies with watersheds over 10 to 25 ha, along stream banks, etc.).

In the semi-arid zone of India, on soils with low water-holding capacities, irrigations are given every 4 to 5 days for the first two months and about every 7 days thereafter.

Photo courtesy of Dr. P.K. Yoon

Photo 4. Attendees at the April 1992 International Vetiver Workshop inspect one of Dr. Yoon's hedges. Less than two years old, this well-formed hedge has already trapped a substantial volume of sediment.

Weeding

Nurseries should be weeded as necessary. Weed competition can affect nursery production. Unweeded nurseries in Andhra Pradesh, India were reported to produce 60% less tillers than weeded nurseries. Nurseries in Malaysia reported that vetiver grew well in competition with *Borreria sp.* and some sedges, though noted that *Borreria sp.* is a weak weed.

Establishment of nurseries in sand to loam soils will reduce labor needed for weeding. Row spacing to accommodate mechanical or animal drawn implements for interrow cultivation may also reduce weeding costs.

While herbicides generally are cost-effective in nursery use, the Network has little information at this time on specific herbicides and their use along side of vetiver. From India, Atrazine is reported to be in nursery use and in Malaysia work is being carried out on this subject. It is reported that Roundup (glyphosate), Fusilade 2000 (fluazifop-p-butyl), and sethoxidimate will effectively kill vetiver (**Igbokwe, et al,** Vetiver Newsletter #8) and therefore are not recommended. Dr. Yoon, in Malaysia, has also reported that Paracol damaged vetiver tops when it drifted onto them unintentionally. In this case, however, the plants fully recovered within 2.5 months.

Pruning

From all accounts pruning increases tiller production; pruning on a monthly basis is suggested. Pruning below 40cm is not recommended at this time. According to our best information, pruning below this level may retard growth. Prunings can be used as mulch to reduce water losses and slow weed growth. If labor is expensive, a mechanized grass-cutter would would decrease labor input to less than 1.5 mandays/ha per cutting.

Pest Management

Fungal attacks have been reported within crowded nurseries in Malaysia (*Nigrospora sp., Curvularia sp.*, and *Helminthosporium sp.*) by Dr. Yoon. Treatment consisted of topping the affected plots at 40cm and was effective.

In Weili County, Sichuan Province, P.R. China a so-called "sticky worm" — a 5cm long x 1cm in diameter worm with a red dot on its forehead — was found in their nursery and seemed to be concentrating on vetiver leaves to the exclusion of other available weeds and grasses. Control was achieved with a contact insecticide.

The Boucards in southern Texas report that they had severe damping off problems some 15 years ago when they first began planting vetiver. Control was achieved through application of fungicides. (***ed. note:*** *damping off,* a common nursery disease, has not been reported in any other nurseries with which the Network is aware and so does not appear to be a common phenomena at this time.)

The Network has no reports of significant nursery pests or diseases.

Culling

A nursery should have the goal of producing only high quality, healthy, and vigorously growing plant material. It is only such material which makes any sense to plant, regardless of whether it is vetiver or any other plant. It is extremely foolish to waste time and resources planting poor quality material out in the field. It can cause frustration, extra labor, and even failure. To achieve the aim of providing farmers with good quality material one of the simplest things a nursery can do is just throw away any plant which does not look good. Production planning should allow for a minimum of 15% - 20% of total estimated production as being substandard. If in doubt, throw it out. Train yourself and/or your nursery workers to get rid of poor plants and poor plant parts. At harvest, throw out tillers which are not healthy and vigorous. Make sure that if you purchase vetiver, that you let it be known that you will only buy quality tillers.

Also, this is one area of nursery management on which the Network has little information. If you have a nursery, let us know what percent cull you find necessary.

Photo courtesy of James Smyle

Photo 5. An informal, roadside nursery in an Ethiopian coffee plantation. These plants may be left for 2 years and produce up to 250 tillers/plant before they are harvested for hedgerow plantings within the coffee fields.

Low Input Nurseries and Low Cost Production

Previous articles in this Newsletter have stressed a high input approach to vetiver nurserying; from a planning perspective this makes sense. One should never start off by asking, "How cheaply can I do this?" The correct question is "What is the best job that I can do with the resources at my disposal?" In nurserying of vetiver (and most other activities) there are economies of scale and inputs— the bigger the operation the cheaper the unit cost of production and up to some optimum the returns to production for any given input will often more than pay for themselves. That having been said, what we have presented in other articles is a mix of basic and ideal practices. It is up to you to judge the resources that you have available relative to the work you wish to accomplish and figure out what is the best job you can do in propagation. As we have said before, vetiver is a tough plant and will grow under some fairly unfavorable conditions. But it is a plant and it is tough only relative to other plants...if you do not get water to it, it will not grow; if it has no nutrients upon which to draw, it will not grow; if it is choked out by weeds or stomped on and grazed from the moment it is put in the ground, it will not grow. This is not to say that if you cannot afford irrigation, fertilizer and a lot of labor that you cannot nursery vetiver; rather if you cannot provide these things from purchased inputs, you can provide a better environment through planning. Below are some ideas.

A number of suggestions come from the Network on how to minimize inputs for vetiver production. Most of these suggestions would be appropriate for the individual user or small groups.

- *no formal nurseries, just plant slips along the roadside, etc. On the coffee plantation we leave them for 2 years during which time we cut them for mulch. We get up to 250 tillers/plant.* From **Mr. Shimelis Kebede** in Ethiopia, where has about 500km of vetiver hedges on the plantation where he is located.

- *plant double rows of vetiver as hedges, next year uproot one row and use it to gapfill the other. Then plant another double row with the rest, repeat each year. Plant a nursery only if vetiver is scarce.* From **Mr. R.S. Patil.**

- *maintain a small nursery with year around production, take plants whenever you need them. Always replant what you take, when you take it.* From **Mr. F.W. M'buka.**

- *casual propagation of plants wherever there is space and good moisture such as paddy bunds, banks of tanks, and streams.* From **Mr. Mihir Kumar Jha.**

- *establish local, farmer-managed nurseries in the wetter sites within each watershed — in all watersheds a spot can be found that is wet throughout the year.* From **Mr. Gunnar Jakobsen**.

- *contract with farmers to produce small amounts, give them enough material to establish about a 750 plant nursery. Buy it back at an agreed upon price.* From **Mr. P.C. Romkes**.

- *provide credit and procurement contracts to small farmers.* From **Mr. Konaje Gopalkrishna.**

- *small individual nurseries and farmer nurseries are best.* From **Mr. Ranjit Kumar Roy , Mr. M. Singa Rao, Mr. Chris Eijkemans,** and **Mr. Vaughn Redfern.**

- *take tillers from established hedges.* From **Mr. Michael Poshkus** and **Mr. Alemu Mekonnen.**

- *small nurseries, plant at the onset of the rains; good water supply makes all the difference.* From Mr. Michael Poshkus.

- *if there is no hurry, simply remove slips from your own established plants year-by-year and extend the length of the hedge.* From **Mr. C. Buford Briscoe**.

- *nursery in damp valley bottoms.* From **Mr. Robert J. Sims.**

Dr. Yoon also provides us with his recipe for a low input nursery :

A large block of approximately 0.2 ha was ploughed and rotovated. Tillers were directly planted with a planting distance of 15cm x 15cm. One round of dried chicken dung was applied at one week after planting. This approach ensures low establishment cost. There was little maintenance cost — with planting in the normal rainy season, watering was not needed. Also, there was no weeding nor any pest and disease control measures. Plants were growing well by 2.5 months and managed to compete with other weeds. Sampling of 100 clumps at 4 months showed average of 11 tillers per clump (farmer's report). This rate of production was considered satisfactory because of the low input.

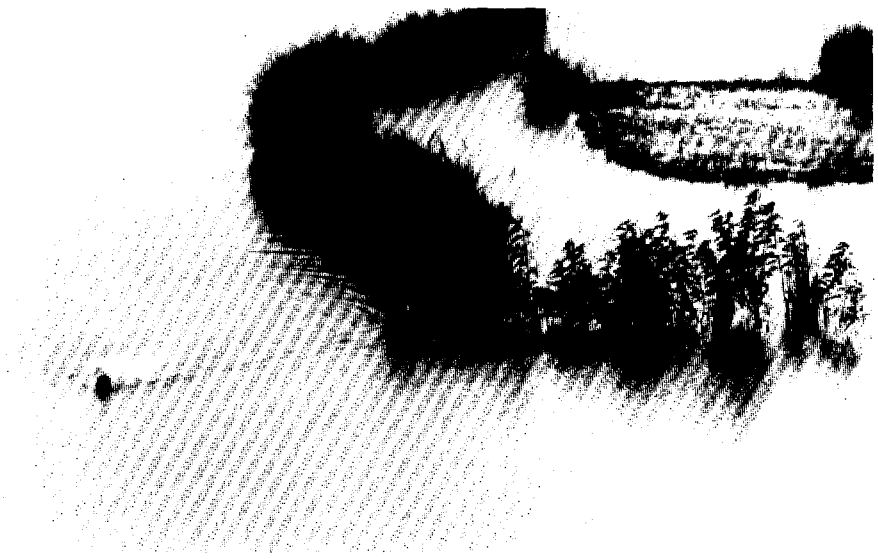


Photo courtesy of Dr. P.K. Yoon

Photo 6. Where a house once stood along this riverbank in Bangladesh, a vetiver hedge continues to protect the site long after the occupants who planted it moved away.

Production from Dr. Yoon's low input nursery, at 4 months, would provide enough material for about 40 to 60km of hedgerow. This assumes a 20% cull and 2 or 3 slips every 15cm.

Nurserying in Raised Soil Beds

Raised beds may have an advantage over planting in the ground based on reduced labor inputs for harvesting of the plants and weeding. The raised beds themselves might be formed either by hand or with a walking tractor, with the latter the less expensive of the two. In areas where labor costs especially limit nursery management options, this system may result in lower plant production costs.

The following information comes from the Network's all-around expert on vetiver, **Dr. P.K. Yoon** of Malaysia.

The width of the beds prepared should be based on the number of rows of vetiver slips which will be planted across the bed. Based on experience in Malaysia, if time in the nursery is to be more than 3 months, than ideally no more than 2 rows of vetiver should be planted in each bed. This is because growth up to 3 months has been satisfactory, but after that the plants in the central rows tend to grow and multiply more slowly as a result of the shading effect. Unless land is a constraint, or nurserying will not go past 3 months (or the time at which under your nursery conditions the plants would enter into severe light competition), then 2 rows of vetiver slips planted 15cm apart works well. If you can (or must) use more than 2 rows, then the bed width should not be any wider than what can be easily managed or about 1m.

To ensure good growth, one nugget of Kokei/plant (6 gm of 5-5-5-1(Mg)) is recommended. Dr. Yoon also recommends the Sumisansui tube irrigation system (produced by Japan) as in the polybag nurseries. In harvesting his nurseries at 5 months, on 2 occasions the average yields from the 2 plant/row system were 21.1 tillers/plant (±0.59) and 20.6 tillers/plant (±0.92),

based on counting 486 and 185 plants, respectively.

In a 6 plant/row nursery, plants were established on a 15cm x 15cm spacing, with a Sumisan-sui irrigation system in beds that had received a liberal application of dried chicken dung. Each bed was about 1m x 50m with 0.9m spacing in-between and had 1800 plants. In total, 6 beds were planted with 10,800 plants. The plants were ready for use in the field after 2 months; however, for multiplication, the plants were left to grow longer. It was estimated that these beds produced more than 150,000 tillers after the first 3 months.

On a per ha basis, Dr. Yoon's production is equivalent to about 189,000 plants producing about 2.63 million tillers in 3 months. This is sufficient planting material to establish about 131km to 195km of hedgerow assuming 2 or 3 slips each 15cm, without any culling of plants. In practice, it is a good idea to assume that some percentage of plants should not be utilized as there will be some older, less vigorous material. Assuming a 15% cull, this still leaves adequate material to establish 110 to 167km of hedgerow using top quality plants.

Photo courtesy of Dr. P.K. Yoon

Photo 7. A polybag nursery in Malasia.

Containerized Nursery Stock

A number of individuals on the Network are currently using polybags or other containers in which to nursery vetiver. While costs are higher using this method, it has certain advantages for particular situations. The advantages of containerized stock are : First, plants grown in containers are planted in the field with well-developed, relatively undisturbed root systems. This reduces establishment time considerably. Second, planting with containerized stock is almost equivalent to putting out a one year hedgerow immediately. At close spacing, the containerized material with its larger plants, in effect, gives an almost functional hedgerow within the time it takes for the roots to penetrate the surrounding soil and anchor the plant. Thirdly, under high stress situations, e.g. very poor and friable soil with low nutrient content, severe erosion from multiple directions, and difficult climatic conditions, the use of polybag materials with their vigorous root systems encased in a core of soil will allow early establishment and growth when transplanted. In Photo 8, it can be seen that the root system is well-developed and has bound the soil in the container effectively. Finally, polybag production should rarely result in plants which must be culled. Nursery output should be close to 100% of production.

Situations under which the increased cost may be justified would normally be those where protection of high value infrastructure is the goal. Examples of this might be for the farmer who has constructed a new house on a steep slope, for new road cuts, on any fill slopes or main irrigation canals. Literally anywhere where the cost of stabilization would be measured against the replacement costs of the infrastructure should stabilization methods fail. Containerized stock might also be found economic in stabilization of gullies. **Mr. Mike Materne**, with the U.S. Soil Conservation Service found that he could take containerized plants and, using old welding rods as pins, establish hedges right across areas where concentrated flows were causing active down-cutting. The potential use in these areas — infrastructure protection and gully control — is enormous.

According to some of the writings of Dr. P.K. Yoon, polybags (0.05mm) of 5" x 7" work well. Multiple tillers can be used instead of single tillers. This way the tillers

primarily need only to regenerate their root systems; accordingly, the time in the nursery to produce quality plants may be reduced.

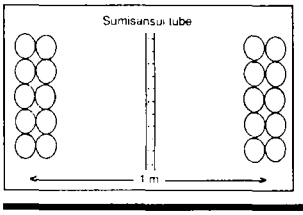
In preparing tillers for polybag planting, Dr. Yoon suggests that the tops should be cut to about 20 cm with the roots cut to 4-5cm. At planting, not more than 2cm of the tops should be buried. To ensure good growth, especially of the root system, one nugget of Kokei (6 gm of 5-5-5-1(Mg)) should be put into the polybags one week after planting.

He reminds us that vetiver is sensitive to shade and the arrangement of polybags is therefore critical. Only 2 polybags per row should be used. With more polybags per row, the plants in the centre will be shaded and thus perform poorly. For the same reason the spacing between the polybag rows should be one metre. A good arrangement is shown below in Figure 1.

Dr. Yoon prefers mechanized watering to normal watering because of better control of the quality of watering. The Sumisansui tube irrigation system (produced by Japan) is favoured in Malaysia because it is cheap to install. However, any irrigation system may be used and he has seen seen overhead sprinkler systems that appear to meet the need.

On a recent consultancy to Bangladesh, Dr. Yoon estimated the cost of the system described above. Such an arrangement, in Bangladesh, would allow production of one polybag of quality planting material (with more than 10 tillers) for US$ 0.05 ea.

Figure 1. Arrangement of polybags for a vetiver nursery.



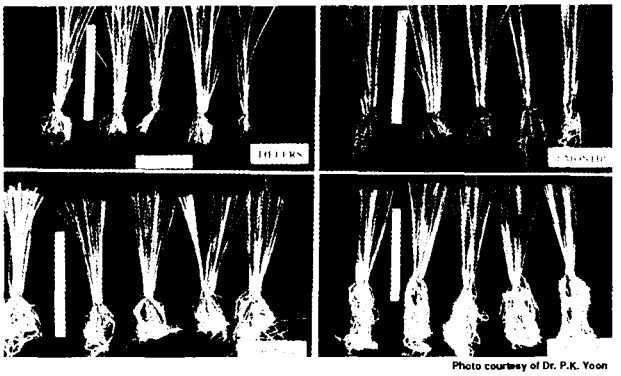


Photo courtesy of Dr. P.K. Yoon

Photo 8. A comparison of the root systems of plants raised in polybags and the roots of freshly cut tillers. The ages of the polybag plants are given. Note the active root mass after 2, 3, and 4 months.

A plan for an irrigated 10-acre polybag nursery (4 ha) in Bangladesh showed estimated nursery startup costs at US$ 3,000. The nursery would produce 1.3 million plants annually on a 4 month cycle, i.e. raise and distribute 3 lots of plants/year. This would provide enough planting material for 195 km of hedgerow/year when planted on 15cm centers. Recurrent costs would be covered under the US$ 0.05/polybag plant.

Dr. Yoon suggests regular monthly pruning to 40cm to encourage tiller formation.

Mechanized Nurserying of Vetiver For Large-Scale Production

The following article was contributed by **Mr. Gueric Boucard**, who, with his brother **Victor**, has operated the largest vetiver farm (of which we are aware) in the world. The Boucards have been involved with vetiver for more or less their entire lives as their father was an enthusiast about the plant as well. Their interest in vetiver farming in recent decades has been to produce oil from the root, however, their operations for this purpose would equally serve for mechanized nurserying and hedgerow establishment. Please note that the Boucards operation is an irrigated one, as should be any nurserying operation.

In American agriculture, "large-scale" is a relative term. ***American Vetivert Corporation*** *or AVC (ed. note : the Boucard's company) has had up to 200 acres of vetiver under cultivation in South Texas, and called it large-scale vetiver farming, primarily because of its large drain on the company's small research and development budget. On the other hand, AVC's farming partner has some 5,000 acres under the plow at any given time, and another 5,000 acres in cow pastures and idle farm land. But, certainly, the large-scale mechanized propagation of vetiver would seem to have considerable merit.*

The question that arises is, how does one propagate vetivert on a large scale? Propagating vetiver on a large scale is relatively easy, because there are only 15 or 20 mistakes and pitfalls to avoid.

Photo courtesy of Joan Miller

Photo 9. The Boucard's vetiver root digger (harvester).

Unfortunately in agriculture, it takes one full calendar year to discover the results of each mistake and correct them. Therefore, after nearly 20 years of experimentation (17 to be correct), AVC can make some basic recommendations for the large scale planting and harvesting of vetiver, to those who may wish to do so. It should be noted that certain requirements which pertain to high quality root production do not apply to the growing of vetiver for seedling harvest. For instance, vetiver will grow in sand, heavy clay, rocky soils, volcanic soils, in swamps, in saline river deltas, and just about everywhere in tropical and subtropical climates, but the good roots with high quality oil occur only in a few of the above. Once the right soil and geographical location has been selected, the main problem lies in the development of adequate farming machinery. Unfortunately, specialized vetiver farming machinery is not to be found in the catalogues of John Deere, New Holland, and International Harvester.

Needless to say, full mechanization of the vetiver crop is an absolute necessity for large-scale propagation, especially in the United States. Often however, the patient and skillful modification of existing conventional farming machineries can produce satisfactory results. One may find that a 90% mechanization of a particular agricultural operation may be commercially acceptable, while the achievement of the 100% mechanization goal may be $1 Million down the road, and bring little additional profit. It is along these lines that AVC has developed its own special machinery. It must he stressed, however, that regardless of all the special farming equipment developed by AVC, vetiver remains in the category of labor intensive crops, such as vegetable crops, fruit crops, and tobacco.

There is, however, one important distinction which separates vetiver from other labor intensive crops, and makes all the difference in the world. Fruit and vegetable crops have to be harvested within a narrow time window, and very large scale operations of several thousand acres are rarely practical. However, vetiver is a perennial grass which can he harvested at virtually any time of the year (at least in south Texas). A 3,000 acre farm, taken a day at a time, is the same as a 16 acre Mom & Pop farming operation.

Some of the specialized vetiver farming machinery developed by AVC is described below.

1. Vetiver transplanter. *The AVC transplanter is a 4 or 6 row machine for 30" to 38" rows requiring two men per row to plant 8" to 10" tall vetiver seedlings of 2" diameter, 3" deep, and 18" on the row. A mechanism allows the injection of water and fungicide, root activator, or any other chemical with each seedling. The machine is a modified tobacco transplanter which can plant 8 to 10 acres per day. (ed.*

Photo 10. Mr. Victor Boucard holds up a clump of vetiver which was harvested with their root digger.

Photo courtesy of Joan Miller

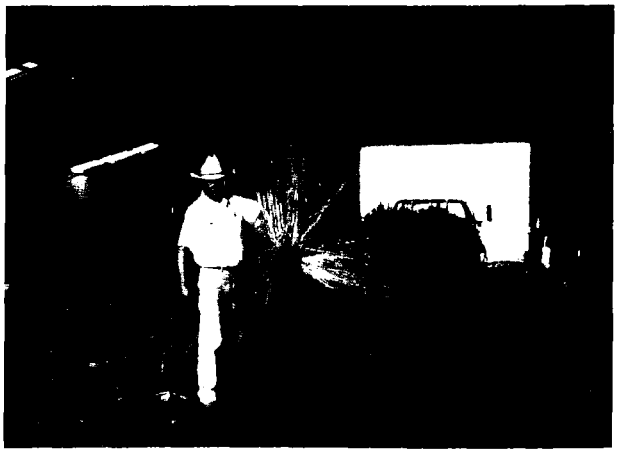


Photo courtesy of Joan Miller

Photo 11. The Boucard's vetiver stump slicer which cuts clumps into 5cm x 5cm blocks for use in the planter.

Photo courtesy of Joan Miller

Photo 12. Mr. Gueric Boucard demonstrates how a mechanized planting unit works.

note: Mr. Boucard has confirmed that his planter could be modified easily to both accommodate closer spacings between slips and planting across steep (by United States standards) slopes.

***2. Vetiver grass mower.** AVC can assert with confidence, for having tried them all, that no commercial mowers of any design, currently available on the U.S. market, will mow a 24" diameter vetiver clump. The special sickle bar mower designed by AVC and mounted on a New Holland self-propelled mower will even mow vetiver to ground-level at nearly normal mowing speeds. In the event that all the clumps will be used either for replanting or for sale to others for erosion hedges, the entire field will have to be mowed 8" above ground in order to accommodate the mechanical transplanter. The cost of manual shaving of root from the clumps will have to be offset by revenues from the sale of the clumps.*

***3. Vetiver root digger.** After modifying, testing and destroying several potato diggers, peanut diggers, rock pickers etc, AVC developed its own heavy duty vetiver root digger. This implement must be pulled by a very large 4-wheel drive tractor such as the Steiger tractor or other makes of similar horsepower and wheel traction. The machine goes 16" deep and uproots two rows of vetiver clumps with each pass. Given good loose sandy soil, the roots are shaken clean before falling into the wagon riding next to the digger. In less advantageous soil conditions, the roots have to be shaken again by means of a stationary tumbler, at the processing shed where the seedling preparation takes place.*

***4. Vetiver stump slicer.** After shaving the roots, the clumps with 8" long leaves remain to be divided up into seedlings of the adequate uniform size to accommodate the mechanical transplanter. AVC has devised a machine with two sets of gang saws which slices the clump into clusters of seedlings (4 to 6 seedlings per cluster) measuring 2" by 2", 8" long. This machine would not needed be needed if preparing large 12" diameter clumps for planting fast-developing erosion hedges. This is not to say that the smaller seedlings could not be used for erosion hedges. But the shorter the growing season, and the shorter the rainy season, the more advisable it is to plant large clumps in order to get the hedge established quickly.*

Mr. Boucard provides some estimated cost figures for a mechanized 3,000 acre (1215 ha) vetiver farm, more about which can be found in this Newsletter on Page 14 in the article entitled "The Potential For Commercialization of Vetiver"

Alternative Propagation Methods

The paragraphs immediately below are taken from BOSTID's upcoming publication : ***Vetiver : The Thin Green Line Against Erosion.***

Currently, vetiver is propagated mainly by root division or slips. These are usually ripped off the main clump and jabbed into the ground like seedlings. Although the growth may be tardy initially, the plants develop quickly once roots are established. Growth of 5 cm per day for more than 60 days has been measured in Malaysia. Even where such rapid growth is not possible, the plants often reach 2 m in height after just a few months.

It is easy to build up large numbers of vetiver slips. The plant responds to fertilizer and irrigation with massive tillering, and each tiller can be broken off and planted. It is important to put the nurseries on light soil so the plants can be pulled up easily.

Planting slips is not the only way to propagate vetiver. Other vegetative methods follow:

- ***Tissue culture.*** *Micropropagation of vetiver began in the late 1980s*
- ***Ratooning.*** *Like its relative sugarcane, the plant can be cut to the ground and left to resprout.*
- ***Lateral budding.*** *Researchers in South Africa are having success growing vetiver "eyes" (intercalary buds on surface of crown) in seeding dishes.*
- ***Culms.*** *Young stems easily form new roots. This can be an effective means for propagating the plant. Laying the culms on moist sand and keeping them under mist results in the rapid formation of shoots at each node. This is an effective way to propagate new plants from hedge trimmings.*
- ***Cuttings.*** *One Chinese farmer has successfully grown vetiver from stem cuttings. The cuttings, each with two nodes, are planted at a 60 degree angle and then treated with a rooting hormone—in this case, IAA (indole acetic acid). He achieved 70% survival. An interesting point was that the original stems were cut in December, buried in the ground over winter, then, stem cuttings were taken from these in early spring and planted in April.*

Photo courtesy of Joan Miller

Photo 13. The Boucard's multi-row vetiver planter. The tank on top holds a liquid fertilizer/fungicide mixture which treats each piece of planting material as it is put into the ground.

The following is reprinted from Dr. P.K. Yoon's article in Vetiver Newsletter #6. Since the Newsletter's readership extends beyond those on our mailing list, we want to be sure that this Newsletter is as complete as possible for those who may not have access to the previous ones.

Multiplication By Culm-Branches

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

Multiplication By Culm-Cuttings

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

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

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

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

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

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

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

Conclusion

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

Photo 14. A mist chamber and sand bed for propagation of vetiver from culms.

Photo courtesy of Dr. P.K. Yoon

Different Tiller Types

Preliminary observations have suggested that each clump of vetiver produces different types of tillers; thus their growth and tiller formation would be quite different. This would lead to high variations in response of experimental treatments where assessment is by tiller formation and dry matter production. This could be one of the causes of non-significant effect of fertilizer, soil types, etc. previously reported. The experimental error may be higher than the treatment effect. To overcome this, the tiller types must be sorted out and the within-population studied before planning any experiment. The starting material must be the same tiller type and fine-tuned to minimize experimental errors. The 4 major types are :T

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

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

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

Different Culm-Branches

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

pose the different types of culm-branches should be grouped separately.

TISSUE CULTURE

There are a number of individuals on the Network who are currently working with tissue culturing of vetiver. For a listing of those individuals names and addresses, please write to :

James Smyle
Attn : Vetiver Tissue Culture
1818 H St. NW
Washington, DC 20433
USA

Specify whether you currently are carrying out tissue culture with vetiver or if you are in need of information on how to tissue culture vetiver.

THE POTENTIAL FOR COMMERCIALIZATION OF VETIVER

The following is abstracted from a very interesting letter which **Mr. Guerlc Boucard** sent to the Network. It envisions the development of a unique, vetiver-based, farming/commercial operation.

As producers of vetiver and other essential oils, it would be fair for ***American Vetivert Corporation's*** *(AVC) principals to caution vetiver enthusiasts that vetiver farming for the purpose of root production and essential oil production is not to be looked upon as a new crop for every farmer to get into on any significant scale. We estimate the world consumption of vetiver oil from all sources to be 2,000 drums per year or roughly 1 million pounds (see editors note. below). Based on the yield of roots per acre and the yield of oil per ton of roots, this translates into approximately 10,000 acres of vetiver worldwide, planted by small farmers in garden-size plots, in countries such as Haiti, Indonesia, China, etc. Apparently, producers in the Reunion Island and Brazil do have larger fields and some degree of mechanization. A vetiver plantation of 1,000 acres would have to claim a 10% market share and one new 2,000 acre would immediately create a glut and, typically, the price of the oil would drop below the cost of production for several months, hurting all the producers in third world countries, and perhaps putting them out of business.*

However, the large-scale mechanized propagation of vetiver would seem to have considerable merit in other areas of agriculture, such as a combined biomass fuel production and as a source of vetivert seedlings for planting erosion hedges in the entire Southern United States and Mexico. For instance, based on AVC's own yields of vetiver grass per acre, a 3,000 acre irrigated vetiver farm could produce 120,000 tons per year of dry biomass fuel (vetiver leaves). Vetiver being a perennial grass which can he harvested (mowed) all year around, the entire 3,000 acres could he mowed once or twice a year at the rate 8 or 16 acres per day (say a maximum of 50 acres a day to make up for rainy days), and furnish an average of 329 tons per day, i.e. 14 tons of fuel per hour to fire a boiler. Again, based on AVC principal's own experience of firing boilers with waste biomass on a smaller scale, such an amount of fuel (taken at 6,000 btu/lb) could produce sufficient steam to generate 14 Megawatts of electricity. Assuming that the operation of such a large-scale vetiver grass farm would cost US$100 per acre per year (grass farming only), the cost of biomass fuel would translate into US$ 0.002 per KWh, notwithstanding the cost of operating the power plant. Power utilities would purchase the electricity at about US$ 0.03 per KWh, generating more than US$ 3 million of revenues for the farm. Or, the dry, pelletized vetiver leaves could be sold as roughage to feed mills, or as fuel to existing power plants and cement kilns at US$ 10 per ton, for US$ 1.2 Million per year, without the capital cost and the headache of running a power plant or any other major industrial facility.

After 3 years, the diameter of the vetivert clumps will become so large that they will touch each other on the row, and become too large (about 24 inches diameter) for the mower wheels to ride on the soil between the rows. The clumps will have to be uprooted, divided up, and replanted, the latter which would require only 20% of the uprooted vetiver. There will be considerable

Photo 15. Tissue culturing of vetiver.
Source unknown

root production from this operation, and although the quality and the yield of the roots of 3 year old plants is poor, sufficient oil could be extracted from such roots to pay for the operation and generate a profit, without upsetting the vetiver oil market. ***Texarome Inc.****, of Leakey, Texas, a distiller of essential oils has a standing offer to purchase vetiver roots at US$ 350 a ton. At a root yield of 3 tons per acre, this translates into over US$ 1 million of additional revenues for the farm.*

Still, some 70% to 80% of the uprooted clumps would be available for sale to farmers for planting erosion hedges. Assuming that one-third of the farm (1,000 acres) would be replanted every year, just so that no plant is ever more than 3 years old, then 1,000 acres of 3 year old clumps up to 24" in diameter would produce 2.6 linear miles per acre, or a total of 2,600 solid miles of vetivert clumps 24" wide. Preferably, such large clumps should be at least quartered for planting erosion hedges with clumps of 12" diameter on 18" centers. If that is the case, then, after using 20% for replanting, the 1,000 acres could furnish enough extra material to plant 12,480 miles of erosion hedges per year — assuming the clumps are quartered and planted 18" apart. Given the economy of scale, if the 12" diameter clump seedlings were to be sold to farmers at US$ 0.05 a piece, the farming operation would have additional revenues of US$2,196,480. From the point of view of the erosion fighting farmer, could plant one mile (5,280 ft) for US$176. After just one summer's growing season, the vetiver would grow to a solid and permanent hedge. The cost of doing the same thing with any other erosion fighting method would be significantly higher and perhaps prohibitive for most farmers.

As shown above, the total yearly revenues of such a farm could add up to more than US$4.2 million, and do a lot of good things in the process. A rough estimate of capital and operation costs for this hypothetical 3,000 acre vetiver operation would be US$ 5 million, of which, 60% would be for the irrigated farm and irrigation system, 20% for farming and processing equipment and buildings, and 20% for operating capital.

Ed. Note : According to information from the International Trade Centre, in 1986 the world trade in vetiver oil comprised about 250 tons or 550,000 pounds. World demand for vetiver oil has not significantly increased in recent years nor does it appear to be doing so now.

Reminder — Vetiver Awards To Be Given In June 1993

Please remember that once again the Network has found funds which will be utilized to recognize those 'jobs well done' by both individuals and groups in promoting, managing and researching the use of vetiver grass for contour vegetative barriers. A total of $32,000 will be awarded. Below are the categories within which the awards will be given. The Network has split the awards in order to encourage a number of different, valuable areas. Please note that "work of interest" is indicative only, we do not want these categories to limit anyone, on the contrary we encourage any useful and practical work outside these areas as well. Be assured that any one sharing information on an area not contained below will have their work treated equally with that which does fall under the categories set out below. Wherever appropriate and possible, costs or cost estimates for implementation of recommendations should be included.

The Network will be accepting your 'entries' until April 15, 1993. At that time an independent, external panel will choose the awardees (with the exception of the Yolo County Award, see below); all awards will be made by June 1, 1993. All materials received should be sent with the understanding that they will not be returned and that they will become public information and shared with the Vetiver Network. All relevant information received will be incorporated into a Newsletter (or Newsletters if warranted) for publication by July 1993.

The Awards

The King of Thailand Research Award.

His Majesty, The King of Thailand has offered $10,000 in awards to promote the dissemination of useful and practical information on vetiver grass. One-half of these funds ($5,000) will be awarded to the individual contributing the most significant piece of research work.

Research Awards

The Plant - Total $7,000

Work of interest on : Vetiver taxonomy, e.g. species/varieties/types, their identification & comparison of characteristics in : growth and/or management needs and/or palatability/non-palatability and/or applications based on differences and/or pollen, flower, seed fertility/sterility by type; effectiveness as soil/water conservation species as a function of its roots, strength of tops and hedge-forming ability; pest repellency effects by type; allelopathy; cold or drought tolerances; pests and/or diseases; mycorrhiza and vetiver; pH-related questions; and other physiological characteristics. Awards = 1st - $2,500; 2nd - $1,500; 3rd - 1,000; 4th - 4 awards of $500 each.

Engineering Applications - Total $ 6,500

Yolo County Flood Control and Water Conservation District

Award for most comprehensive and/ or unique viable applications for vetiver in stormwater and wastewater reclamation. The winner of this award will be determined jointly by Mr. James Eagan, General Manager of the Yolo County Flood Control and Water Conservation District and Mr. R.G. Grimshaw, Chief, ASTAG/World Bank. Award = $2,000;

Other work of interest on : stabilization of cuts and fills, protection of infrastructure from run-on and sedimentation, stabilization of the infrastructure:soil interface, stabilization of canals and ponds, groundwater recharge. Awards = 1st - $2,000; 2nd - $1,500; 3rd - 1,000.

Management - Total $7,000

Work of interest on : pests, their importance/significance and management (insects and/or weeds); "how-to" guides for most efficient propagation and/or viable, alternative propagation methods (eg. layering); "how-to" guides for most efficient establishment of hedgerows (be specific about soils, climates and land use conditions); establishment and management system costs under varying conditions; "how-to" guides on mycorrhizal inoculation of vetiver; management of vetiver hedgerows for secondary benefits; economic analysis of the benefits of vetiver hedgerows relative to other approaches; im pacts on soil loss, runoff/soil moisture and crop yields on steep slopes. Awards = 1st - $2,500; 2nd - $1,500; 3rd - 1,000; 4th - 4 awards of $500 each.

Promotional/Extension Work and/or Materials - Total $5,000.

Best Video. Awards = 1st - $1,150 and a painting contributed by Mr. Reginald Pollack, a renowned contemporary artist, 2nd - $600, 3rd - $250; please include an english-language script if there is any untranslated speech in the video. While the quality of the video, editing, etc is appreciated, the content of the video will be more important. Do not worry if your video is not a 'professional' production.

Best Photograph, Poster, or Drawings. Awards = 1st - $850, 2nd - $400, 3rd - $250

Best Proven Approaches for Extension/Technology Transfer. Awards = 1st - $850, 2nd - $400, 3rd - $250; please include photgraphic evidence and testimonials from farmers/users.

Farmer Awards - Total $1,500

These awards will be given out to farmers who are using vetiver grass hedges and have sufficient experience to be able to discuss what they are doing, tell how they work with other farmers and/or report other farmer's opinions of what they are doing, give their honest opinions of vetiver's strengths and weaknesses, and recommend to us what we should be telling other farmer to convince them to give it a try. The form provided on the back page of Newsletter #8 (6/92) may be used or a voice recording of the farmers with an english translation; photographic evidence should, if at all possible, be included. Awards = 15 awards of $100 each.

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

VETIVER NEWSLETTER

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

THE NEWSLETTER

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

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

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

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 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

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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 pro-

duction and planting of vetiver. Information on their work may be found in Vetiver Newsletter #9.

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

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

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

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

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

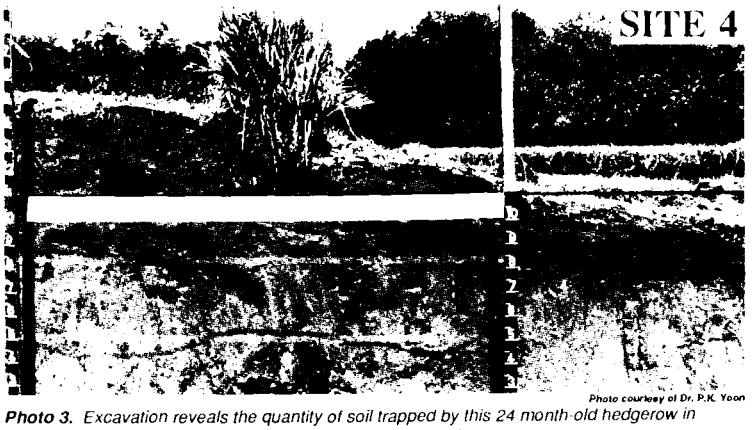


Photo courtesy of Dr. P.K. Yoon

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

Promotional/Extension Work and Materials

Best Video Award

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

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

Best Photograph, Poster or Drawings

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

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

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

Extension/Technology Transfer

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

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

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

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

Farmer Awards

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

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

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

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

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

Third Prize (US$100) : Mr. Patil of India.

The six additional third prizes were not awarded as no other eligible entries were received.

Letter from Dick Grimshaw

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

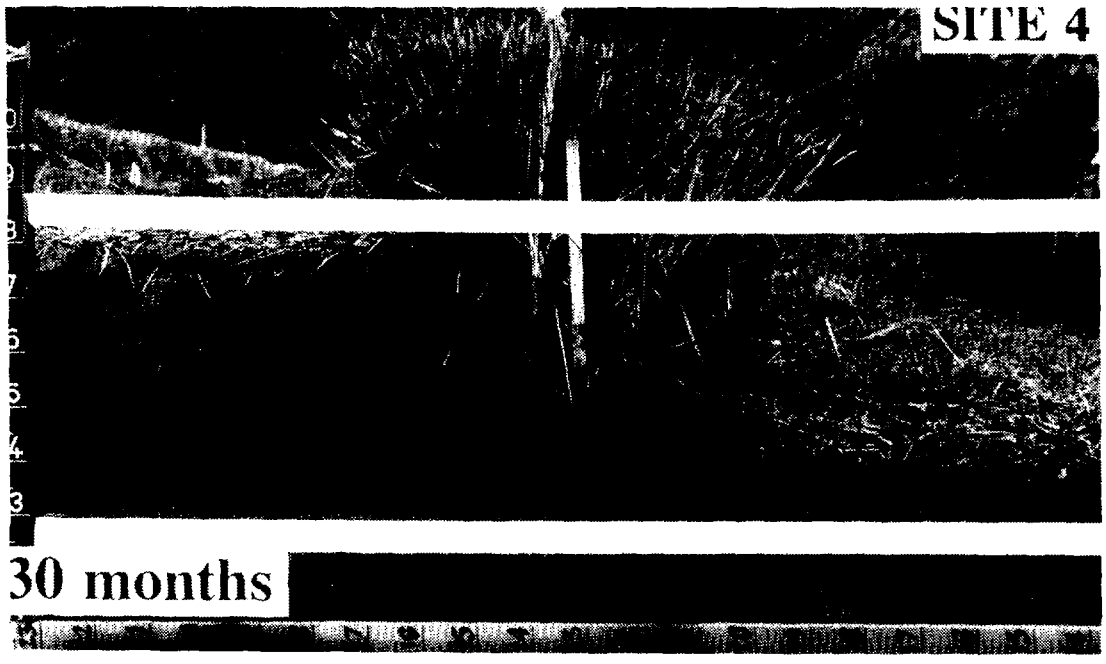


Photo courtesy of Dr. P.K. Yoon

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

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

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

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

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

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

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

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. The readers will have to calculate the

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.*

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 waste of materials with little advantage

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.

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 :

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

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

The approaches affecting production of quality hedgerows are:

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

These are discussed in the following sections.

Photo courtesy of Dr. P.K. Yoon

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

Effect of Bag Sizes on Establishment of Quality Vetiver Hedgerows

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

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

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

Photo courtesy of Dr. P.K. Yoon

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

However, the data from 10 and 12 months are too variable. Thus the validity of the mean as an indicator is questionable and gap measurement for planting distance of 15cm should not be considered after 9 months.

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

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

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

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

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

Effect of Spacing Cum Fertilizer on Growth Of Vetiver Hedgerows

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

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

Use of Selective Herbicides To Maintain Quality Vetiver Hedgerows

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

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

Based on other ad hoc experi-

ments 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

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%		

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 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. Truong

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 $CaCO_3$ 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, $CaCO_3$ or basal fertilizers were applied (Table 4).

The required quantities of S and $CaCO_3$ were thoroughly mixed with the dry soil of each pot. Following the application of S and $CaCO_3$, 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 $CaCO_3$ 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.*

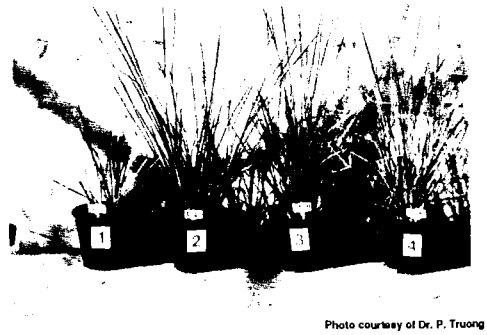


Photo courtesy of Dr. P. Truong

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.

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

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

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

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

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

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

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

Comparative Measurements of Vetiver and Miscanthus

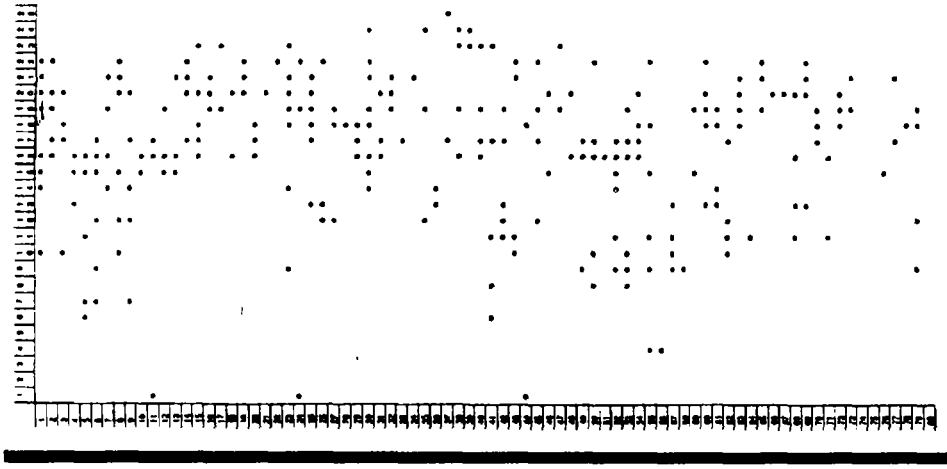
By Mr. M. Materne and Ms. C. Schexnayder

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

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

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

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



Effects of Shading and Cutting On the Growth of Vetiver

By Dr. Xia Hanping

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

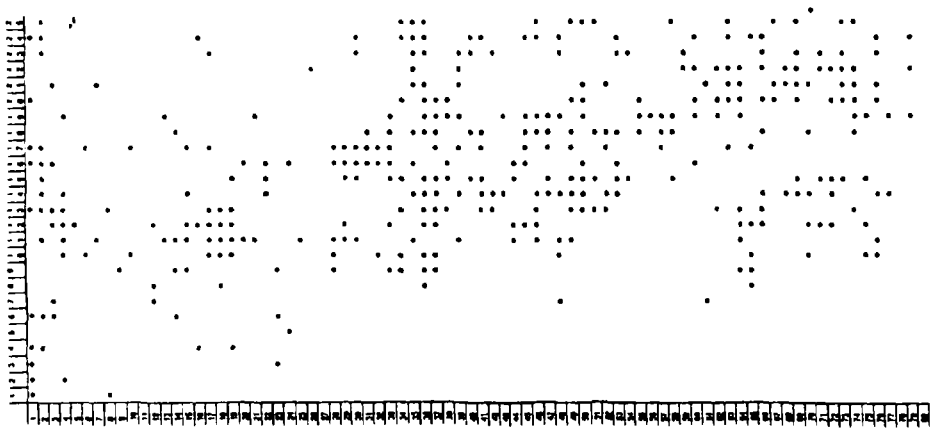


Figure 2. A stem map of Miscanthus zebrinus; each dot represents one stem. Marks on the scale are in centimeters. The area mapped is 25cm x 80cm, and represents a section of Miscanthus hedge.

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 m² of hedgerow) averaged 11.4, 14.7 and 17.8 in years 1, 2 and 3, respectively. (**Ed. Note:** *100 m² of hedgerow was equivalent to about 230 linear meters of hedge)*

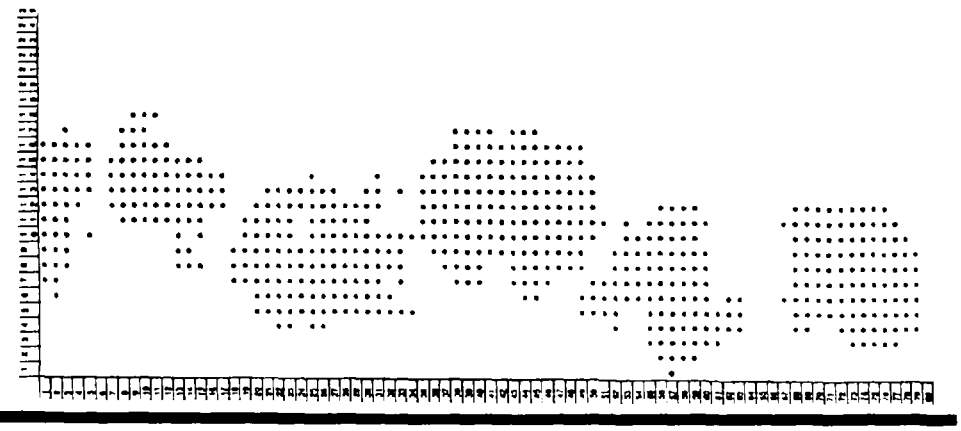
Hedgerows, functioning i) as windbreaks, ii) to shade the soil, and iii) as a source of mulch provided a synergistic effect resulting in amelioration of the micro-climate. For example, on 22 August 1992 the differences between the controls and the vetiver treatments were measured. Air, soil surface and

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.

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



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

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

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

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

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

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

By Mr. G. Cook

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

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

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

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

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

V. zizanioides tolerance to salt was high and even at the highest salt concentration there was still active growth in some of the culms. The LD_{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.

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

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

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

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

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

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

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

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

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 θ = D / ((T - B)/2)	θ = 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 measures. Similarly, the incremental

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.*

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* (Lemongrass) and *Chrysopogon martinii* (Tikhadi). The study areas receive about 840mm average annual rainfall.

Vetiver vs. Bunding

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

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

status of soil was carried out before and after the harvest of crops.

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

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

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

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

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

Vetiver vs. Other Vegetative Barriers

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

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

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

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

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

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

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

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

Experiences with Vetiver
By Dr. G.M. Bharad

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

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

Selection of non-flowering material : Variation in the flowering patterns of our vetiver stocks was observed. It was also seen that flower culms die in the next season and flowering diminishes plant vigor. Non-flowering clumps were identified, propagated and planted out in lines in 1991. Neither in 1991 or 1992 did any of this material flower.

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.*

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. Never plant just the one line on top (e.g.

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

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

Photo courtesy of Mr. M. Robert

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

line 3) as you will get undermining in the waterway and eventually the bank will collapse.

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

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

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

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

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

A Commercial Source For Vetiver Planting Material

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

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

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

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

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

Report On Mortality In Vetiver Hedgerows In India

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

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

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

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

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

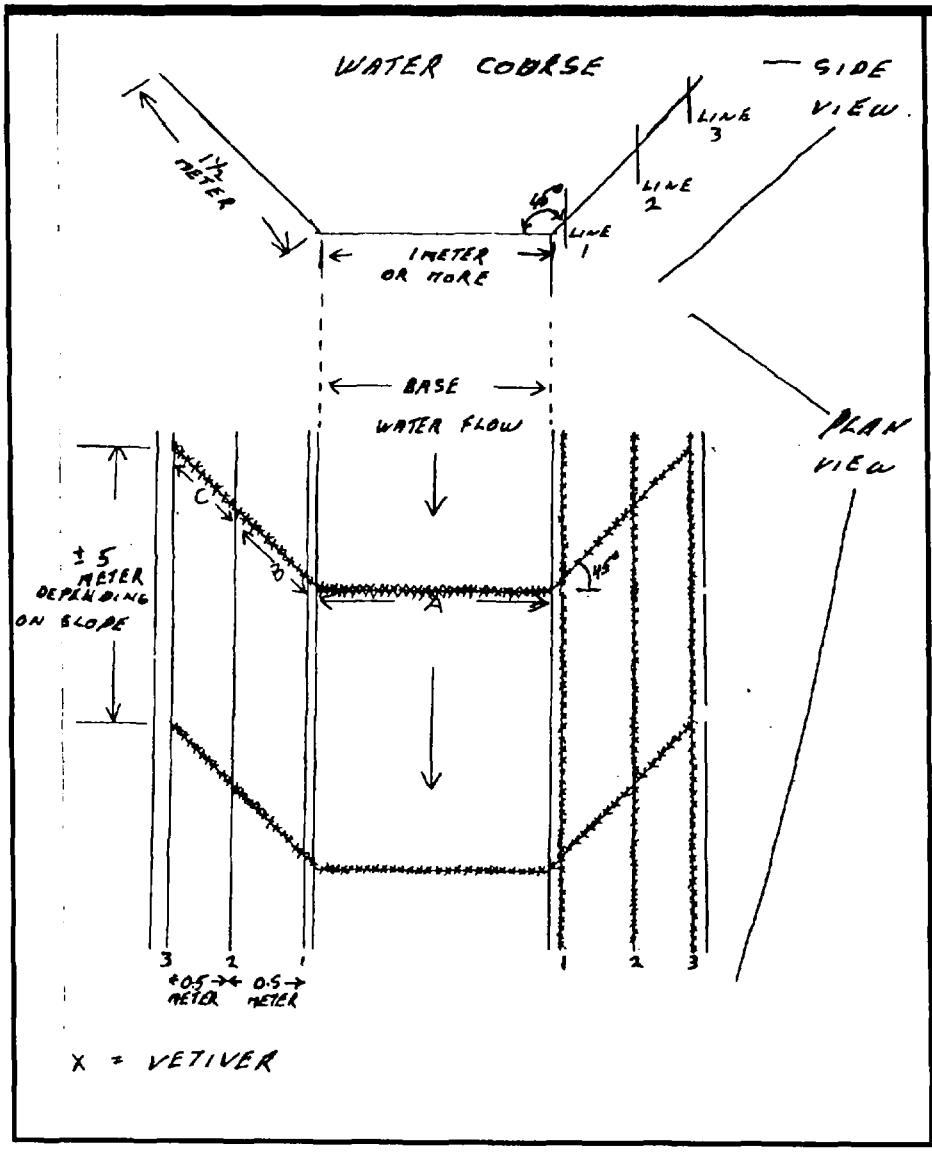


Figure 4. Mr. Robert's approach for stabilizing watercourses. This is a method which Mr. Robert has used successfully on his own farm. Note the lines of vetiver running parallel to the direction of the flow.

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

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

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

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

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

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

Recommendations

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

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

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

acceptable.

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

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

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

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

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

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

Hedgerow Management

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

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

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

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

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

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

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

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

Footnotes

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

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

VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER INFORMATION NETWORK, NUMBER 11, JUNE 1994

THE NEWSLETTER

This newsletter has been entirely prepared by the vetiver users of Thailand and we give special thanks to **Dr. Sumet Tantivejkul**, Secretary-General, The Office of the Royal Development Projects Board. The newsletter provides an interesting account of the remarkable progress that has been made in the introduction of vetiver in a relatively short time. It is particularly important in that it describes how a major-country wide initiative has been undertaken involving policy makers, agencies, officials and the general public. I believe that we can all learn a lot from this initiative in Thailand, and I hope that it inspires some readers to mount similar efforts to reduce soil losses and improve water conservation. The Thai initiative also reflects on the professionalism and leadership of Thailand's King, **His Majesty, King Bhumibhol Adulyadej**. His Majesty has provided the leadership, and has demonstrated his keen interest through His personal participation and that of His Family. He has clearly inspired his people to act. He has also inspired a lot of people outside of Thailand, and in recognition of this, the Vetiver Information Network, at a private ceremony at the Royal Chitralada Palace, awarded His Majesty a specially commissioned bronze vetiver sculpture.

I would also like to take the opportunity of the occasion of this Newsletter to notify you that **Jim Smyle** will, from the beginning of June, be full time in Central America working out of San Jose, Costa Rica. I would like to take the opportunity of this newsletter to thank Jim for all the hard work that he has put into the Network both in the field and for the Newsletter. Without him we would not be where we are today. Fortunately we have not lost him. He will be establishing a vetiver network for Central and South America, and I hope, over time, those of you from that part of the World will direct your queries to Jim. He will respond to you in Spanish!! His address in Costa Rica will be: James Smyle, RUTA, Barrio Escalante, Del Parque Francia, 25 Metros Sur, Casa #342, San Jose, Costa Rica. Tel (506) 255 4011; fax (506) 222 6556.

Photo # 1. *Bronze sculpture, by Reginald Pollack, of Vetiveria zizanioides presented to His Majesty The King of Thailand, by The Vetiver Information Network.*

Photo Credit: R.G.Grimshaw

The next Newsletter, #12, will be published very shortly and will contain feedback from many of you who have kindly supplied information to the network, as well as some notes on my recent visit to India where there are some interesting activities occurring in the use of vetiver.

Dick Grimshaw

Development and Promotion of the Utilization of Vetiver Grass in Thailand

Photo # 2. *His Majesty The King of Thailand and Her Royal Highness the Princess Mother discussing the merits of some good quality vetiver planting material at Doi Tung Development Project.*

Photo Credit: Dr. Sumet Tantivejkul

BACKGROUND

Thailand's soils are currently deteriorating at an unacceptable level that have reached a critical stage. Statistically, one third of the country, equivalent to 107 million rai (17 million ha —1 ha = 6.25 rai) has been seriously affected by soil erosion, particularly in the northern, north-eastern, central and southern parts of the country.

The problem arises from continuous misuse and non-protection of arable lands, deforestation, expansion of the business and industrial sectors into agricultural areas and increase in population, all of which combine to force farmers to exploit and devastate forest lands in the high plains or mountainous areas including the cultivation of short term crops without appropriate preventive measures against soil erosion. Recognizing the importance and necessity of solving the problem, His Majesty the King initiated the use of vetiver grass for conserving soil and water and improving the environment in cultivated and forested areas. His Majesty's initiative concerning vetiver grass was first received by Dr. Sumet Tantivejkul, Secretary-General of the Office of the Royal Development Projects Board, and other concerned people on June 22, 1991 at the Royal Chitralada Palace as quoted below:

"Vetiver Grass is a plant which has a deep root system penetrating straight into the soil and spreading like an underground fence capable of filtering sediments and protecting soil surface runoff. Given these favourable characteristics, studies and experimentation on the cultivation and use of vetiver grass should be conducted at the Royal Development Study Centres and other appropriate locations on a wide scale, and consistent with topographical conditions of the areas. On mountainous locations, vetiver grass should be planted as horizontal contour hedges across the slopes and gullies for protection against soil erosion and slippage and the maintenance of moisture in the soil. On the plains, vetiver grass should be cultivated around or on cultivation plots, in one or two contour lines. When inter-cropped with field crops it should preserve moisture in the soil, absorb nitrogen, and prevent toxic, and other chemicals from flowing into rivers and canals. Moreover, vetiver grass should be planted around reservoirs to prevent the soil from collapsing into and filling up the reservoirs, as well as preserving the soil surface at the upper part of the reservoirs and accelerating tree growth in forest areas which receive adequate water. In addition, there should be a study on efficiency of vetiver grass in controlling the spread of the lalang grass (Imperate cylindrica) in the areas where the lalang is wide spread. At the upper part of the reservoirs, vetiver grass should be cultivated to trap sediments and absorb chemicals and toxins before flowing into waterways. These substances are then stored in the root and stem until they transform into fertilizer useful for plants. It is important to photograph the vetiver before and after the experimentation Additionally the results should be recorded with respect to vetiver's growth, i.e. stem and root; capability of vetiver grass in conserving soil, increasing soil fertility and preserving soil moisture as well as studies on different species and ecotypes of vetiver".

His Majesty the King has paid regular visits to various areas where vetiver grass is grown in order to observe the results of the experimentation and give advice. Furthermore, His Majesty donated US$10,000 from His private fund to the Vetiver Information Network to support research on vetiver grass and its uses. His Majesty made the following observations to Dr. Sumet Tantivejkul on August 28, 1993 at the Royal Chitralada Palace.

"Vetiver grass must be planted 15 cm. apart for large clumps and 2-3 cm. apart for small clumps. However, the latter approach using small clumps at 2-3 cm. interval is believed to be more effective as it will economize the planting slips and form a dense hedge within a few months. By using large clumps with wider intervals, it may take about 2 years for the hedge to become effective. This time frame is too long. The plantings at the Doi Tung Project are rather expensive because vetiver grass is planted in a very dense hedge. However, the project is intended to be an experiment with rapid results. In conclusion, planting smaller clumps at closer distance is appropriate. The vertical interval between rows should be two meters according to the technical paper; the interval being measured vertically along the slope of two meters descending from top to bottom. The interval might not always be 2 m. distance, but can be 1.50 m. as practical. At 1.50 m. apart, it might be more "comfortable" since it is approximately the height of a person. If it is 2 m., a person would have to stretch, but this is also practical, since it would enable the person to view the second row more easily".

Following His Majesty's initiatives to use vetiver grass for soil and water conservation, government and non-government agencies gave greater attention to the impotance of soil and water conservation. The Office of the Royal Development Projects Board provided a central coordinating role for 16 agencies: Department of Land Development, the Royal Forestry Department, Department of Agriculture, the Royal Irrigation Deprtment, Department of Agricultural Extension, Office of Agricultural Land Reform, Department of Livestock Development, Department of Border Patrol Police, Department of Public Welfare, Office of the Accelerated Rural Development, Department of the Royal Highways, Kasetsart University, Chiang Mai University, Khon Kaen University, Prince of Songkla University and Scientific and Technological Research Institute of Thailand.

These agencies were assigned the role to conduct studies and experiments on cultivating and using vetiver grass at different locations and under different uses. In order to allow the activities of these agencies to operate in a cooperative and consistent manner, former Prime Minister Anand Panyarachun, in his capacity as the Chairman of the Royal Development Projects Board, mandated the establishment of the Committee on Development and Promotion of the Utilization of Vetiver Grass under His Majesty's Initiatives on June 24, 1992. The late, His Majesty's Privy Councilor, His Royal Highness Prince Chakraphandphensiri Chakraphand, was the

President of the Committee, with the Permanent Secretaries of the participating Ministries and Director Generals of different agencies acting as the executive members of the Committee. The Secretary-General of the Royal Development Projects Board was appointed as the member and secretary. This Committee is responsible for formulating policies and guidelines in the development and promotion of the use of vetiver grass according to His Majesty's initiatives, as well as monitoring and providing suggestion concerning the operation of the projects.

On August 13, 1992, the Chairman of the Committee on Development and Promotion of the Utilization of Vetiver Grass officially set up the Master Plan Team on Development and Promotion of the Utilization of Vetiver Grass, and the Monitoring and Evaluation Team, both involving representatives from the agencies. The Master Plan Team drafted a master plan for the development of the vetiver grass program, the features of which reflected the consistent and supportive framework of an operation due for completion within 2 years (1993-1994).

The Master Plan contains five plans for the overall operation of the project as follows:

Research, investigation and experimentation plan is subdivided into three groups comprising: the botanical and genetic research group; appropriateness of the utilization of vetiver group; and propagation of vetiver grass using tissue culture techniques group.

Public relations plan involves making of posters, publications, leaflets and brochures; promotion through various sources of mass media; making of video and slides; organizing of seminars targeting 200 concerned officials per year throughout the country as well as preparation of occasional exhibitions.

Dissemination of knowledge plan embraces organization of training for the trainers from concerned agencies, practical seminars for research officials and field practitioners, as well as overseas training in specific fields on technology for the utilization of vetiver grass.

Demonstration and promotion of cultivation in targeted areas plan focuses on campaign promotion on the use of appropriate vetiver species (Vetiveria zizanioides), appointment of the Office of the Royal Development Projects Board and the Department of Land Development to be the central agencies to distribute the correct species/ecotypes of vetiver grass; and to prevent the uses of wrong species which may become noxious weeds and damage the country. At present, the agencies have produced and propagated more than 3 million tillers for distribution to other agencies for further propagation purposes.

Monitoring and evaluating plan: The Committee on Development and Promotion of the Utilization of Vetiver Grass is responsible for studying documents, collecting field data, interviewing the field implementing officials for field data and taking photographs. Moreover, the responsible agencies in the areas where vetiver grass is grown are required to report the results of the operation to the Committee every four months, in the form of a published report, including detailed data analysis. The reports would be further disseminated.

The results thus far of the monitoring and evaluation of the vetiver plantings in the targeted areas from October 1992 to September 1993 are summarized below:

STUDY AND RESEARCH

Collection of Species of Vetiver Grass: The Department of Land Development has collected all the species of vetiver grass, both locally and abroad, to grow in different habitats of the country so as to conduct a comparative study on their growth in different conditions of habitats. Currently, the vetiver grass can be classified into two species as follows:

Vetiveria zizanioides (Nash). This species is able to adapt very well and grow fast in various environmental conditions. Most of the exotic types which were introduced from India, Sri Lanka and Indonesia are especially selected plants and are treated under the factors different from the natural conditions, such as regular cutting, in order to accelerate stem propagation, limit the emergence of inflorescence and prevent cross breeding and mutation. The vetiver grass which is commonly found in natural habitats in Thailand adapts itself to suit the different conditions of the ecosystem, exhibiting many inflorescences and cross-pollination every year.

Although the cross-pollination makes the vetiver grass tolerant to diseases and climatic crisis, mutation may cause the unsteadiness and reduction of the volatile oils. The blade of the grass is 45-90 cm. long and 0.6-0.9 cm. wide, curved on upper surface and flat near the apex, with a smooth and waxy texture, and dark green in color. The color of the lower surface is paler than that of the upper surface. The septum can be seen clearly especially at the basal and middle part of the blade; whereas, the midrib is obscured and buried in the blade.

The one year vetiver has long roots that enable it to penetrate more than one meter below the soil surface. This depends on soil conditions and on the strength of the plant. In alluvial sandy soil, the grass will produce the longest root possible. On December 19, 1991 at the Doi Tung Development Project, Chiang Rai Province, observations showed (by digging around the grass and washing off the soil with water) the deep and expansive pattern of the root of the Surat-Thani ecotype grown on laterite soil, the upper part being alluvial and the lower part being clay. The vetiver grass which was 7 months old had leaves 1.50 m. high and roots penetrating vertically 3.10 m.

Vetiveria nemoralis (Camus). This species is known as the local vetiver,

and appears limited to the Southeast Asian region which embraces Thailand, Laos, Cambodia, Vietnam and Malaysia. Nevertheless, there is no evidence of its uses. This type of vetiver grass is normally found in dry areas or in the type of soil which allows good water drainage in every region of Thailand, especially in dipterocarp forests. However, the species is rare on the peninsula. The grass grows well in areas exposed to both strong and moderate sunlight. The uppermost part of the "bush" bends down in the same manner as in Cymbopogon sp. The stem does not stand upright as in Vetiveria zizanioides. In some areas, the grass forms a dense bush serving as ground cover over a large area, for example, in the area of Wong Tee Kai at Huai Kha Khaeng Wildlife Sanctuary, Uthai Thani Province. Those grown in dipterocarp forests are often threatened by forest fires because their dry leaves can easily catch fire. However, since the basal part of the bush is very dense, it is not easily destroyed by forest fire, and new leaves emerge shortly afterwards. The Vetiveria nemoralis leaf is 35-6 cm long, 0.4-0.6 cm. wide, and pale green. The transverse section of leaf shows triangulate shape in outline.

The leaf texture is coarsely rough and slightly waxy making it fade in appearance. The color of the lower surface of the leaf is the same as that of the upper surface except it is paler. The septum can not be seen; whereas, the midrib is hard and forms the prominent ridge.

The root of this type is shorter than that of Vetiveria zizanioides. The grass of about one year produces a root which is 80 - 100 cm. long. The inflorescence can appear in many different colors, particularly that of the Uthai Thani and Nakhon Pranom ecotypes. Commonly found are those ranging from creamy white to purplish red.

Production and Propagation of Tillers: The Department of Land Development is the principal government agency responsible for producing and propagating vetiver grass. The Department has been propagating 10 ecotypes of vetiver which are primarily selected according to their individual locality. These ecotypes are Loei, Nakhon Sawan, Kamphaeng Phet 1, Kamphaeng Phet 2, Roi Et, Ratchaburi, Prachuap Khiri Khan, Surat Thani, Songkla 3 and Sri Lanka. The Deparment intends to propagate a total of four million tillers in the fiscal year 1993. The purpose is for distribution to other agencies for further multiplication.

Photo # 3 *Different ecotypes of vetiver grass after one growing season at the comparative experimentation plot at the Pikun Thong Royal Development Study Centre.*
Photo credit: *Dr. Sumet Tantivejkul*

Photo # 4 *Propagation of vetiver grass in plastic bags conducted in Department of Land Development's various stations in the country.*
Photo credit: *Dr. Sumet Tantivejkul*

The rest will be distributed to interested farmers and used in demonstration activities in other locations under the Department of Land Development.

The production and propagation of vetiver tillers is also undertaken at the Royal Development Study Centers, where it is mostly used. The Doi Tung Development Project, the largest producer in the country, has also been producing a large number of tillers for uses in the project. At present, it has reached a total of eight million tillers, most of which are the Surat Thani ecotype of Vetiveria zizanioides. The most popular method of propagation of vetiver is by shoot separation, since the grass can produce many shoots at a fast rate. The propagation of vetiver using this technique is performed in three ways: in plastic bags; in raised fields; and in large cultivated plots.

Study of Propagation of Vetiver Grass Using Tissue Culture Techniques: Since propagation of vetiver grass in plastic bags imposes problems on transportation, Dr. Uthai Jaranasri, of the Doi Tung Development Project, has succeeded in propagating vetiver grass using a tissue culture technique using maristematic tissue of the inflorescence. This method is appropriate because it

Photo # 5. *Propagation of vetiver grass in large cultivation plots at the Doi Tung Development Project.*
Photo credit: Dr. Sumet Tantivejkul

does not promote mutation; besides, tiny vetiver tillers make it easy for transporting large quantities to other areas. Moreover, the Department of Botany, Kasetsart University (Deputy Professor Kamolpan Namwongseprom and Assistant Professor Malee Nanakorn, 1992) has experimented with this technique using lateral or terminal buds of vetiver in order to promote rapid multiplication. The experimentation indicates that 70% of plantlets survive which renders the method effective. The vetiver grass tillers produced by this technique are then planted on sites of the Kasetsart University and Kamphaengsaen Campus and show healthy growth.

Study of Germination of Vetiver Grass Seeds: The Huai Hong Khrai Royal Development Study Centre (by Chiang Mai University) and the Kung Krabaen Bay Royal Development Study Centre (by the Department of Land Development) have studied germination of vetiver seed and reported that the seed does not germinate. The reason is believed to be because of defective seed collected from the immature inflorescence. After studying the development stages of the vetiver's inflorescence from flower to seed, Dr. Weerachai Nanakorn (Botanical Garden Organization) found that under optimum conditions, seed can germinate.

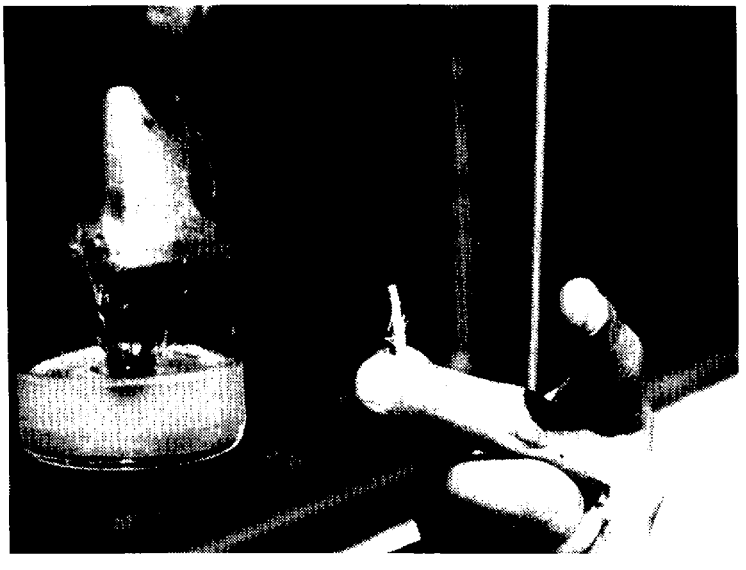


Photo # 6. *Between the fingers is the maristematic tissue which will develop into an inflorescence, and in the bottle is the seedling (plantlet) of vetiver produced from the tissue culture of the buds.*
Photo credit: *Dr. Sumet Tantivejkul*

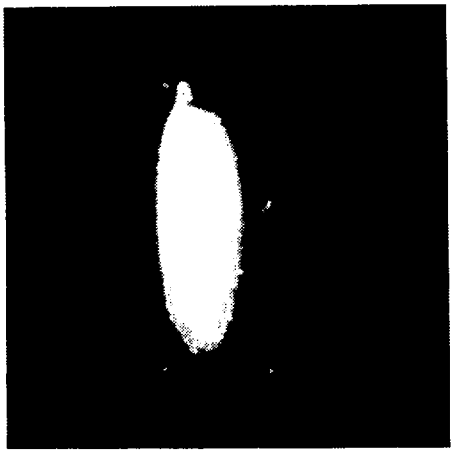


Photo # 7. *Vetiver seed having sticky, tapioca like, brown color texture.*
Photo credit: Dr. Sumet Tantivejkul

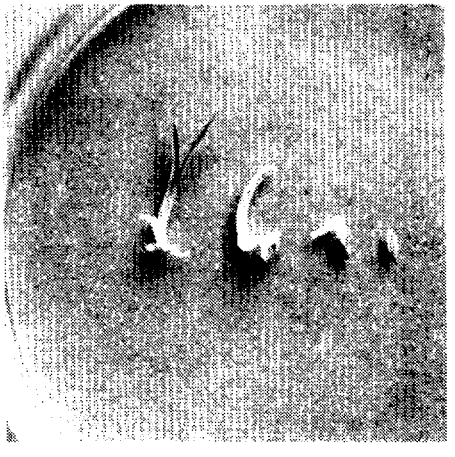


Photo # 8. *Different stages of germination.*
Photo credit: Dr. Sumet Tantivejkul

Study of Efficiency of Vetiver Grass in Soil and Water Conservation in Agricultural Areas: Presently, experiments relating to the efficiency of vetiver in soil and water conservation have been conducted in many agricultural areas throughout the country. The agencies responsible for the projects are the Department of Land Development, the Royal Irrigation Department, Kasetsart University, Chiang Mai University, Khon Kaen University, Scientific and Techno-

logical Research Institute of Thailand and Department of Agricultural Extension. Most of the experiments have only just started and the monitoring work in the field has not yet been conducted.

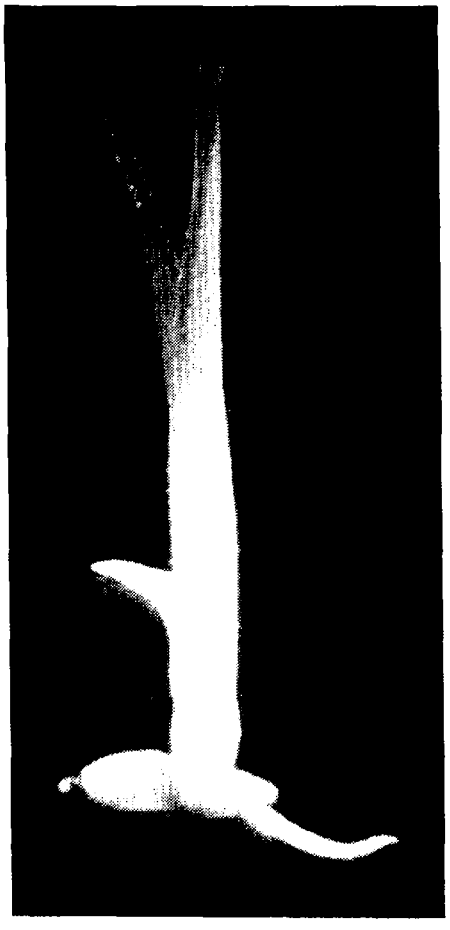


Photo # 9. *Seedling at four days develops clear spines on the edge.*
Photo credit: Dr. Sumet Tantivejkul

Study on Root System of Vetiver Grass: The Khao Hin Sorn Royal Development Study Centre has conducted the study on root system of the six ecotypes of vetiver by planting the material in individual rows measuring one meter with vertical interval of 50 cm. and digging the soil to observe the root depth. The Doi Tung Development Project has also studied the growth of the root of the Surat Thani ecotype and indicated that vetiver grass at seven months of age had a height of 150 cm. and a root 3.10 meters long.

Study on Growth of Vetiver Grass under Critical Conditions: Vetiver grass was planted under **shade** in the conserved forest at the Khao Cha-ngoom Deteriorated Soil Rehabilitation Project in Ratchburi Province and in Suan Phai Ruak at the Sirikit Conserved Forest Project. Most of the plantings died. From this experimentation, it can be concluded that the vetiver grass hardly grows under shade. At the Khao Hin Sorn Royal Development Study Centre, Chachoengsao Province, experiments on the cultivation of vetiver grass, both of Vetiveria zizanioides and Vetiveria nemoralis, under an eight year para-rubber plantation revealed that these two species responded to shade to a different degree. Only 50% of the Khao Hin Sorn ecotype of Vetiveria nemoralis survives, whereas, the Surat Thani ecotype of Vetiveria zizanioides showed increase in height despite little branching. The Khao Hin Sorn Project finds that **In flooded areas** the Surat Thani ecotype of Vetiveria zizanioides had good growth.

Photo #10. *Vetiver at seven months grown on natural loose and solid laterite developed a 3.10 meters long root.*
Photo credit: *The Doi Tung Development Project, Chiang Rai Province*

At the Kung Krabaen Bay Project, vetiver grass survives on laterite soils and in spaces between rocks on roadside slopes (where it is a good soil binder). The Puparn Royal Development Study Centre, Sakon Nakhon. The Regional Forestry Office, Petchburi Province, has grown vetiver (with supplementary and occasional watering) on **hard pan soils**, and found that vetiver shows moderate growth. The result showed that vetiver grass roots can successfully penetrate hard soil.

Photo #11. *Vetiver grass of one year and six months old can grow well in laterite soil.*
Photo credit: Dr. Sumet Tantivejkul

Study on Cultivation of Vetiver Grass to Maintain Moisture for Fruit Crops: The Khao Hin Sorn Royal Development Study Centre conducted an experiment on the cultivation of vetiver grass in a circle around fruit trees and obtained unfavorable results, for the likely reason that the vetiver grass blocks the flow of soil moisture to the fruit trees and/or effect of competition between the vetiver grass and the fruit trees. Additional studies on cultivating vetiver grass in semicircles around the fruit trees are being undertaken, but have yet to be analyzed.

DEMONSTRATION AND IMPLEMENTATION WORK

Cultivation of Vetiver Grass on the Banks of the Pond: Cultivation of vetiver grass on the banks of ponds to collect sediments and prevent collapse of newly constructed banks was successful and efficient.

Photo # 12. *Vetiver planted to bind earth banks which were constructed to prevent the brackish water from flowing into the fields at the Pikun Thong Royal Development Study Centre.* ***Photo credit: Dr. Sumet Tantivejkul***

Cultivation of Vetiver Grass on Earth Banks: At the Pikun Thong Royal Development Study Centre, Narathiwat Province, vetiver grass has been planted on earth banks built to obstruct the flow of brackish water into farmers' land. The results indicate that the grass maintains the shape of the banks and reduces the degree of damage from the brackish water.

Cultivation of Vetiver Grass in Water Gullies: Demonstration of using vetiver grass hedges in the inverted "V" shape, and other configurations, have been carried out at the Huai Hong Khrai Royal Development Study Centre, Chiang Mai Province; the Kung Krabaen Bay Royal Development Study Centre, Chantaburi Province; and the Khao Chagoom Deteriorated Soil Rehabilitation Project, Ratchaburi Province.

Cultivation of Vetiver Grass to Rehabilitate and Improve Deep Gullies: At the Kung Krabaen Bay Royal Development Study Centre, vetiver grass has been cultivated in association with sand bags to arrest sediments in deep gullies. At the Doi Tung Development Project, the vetiver grass has been cultivated in small gullies by the road sides to collect sediments and reduce the velocity of water flows.

Cultivation of Vetiver Grass to Rehabilitate Deteriorated Soil: The Khao Changoom Deteriorated Soil Rehabilitation Project, Ratchburi Province, demonstrated the cultivation of vetiver grass as horizontal contour hedges on slopes of hard, dry and barren laterite soil that are affected by surface run-off. Cultivation of vetiver grass in this manner reduces erosion, allowing water to penetrate the soil and increase soil moisture. The result is that the yellow barren soil became covered with fresh green plants; a condition that indicates an improvement of soil quality to the extent that it could eventually come back into gricultural use.

Prevention of the Collapse of High Road Cuts and Road Shoulders: Vetiver has been cultivated on steep road shoulders in the Doi Tung Development Project. The results are under study.

Cultivation of Vetiver Grass to Trap Toxic Substances: The demonstration is conducted along the edges of the reservoirs at the Huai Sai Royal Development Study Centre with the objective of preventing toxic substances from the nearby golf course flowing into reservoirs.

Other agencies which have carried out experimentation on vetiver grass are as follows:

The Department of Agricultural Extension has cultivated vetiver grass for demonstration and propagation purposes in area covering 5,870 sub-districts in 73 provinces, each with one kilometer of vetiver.

The Royal Forestry Department has cultivated altogether 1,408,500 vetiver tillers within 60 watershed management units in Chiang Mai, Chiang Rai, Phayao, Phrae, Nan and Lampang provinces.

The Royal Irrigation Department has propagated and conducted studies and research on general aspects of vetiver grass as well as the use of vetiver grass to conserve large water resources.

The Office of Accelerated Rural Development has cultivated 803,673 vetiver tillers in the area of reservoirs and check weirs in Lampang, Lamphun, Chiang Mai, Chiang Rai, Phayao and Phrae provinces.

Border Patrol Police Headquarters has cultivated 626,175 vetiver tillers within schools and villages under their responsibility, covering an area of 124 rai.

The Department of Public Welfare has cultivated vetiver grass within the area of the Hill tribe Development and Welfare Centres in the northern part of Thailand covering 13 provinces.

The Department of Livestock has conducted studies on efficiency of vetiver grass for feeding animals in terms of nutritious value.

The Department of Agriculture has conducted studies on the efficiency of vetiver grass as part of integrated farming systems.

The Royal Highway Department has cultivated vetiver grass along road embankments.

The Office of Agricultural Land Reform has cultivated vetiver grass along the banks reservoirs and dikes within Udon Thani, Nakhon Ratchasima, Nong Khai and Lop Buri provinces.

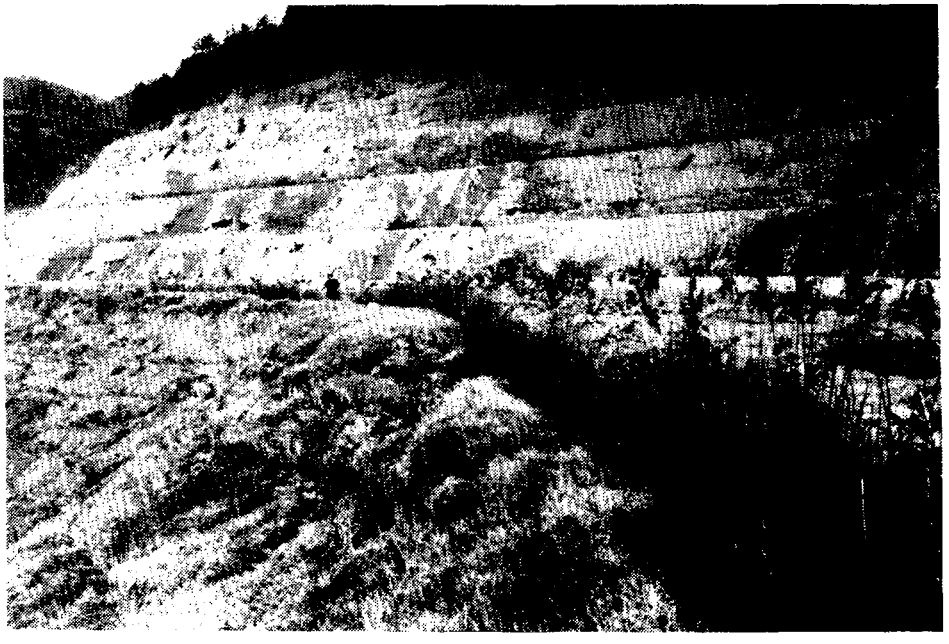


Photo # 13 *Vetiver planted on cut and fill slopes of newly constructed roads to prevent erosion and collapse of cut and to stabilze fill embankment at Doi Tung Development Project, Chieng Rai Province.* ***Photo Credit : Dr. Sumet Tantivejkul***

The Department of Cooperatives Promotion has prepared propagation plots and encouraged the members of the cooperatives to participate in the activities of the Community Cooperative Units, Cooperatives Demonstration Centres, Cooperatives Demonstration Units and Agricultural Cooperatives. The total area of the plots is 10 rai with 32,800 vetiver tillers.

The Department of Land Development has cultivated 5,367,224 vetiver tillers within the areas of land development stations throughout the country.

The Scientific and Technological Research Institute of Thailand has conducted study on the use of vetiver grass' root and volatile oil extraction from its root.

The Universities of Kasetsart, Ch iang Mai, Khon Kaen and Prince of Songkla have conducted studies and research on efficiency of vetiver grass in various aspects.

Vetiver grass can be used in many ways, using its different components, i.e. leaves or root. Vetiver grass can also be cultivated for soil and water management to protect against soil deterioration and to maximize land use. Its use can be summarized as follows:

In terms of environmental and biolgical conservation Vetiver grass can be used for soil and water conservation in many ways:

Cultivation of vetiver grass as horizontal contour hedges on slopes to reduce the rate of water flow and to increase the trapping of soil sediments (the latter naturally become earth banks).

Cultivation of vetiver grass to protect against gully erosion.

Cultivation of vetiver grass to maintain underground moisture.

Cultivation of vetiver grass to protect against damage to bench terraces or hillside ditches.

Cultivation of vetiver grass to prevent soil sediments from flowing into canals, waterways, and farm reservoirs.

Roofing and household uses e.g. using its fragrant roots to freshen the air and repel insects in the closets.

Feeding animals such as cattle and goats with part of the tillers and young leaves. Research shows that vetiver grass can bet used as animal fodder.

Making herbal medicine and fragrance. It is reported that vetiver grass has traditionally been used as ingredients in ancient herbal medications which are capable of eliminating stomach gas, and treating stomach problems. The root can be extracted for volatile oil which is made into fragrance and thus, becomes commercially beneficial and valuable.

INTERIM REVIEW

After a period of implementation of the Project on Development and Promotion of the Utilization of Vetiver Grass Under His Majesty's Initiatives, the Office of the Royal Development Projects Board, as the coordinating agency organized a practical seminar in Chiang Rai Province on September 1- 4, 1993. The purpose was to offer the opportunity for representatives from participating agencies, both at the policy making and implementing levels, to exchange experiences, academic viewpoints, and opinions; as well as problems and obstacles in the administration and their solutions, so as to fulfill the objectives and produce the greatest benefits according to His Majesty's initiatives.

Furthermore, the Department of Land Deveopment has been assigned the leading role in collecting and propagating species and ecotypes of vetiver grass as well as disseminating knowledge and technology with respect to vetiver to other government agencies. The Department organized a practical seminar for scientists, technicians and field practitioners working within the Project on Development and Promotion of the Utilization of Vetiver Grass Under His Majesty's Initiatives on September 21-22, 1993 in Chon Buri Province.

Overall, the aforementioned seminars contributed to the understanding of the principles of project implementation arising from participant exchange of viewpoints and experiences. The seminars also laid the foundation and prepared-

ness on the part of the project officials to be able to accommodate the organization of the 1995 international seminar on vetiver grass in Thailand in partnership with the World Bank. The two seminars have further led to constructive understanding of the following viewpoints:

Project operations in general, results and activities, should be reported and presented to the concerned parties every year. Moreover, a yearly conference to discuss progress and encourage exchange of viewpoints should be organized.

With regard to the collection and evaluation of species and ecotypes of vetiver grass, there should be a discussion on the methods, use and standardized classification.

Study and research work should be broadened in order to cover a variety of fields. Characteristics of vetiver grass should be considered in full details so as to promote various and appropriate uses by taking account of the direct use in soil and water conservation, along with indirect and economic uses in which vetiver grass can beneficially coexist with other plants.

In the future, there should be greater emphasis placed on extending the advantages of vetiver grass for on-farm soil and water conservation. There is a need to furthe evaluate whether the technology is accepted by farmers. The promotion of the use of vetiver grass at present is limited by seedling propagation and transportation from nurseries to the planting areas, especially on slopes which rely solely in rainwater.

CONTACT PERSONS

Interested people can access additional information regarding Thailand's vetiver program by contacting the following persons:

Dr. Sumet Tantivejkul, SecretaryGeneral, The Office of the Royal Development Projects Board. Research and utilization of vetiver grass in the Royal Development Study Centres.

Mr. Sitthilarp Wasuwat, Director General of the Department of Land Development Research and demonstration on the use of vetiver grass for soil and water conservation.

M. R. Disnada Diskul, Director of the Doi Tung Development Project. Propoagation and the use of vetiver grass for embankment stabilization and protection against soil collapse along the slope of highway embankment and cut.

Mr. Taweep Taweepanich, Director General of the Department of Public Welfare. Demonstration and promotion on the use of vetiver grass on high plains.

Mr. Taweesak Sesavej, Director-General of the Department of Livestock. Research on evaluation of the nutritious value ofVetiver grass for animal fodder.

Dr. Weerachal Nanakorn, Director of the Botanical Garden Organization. Study and classification of species and ecotypes of vetiver grass.

The Vetiver Information Network, Room MC 8-307, Asia Technical Department, The World Bank, 1818 H Street N.W, Washington DC. 20433, USA.
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VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER INFORMATION NETWORK

July 1994
NUMBER 12

Commentary

This newsletter, number 12, pulls together information from a number of states in India, that we recently visited, that are in the process of developing comprehensive watershed development programs. The states include those from the relative high rainfall areas of eastern India (Orissa > 1,000 mm of annual rainfall) to the drought prone western India (Rajasthan) where rainfall is sometimes less than 300 mm. We visited three groups of programs: The Pilot Project for Watershed Development in Rainfed Areas (covering the states of Andhra Pradesh, Karnataka, Madhya Pradesh, and Maharashtra - started in 1984 - recently completed and under evaluation); The Integrated Watershed Development (Plains) Project (covering the states of Orissa, Gujarat, and Rajasthan - started in 1990); and the Integrated Watershed Development (Hills) Project (covering Jammu and Kashmir, Punjab, Haryana, and Himachal Pradesh — started in 1990). The main objective of all the projects is to improve farm incomes and nonfarm land productivity, through interventions that include: in-situ moisture conservation measures, rehabilitation of degraded lands and gullies, planting of trees, shrubs and grasses, livestock developing, the training of participants, and expanding the use of NGOs. The newsletter will focus on vetiver and related in-situ moisture conservation components.

You will also find in this newsletter information from users in Asia, Africa, and Central America. Some notable activities are taking place in southern Africa following **John Greenfield's** visit in November 1993. **Steven Carr**, from

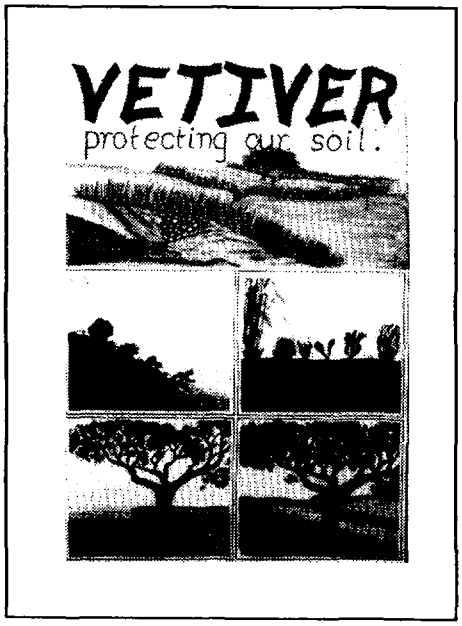

Photo #1. *Eco-Link - a South African NGO's promotional poster for using vetiver grass for soil and water conservation.* ***Photo credit...Sue Hart***

Malawi, reports a growing interest in vetiver in his country, as there is also in Zimbabwe, Zambia and South Africa. **Ato Akalu**, from Addis Ababa, has reported on the effective application of vetiver in Ethiopia. **Jano Labat** (Zimbabwe) and **Tony Tantum** (South Africa) both report new interest in the use of vetiver for mine dump stabilization. **P.K. Yoon** (Malaysia) has once again demonstrated how vetiver can be used to stabilize very large highway embankments in Malaysia. **Paul Truong** continues to demonstrate the tolerance of vetiver to very high levels of toxic minerals, in this case manganese. **Ray Wijewardene** of Sri Lanka reports on the inclusion of vetiver hedges as part of the SALT system for soil and moisture conservation in tea and tobacco.

As demand grows within and outside your countries, some of you may be involved in the sale of planting material — a word of reminder that we must aim to produce high quality planting material and handle it properly, and reduce transportation time to a minimum to assure high survival rates.

During the past six months, the Network has sent to selected participants a number of interesting documents. These include (a) Technical Information Package Volumes 1 and 2 — these volumes reprint (including photographs) of some of the work submitted for last year's Vetiver Awards; (b) Use of Vetiver for Soil Erosion Control of Embankments in Bangladesh by P.K. Yoon; (c) Neem - A Tree for Solving Global Problems by the U.S. National Research Council; and (d) a manual on "Communications for Technology Transfer in Agriculture" by the U.S. Academy of Educational Development. Anyone not receiving

these papers and who would like a copy please let us know. We will bulk up the responses and get a print rerun in October.

India — A Progress Report

In-situ moisture conservation, applied in a number of forms, has proven in all localities to have been successful in: improving crop yields; tree and shrub survival and associated growth rates; reducing rainfall runoff and soil loss, and improving ground water recharge. There are differences as to the degree of success between technologies and between sites:

- Contour, across the slope cultivation: This measure has virtually zero cost and depending on soil type and rainfall has, compared to traditional along the slope (AS) methods, increased yields of annual crops from 10% to 25%.

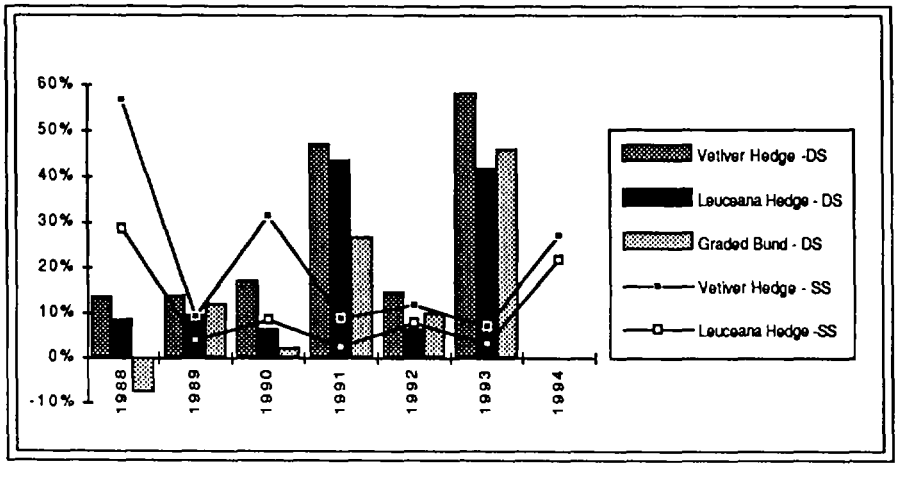

Chart #1. *India, Maharashtra, Akola. A comparison of the impact of three soil and water conservation sytems on shallow (SS) and deep (DS) black vertisols measured as percentage incremental yield increases.* ***Source ... Dr. G.M.Bharad.***

- Vetiver grass hedges: 15% to > 50% incremental crop yields are reported as compared to AS cultivation methods. Vetiver when planted on black (vertisols) soils, particularly black shallow soils, show significant incremental yields (**Chart 1**). This technology has a good chance of success (**Photo 2**) under rainfall regimes of more than 700 mm, and on selected moisture rich sites (such as gully bottoms, river banks and saline areas) in areas where rainfall is less than 700 mm.

- Other grasshedges: Other species are being tested. These include Saccharum munja, Agave sislana, Eulaliopsis binata, and Pennisetum purpureum. Saccharum and Eulaliopsis are difficult to establish as effective hedges (as amply demonstrated at the Kandi Research Station in Punjab and by their general absence in the project areas. Agave has potential in the very dry areas, particularly on nonfarm land. Napier grass (P.Purpureum), unless fully protected, has no chance of survival under drought or uncontrolled grazing conditions. Over 95% of all grass hedges appear to be based on vetiver grass.

- Continuous Contour 'V' Ditch (CCVD). CCVD as applied to non farm land, is now a widely accepted technology as is the basis for land preparation for tree planting. Survival rates are normally well above 80 to 90%, and growth rates have improved significantly. CCVD is occasionally modified as a trench rather than a "V" ditch; there appears little evidence for the additional expense involved in trenching. CCVD at 8 meter horizontal intervals in most cases reduces runoff by as much as 97%.

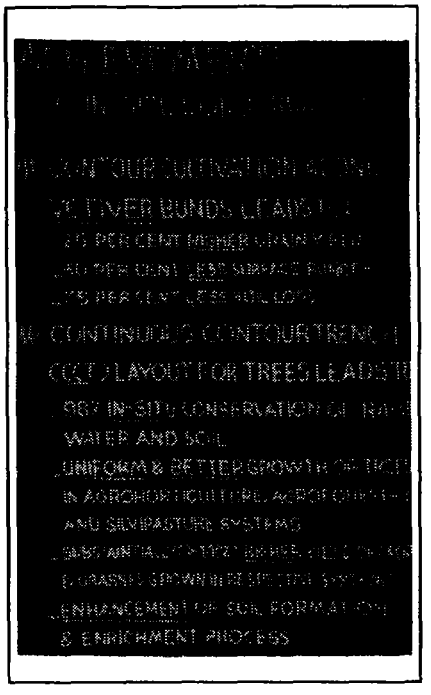

Photo # 2. *Dr. Bharad's Information Board at his 20 ha experimtal site at Akola.* ***Photo Credit ...R.G.Grimshaw***

- Chisel ploughing: This technique as being experimented in Rajasthan involves ripping to 50 cm depth, in contour lines 2-3 meters apart, using a chisel plough powered by a 40 HP tractor. It has good potential and may have equivalent water conservation benefits as CCVD. More testing is required.

Reduction in rainfall runoff: At all long term experimental sites, vetiver grass hedges reduced rainfall runoff better than any other method under on-farm

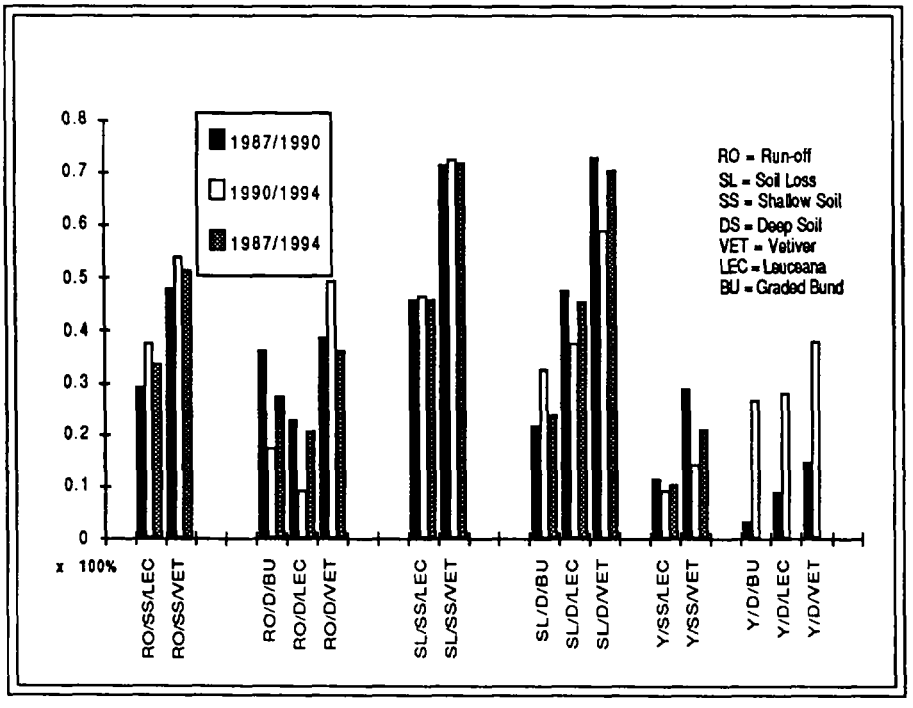

Chart # 2. *Comparison of different conservation barrier treatments at Akola Maharahtra. Incremental soil loss (SL) and run off (RO) reductions expressed as a percentage of the control (along the slope cultivation).* ***Source...Dr. G.M. Bharad.***

conditions. CCVD, supported by vetiver, performed best under nonfarm (nonarable) conditions. Runoff reductions varied between 35 and 70% with the best results on shallow soils. There seemed not much difference between runoff reductions at ICRISAT (Hyderabad — red soils) and Akola (Maharashtra — black soils). As a rule of thumb, Vetiver hedges were significantly better at reducing runoff as compared to both Leuceana sp. hedges and earth bunds (**Chart 2**). The probable reason for this is vetiver's ability to spread water more evenly, bring water velocity to a minimum, and, via its deep root system, provide a better infiltration zone at the hedge barrier.

Reduction in Soil Loss: At all sites, vetiver hedges proved significantly better than other technologies for reducing soil losses. For example, on shallow soil, at Akola, soil losses were reduced by a mean of 70% over 6 years compared to 45% for Leuceana and 24% for earth bunds. Similar results were obtained under operational research projects in Karnataka and at ICRISAT. In physical terms, a vetiver hedge will reduce soil loss from about 8 -11 tons (somtimes very much higher rates i.e.> 40 tons) per ha to 2-3 tons per ha. This is well within acceptable soil loss limits.

Gully and structure stabilization: There appears to be virtual unanimity of the superior performance of vetiver for gully stabilization and for the stabilization of structures. This is because in most cases there is better moisture conditions on water course sites, and vetiver grows particularly well under such conditions. The most impressive results appear to be in Orissa, where in some areas the use of vetiver has been a traditional practice for stabilizing outflows in field-to-field irrigation of paddy fields (**Photo 3**). This practice is now being used at Phulbani and Jagganath Prasad Districts to stabilize earthen spill ways, gully check structures, etc.

Photo # 3. *Orissa, India. For generations, farmers have used vetiver grass as a means of stabilizing paddy field bunds at the point of outflow to the lower field.* ***Photo credit...R.G.Grimshaw***

Ground water recharge: As should be expected by the positive runoff reductions, ground water shows significant recharge where in-situ moisture conservation techniques are being practiced. At Manoli (Maharashtra), as a result of ground water recharge, some 319 new wells have been dug, and over 500 ha of land has been brought under irrigation. At the research farm at the University of Akola, it is estimated that recharge has improved by 30%, and is sufficient to drip irrigate 25% of the unit area if put under perennial horticulture. **We may well find that this recharge, if properly used, will be one of the most important economic benefits from in-situ conservation.**

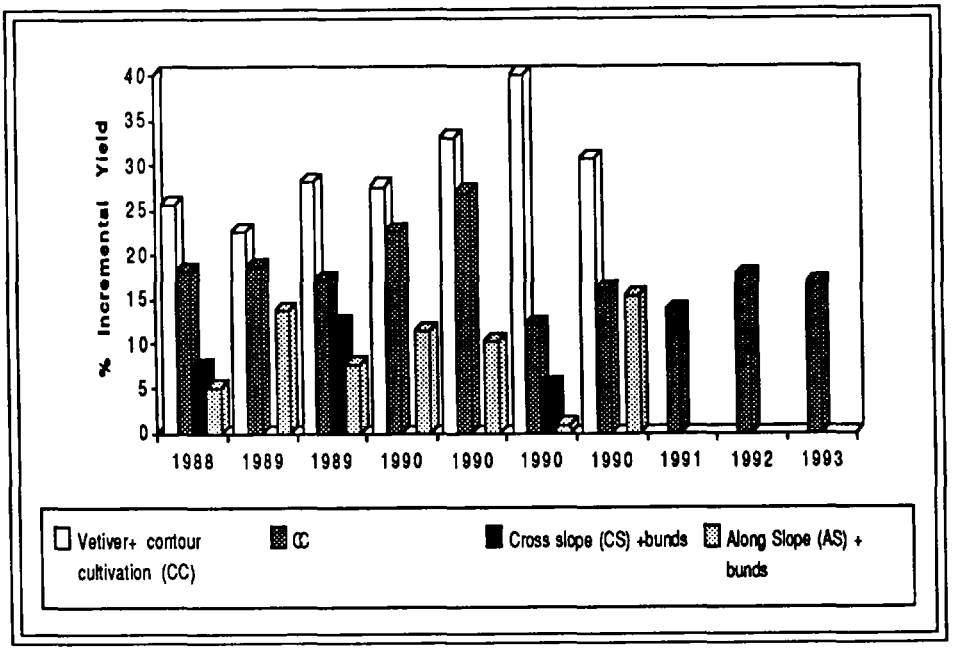

Chart # 3. India, Mahahrashtra, Department of Agriculture annual crop cutting statistics on farmers' fields from Manoli Watershed comparing the impact of different land treatments on incremental yields with along the slope cultivation as the base comparator. ***Source...Maharashtra D.O.A***

Technical issues, observations and recommendations

Vetiver Grass: In most instances, vetiver should be the preferred species on the basis of its functionality and its adaptation to a wide variation in site conditions. There appears to be few problems where there is no major water stress. There can be problems in drought years, and when planted on soils with extremely limited water capacity. For instance, in Rajasthan, trials show that the survival rate of vetiver in the first year increases from 55% to 80% if grown in the bottom of a "V" ditch as against on the top of the "V" ditch bank. The same applies to planting vetiver on the edge of inward sloping terraces on the steep slopes of the Shivalik Hills. The latter have very shallow to no soil at all, and the terrace lips are devoid of moisture. In these cases, it is better to plant at the intersection of the terrace bed and riser. The effect should be the same, but more moisture will be available for hedge establishment. (Incidentally on the deeper and wetter soil of Assam, it is reported that planting vetiver on the lip of terraces has reduced terrace collapse from 25% to zero). It is suggested that in dry areas, experiments should be made in planting vetiver directly into chisel plough rip lines (a continuous lateral column of water can be expected in these rip lines immediately after a rainfall occurrence). In Rajasthan, 100% first year survival has been achieved by using vetiver slips grown in containers (4 inch polybags). The cost is about Rps. 4 (US $ 0.125) per linear meter and is probably economical. Further testing of this technique should be carried out. In dry areas, site location will be an important factor in using vetiver. In all areas, the correct time of planting (early in the monsoon — Kashmir and other Himalayan eco-sites in early spring) will effect survival rates considerably.

Photo # 4. Maharashtra, Akola. Use of vetiver to protect raised beds in wet areas. ***Photo Credit...R.G.Grimshaw***

It is agreed that many of the failures can be attributed to the incorrect application of technology, including: use of poor quality planting material (perhaps even dead), delays between removal from nursery and actual field planting (more than two days delay results in only 60% survival), planting at the wrong time (late in the wet season), and sometimes deliberate mismanagement (yes, it's true) of the planted material.

There are two immediate problems effecting the use of vetiver grass barriers:

- Farmer acceptance: Farmers are slow to accept the technology. It will take time, maybe four years, for farmers to adopt a new technology, particularly one that, to the farmer's eyes, appears to have no immediate short term benefits. There is a need to greatly improve farmer participation in the use of, and the marketing of the technology. Farmers need proper training in all aspects of the technology including reasons for using it (conservation, risk reduction, crop yield increases, thatching, mulching, fodder, handicrafts), and proper training in its application. A **social marketing strategy** should be developed that would include demonstrations, training, radio, TV, and written propaganda. The marketing plan should take account of the role of all the stakeholders including farmers, extension, research, conservation and forestry staff. Farmers are likely to adopt the technology more quickly in the better rainfall areas (>700 mm). Farmers should be involved in the production of vetiver planting slips, and except, perhaps, for initial demonstration, should not be paid to plant the material on their farms. *Farmers need to learn good management practices, including:* gap filling, cutting for fodder, burning for termite control, and adjacent cultivation techniques to minimize damage to the hedge. If farmers could relate the use of vetiver with the significant recharge of ground water and the consequent improvement in well and pumped water, adoption of the technology could be expected to accelerate.

At the end of the day, farmers are looking for yield increases. Chart # 3 shows, from a random sample of farms in Manoli Watershed near Akola, that a vetiver hedge barrier consistently (where recorded) shows the highest incremental yield increase, whatever the crop. Cultivation on the contour is the next best technology. The relative small difference between the two may be the reason why the adoption of vetiver grass barriers is rather slow. The key to accelerated adoption will come through better farmer training and greater farmer comprehension of the other benefits (particularly long term) that vetiver hedges provide.

- Vetiver dieback: In the drier areas (< 600 to 700 mm) and on shallow soils (< 15 cm), vetiver may be subject to dieback from about the fourth to sixth year after planting. This is compounded by intensive overgrazing. Dieback is associated with termite infestation, but it is now thought that the termite damage may be a secondary symptom as a result of a primary attack by a root fungus occurring under conditions of moisture stress. This fungus has been identified by AKV Akola. It can be contained. Investigations by **Dr. B.S. Hegde** at Bangalore (Karnataka) show that vetiver cultivars differ in susceptibility to termites (or perhaps to primary root fungus). We may therefore be able to deal with the problem through cultivar selection. **It is very important to test out under different ecological conditions the main vetiver cultivars available in your countries**, as has been done in Thailand. In India, it is reported that over 100 cultivars exist. Apart from testing for dieback, testing will enable appropriate cultivar selection according to need and rainfall conditions. (It should be noted that in Thailand, of 30 cultivars site-tested (20 sites), about 8 have been recommended for use). Additionally, bad management practices, such as ploughing through the hedges, dumping crop residues on hedge rows, and failure to fill gaps and control livestock, has also led to the destruction of the hedge rows. These bad practices can be reduced through better farmer education.

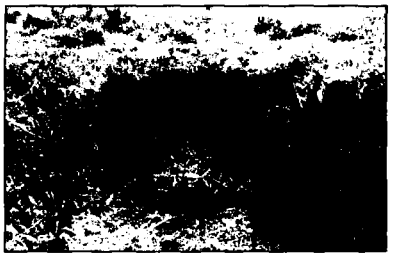

***Photo # 5** . Vetiver planted in a "triangular wedge" at the bottom of a gully in Orissa.* **Photo Credit ... R.G. Grimshaw.**

Other Observations

Regenerating vetiver hedges: Under dry hostile farm conditions, it may be necessary to replant vetiver hedges every 6 to 10 years. The cost of this is minimal. Probably no more than the cost of 1 man day per 100 running meters.

Photo # 6. *India - Phulbani District, Orissa. Containerised vetiver plants ready for transport to field site. Note nurseries are in close proximity to final point of planting.* ***Photo Credit... H.S.Kumar***

A useful technique has been developed by **Dr. Bharad**, at Akola, in the use of planting vetiver to protect the edge of raised beds (8 sorghum rows wide) on wet badly drained black soils. A good crop of sorghum can be grown on the raised bed, and the surplus water drained off to the inter-bed area is enough to support paddy rice (**Photo 4**). Vetiver can also be used to spread flood water on gently sloping lands and can help channel the surplus along vetiver defined waterways. This system is also an effective method of flushing excess salts from saline areas (Akola District - Maharashtra, and Bhilwala District - Rajasthan).

Rats are not welcomed by vetiver in the higher rainfall areas, or along paddy field bunds - could this be because the soil is moist, as would be the root system of vetiver? In the dry areas, there is ample evidence of rats making their homes in vetiver hedges (as seen at the Kandi Watershed Research Station in Punjab). In the latter case, the vetiver roots are dry, and probably make a pretty good habitat for rats. The rat issue is more likely to relate to moisture conditions rather than to root odor. Interestingly, we heard recently that USDA Wildlife Research Center at Denver Colorado may be doing some research in this area.

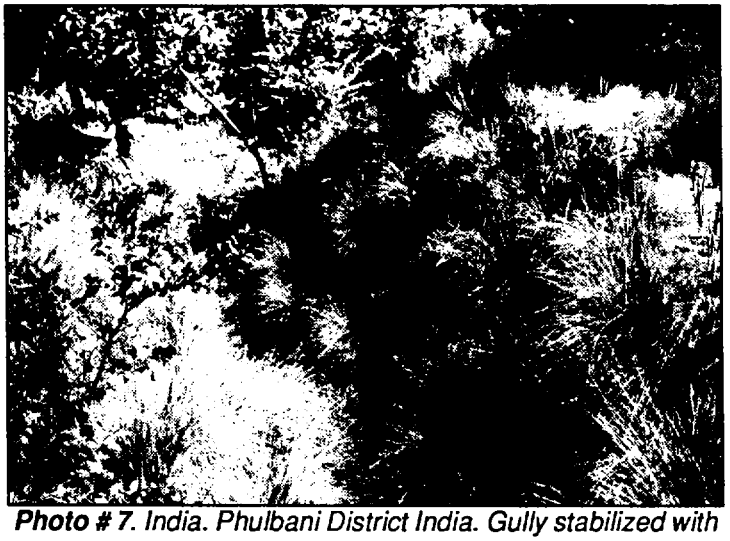

Photo # 7. *India. Phulbani District India. Gully stabilized with vetiver at 1 year old.* ***Photo Credit... H.S Kumar***

Vetiver and gullies: Vetiver will be most effective when planted as a hedge across the gully floor, and along the bottom of the gully wall adjacent to the gully floor. In such cases the vetiver hedge will reduce undercutting and will allow a slow collapse of the gully wall to form an angle of natural repose. Of course, where the gully wall is sloping, vetiver can also be planted along the wall, but one can often see poor growth when planted along the top lip of the gully with vertical sides because of limited soil moisture (**Photo 5**).

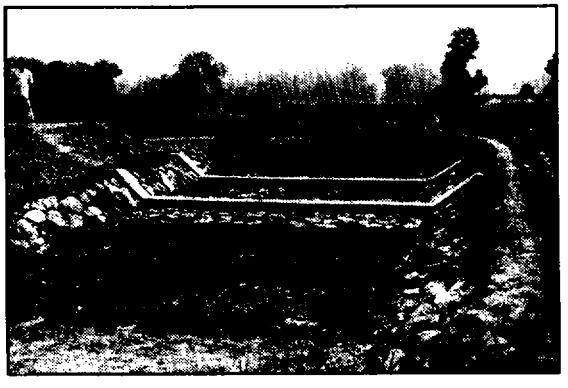

Photo #8. *India. Phulbani District, Orissa. Vetiver used for spillway stabilization - note vetiver has been heavily grazed.* ***Photo Credit.... R.G.Grimshaw***

Vetiver nursery information It is important that farmers get involved in producing vetiver slips. They can do it easily, and often they have better land resulting in better output. The following data from Akola gives some indication of production costs (note US 1= Rps 30):

- Nursery production: 40 - 70 tons of slips per ha. 40 slips/kg @ Rps. 2/kg i.e. Ps. 0.05 per slip.
- Planting material requirement for nursery establishment at 20 x 40 spacing is 2.5 tons per ha.
- Net nursery income approx. Rps. 24,000 per ha.

- Hedge establishment. Rps. 120 per running 100 m (6x3x100x0.05) = Rps. 90 + labor + transport.

Photo 6 shows some good quality poly-bagged vetiver produced at Phulbani, Orissa, used for stabilizing gullies and spillways (**Photos 7 & 8**).

Treatment/grasses	Run off - mm	Soil Loss - Kg/ha
Discharge 180 litters per hour, 60 mm applied.		
Vetiveria zizanioides	2.4	14
Cymbopogon martinii	8.7	48.5
Panicum maximum	6.1	33.9
Saccharum munja	10.7	209.4
Fallow Field (control)	12	223
Discharge 2,400 litters per hour, 40 mm applied		
Vetiveria zizanioides	20	201.3
Cymbopogon martinii	21.6	216.3
Panicum maximum	22.4	218.6
Saccharum munja	25	3495.8
Fallow Field (control)	30	6716.2

Table 1. India - Madhya Pradesh. Comparison of effectiveness of different grass species in controlling erosion and runoff when grown as a barrier hedge. ***Source...Dr. D.P.Nema***

India - Madhya Pradesh - Vetiver: Its Application to Black Vertisols - Great Possibilities

The Jawaharlal Nehru Krishi Vishwa Vidyalaya (University) at Jabalpur has been conducting research into vegetative soil and water conservation measures at three sites with rainfall ranging from 900 to 1,200 mm. **Dr. D. P. Nema,** Director of Research, has sent us some of the results. All the sites are classified as semiarid. Studies were carried out in planting vetiver in gullies on the Kymore Plateau. It was found that due to the high velocity of rainfall, in order to assure high survival rates, vetiver needed to be planted in more than one row across the gully or be reinforced with loose stones (*another alternative is to use poly-bagged vetiver as done in Orissa).*

Another experiment compared plots, one barren and the other having a vetiver hedge (3 rows at 1.1 m vertical interval) + natural grasses + wild fruit trees, both on a 4.1% slope. After three years, there was a deposition of 44.6 tons/ha of soil on the vetiver plot, and a soil loss of 350.6 tons/ha on the barren plot.

At Sehore, Vindhyan Plateau, measurements of soil loss/deposition at two vetiver contour hedges showed that over 6 years soil deposition had increased from 6.8 cm to 19.1 cm and that by the fifth year (due to the increased density of the hedge) soil erosion had been reduced to zero.

In comparative trials to evaluate survival rates of grasses, it was found that vetiver had the highest survival rates (V. zizanioides - 98.3%, Sorghum halepens - 92%, Cymbpogan martinii - 83.7%, Saccharum munja - 78%, Cynadon dactylon - 16.7%).

Another study compared runoff and soil losses between grasses. The results are shown in - Table 1:

Rajasthan - the Driest Region of India - Vetiver's Limit?

We received a special report on experimental studies involving some of the agronomic features of vetiver grass. Experiments were carried out at five sites on soils that were primarily sandy loam to sandy clay loam Alfisols. Average annual rainfall, depending on site was from 300 mm to 630 mm. The average number of rainy days per annum varied from 12 to 29. The pH was between 8.3 and 9.

Generally under these dry conditions soil moisture is the critical factor in establishment and growth. The work, under well recorded and controlled conditions by **Dr. Mahnot** at the College of Technology and Engineering at Udaipur, is worth following, and some of his three years' experiments are recorded below.

- Under dry conditions, vetiver should be planted 10 to 20 cm apart with 3 slips per planting hole. The difference in spacing was not significant, but survival increased from 51% (1 tiller) to 82% (3 tillers).

- Inorganic and organic manures and polymers had an impact on survival. The most cost effective and practical was farm yard manure, which when applied at 0.6 kg per meter, resulted in survival of 87% (control 67%), tillers per clump — 24 (control 10.5) and girth of clump - 44.5 cm (control 22 cm).

- Vetiver planted in bottom of "V" ditch resulted in highest survival of 80% after one year.

- If field planting was delayed to 3 days after lifting from nursery, survival rates were reduced to about 70%.

- Polybag-raised vetiver plants had 98% survival as compared to bare rooted vetiver - 17% (2 tillers per planting hole).

Because vetiver is very responsive to moisture availability at the time of planting, and conversely is difficult to establish under very dry conditions (as in Rajasthan during the past two or three years), it will be essential to look into different establishment techniques that involve optimizing soil moisture at planting time. The use of polybags is clearly a successful technique, but may be too expensive for general use. On the other hand, it may be quite economic for use under special circumstances involving the stabilization of costly structures.

Kerala - the Church and Vetiver

The Archbishop of Trivandrum, the **Most Reverend Benedict Mar Gregorios** writes to say that he has started the multiplication of vetiver and is widely promoting its use. He sees a good potential for vetiver in sea shore stabilization — Kerala has 600 miles of eroding shoreline. He writes, "Although vetiver is a native of Kerala. It is very much neglected. People emotionally care for crops that bring money immediately!" The issue of farmer adoption of vetiver is critical and requires special attention in designing and implementing soil and water conservation programs.

The following quote sums up the diference between adoption and non-adoption:

"There is a huge difference between telling someone to do something because it is good for them and explaining clearly why something is good so that they can make up their own minds" Isabel Carter

Too often we tend to "tell" farmers; the successful vetiver programs should be characterised by the inclusion of a well thought out action plan that includes good farmer programs that explian the benefits and use of vetiver (through, for example, quality promotional programs and training).

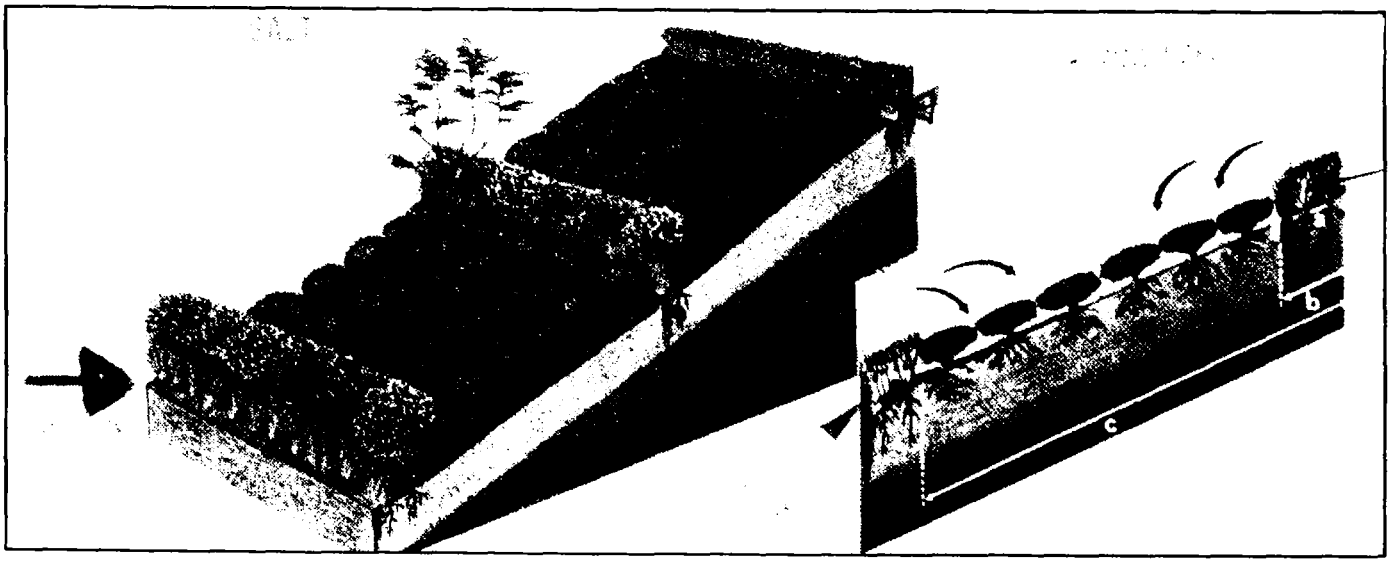

Figure 1. *The width of the avenues between the double-hedgerows varies between 6 and 7 meters depending upon the tea clone used and the corresponding planting density. The total width covered by the hedgerow, inclusive of the vetiver-grass strip need not exceed 1 meter. Spacing between hedge row and tea row 1 to 1.5 meter. a = 40 - 50 cm, b = 100 cm; c = 6 - 7 meter.* ***Source...Tea Research Institute of Sri Lanka, and the Upper Mahelwali Watershed Management Project.***

Photo # 9. *Malawi. Vetiveria zizanioides hedge protecting a young pine plantation.* ***Photo credit...Stephen Carr***

Sri Lanka -Tea - SALT and Vetiver Grass Hedges

Ray Wijewardene has developed a "sustainable land management system for tea" that combines a double row of leguminous hedge row and a single row of vetiver (known in Sri Lanka as *Savandra* grass) aligned on the contour with 6 rows of tea between hedge rows. A 1.5 m space is allowed between hedge row and the first line of tea (**Figure 1**). There are eight different species of leguminous shrubs that can be selected according to site and end use. Ray writes to say that they now have more than 6,000 ha of degrading tea and tobacco lands under this system. Benefits include improved soil nutrition, reduced erosion and improved soil moisture which together adds up to sustainable and increased tea and tobacco yields. It also results in reduced costs because drains no longer fill with sediment, and eventually he thinks that drains will not be needed. The SALT (Sloping Agricultural Land Technology) system pioneered by Rev. Harold Watson in the Philippines is a well known technique and the incorporation of vetiver into SALT provides pretty nearly a fool proof system. Just one more bit of history. Back in 1947, vetiver hedge rows were identified by Eden (the recognized "tea" scientist at that time) as the best means of erosion control in tea following experimentation in the Usambara Mountains of Tanzania. So there is nothing new in this technology! If you need more information on this application in Sri Lanka I suggest you write to the Tea Research Institute of Sri Lanka, St. Coombs, Talawakelle and/or The Upper Mahaweli Watershed Management Project, PO Box 98, Kandy, Sri Lanka. Fax 08 32343. They have produced a very simple and descriptive brochure about the system.

Photo # 10. *Malawi. Vetiver hedge protecting fruit orchard.* ***Photo Credit ...Stephen Carr***

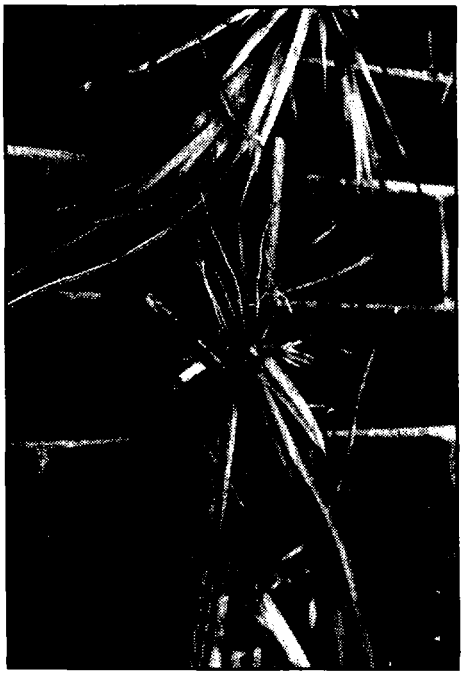

Photo # 11. *Bangladesh. Vetiver can be propagated from nodal shoots.* ***Photo Credit.... Pou Jensen***

A Malawian Initiative

Stephen Carr writes to say that vetiver workshops have been started in Malawi for all senior soil conservation officers. He has sent some good photos of vetiver being used on farm and forestry demonstrations (**photos 9 & 10**). He has encountered problems in some nurseries from a fungus that has led to reduced growth in the nurseries and extensive dieback in the field. It has been identified as Helminthosporium spp. I wonder if there is any relationship with the Indian problem mentioned above. Perhaps Malawian and Indian researchers could exchange some views. The wife of one of his farmers was "delighted with vetiver stalks which made far better fire lighters than other local grasses (Hypperhenias) particularly on damp mornings." IFAD is reportedly about to implement a project in Malawi that will use vetiver as a key technology.

Philippines On-Farm Research Notes

The Farm Resource Management Institute (FARMI) of the Eastern Visayas has initiated a project on the "Adaption/ adoption of Appropriate Upland Technologies at Punta". One of the studies includes the adoption of contour hedge rows using vetiver grass as the foundation. The activity is not yet completed, but it is promising that the initial 40% turn out of targeted clientele who are adopting the intervention on contour hedge rows using vetiver grass on a trial basis is indeed noteworthy. Observations show that the receptivity of farmer cooperators is promising; from the original two farmers, it had risen to 15 - 20 farmers at the time of the report. We will keep a watch on this study.

Bangladesh Vetiver is Ideal Plant for Erosion Control and FloodEmbankment Stabilization

Pou Jensen of the Royal Danish Embassy in Dhaka (previously she was a vetiver enthusiast in Africa) writes to say that vetiver is quite common in Bangladesh. Its local name is *Binna or Binda* and is used for thatching, fodder and bund protection. There is plenty of vetiver in the Chittagong District, and she says it is also used widely in the northern Dinajpur District. She says that she has not seen any flowering vetiver - yet. In drier areas, she has found that vetiver can self-propagate at the stem nodes (**Photo 11**). We have seen this phenomena in other countries. It provides a means of multiplication, and of course is the basis for "layering" of vetiver. As a reminder, we have copies of P.K. Yoon's report on embankment stabilization in Bangladesh (it contains some very useful photographs). If you would like a copy, please let us know.

Photo # 13. *Zimbabwe - Chiredzi. Jano Labat's sugar cane field drain protected by vetiver grass. Hippo Valley Estates are now following this practice. John Greenfield on left side.* ***Photo credit... John Greenfield***

Please note we are told that the Government spends over $150 million a

Photo # 12. *Zimbabwe - Centenary. Vetiver used to stabilize wall of dam on tobacco farm.* ***Photo Credit....Colin Nethersole***

year for maintenance of river and sea wall embankment stabilization — Vetiver could reduce this cost considerably.

Zimbabwe - Commercial Farming Applications

Colin Nethersole is a relatively new vetiver user. He farms at Centenary, and incidentally has the nicest vetiver logo that we have seen. He has used vetiver to protect a dam wall (**see photo 12**), and is about to protect 30 hectares of his farm using the vetiver as contour hedge rows. He has established a number of nurseries and has vetiver planting material for sale. He reports that most seeds seem to appear sterile; no visible pest or disease problem, and no nematode damage to roots; vetiver shows very vigorous regrowth are burning; vetiver is not a weed problem; and

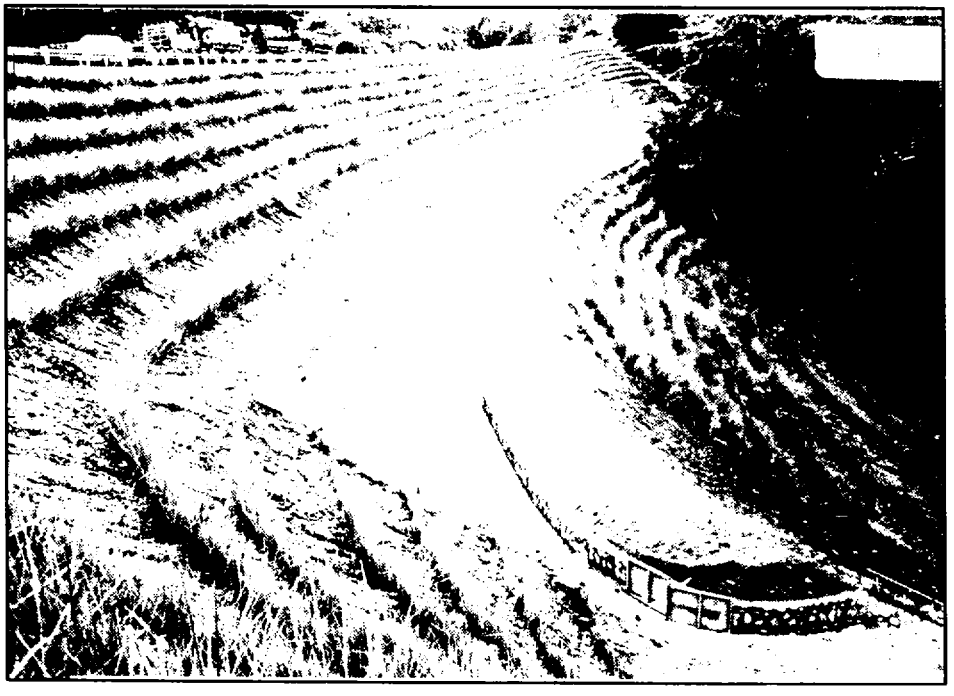

***Photo # 14** .Malaysia - East - West Highway. Stabilization of down slope fill of highway using Vetiveria zizanioides. Six months old vetiver planted from containerised grown plant material. Consulting Biologist - P.K.Yoon.* **Photo Credit:... P.K.Yoon**

in fact keeps invasive weeds out, and reduces the need for herbicides. He seems pretty happy with vetiver, growing it on sandy to sandy loam soils, temperature range 10°- 30° C, and rainfall averaging 800 mm (the last two years > 600 mm).

Jano Labat from Chiredzi, the network's most dynamic and dedicated vetiver user in Zimbabwe, has used vetiver in a number of ways on his farm, including for the stabilization of drains (**photo 13**). He has been working with Zimbabwe's largest sugar estates - Hippo Valley Estates Ltd. - which produce 250,000 tons of sugar per year. Hippo's Assistant Field Manager, **John Kavumbura**, wrote to Jano, "We now believe there is no other grass that will serve the same purpose as vetiver grass, and to this end we have embarked on an ambitious program of planting vetiver to the tune of 6 km per section per month. All our vetiver will be planted in drains..."

United Kingdom, An NGO at Work

Bob Mann of the Methodist Relief and Development Fund writes that his organization has established vetiver nurseries in the Gwembe Valley in Zambia, also at Pobe in Benin. On a recent visit to northern Ghana, he found vetiver (Vetiveria nigratana) on the banks of reservoirs near the town of Wa in the west. The local people simply know it as "conservation grass", brought to the area many years ago by engineers who were building the dams. It was surviving well in this very dry area. He understands that V. nigratana grows naturally in northeast Ghana, but not in the north west.

In the Gwembe Valley, a drought stricken and very poor area adjacent to Lake Kariba, Bob Mann and **Felix Kalikiti** (a Zambian forester) found vetiver in a remote valley south of Chirundu. The seeds are sterile, the grass is used to thatch huts, and the cane-like stems are used to make the walls of their huts. The local names are "Masanga" in Tonga, and "Masindasulu" in Goba. Felix Kalikit, who is multiplying vetiver for farmer soil conservation trials has confirmed that the vetiver is V. zizanioides. For those of you working in northern Zambia, V. zizanioides is available at Mpika Research Station. Also John Greenfield found it at Msamfu Research Station, in the early 1980s, where it had been established in the same lines for 60 years. Bob sees (and we agree) that it is very important that farmer managed vetiver nurseries are established so that farmers can see how the plant grows and behaves before it is established on the farm. In the Gwembe Valley, vetiver was sold for thatch - so here we have an alternative economic use.

China - "A Fix for Soil Aluminium Toxicity"

Mr. Xia Hanping from the South China Institute of Botany reported on some of his Institute's experience in Guangdong Province. Using vetiver, some 400 ha of severely eroded lands in four counties have been brought under control. At one area, known as "the Red Desert", erosion has been completely controlled over two years, and has resulted in economic and environmental benefits. One interesting observation relates to vetiver's ability to decrease the content of exchangeable aluminium, and take up other toxic minerals. For further information on these initiatives in south China, refer to the special edition of the Vetiver Information Network bulletin of December 1993.

Photo # 15. *Malaysia - East - West Highway. Cross section of vetiver hedgerows (photo #14) across road fill embankment. Note overlay lying on original land form (see root - lower right). Vetiver roots have struck through fill into original material - some measure 3.4 meters.* ***Photo credit:...P.K.Yoon***

Malaysia The Wizard at Work!! Highway Stabilization

P.K. Yoon, the winner of the King's Award for Vetiver Research, has extended his initial trials on Malaysia's East-West Highway to a large test site on a very unstable section of the Highway affected by serious slippage. Although only planted within the last six months, the hedges have been well established and are effective. (**Photos 14 and 15**). It seems that Malaysia's engineers are impressed as the demand for containerised grown vetiver planting material is greater than supply. P.K. is also helping a company in Spain to get started in vetiver. **One of the many reasons that he is so successful is that he combines his great depth of scientific knowledge with a very practical approach which, above all, depends on assuring that the technology is applied properly.** For those of you who know the plantation industry (P.K. is a rubber scientist), a key to success is in the correct application of technology. The same should apply to small farmer and engineering uses of vetiver as well. P.K. has recently been to Spain to help establish a vetiver grass operation there, it will be interesting to hear his views on the possibility of using vetiver grass in Mediterranean type climates.

Nepal - Abundant Opportunities, but Very Few Takers

The Community Welfare and Development Society of Nepal is undertaking trials using vetiver. Other users in Nepal might be interested in contacting the Society for more information. We are concerned that a lot more use could be made of vetiver in Nepal, but we don't get much feedback, and there seems to be little promotion of the technology. It has been used successfully on irrigation projects in the Terai, and for hill road embankment stabilization in eastern Nepal. Please, could readers of this Newsletter in Nepal give us some feedback.

Fiji - Where it All Started

David Meadows, the World Bank's coconut specialist, while visiting Fiji, took time out to look at vetiver. He writes "It was quite clear that Vetiver had been extremely effective in controlling sheet erosion. Vetiver hedges were also extremely effective in protecting the banks of waterways and strengthening bunds, even under extremely saline conditions ..... because of neglect and lack of maintenance, vetiver, that had been planted in the 50s and 60s, had spread ....farmers reacted by tearing out the whole thing rather than restoring the hedge to the original dimensions ....vetiver hedges have been damaged by cane trucks, since the hedges have impeded the trucks, large gaps have been cut in the hedges with consequence reduction in conservation effectiveness .... the Chief Extension Officer, **Mr. Subramanian**, indicated that vetiver did well under tree crops including tea, and needed no maintenance as the shade from the trees reduced the vigor of the grass..."

Ethiopia - Vetiver could be the Key to Soil and Water Conservation

Ato Akalu Ngewo from Addis Ababa has written to say that there is a growing interest and use of vetiver in western and southern Ethiopia. There are a number of NGOs promoting vetiver, and the Fincha Sugar Estates are using it for erosion control. Ato Akalu writes "...With the devolution of power to the regions, many institutions, NGOs, civic organizations, development associations are mushrooming in all regions ... It is interesting to note that all of them aspire for relief, rehabilitation and development through conservation and other infrastructural development... Government is also making a conducive atmosphere for NGOs to participate in rural development .... The coming three or four years could be crucial for Vetiver

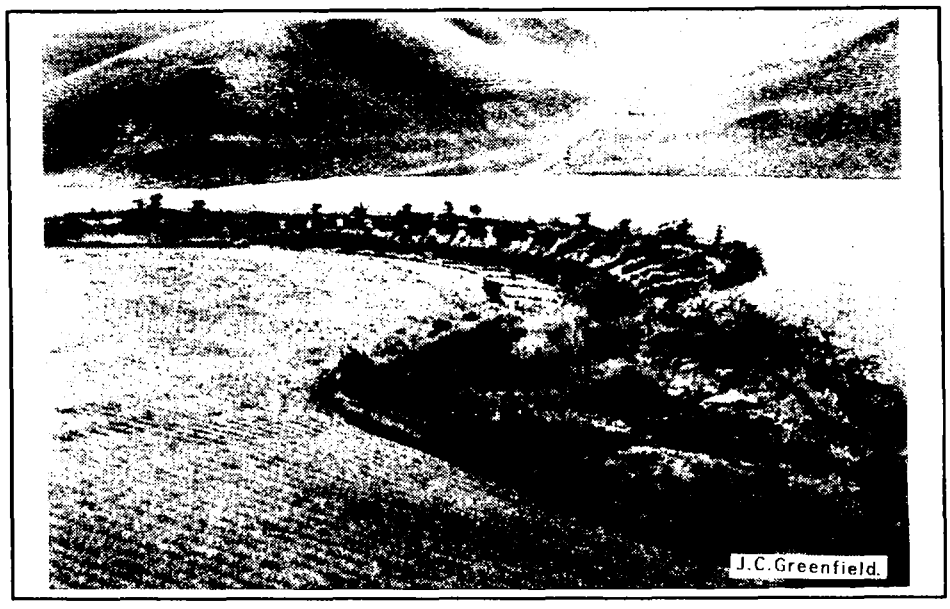

Photo # 16. *South Africa - Natal. Maxime Robert's main farm drain running through a sugar cane field stabilized with vetiver. Note the spurs to deflect storm water from the center.* ***Photo Credit ...John Greenfield***

Grass Technology (VGT) promotion, trials, demonstrations, research and development in Ethiopia, and the opportunity should not be missed ..... I believe that the jump start of VGT could be turned into sustainable vegetative soil and water conservation development in Ethiopia.." There has been some excellent work done with vetiver in Mettu (Western Ethiopia) and there are some very good opportunities for the technology in this highly erodible but potentially very fertile country. **Ato Akalu** has been the driving force behind the introduction of vetiver in his country, and The Network would like to congratulate him on his efforts. Those NGOs and others who participate in the Vetiver Information Network and who are working in Ethiopia and want to know more about the technology should contactAto Akalu Ngewo at his home address — PO. Box 1562, Addis Ababa, Ethiopia.

Kenya - Slow Progress, but Opportunities Abound

Vetiver hedges have been tested in a number of areas in Kenya, and have been found to be effective. Perhaps it might be a good idea to test vetiver in the tea and coffee growing areas. If anybody needs further information, please contact Jacob Kampen at the World Bank's office in Nairobi or fax the Vetiver Information Network directly - **USA - 202 522 1658**

Costa Rica and Central American Growers Accelerating Interest in Vetiver

Following a Vetiver Network visit to Costa Rica last year, the **Department of Agriculture** has stepped up its promotion of vetiver in the south of the country, particularly in coffee growing areas. We look forward to hearing more about the program there, as well as in other Central American countries, following Jim Smyle's establishment in San José. **SHARE - Guatemala**, having tested vetiver with farmers for the last four years, and convinced of its utility, have, we understand, decided to go ahead with a program that will train 22 other NGOs in Guatemala and 3,500 farmers in the use and merits of vetiver grass hedgerows. Those Panama readers who are always looking for vetiver We now have confirmation that it is growing and thriving.

Indonesia - River Bank Stabilization

We have heard from **Dr. Ramu**, River Basin Adviser, that the Directorate of Water Resources has the funding to establish four substantial test sites in different river basins in Sumatra in order to study and test the effectiveness of vetiver for river bank stabilization.

South Africa - New Horizons

Tony Tantum is the Network's key person in South Africa and has been instrumental in the promotion of vetiver grass technology. Under South Africa's new government, opportunities abound for using the technology for the conservation of natural resources. In previous Newsletters, we have reported on Tony's work, but would remind you that in South Africa the technology has already been effectively applied to: on-farm conservation **(Mr. Maxime Robert - Photo 16)**; highway stabilization; erosion control on firebreaks; railroad embankment stabilization; building site stabilization; and now the mining companies (Anglo American) are taking a keen interest in using vetiver grass to stabilize mine dumps . *The Network suggests that containerized grown vetiver be used for this task, since mine dump soils are generally very bad (low pH, devoid of nutrients, and often with limited water).* Tantum also suggests that Salt bush will grow on these mine dump "soils", and is quite a good stabi-

lizer.

Australia - Believe it or not

Paul Truong has just completed a study on the tolerance of vetiver grass to manganese toxicity. Together with its tolerance of aluminium toxicity the results help to explain why it can thrive on poor and hostile environments. He was unable to induce Mn toxicity when reducing soil pH to 3.30 and increasing extractable soil Mn to 578 ppm (**Photo 17**). Plant Mn at 890 mg/kg was also very high without showing any toxicity symptoms. In comparison Mn toxic contents of some of the common crops are 217 ppm for sorghum, 494 ppm for cotton, and 210 ppm for corn. Paul adds that he hopes to start a project looking at some of the native Australian vetiver species such as V. filipes, V.elongata,V.pauciflora, V. rigida. This would be a valuable contribution to expanding our knowledge about vetiver grass. Are there any of our readers prepared to help finance this new task?

Paul Truong has received funding to test out vetiver to replace terraces on very steep sugar lands near Cairns (Queensland), and for the replacement of stubble-fallow strips in a strip cropping layout on the flood plain in the sub-tropical/temperate region near Brisbane. The objectives of this latter work would be to monitor in the field the effectiveness of the hedges in spreading flood flows and in reducing flow velocities and soil movement -- Altogether about 10 km -- of hedge. In connection with the latter **Paul Dalton** and **Dr. Rod Smith** of the University of Southern Queensland have carried out experiments to determine some of the hydraulic characteristics of vetiver hedges. The first year's results are positive and it appears hydraulically feasible to use vetiver hedges to control flood flow and erosion on cropped flood plains. The hedge spacings required are comparable to, and slightly greater than, the strip spacings required for conventional strip cropping, but are far less sensitive to the magnitude of discharge. There appears to be a limited range of slopes for which the hedges alone would provide adequate protection against erosion. Note this experiment was carried out on vetiver grass of less than one year old. Experiments will continue with mature hedges.

Photo # 17. *In search of Vetiver,*
Photo Credit:...Charles Maquire

Vetiver Information Network, Room MC - 8-307, The World Bank, 1818 H Street N.W. Washington D.C. 20433. U.S.A.
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Fax # 202-522-1658

Vetiver Grass
The Hedge against Erosion

The World Bank
Washington, D.C.

(First edition 1987, Fourth edition April 1993)
Cover design by Bill Fraser
ISBN 0-8213-1405-X

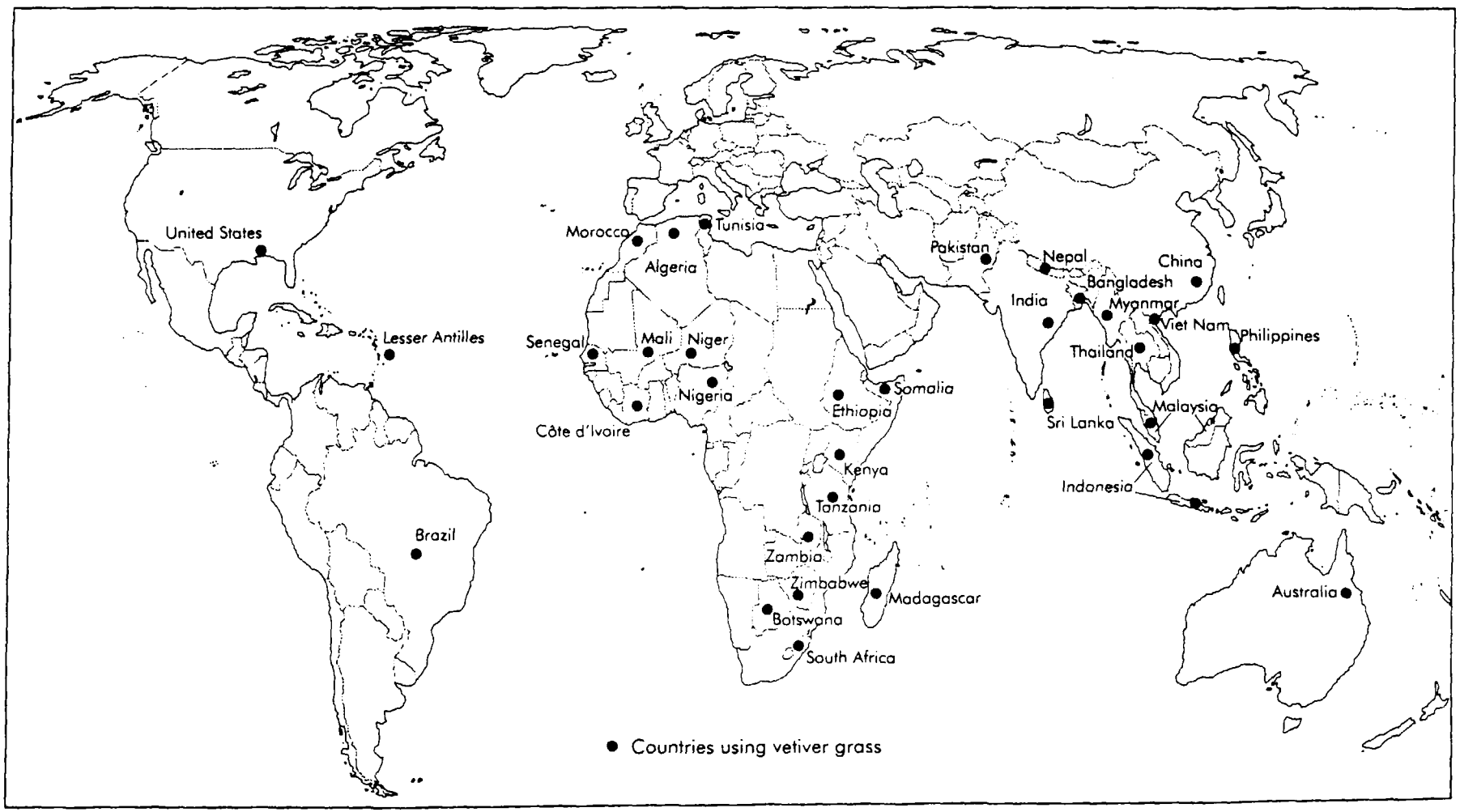
Preface

For at least the next decade environmental issues will dominate the agricultural and natural resource sectors. Already the focus of much attention are the problems of deforestation, increased flooding by major rivers, and reduced dry-season water flows for irrigation and urban and industrial supplies. Not enough attention, however, has been given to the massive problem of soil erosion and, more specifically, to the need to reduce soil and water losses caused by excessive rainfall runoff. Of the 11 million hectares of forest cut down each year, one-half is estimated to be needed to replace cropland that has gone out of production owing to erosion and the consequent loss of fertile soil. At the same time, many millions of hectares of land once deemed cropland with high potential are annually being downgraded to land with low potential and high risk, even in areas receiving substantial rainfall. This is because excessive runoff prevents the land from making effective use of the rain that falls. The prime cause of soil erosion and excessive rainfall runoff is the removal of vegetative ground cover by human and livestock populations—one of the dire consequences of our continuing and accelerating overuse of the world's land resources.

Topsoil losses in the past have brought down whole civilizations. The Mayas of Central America are one example, and North Africa used to be the "granary of the Roman Empire." Soil erosion is truly a global problem, and the need for conservation has become critical in many countries. For example, more than half of India's cropland is losing productivity because topsoil is being washed or blown away faster than natural forces can replace it. Reducing the topsoil layer means reducing plants' access to essential soil nutrients and water.

Changes in farming practices have made the problem worse in recent years. In response to the growing need for grain for exploding human and livestock populations, farmers switched from traditional rotations and multiple cropping to continuous-row cropping, a practice that encourages rainwater to run off the land at a faster and more destructive pace. As a result crops are denied the moisture they need for optimum growth.

Recognizing the problem, top-level policymakers in many countries have devoted substantial portions of their budgets to finding a solution. But the sums allocated are often insufficient, costs are too high, and many of the conservation techniques attempted have been ineffective and are inappropriate for small


United States
Lesser Antilles
Brazil
Morocco
Tunisia
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Kenya
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Zambia
Zimbabwe
Madagascar
Botswana
South Africa
Pakistan
Nepal
China
Bangladesh
India
Myanmar
Viet Nam
Philippines
Thailand
Malaysia
Sri Lanka
Indonesia
Australia
● Countries using vetiver grass

farmers. Soil erosion continues at an accelerating and alarming rate. Governments have only limited access to public funds. Many think that farmers should bear the cost of soil conservation, but most cannot afford to unless cheaper methods—preferably linked to direct income benefits—can be identified that are acceptable to farmers.

This handbook has been prepared to support fieldworkers and farmers in developing vegetative systems of soil and moisture conservation that will meet the requirements of small farmers in developing countries, most of whom reside in the tropics and semitropics. Experience has shown that conventional systems of earth bunds or terraces on small farms are expensive and in many cases, especially in modern times, ineffective. When applied correctly, vegetative systems of soil and moisture conservation—particularly the system of hedges of vetiver grass described in this handbook—have proved cheaper and more effective.

Since the publication of the first edition of this handbook in 1987, we have learned that Indian farmers near Mysore have been using vetiver grass as hedges for perhaps as long as two hundred years. This fact has given the new users of vetiver grass more confidence in the technology. Since 1987 the technology has been tested in the field in many countries—India, China, Philippines, Indonesia, Nigeria, Madagascar, Brazil, and Australia, to name a few. Soils and climate vary tremendously within this group. For example, in China vetiver is being grown as hedges on 60 percent slopes to protect tea and citrus crops on low pH (4.1) red soils. In India it is being used successfully on black cotton soils (severely cracking vertisols) on slopes of 2 percent or less. In other countries such as Trinidad, it has been used for years to stabilize rock-based roadsides. In every case this unique grass has displayed the same extraordinary characteristics that make it an ideal low-cost, non-site-specific system for controlling soil loss and improving soil moisture.

We have learned during the past few years that the introduction of a new technology requires persistence and patience. We believe that the effort and persistence of the many new promoters of vetiver technology are paying off; both the demand for and use of the technology are accelerating. If the system is adopted to the extent that we hope, two landmark objectives will be met in the effort to help more and more of the developing world reach a sustainable basis for rainfed agriculture and land resource conservation; namely, soil stability and in-situ moisture conservation. We are indebted to many workers active involved with this technology. We have to realize the early users of the technology: farm such as those in south India whose ancestors have used the grass for centuries; sugar companies in the West Indies and Fiji that have successfully used the technology for more than fifty years; and West African farmers such as the Hauser of Nigeria, who know well the merits of the grass farm boundary markers. We must recognize the dedication of John C. Greenfield, who renewed the use of the technology in India during the 1980s and was responsible for the preparation this handbook. We must also acknowledge the contribution of the agricultural staff and scientists in the Indian states of Andhra Pradesh, Karnataka, Madhya Pradesh, and Maharashta who have dedicated part of their work to establishing this technology for farmers in these poverty-stricken areas of India. Most recently we must acknowledge efforts by the management and staff of China's Red Soil Project who have taken the lead in testing and demonstrating the technology in their country in the hope of aiding the millions of farmers who live on the badly degraded soils of south China. Finally we have to thank the World Bank staff in New Delhi and Washington, D.C. who have been responsible for editing this handbook and the two earlier editions published under the title, Vetiver Grass (*Vetiveria zizanioides*): A Method of Vegetative Soil and Moisture Conservation.

This handbook is intended primarily for

practitioners and users, and as in previous editions we ask for your views and ideas so that they can be incorporated in future editions.

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Chief, Agricultural Division
Technical Department, Asia Region
The World Bank
Washington, D.C.

Contents

Vetiver Grass: The Hedge against Erosion

Sheet Erosion

Sheet erosion is the most damaging form of erosion, mainly because it is often not recognized and therefore seldom treated. Triggered by rainfall, sheet erosion accounts for the loss of billions of tons of soil every year. As raindrops pound the ground, particles of soil are knocked loose and then carried away by the runoff. This runoff further strips unprotected areas of their valuable topsoil and becomes the muddy water that ends up in drains, streams, and rivers. sheet erosion leads to more striking forms of erosion—rills and gullies, for example, the focus of most conservation efforts to date. Although not as spectacular, sheet erosion does leave visible marks, as shown in **Figure 1**: soil collecting behind obstructions on a slope (such as the brick in example **A**); stones left behind by the runoff because they were too heavy to be carried away (**B**); or moldy mounds of soil and other debris trapped under branches, twigs, or even clumps of straw (**C**).

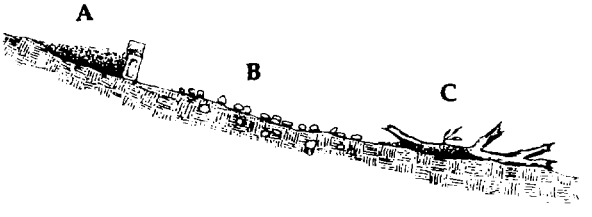


Figure 1. Signs of sheet erosion

The effects of sheet erosion are more readily apparent in forest areas that are devoid of ground cover—and in fields or wastelands with a few standing trees—where the loss of soil exposes the roots of the trees (**Figure 2**). Water can then easily pass beneath the trunks of the trees and between their roots. Once all the soil that supported them and gave them life is washed away, the trees will be washed out of the ground as well.

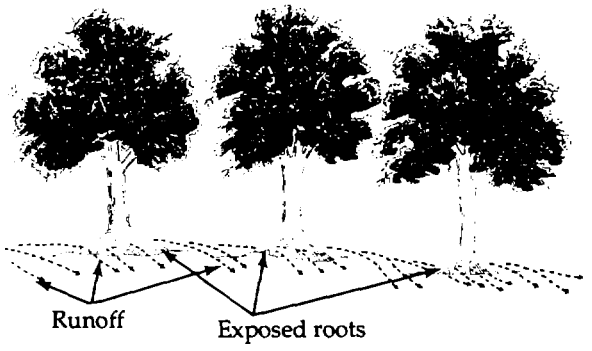


Figure 2. sheet erosion and Trees

Trees by themselves do not prevent soil losses caused by sheet erosion; forests do, with their thick litter and low-growing vegetation. In areas where forest cover is not possible or practicable, vegetative barriers can be used to stop the loss of soil. Fibrous-rooted shrubs and grasses planted as hedges along the contour of the land slow the runoff, spread the water about, weaken its erosive power, and cause it to deposit its load of valuable soil behind the hedgerows. As a result the runoff proceeds gently down the slope, and, if the hedges have been planted at the correct vertical interval (see page 40), without further erosive effect.

The amount of soil lost through sheet erosion is alarming. **Figure 3**, which depicts two surviving plants whose roots prevent sheet erosion, shows how the amount can be measured. In this case a layer of soil 50 centimeters deep—as measured by the distance between the top of the plant mounds and the present soil surface—has been lost across the entire area of the field since the plants became established.

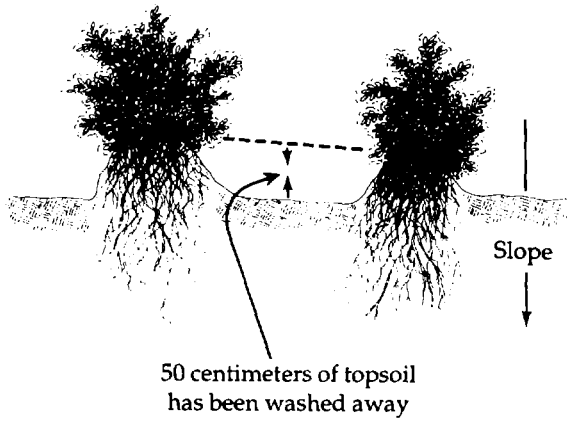


Figure 3. Loss of Topsoil

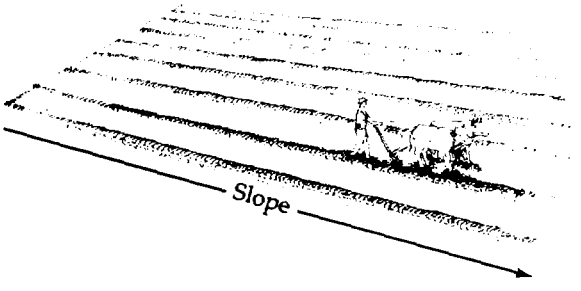


Figure 4. Traditional Rainfed Farming

Rainfed Farming

The traditional way of farming in rainfed areas, no matter how flat the land may seem, is along the slope, or up and down the hill (**Figure 4**). This system encourages runoff and soil loss and thus makes sheet erosion worse. Often more than 50 percent of the rainfall is lost as runoff and thereby denied to the crops, and the steeper the slope, the faster and more erosive the runoff. Rainfall is less effective because the water is not given a chance to soak in. By plowing along the slope, the farmer in **Figure 4** is unknowingly

encouraging the rainfall to leave his field.

Figure 5 illustrates the method advocated in this handbook—the use of *vegetative contour* hedges to prevent erosion and conserve natural moisture in the soil. Once established, such hedges need no maintenance and will protect the land from erosion for years, as they build up natural terraces. In contrast to the planting furrows in **Figure 4**, those at **A** in **Figure 5** follow the contour of the land as laid out by the vegetative hedges (**B**).

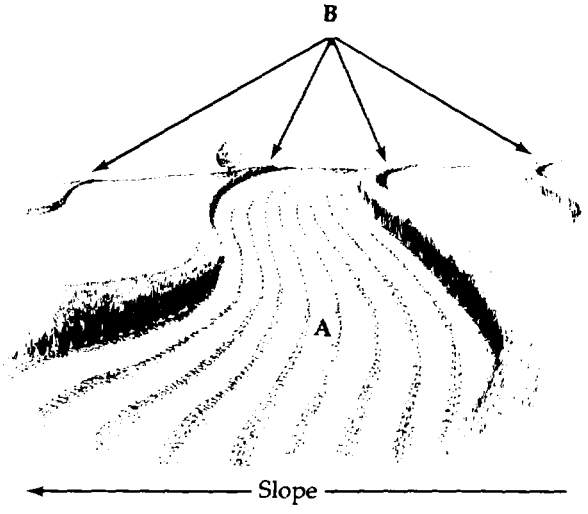


Figure 5. Farming with Vegetative Countour Hedges

Constructed earthen embankments, or contour bunds, have slowed erosion throughout the world since the 1930s. But this method of soil conservation creates an unnatural system of drainage and is no longer considered appropriate for small holders. The embankment in **Figure 6** was constructed with topsoil taken from point A, which was thereby transformed into a channel to convey the runoff sideways.. But the bank is made of the same soil it is supposed to protect, and because its construction makes the slope steeper, over time the bank will erode and "melt" away.. Then it will have to be replaced—at great cost to the farmer. Moreover, to collect sufficient soil to make the bank and channel shown in Figure 6, a 5-meter-wide strip of land must be taken out of production over the entire length of the bank. This represents a loss of 1 hectare of productive farmland for every 20 hectares of land treated with embankments or bunds.

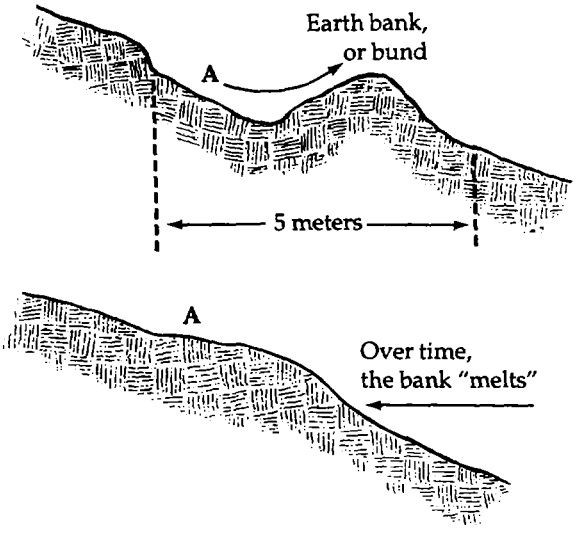


Figure 6. Constructed Method of Soil Conservation

Figure 7 shows the unnatural way the land is drained by this system. All of the runoff is channeled sideways and dumped into a waterway that no small holder would want running through his or her farm. This system makes the areas below the banks too dry, and the channel areas too wet, for optimum crop production.

In contrast, the vegetative method of soil and moisture conservation uses nature to protect itself. In the system demonstrated in this handbook with vetiver grass (*Vetiveria zizanioides*), only a 50-centimeter strip—or one-tenth of the land occupied by earthen embankments or bunds—is taken out of production (**Figure 8**). Because the grass root divisions, or slips as they

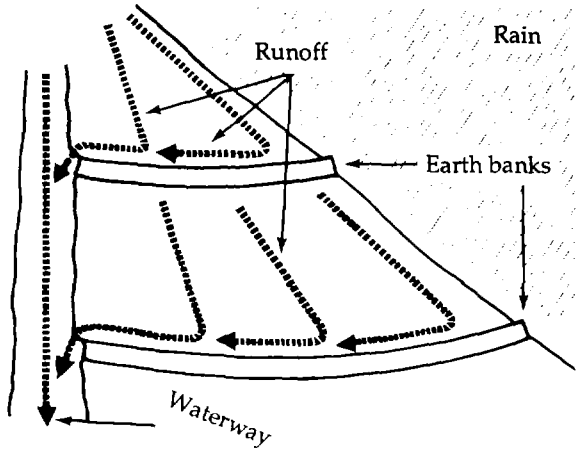


Figure 7. Drainage Under the Constructed System

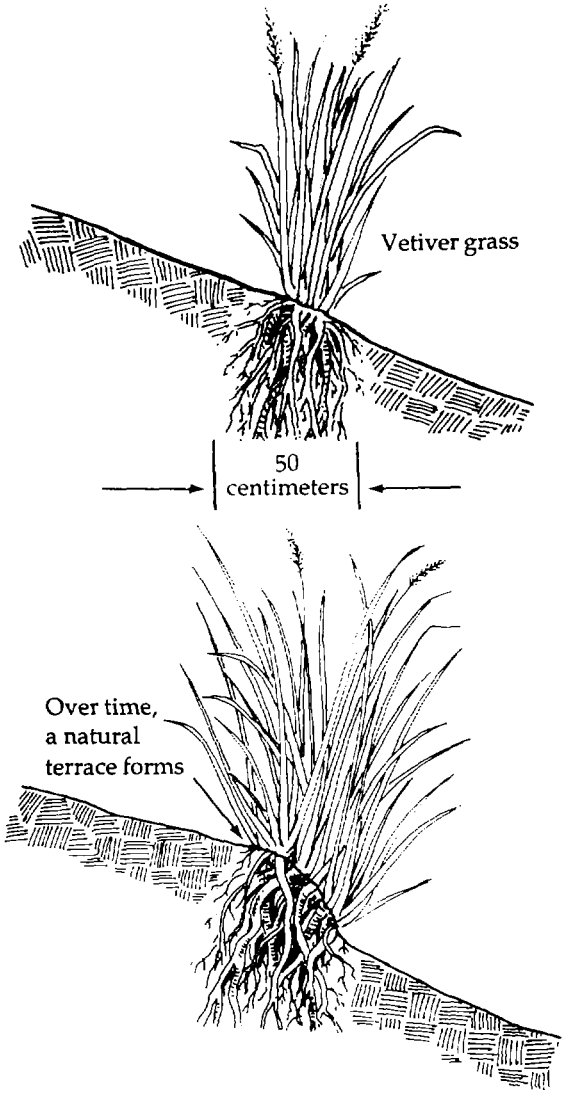
are called, are planted in a single plowed furrow, little soil is disturbed. And whereas earth banks have to be made with bulldozers or by hired labor, the vegetative system requires no special tools or labor beyond that which a farmer would already have.

The bottom illustration in **Figure 8** shows what happens over time in the vegetative system: the runoff drops its load of soil, the grass tillers up through this silt, and a natural terrace is created. The terrace becomes a permanent feature of the landscape, a protective barrier that will remain effective for decades, even centuries.

When the runoff reaches the vegetative hedges, it slows down, spreads out, drops its silt load, and oozes through the hedgerows, a large portion of the water soaking into the land along the way (**Figure 9**). No soil is lost, and there is no loss of water through the concentration of runoff in particular areas. The system requires no engineering—the farmers can do the whole job themselves.

Near Mysore in the southern Indian state of Karnataka (in the villages and hamlets of Gundalpet and Nanjangud, for example), farmers have been maintaining vetiver hedges around their farms for more than a hundred years. To keep the hedges narrow, the farmers simply plow around the edges of the hedgerows whenever they plow the rest of the field for cropping. The hedges are in perfect condition and provide permanent protection against erosion.

Figure 8. Vegetative System of Soil Conservation



Vegetative Control Hedges

Figure 10 presents a cross-sectional view of a vegetative contour hedge at work. The leaves and stems of the vetiver plant slow the silt-loaded runoff at **A** and cause it to deposit the silt behind the plant at **B** while the water continues down the slope at **C** at a much slower pace. The plant's spongy root system, pictured at **D**, binds the soil beneath the plant to a depth of up to 3 meters. By forming a dense underground curtain that follows the contour of the land, the roots prevent rilling, gullying, and tunneling. The strong aromatic oil they contain makes the grass unpalatable to rodents and other pests; many Indian farmers report that it also keeps rats from nesting in the area. Because the dense root system repels rhizomes of grasses such as *Cynodon dactylon* the hedgerows prevent them from entering the farm field and becoming a weed. And according to the farmers near Mysore the plant's sharp, stiff leaves keep snakes away as well.

To be effective as a method of soil conservation, the vegetative system *must form a hedge*, as shown in **Figure 11**. Although under certain circumstances thick hedges can be formed in one year, it generally takes two to three growing seasons to establish a hedge dense enough to withstand torrential rains and protect the soil. During the first two seasons, and sometimes the third, the plants need protection, and any gaps in their line have to be filled. (During the first two seasons it should also be easy to see the silt being trapped behind the plants as they are establishing, a phenomenon that extension workers should try to point out when explaining the system to farmers.) Although the earth banks used in the conventional method of soil conservation are effective immediately, they break down over time and frequently burst open in heavy rainstorms. Once the hedge has been established, it will neither wear out nor require further maintenance, other than periodic trimming.

Trimming the hedges to a height of 30-50 centimeters prevents them from seeding, makes them thicken up, and thereby increases their effectiveness in filtering runoff. In several villages and hamlets near Mysore, the farmers trim their hedges every two weeks throughout

Figure 9. Drainage Under the Vegetative System

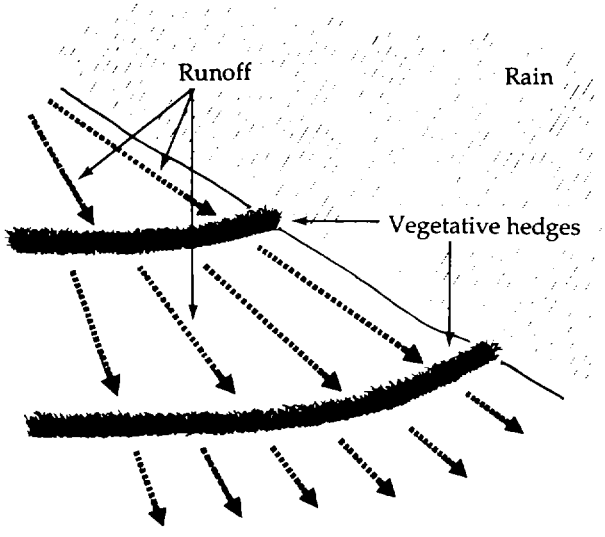
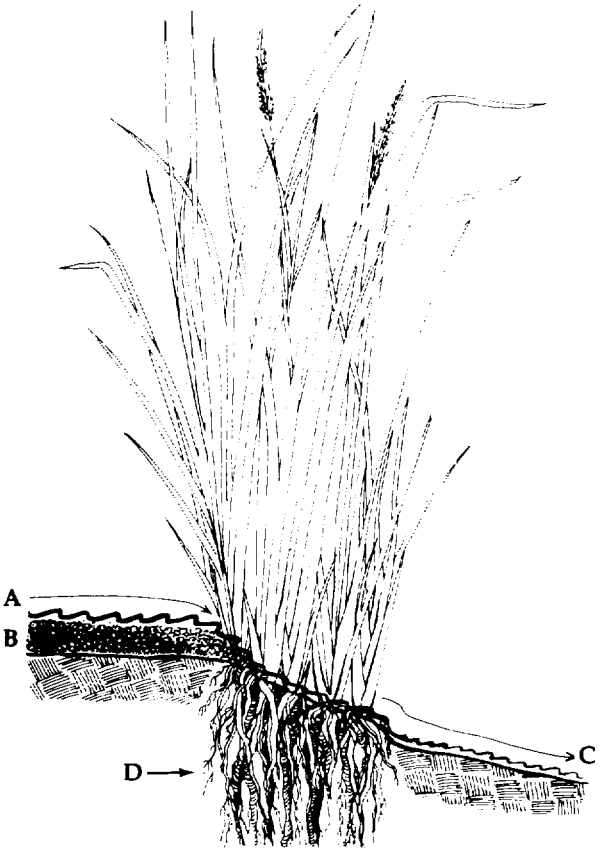


Figure 10. Cross Section of a Vetiver Hedge



the year and feed the young palatable leaves to their livestock. They are thus ensured a year-round supply of stock fodder regardless of rainfall.

It has become evident that many fieldworkers—and even research workers—lack a clear understanding of what is meant by "the contour." **Figure 12** illustrates a common misconception: that a furrow plowed along "the main slope" follows the contour. This is incorrect. A true contour embraces all slopes, major or minor; it is a line of equal elevation around a hill. The furrows in **Figure 12**, which starting from point **A** follow the main slope straight down to point **C** instead of curving around the hill, are *not* on the contour and therefore will neither conserve moisture nor prevent erosion. The true contour, pictured in **Figure 13**, runs from **A** to **B** to **D** and continues around the hill, maintaining equal elevation all the way.

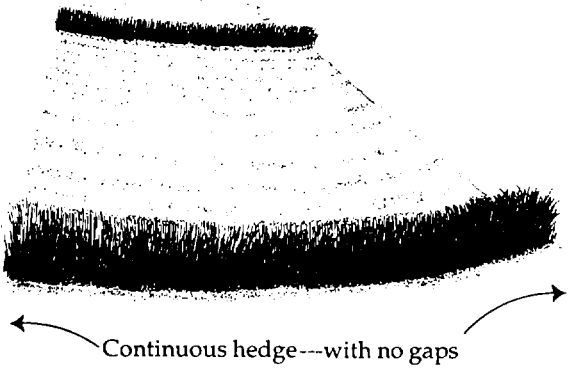
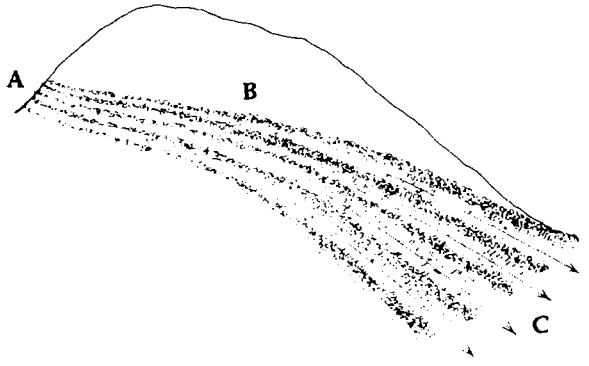


Figure 11. Vegetative System

Figure 12. False Contour



Because the earth banks conventionally are used to control erosion must convey the runoff to a waterway off to the side of the field, they have to be constructed on the exact contour. As shown in **Figure 14**, such a line (marked with pegs at **A**) can be difficult for the farmer to follow when plowing. The vegetative hedges, however, do not have to be exactly on the contour to provide effective soil and moisture conservation since their purpose is to reduce the velocity of the water as it passes through them and not to channel the water elsewhere. Once the

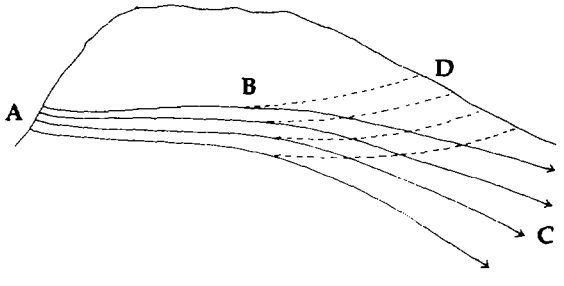
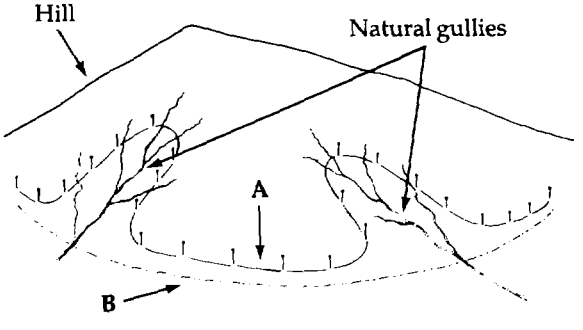


Figure 13. True Contour

contour line has been pegged in (see page 30), the extension worker can smooth it out to make it easier for the farmer to follow. In **Figure 14**, contour line **A** has been "averaged" into the smooth curve of line **B**. To control sheet erosion, the hedges and plow furrows (crop lines) need only follow line **B**. The silt filtered from the runoff will build up behind the hedges and eventually form a natural terrace. Because the hedges run across the slope, the ends of each hedgerow should be turned up the slope to prevent runoff from spilling around the sides—this will encourage natural terraces to form more readily and prevent erosion at the ends of the hedgerows, especially in steep lands.

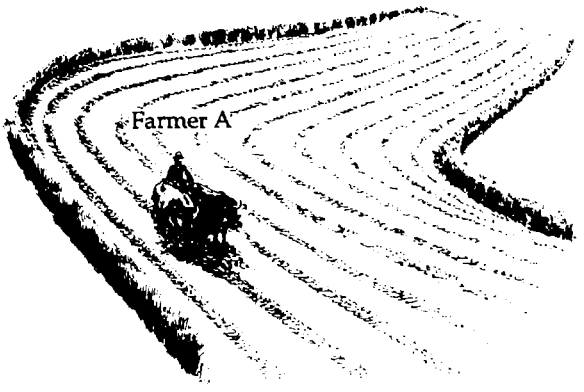
Figure 14. Averaged Contour



In **Figures 15** and **16** we see two farmers, A and B. Both are good farmers, but A in Figure 15 is a wise farmer; he has protected his land against soil loss by planting vegetative hedges on the contour, and he is using the hedgerows as guidelines to plow and plant on the contour. The furrows created in this fashion will hold rainfall and store extra moisture in the soil, thus allowing crops to withstand long periods of dry weather. What farmer A is doing costs no more than what farmer B in Figure 16 is doing. All that is involved is a change in management.

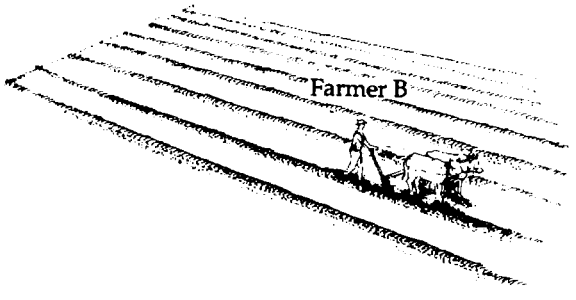
Farmer B is a good farmer, but he is not

Figure 15. Protected Farm



farming wisely; he is not thinking. By plowing just straight up and down the slope he is encouraging the rainfall to run off his farm, taking his farmyard manure and an irreplaceable layer of topsoil along for the ride. The rainwater runs off so quickly it does not have a chance to soak into the soil, and thus his crops have no protection against dry spells.

Figure 16. Unprotected Farm



Figures 17 and **18** illustrate what happens when the two farming systems are exposed to heavy rainfall. Farmer A's field is protected by the vegetative hedges, and there is no loss of soil (Figure 17). The contour furrows store all the rainwater they can hold. Any surplus rainfall runs off, but the vetiver hedges control the flow—slowing it down, spreading the water about— and cause the silt to be deposited. As a result the runoff is conducted down the slope in a safe, nonerosive manner.

On Farmer B's unprotected land, the rainfall runs off at great speed, taking along his fertilizers and topsoil. The uncontrolled ride down the slope causes unnecessary and damaging erosion (Figure 18). Because the runoff races by so quickly, no moisture is stored. Rainfall is only 40-50 percent effective, and farmer B is always complaining about droughts. Ultimately he will have to abandon his farm because there will be no soil left in which to grow crops. Farmer A will never have this problem; his yields will increase over the years.

Figure 17. Rainfall and the Protected Farm

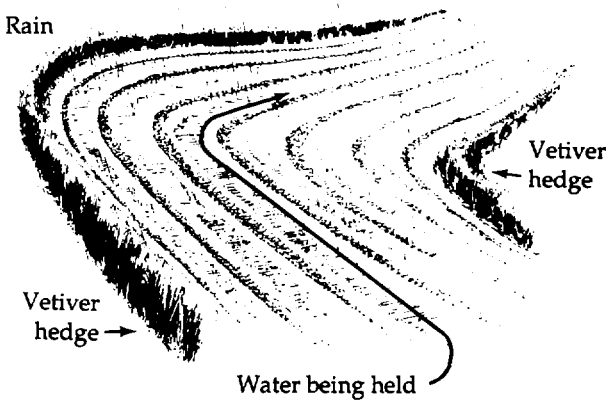
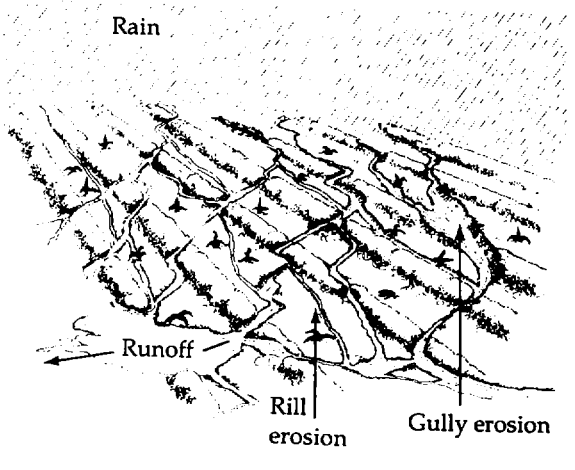
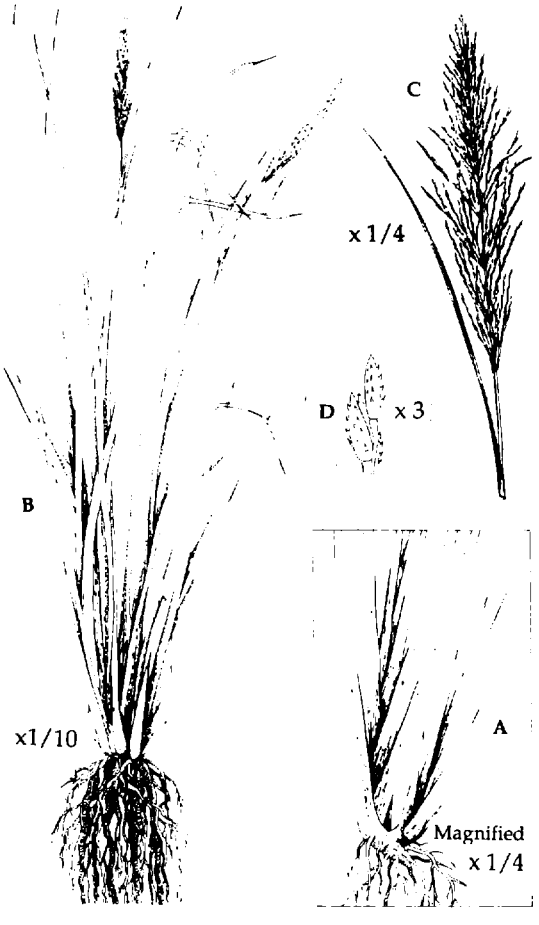


Figure 18. Rainfall and the Unprotected Farm





Vetiveria zizanioides

Vetiveria

Of the ten species of coarse perennial grasses found in the tropics of the Old World that belong to the tribe Andropogoneae, *Vetiveria zizanioides* has proven ideal for soil and moisture conservation.

V. zizanioides (L) Nash (2n = 20) Khus; vetiver grass; a densely tufted, awnless, wiry, glabrous perennial grass that is a "shy breeder" and is considered sterile outside its natural habitat of swampland. It has no rhizomes or stolons and is propagated by root divisions, or slips. The plant grows in large clumps from a much-branched "spongy" root stock (view **A**) with erect culms 0.5-1.5 meters high (**B**). The leaf blades are relatively stiff, long, and narrow—up to 75 centimeters long and no more than 8 millimeters wide—and although glabrous are "downward rough" along the edges. The lower glume is muriculated. The panicle is 15-40 centimeters long (**C**); joints and pedicels, glabrous. Spikelets are narrow, acute, appressed, and awnless (**D**). One spikelet is sesile, hermaphrodite, and somewhat flattened laterally with short sharp spines. It has a glabrous callus, three stamens, and two plumose stigmas. The other spikelet is pedicelled and staminate. Some cultivated forms rarely flower.

Both a xerophyte and a hydrophyte, *V. zizanioides* can withstand extreme drought—perhaps owing to the high salt content of its leaf sap as well as long periods of inundation (up to forty-five days has been established in the field). It has an exceptionally wide pH range, seems to be able to grow in any type of soil regardless of fertility, and has been found to be unaffected by temperatures as low as -9° Centigrade.

V. zizanioides does not produce seeds that germinate under normal field conditions. *V. nigritana* (the Nigerian species) does seed, but the seedlings are easily controlled .

Figure 19. Farmer A's Crop

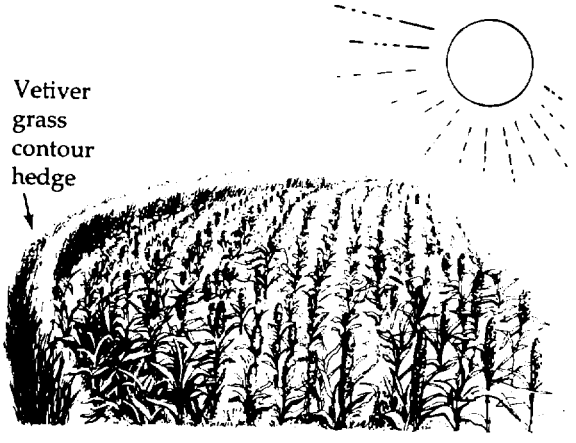


Figure 20. Farmer B's Crop

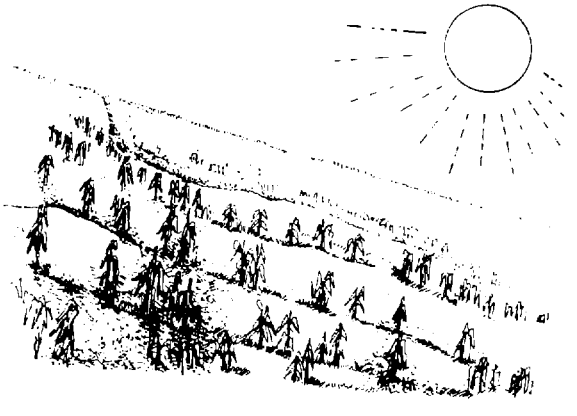


Figure 21. Marking the Contour

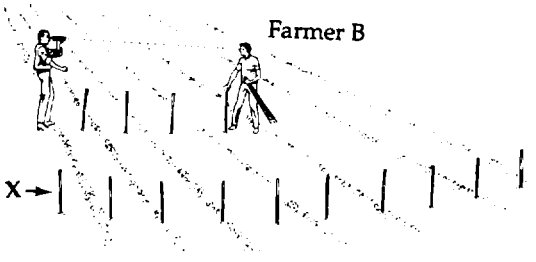
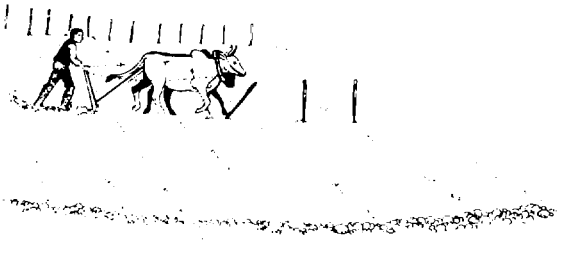


Figure 22. Plowing on the Contour



Thanks to his vetiver contour hedges, farmer A obtains an excellent crop (**Figure 19**). Because the soil has retained ample moisture from earlier rains, his crop is benefiting from the warm sunshine, all the grains are filling, and the crop stand shows even growth. Farmer A will reap a high yield.

In contrast, farmer B has a disappointing harvest (**Figure 20**). His crop has all but failed, and what little remains—growing in patches where some moisture was trapped—is being dried out by the sun. Only a small percentage of the grain will fill, and the resulting crop is uneven. Farmer B can expect a low yield. Yet he planted the same crop as farmer A and used the same fertilizer; both crops were planted at the same time and received the same amounts of rainfall and sunshine. Unlike his neighbor, however, farmer B lost most of his fertilizer, together with 60 percent of his rainfall and a layer of soil from his farm possibly a centimeter thick—all because he did not plow on the contour and use vegetative hedges to protect against erosion and help his cropland retain moisture from the rain. If he had taken the advice of his extension service and plowed and planted on the contour, farmer B could have obtained the same high yields as farmer A.

Having learned his lesson, farmer B contacts his extension worker, and together they mark, or peg out, contour lines across the old furrows (**Figure 21**). This simple process requires virtually no engineering skills—only the use of a small hand-held level. The extension worker stands at the edge of the field and, sighting through the level, has farmer B move up or down the slope until the two men are standing level, at which point the farmer marks the spot with a peg. In Figure 21, the contour line (**X**) has already been pegged out, and the farmer has but to follow the line of pegs with his plow (as shown in **Figure 22**) to create the furrow in which to plant the slips of vetiver grass that will eventually form a contour hedge. This is all that has to be done to establish the vegetative system of soil and moisture conservation.

Like any long-lived plant, however, the vetiver hedge system normally takes two to three seasons to become fully effective. You cannot plant a mango tree today and expect to pick mangoes next month! But it is possible to get some immediate effect from the system by using dead furrows until such time as the vetiver grass can be established. This preliminary stage of the system is depicted in **Figure 23**. While waiting for vetiver planting material to be produced in the nursery, the farmer laid out the contours, prepared seedbeds following the contour furrows, and every 5 or 6 meters double plowed a dead furrow. The two dead furrows in the figure have been planted on the contour to pigeon peas and intercropped with six rows of groundnuts. The shape of each seedbed is shown beneath the crop illustration: **DF** marks the deeper dead furrow, **PP** the row of pigeon peas it supports. Eventually, vetiver grass will be planted in some of the dead furrows, but in the interim these furrows themselves will provide a bit of protection against runoff. Planting the vetiver grass will stabilize the whole system, as shown in **Figure 24**, where a vetiver hedge has taken the place of one of the dead furrows.

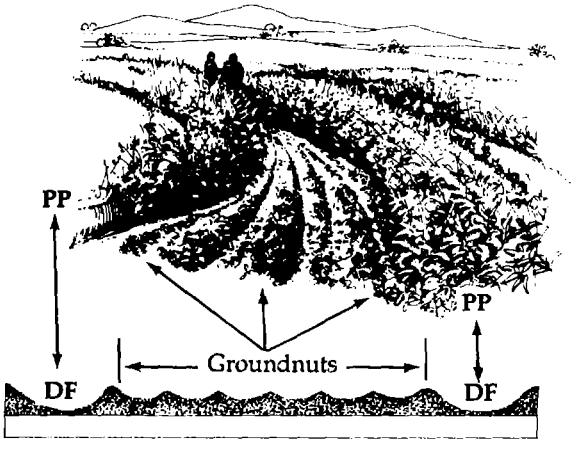
Establishing Vetiver Hedges

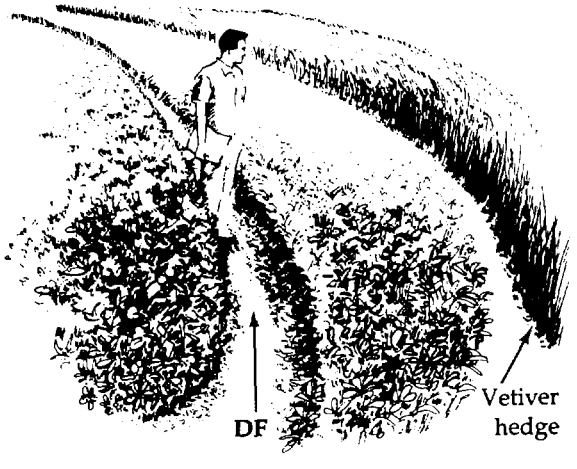
The next few pages provide step-by-step instructions on how to establish a vetiver hedge. Also included are tips on handling the planting material, the best time to plant, and what to expect after the grass is planted.

The first step is to obtain the planting material, usually from a vetiver nursery. If vetiver grass is unknown in your area, check with the nearby botanical gardens. Ask them to look up *Vetiveria zizanioides*. If it has been collected, the herbarium sheet will show what the plant looks like, note where the specimen was found, and provide the local name of the plant. Vetiver is found throughout the tropics and has been grown successfully as far north as 42°

latitude. Vetiver nurseries are easy to establish. Inlets to small dams or water holding tanks make the best nursery sites because water en route to the dam or tank irrigates the vetiver grass, which in turn removes silt from the water. Large gullies protected with vetiver grass also make good informal nurseries. For best results, the vetiver root divisions, or slips, should be planted in a double or triple line to form parallel hedges across the streambed. The hedgerows should be about 30-40 centimeters apart.

Figure 23. Initial Setup



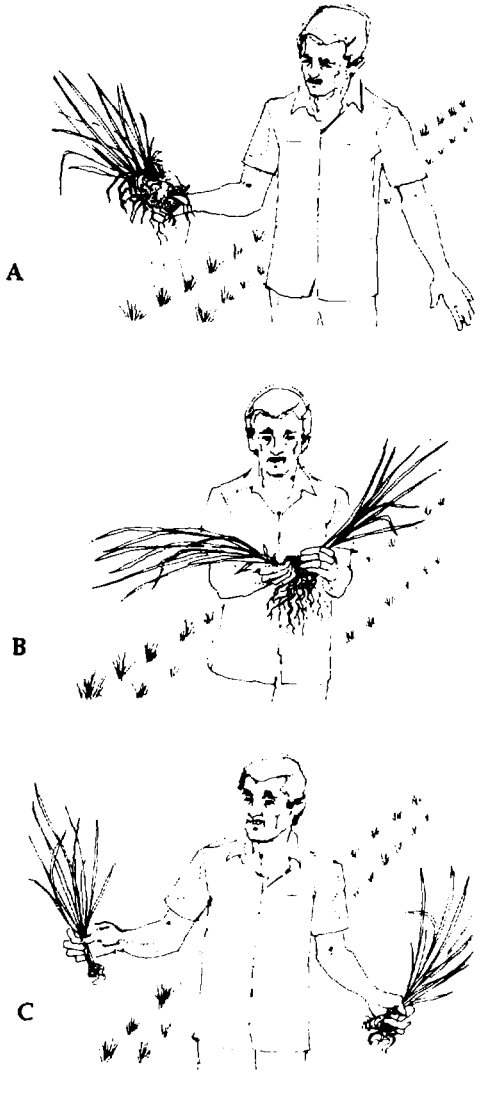


24. Stabilized System

To remove a clump of vetiver grass from the nursery (**Figure 25, illustration A**), dig it out with a spade or fork. The root system is too massive and strong for the grass to be pulled out by hand. Next tear a handful of the grass, roots and all, from the clump (**B**). The resulting piece, the slip, is what gets planted in the field (**C**).

Before transporting the slips from the nursery to the field, cut the tops off about 15-

Figure 25. The Planting Material



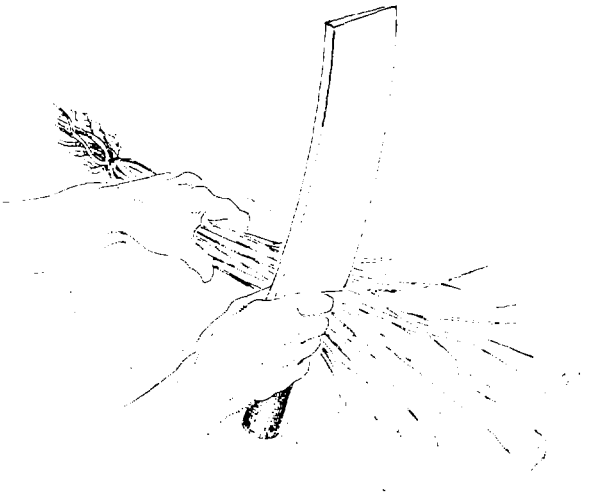


Figure 26. Preparing the Slip

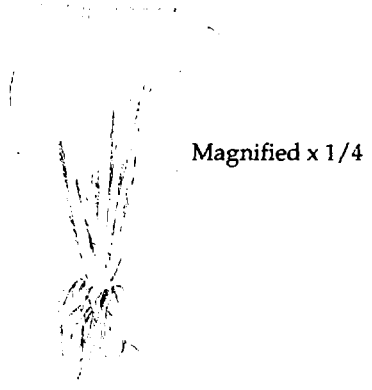
20 centimeters above the base, and the roots 10 centimeters below the base. This will improve the slips' chances of survival after planting by reducing the transpiration level and thereby preventing them from drying out. As shown in **Figure 26**, all that is needed to prepare the slips for planting is a block of wood and a knife—a cane knife, machete, cutlass, or panga will do. The finished planting piece is shown in **Figure 27**.

Although vetiver grass can be planted from single tillers (when planting material is scarce), this practice is not recommended for grass to be planted in the field because it takes too long to form a hedge. Fertilizing the slips with diamonium phosphate (DAP) encourages fast tillering and is helpful both in the nursery and in the field. To do this in the field, simply dibble DAP into the planting furrow before planting the slips.

Always plant the slips at the beginning of the wet season to ensure that they get full benefit of the rains.

Planting vetiver slips is similar to planting rice seedlings. Make a hole in the furrow that was plowed to mark the contour. Push the slip into the hole, taking care not to bend the roots upward. Then firm the slip in the soil. Ten to fifteen centimeters from the slip, along the same contour furrow, plant the next slip, and so on (**Figure 28**). Only a single row of slips need be planted. If planted correctly, the slips can withstand up to one month of dry weather. Some slips may die, however, and leave gaps in the hedge line. These gaps should be filled by planting to new slips. In some instances it may be possible to use the live flower stems, or culms (see the illustration on page 14), of neighboring plants—simply bend the culms over to the gap and bury them. The live stems will produce roots and leaves at the nodes.

Figure 27. The Planting Piece



Of course for this or any vegetative system to work, the plant *must form a hedge*; otherwise the system cannot act as a barrier against soil loss. Planting the slips too far apart (**Figure 29**) would render the system almost useless because they would take too long to form a hedge and would provide little protection. Moreover, without the extra support of a hedge to hold the soil, fertilizer, and moisture against the vetiver grass, the plants would not be able to survive the worst droughts. Even in arid areas that receive less than 200 millimeters of rain a year, an effective vetiver contour hedge could ensure its own viability. The combined effect of contour cultivation and the hedge's performance in slowing and spreading the runoff is to increase infiltra-

Figure 29. What to Avoid

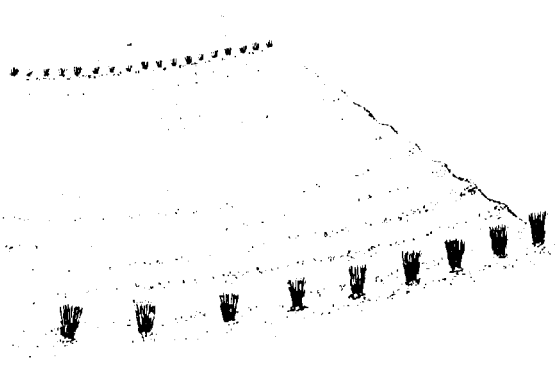
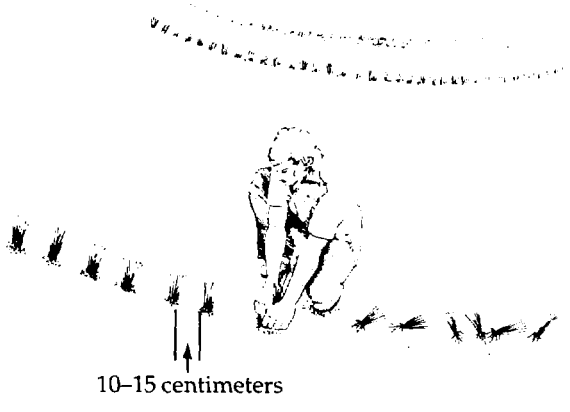


Figure 28. Planting the Slips

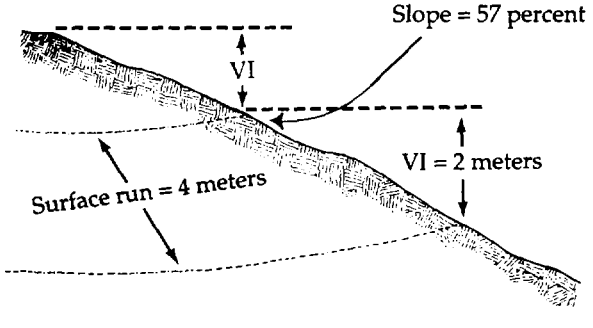


tion of water into the soil. Thus the hedge can help itself to what might be the equivalent of half again as much rainfall.

For the system to provide maximum protection against erosion, the hedgerows should be spaced apart at the proper vertical interval (VI). The VI is the vertical distance from one hedgerow to the next one down the slope. The actual distance measured along the ground, called the surface run, depends on the steepness of the slope. With a vertical interval of 2 meters, for example, the hedges on a 5 percent slope would be about 40 meters apart whereas those on a 2 percent slope would be about 100 meters apart. As shown in **Figure 30**, the surface run between hedgerows planted on a 57 percent slope with a VI of 2 meters is about 4 meters. For a more comprehensive look at the relationships among slope, surface run, and vertical interval, see **Table 1** at the back of this handbook. In practice, a VI of 2 meters has generally been found to be adequate.

Once the hedges have been established in the farmfield, the only care they will need is annual trimming to a height of about 30-50 centimeters to encourage tillering and prevent shading of the food crops. Plowing along the edges of the hedgerows will remove any tillers that encroach upon the field and will thus prevent the hedges from getting too wide.

Figure 30. The Vertical Interval



Moisture Conservation

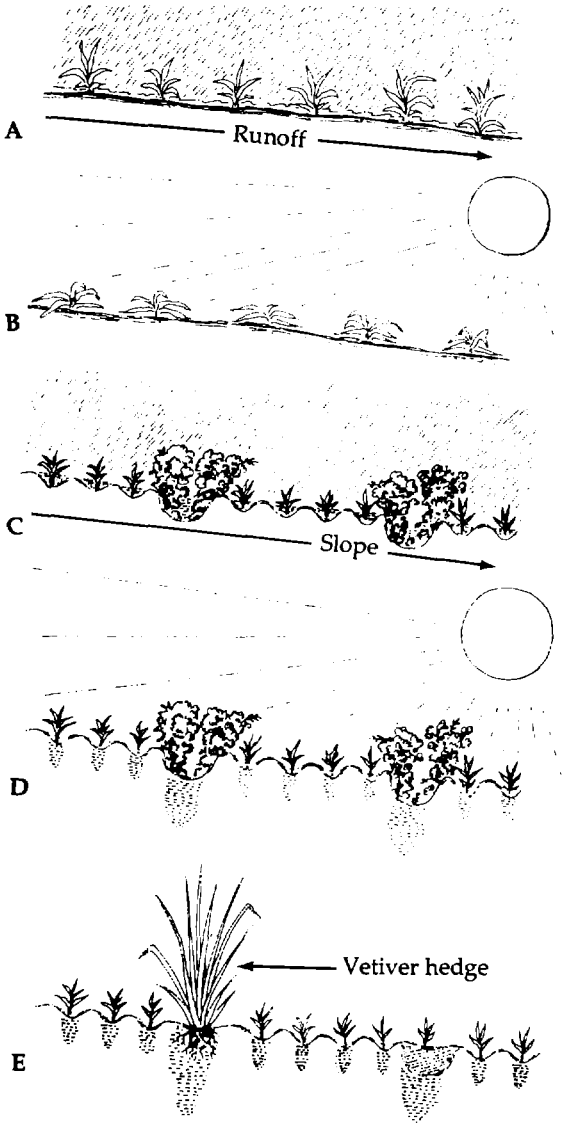
Although measures to retain natural moisture in the soil are essential to all rainfed farming systems, the art of in-situ moisture conservation, as it is called, is rarely practiced and not widely understood. There is no such thing as flat land; water runs off *all* land. No matter how flat it may seem, all land *must be contoured* if it is rainfed. Earthshaping, land leveling, and similar techniques are required in irrigated areas only; rainfed areas must be contoured. **Figure 31** shows what happens when land is planted on the "flat" without the benefit of contour furrows.

In view **A** the rain runs straight off the field. View **B** shows the results: because no moisture has been stored, the plants wilt and die in the sun. View **C** shows the same area planted to contour furrows, with a pair of dead furrows taking up the surplus runoff until such time as the vetiver can be planted. Rain caught and held in each furrow's microcatchment has the chance to soak in. Each furrow can hold 50 millimeters of rainfall, so in most storms there is no runoff. Thanks to this natural system of water storage, the plants can benefit from the sunshine, as shown in view **D**. In view **E** one of the dead furrows has been planted to vetiver grass to stabilize the system.

A vetiver grass hedge is the key to the in-situ moisture conservation system. Once established, it serves as a guideline for plowing and planting on the contour, and in times of heavy storms it prevents erosion from destroying the farmer's field. The beauty of the plant is that, once it has established the hedge, the hedge is permanent.

Figure 32 is a diagrammatic representation of what a vetiver grass system would look

Figure 31. The Benefits of Contour Furrows



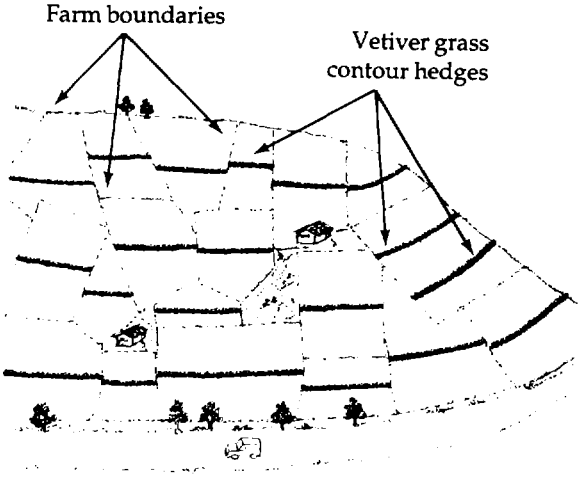
like in a small holder farming area. As can be seen, it fits into the individual farm systems perfectly. There are no waterways, no earthworks. Most farmers have one line of vetiver roughly in the middle of their fields, no matter what the shape; long fields may need two lines to stabilize them. Although each field has its own line or lines of vetiver, the entire hillside is protected against erosion because each line protects the ones farther down the slope. Under this system, once the hedges have established, no further protective work is needed, and maintenance is minimal. The farmers each have their own supply of vetiver planting material. Should a gully start to form anywhere, vetiver can be obtained from an existing hedge and planted across the incipient gully to prevent its spread—permanently and at no cost except for the farmer's own labor.

Why Vetiver Grass Is the Ideal Plant for the Vegetative System of Soil and Moisture Conservation

Although many grasses and trees have been tried over the years as measures to prevent erosion, to date only vetiver grass has stood the test of time. As made clear by the following list of its characteristics—derived from observations of *Vetiveria zizanioides* throughout the world—this truly remarkable plant is ideally suited for the vegetative system of soil and moisture conservation. No other grass is known to rival its hardiness or diversity.

- When planted correctly, *V. zizanioides* will quickly form a dense, permanent hedge.
- It has a strong fibrous root system that penetrates and binds the soil to a depth of up to 3 meters and can withstand the effects of

Figure 32. Vetiver System



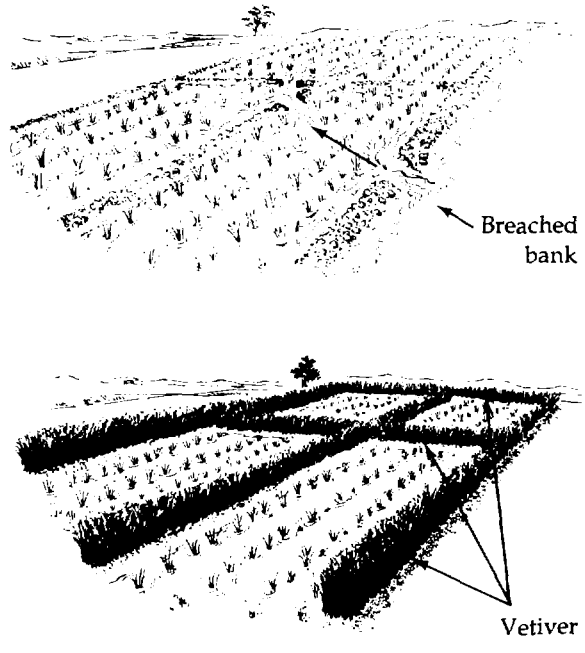
tunneling and cracking.
• It is perennial and requires minimal maintenance.
• It is practically sterile, and because it produces no stolons or rhizomes it will not become a weed.
• Its crown is below the surface, which protects the plant against fire and overgrazing.
• Its sharp leaves and aromatic roots repel rodents, snakes, and similar pests.
• Its leaves and roots have demonstrated a resistance to most diseases.
• Once established, it is generally unpalatable to livestock. The young leaves, however, are palatable and can be used for fodder. (In Karnataka, India, a cultivar of *V. zizanioides* selected by farmers has softer leaves and is more palatable to livestock. This cultivar is also more dense, less woody, and more resistant to drought than some of the other available cultivars.)
• It is both a xerophyte and a hydrophyte, and once established it can withstand drought, flood, and long periods of waterlogging.
• It will not compete with the crop plants it is used to protect. Vetiver grass hedges have been shown to have no negative effect on—and may in fact boost—the yield of neighboring food crops.
• It is suspected to have associated nitrogen fixing mycorrhiza, which would explain its green growth throughout the year.
• It is cheap and easy to establish as a hedge and to maintain—as well as to remove if it is no longer wanted.
• It will grow in all types of soil, regardless of fertility, pH, or salinity. This includes sands, shales, gravels, and even soils with aluminum toxicity.
• It will grow in a wide range of climates. It is known to grow in areas with average annual rainfall between 200 and 6,000 millimeters and with temperatures ranging from -9° to 45~ Centigrade.
• It is a climax plant, and therefore even when all surrounding plants have been destroyed by drought, flood, pests, disease, fire, or other adversity, the vetiver will remain to protect the ground from the onslaught of the next rains.

Other Practical Uses for Vetiver Grass

Apart from its success as a system of soil and moisture conservation, vetiver grass has proved effective for a variety of other purposes. One of the most important is to stabilize the terrain as well as such structures as dams, canals, and roadways. **Figure 33**, for example, shows how vetiver can be used to stabilize a typical paddy field that relies on earth banks to keep irrigation water at the correct level. These banks (top illustration) can be worn down by the action of wind-churned water (lap erosion) and the activities of rats, crabs, and other hole-burrowing pests. The subsequent large-scale erosion, not to mention the loss of expensive and in some cases irreplaceable irrigation water, could lead to loss of the crop.

Vetiver can be planted on top of the paddy banks to stabilize them. Vetiver grows

Figure 33. Stabilizing Earth Banks

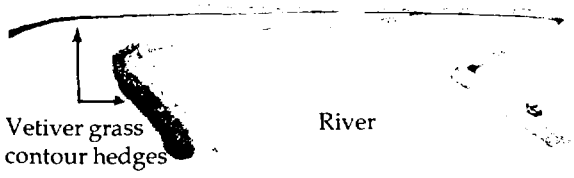


well under these conditions and does not suffer from the occasional inundation. In addition, its roots contain an essential oil that repels rodents. Furthermore, because its roots grow straight down and not out into the crop, the grass has no effect on the rice or its yield. Each year the vetiver can be cut back to ground level to prevent shading of the crop.

In an analogous example, vetiver can be used to maintain river levees by preventing them from being eroded back into the fields (**Figure 34**). It can also be used on river flats to prevent silt from entering the watercourse from the runoff from surrounding fields.

Vetiver's stabilizing influence is especially useful in steep and rolling country, where the distribution of moisture cannot be controlled.

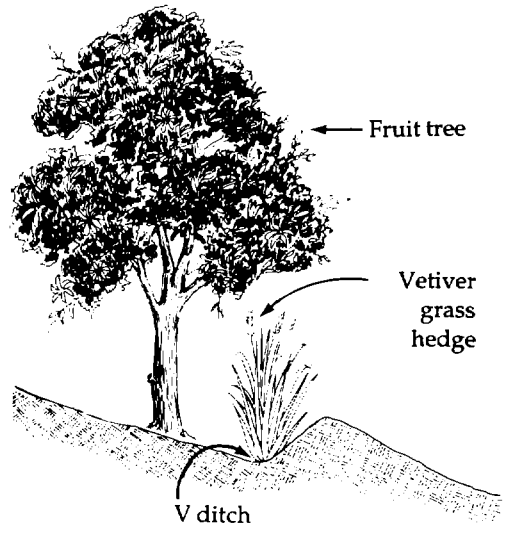
Figure 34. Protecting Riverbanks



Unsuitable for the cultivation of cereal or other annual crops, such areas can be successfully planted to perennial tree crops on the contour when stabilized by vetiver grass. Most attempts to grow tree crops on steep hillsides are abandoned because the resulting poor, uneven stands are not worth the cost of maintenance. Figures **35-37** show a method of establishing tree crops on such hills using contour vetiver hedges. First the contours of the hill are pegged out. Next, by hand or with a bulldozer and ripper unit, the farmer digs shallow V ditches along the contour lines. A row of trees is planted close to the edge of each ditch, and vetiver grass is planted in the ditches (**Figures 35** and **36**).

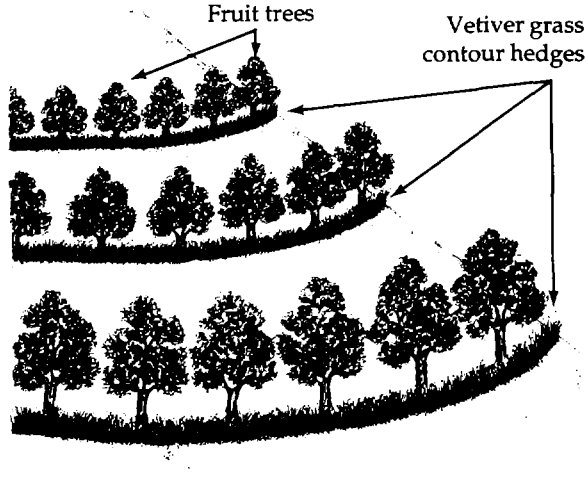
Under this arrangement of planting, the runoff between one row of trees and the next one down the slope collects in the vetiver-lined

Figure 35. Nurturing Trees



ditches. (There is usually sufficient drainage on the slopes to preclude the possibility of waterlogging.) Thanks to the effects of such

Figure 36. Stabilizing Tree Crops



water harvesting, the rows of trees do not have to be planted as close together as the trees within a row. Initially, the V ditch will provide a measure of runoff control, thereby increasing the soil's moisture content, and both the vetiver and the planted trees will benefit. By the time the ditch "melts" away after a couple of years, the vetiver hedge will be established and performing its function of increasing the infiltration of runoff, halting the loss of soil and soil nutrients, and creating a natural terrace.

Because the collection of runoff in the contour ditches has the effect of doubling or tripling the amount of effective rainfall, fruit trees planted by this method need no irrigation in the first three years of establishment. The whole system is stabilized by the vetiver grass lines.

After the vetiver hedges have properly established, the vetiver grass can be cut down to ground level when the dry season sets in and its leaves used as a mulch at the base of the fruit trees to help retain stored moisture (**Figure 37**). The advantage of using vetiver for this purpose is that its leaves harbor few insects and last well as a mulch. Vetiver hedges also protect the young trees in the hot summer months by providing some indirect shade and in the colder winter months by acting as wind-

Figure 37. Vetiver as Mulch

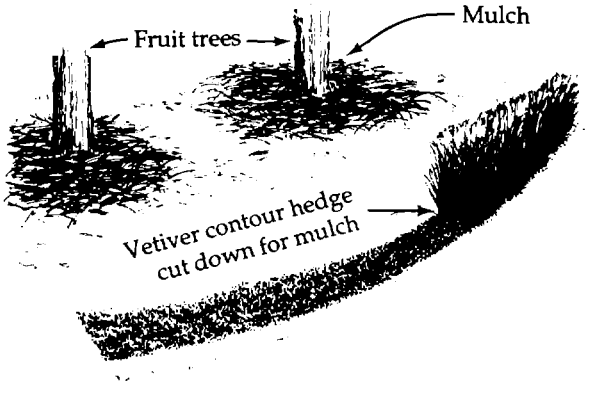
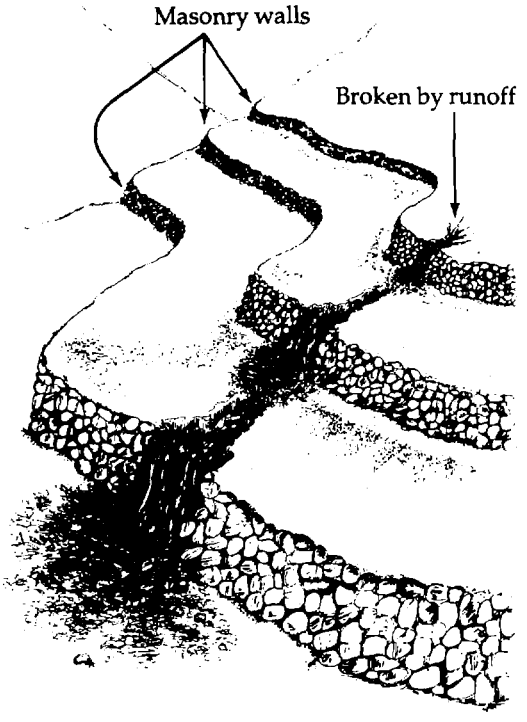


Figure 38. Masonry Terraces



breaks.

Forest trees should be planted by the same method. Where this has been done, the results have been spectacular: more than 90 percent of the seedlings so planted survived the 1987 drought in Andhra Pradesh, India, whereas 70 percent of the other seedlings died.

In the Himalayan highlands, where farming is carried out on terraces, vetiver grass is now being used to stabilize the masonry risers that have been erected over the centuries. Without some form of vegetative support, these ancient structures require continual maintenance. If one riser washes out during a heavy storm, other terraces farther down the slope often suffer considerable damage because of the domino effect. **Figure 38**, which depicts a typical terrace system in the hills, shows the type of damage frequently sustained. To allow for drainage between the stones, the masonry risers are not

bound together with mortar. If the walls were solid, instead of just a small section falling out the whole wall might collapse and trigger a landslide that could destroy the entire farm. Although these terraces have done an excellent job through the years, they do exact a toll in the form of crop losses, and they require a lot of hard work in repairs.

When the vetiver system of stabilization was explained to the hill farmers, they wanted to plant as many areas as possible. In a World Bank project begun in 1986, vetiver grass was planted along the edge of the terraces during the rainy season in the hope that its strong root system would reinforce the masonry risers.

Figure 39 shows what the vetiver grass-protected terraces should look like once established. The grass is planted only at the extreme edge of each terrace, so as not to impede the essential drainage between the stones. According to the farmers, what causes most of the damage during heavy storms is the cascading of water down the slopes and over the top of the masonry terraces, especially if the water has a chance to concentrate into a stream. Once established, the vetiver hedges should take most of the erosive power out of this runoff as well as protect the edge of the terraces.

As shown in the close-up in **Figure 40**, the masonry risers are vulnerable because they are simply stones stacked on top of each other and are usually 2 to 3 meters high. Because its strong root system can easily penetrate to the bottom of the risers, vetiver grass can be used to protect the entire rock face.

Figure 40. Close-up

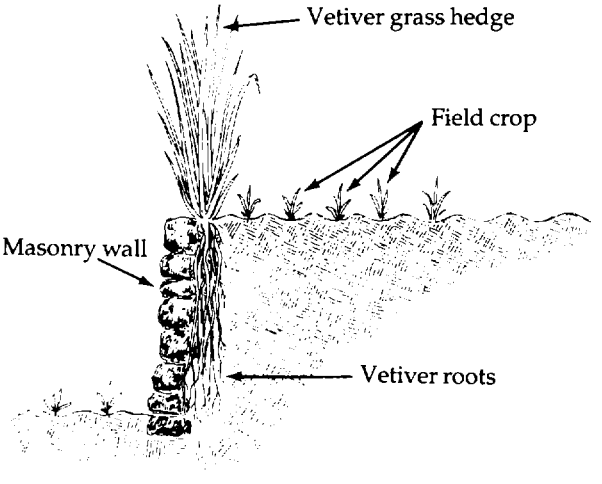
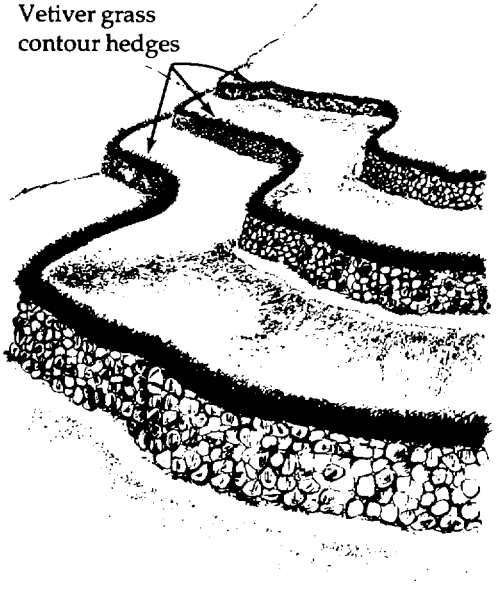


Figure 39. Protecting Masonry Terraces



In another project in the Himalayan highlands, in areas with no masonry terraces to halt massive sheet erosion, vetiver grass contour lines are being established to determine whether the natural terraces that build up behind the hedges will form a base of stable land for the production of fuelwood and fodder crops. In China in the provinces of Jiangxi and Fujian, vetiver grass hedges are being used to protect the edges of citrus and tea terraces.

Vetiver grass is also used to protect road cuttings, as shown in **Figure 41**. In the West Indies, the plant has been used extensively for the stabilization of roadsides and has com-

pletely prevented erosion for years. People in St. Vincent use it to line the outer edge of the tracks to their houses. The grass has exhibited a remarkable ability to grow in practically any soil. In Andhra Pradesh, India, for example, it was observed growing at the Medicinal and Aromatic Research Station at the top of a bare hill. Even though the soils there are skeletal—granite boulders had to be bulldozed to make a plot for the grass—and are deprived of most of the benefits from rainfall (since they are located at the very top of a hill), and supported no other form of growth at the time, the vetiver grass showed no signs of stress. A plant that can thrive under these extreme conditions should be able to do an excellent job of stabilization almost anywhere.

The use of vetiver grass in wasteland development has recently been tested, and vetiver has proved effective as the initial stabilizing plant. In the Sahel region of Africa (in the state of Kano in Nigeria) and in Bharatpur in central India, under the extreme conditions of constant fire and drought, *Vetiveria nigritana* and *Vetiveria zizanioides*, respectively, have survived as the climax vegetation for hundreds of years. When planted as contour hedges in wasteland areas—the first stage in the stabilization of such areas—*V. zizanioides* reaps the benefits of any surplus runoff and harvests organic matter as it filters the runoff water through its hedges. Because the foothills of the Indian Himalayas are very young geologically, they are highly erodible; planting vetiver contour hedges around these slopes and then across the short erosion valleys will stabilize these areas. A masonry plug at the end of the system allows silt to build up and give the grass a basis of establishment (**Figure 42**). The same would apply to normal gullies as shown in **Figure 43**. Once established, the grass would terrace the gullies.

Figure 41. Protecting Roadsides

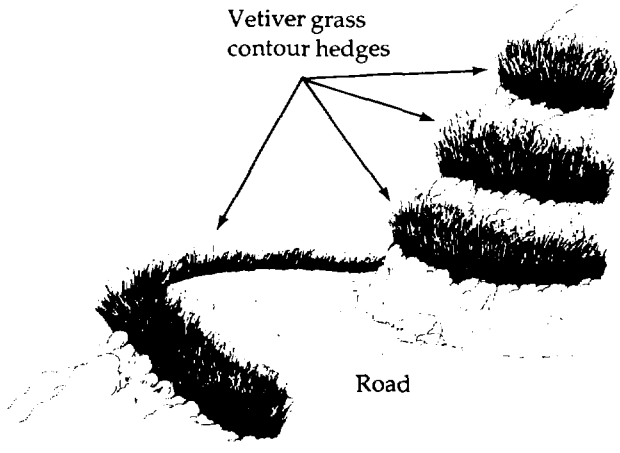
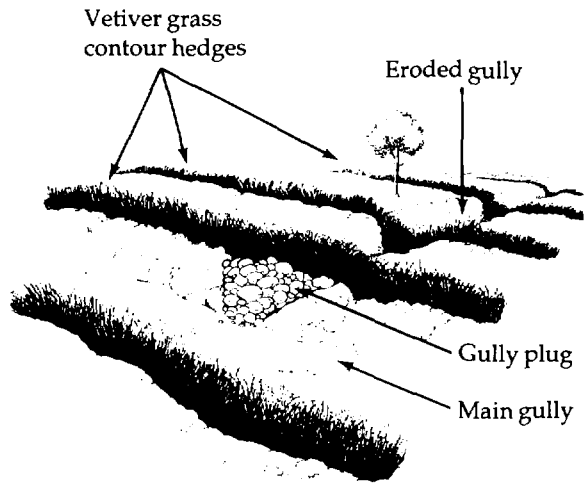
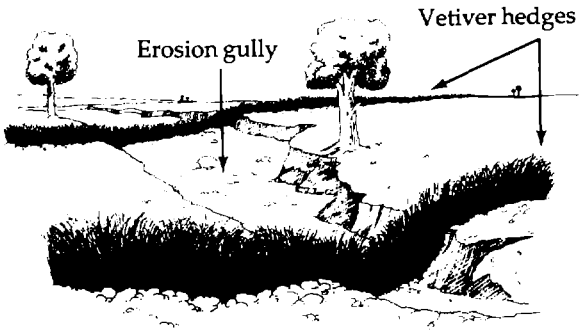


Figure 42. Stabilizing Wasteland Areas



Using vetiver grass to stabilize riverbanks and canal walls is another recommended practice. In an experiment in Tanzania, on the road to Dodoma, a road engineer used vetiver grass to protect the wing wall of a bridge on one side of the river and constructed the usual concrete wing wall on the other side. Some thirty to forty years later, the

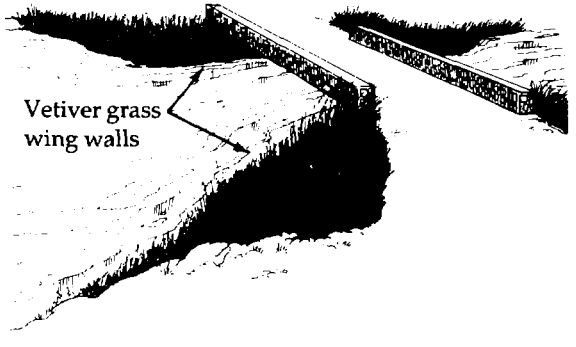
Figure 43. Stabilizing Gullies



concrete wall had already collapsed into the river, and the bank it was protecting was eroded. On the other side, the vetiver grass was still holding the bank in perfect shape. **Figure 44** shows how vetiver grass can be used to protect the river approaches to a bridge.

Figure 45 shows how vetiver grass can be used to protect the banks of a major irrigation canal.

Figure 44. Protecting Bridges



The contour irrigation aqueducts that lead back from the main canal around the foothills to the upper reaches of a command area suffer from siltation and erosion as they wind their way round the slopes. The typical problem is depicted in the top illustration in **Figure 46**: the concrete conduit is undercut by erosion at point A and

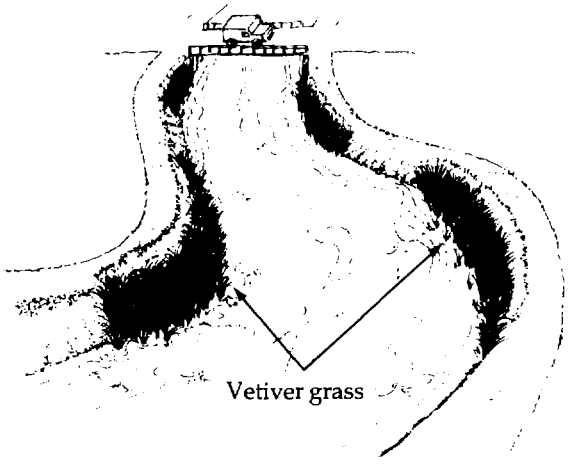


Figure 45. Protecting Irrigation Canals

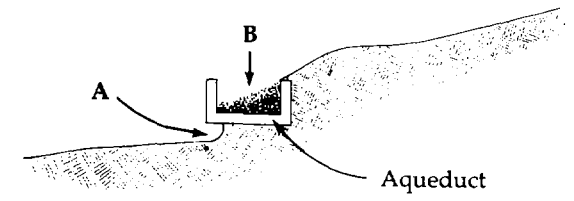
fills with silt at point B.

To overcome this problem, vetiver grass should be planted parallel to the upper and lower sides of the concrete conduit. As shown in the bottom illustration, the upper hedge will prevent silt from entering the canal, while the lower two hedges will prevent erosion and thereby keep the concrete structure from being undermined by rills or gullies.

A similar approach can be taken to protect dams. Small dams are silting up at an alarming rate throughout the world. Once they become filled with silt, they are of no further use—and in many cases there is no other site suitable for a new dam. If vetiver grass is planted around the sides of the dam, as shown in the top illustration in **Figure 47**, the silt carried by runoff from the surrounding hills will be trapped before it reaches the dam. And vetiver hedges planted across the inlets (A) of small dams on intermittent streams will protect the dams from siltation. In time these hedges will form stable terraces that can be used for cropping or tree planting.

In the bottom illustration, vetiver has been planted on the walls of a dam to protect

Figure 46. Protecting Acqueducts



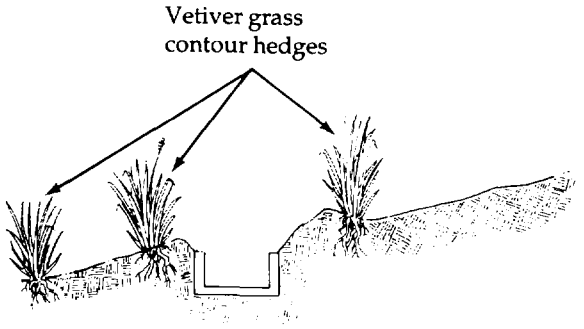
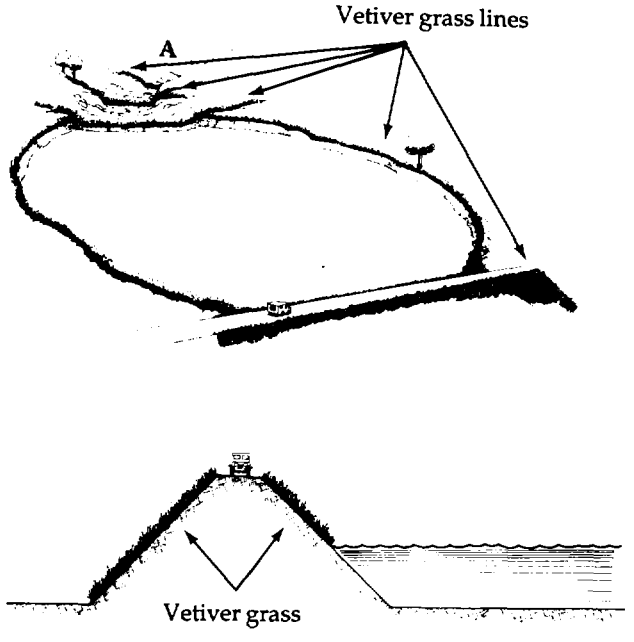


Figure 47. Protecting Dams



them from being worn down by rill erosion, a problem afflicting many unprotected earth dams around the world. To make it easier to spot seepage along the toe, or bottom, of dam walls and canal banks, vetiver should not be planted in those areas.

The versatile vetiver plant has numerous more common applications as well. It makes good bedding for livestock because it soaks up the urine and stays dry longer. Ultimately, it makes good compost. In countries with strong winds, vetiver grass hedges make good windbreaks to protect young fruit and timber trees. The grass also serves as a firebreak. Vetiver is used as thatch for roofs of houses, sheds, and shelters and as mulch for tree crops. The grass is woven into baskets, and the leaf midribs and flower stems make excellent brooms.

Management Tips

In the preface of the first edition we asked users to give us their views and share their experiences. Below are some of the responses we received.

General observations

- Well-grown vetiver hedges result in less runoff and improved groundwater supplies. Dry-season streamflow improves under the hedge system of in-situ moisture conservation.
- In most instances on slopes of up to 5 percent, about 10 centimeters of silt is deposited behind the hedges annually.
- In addition to its use for soil and moisture conservation, vetiver is being used for fodder, thatch, mulch, livestock bedding, windbreaks, roadside protection, and brooms.
- Where hillside crop drainage is required—as in the case of tobacco ridges on a graded slope—vetiver hedges act as an excellent buffer against erosion if placed on the contour at fixed intervals on the hillside.
- The majority of a vetiver plant's roots grow straight down for at least 3 meters. Other roots

will grow out into the field for up to 50 centimeters, but they do not significantly affect crop growth—probably because of the high moisture content of the soil associated with the hedge.
• Vetiver hedges take about three years to be fully effective under low rainfall conditions. If vetiver slips are planted 10-15 centimeters apart, the hedge will form more quickly. Even where there are gaps, interplant erosion does not seem to be a problem because the roots join together in the first year to form a subsurface barrier.
• Where vetiver is planted along the edge of terraces, forward-sloping terraces are better than backward-sloping terraces because less runoff is removed by the terrace back channels. Also, because one can dispense with the back channel—and also in some instances the front channel, where constructed—more land will be available for cropping. The ultimate objective should be to dispense with terracing, where possible, through the use of vetiver hedges, so that the topsoil can remain relatively undisturbed.
• Vetiver has been observed growing under conditions ranging from 200 to 6,000 millimeters of rainfall annually and at 2,600 meters above sea level. It survives snow and frost and grows on most types of soil. It obviously grows better where the soil is moist and fertile, but even under adverse conditions it grows extremely well compared with other grasses.
• Vetiver in many countries has been infected with brown spot. The disease does not seem to have an adverse effect on its growth, however. A few instances of black rust have been observed but are not significant. In India the rust seems to be vetiver-specific and does not cross infect other plants. In China vetiver has been attacked by stem borers, but in most cases the borer dies once it gets in the stem. Farmers are generally unconcerned and tend to respond by selecting plants that are more pest- and disease-resistant.
• Some early results from India, on both alfisols and vertisols, indicate that rainfall runoff was reduced from 40 percent to 15 percent (compared with the control), and silt loss was reduced from 25 tons per hectare to 6 tons per hectare (all for two-year-old hedges on 2 percent slopes). The time to wilting in one demonstration on alfisols increased from seven days to twenty when in-situ moisture conservation measures were applied.
• An interesting technique observed in China was the plaiting, or interlacing, of vetiver leaves and stems from separate, neighboring plants to create a temporary barrier until the full hedge could be established.
• The cost of vetiver hedges depends on the availability and cost of planting material. In India the initial cost of hedge establishment is estimated at US$8 per 100 meters of hedge, $6 of which goes for planting materials and other inputs. Once the live material, in the form of a hedge, is on the farm, the cost to produce new hedges is relatively low—it may be as little as $2 per 100 meters. Under such conditions the economic rate of return is more than 100 percent. Where the slopes are less than 5 percent and the hedges are spaced about 40 meters apart, 250 meters of hedge is required per hectare at a cost of between $5 and $20 (see **Table 2** at the back of this handbook).

Selection of planting material

• In Karnataka, India, to date six cultivars have been identified. One cultivar selected over the years by farmers exhibits superior characteristics for hedge formation, fodder, and insect-, disease-, and drought-resistance.
• When selecting material, choose plants that exhibit resistance to pests and diseases and that tiller well.
• Where winters are cold, select material that is more tolerant of cold temperatures.

Nursery establishment

• Vetiver planted densely in large gullies can be used for replanting elsewhere. Gullies make good informal nurseries because often they are permanently moist and have conditions good for growth.
• Stem and root cuttings grown under plastic

may be a cheap way of vegetative propagation.
• For optimum tillering, nurseries should be fertilized (150 kilograms per hectare of nitrogen) and irrigated (especially in very dry areas).
• Nursery plants should be cut back to about 30-50 centimeters to encourage tillering.
• The best nurseries seem to be in loamy sands to sandy-clay soils where the drainage is good and where it is easy to dig up the plants for transplanting. We have seen excellent nurseries (when well watered) in sandy areas near perennial rivers.

Field Planting

• As long as the vetiver is planted when the ground is wet, it can survive a long period of drought after planting.
• On very small farms and fields where land is scarce and where farmers are reluctant to plant across their fields, vetiver should be planted on the field boundaries.
• On nonarable lands that are heavily eroded, vetiver should be planted first in the gullies and around the gully heads. The material from the gullies can then be used for planting across the slopes in subsequent years.
• Gap filling is essential and should be done at the beginning of the wet season. The possibility of "layering" live stems across the gaps should be tried as a gap-filling measure.
• To encourage tillering and hedge thickening, the grass should be cut back to 30-50 centimeters after the first year. Cutting in the first year does not seem to have any incremental impact on tillering.
• White ant infestation (attacking dead material) can be controlled by applying 1 kilogram of BHC for every 150 meters of hedge line.
• Once the vetiver has established (one month after planting), plowing a small furrow immediately behind the vetiver hedge line helps to capture runoff and results in better growth of the plant.

Common Names for Vetiver Grass

China: Xiang-Geng-chao

Ethiopia:
Amharic: Yesero mekelakeya

Ghana:
Dagomba: Kulikarili

India:
Hindi: Bala, Balah, Bena, Ganrar, Khas, Onei, Panni
Urdu: Khas
Bengali: Khas-Khas
Gujarati: Valo
Marathi: Vala Khas-Khas
Mundari: Birnijono, Sirum, Sirumjon
Oudh: Tin
Punjabi: Panni
Sadani: Birni
Santali: Sirom
Telugu: Avurugaddiveru, Kuruveeru, Lamajjakamuveru, Vettiveeru, Vidavaliveru
Tamil: Ilamichamver, Vettiver, Vilhalver, Viranam
Kannada: Vettiveeru, Laamanche, Kaadu, Karidappasajje hallu
Malayalam: Ramaccham, Ramachehamver, Vettiveru

Indonesia: Aga wangi, Larasetu, Larawestu, Raraweatu
Sudanese: Janur, Narawastu, Usar

Iran:
Persian: Bikhiwala, Khas

Malaysia: Nara wastu, Nara setu, Naga setu, Akar wangi (fragrant root), Rumput wangi (fragrant grass), Kusu-Kusu

Nigeria:
Hausa: Jema
Fulani: So'dornde, So'mayo, Chor'dor'de, Ngongonari, Zemako

Philippines: Ilib, Mora, Moras, Moro, Muda Narawasta, Raiz de moras, Rimodas, Rimora, Rimoras, Tres-moras,Vetiver, Amoora, Amoras, Anias de moras, Giron

Sahel:
Bambara: Babin, Ngongon, Ngoko ba
Songhai: Diri
Fulani: Kieli, Dimi, Pallol
Sarakolle: Kamare
Mossi: Roudoum
Gurma: Kulkadere

Senegal:
Wolof: Sep, Tiep
Fulani: Toul
Tukulor: Semban

Sierra Leone:
Mende: Pindi
Susu: Barewali
Temne: An-wunga ro-gban

Sri-Lanka:
Sinhalese: Saivandera, Svandramul

Thailand: Faeg

Table 1. Slope, Surface Run, and Vertical Interval

Slope			
Degrees	*Percent*	*Gradient*	*Surface run (a) (meters)*
1	1.7	1 in 57.3	57.3
2	3.5	1 " 28.6	28.7
3	5.3	1 " 19.1	19.1
4	7.0	1 " 14.3	14,3
5	8.8	1 " 11.4	11.5
6	10.5	1." 9.5	9.6
7	12.3	1 " 8.1	8.2
8	14.0	1 " 7.1	7.2
9	16.0	1 " 6.3	6.4
10	17.6	1 " 5.7	5.8
11	19.4	1 " 5.1	5.2
12	21.3	1 " 4.7	4.8
13	23.1	1 " 4.3	4.5
14	25.0	1 " 4.0	4.1
15	27.0	1 " 3.7	4.0
16	28.7	1 " 3.5	3.6
17	30.6	1 " 3.3	3.4
18	32.5	1 " 3.1	3.2
19	34.4	1 " 3.0	3.1
20	36.4	1 " 2.8	3.0
21	38.4	1 " 2.6	2.8
22	40.4	1 " 2.5	2.7
23	42.5	1 " 2.4	2.6
24	44.5	1 " 2.3	2.5
25	46.6	1 " 2.1	2.4
26	48.8	1 " 2.0	2.3
27	51.0	1 " 2.0	2.2
28	53.2	1 " 1.9	2.1
29	55.4	1 " 1.8	2.1
30	57.7	1 " 1.7	2.0
31	60.1	1 " 1.7	2.0
32	62.5	1 " 1.6	1.9
33	65.0	1 " 1.5	1.8
34	67.5	1 " 1.5	1.8
35	70.0	1 " 1.4	1.7
36	72.7	1 " 1.4	1.7
37	75.4	1 " 1.3	1.7
38	78.1	1 " 1.3	1.6

Slope			
Degrees	*Percent*	*Gradient*	*Surface run (a) (meters)*
39	80.1	1 " 1.2	1.6
40	84.0	1 " 1.2	1.6
41	87.0	1 " 1.2	1.5
42	90.0	1 " 1.1	1.5
43	93.3	1 " 1.1	1.5
44	96.6	1 " 1.0	1.4
45	100.0	1 " 1.0	1.4

a. The figures for the surface run are based on a vertical interval (VI) of 1 meter. To use this table, multiply the surface run by the VI: for example, with a VI of 2 meters on a 70 percent slope, the surface distance between vegetative barriers = 2 x 1.7 = 3.4 meters.

Table 2. Cost of Land Treatment with Contour Hedges of Vetiver Grass by Slope Classification and the Cost of Labor (U.S. dollars per hectare)

Slope	Daily Cost of Labor					
(%)	$.050	$1.00	$1.50	$2.00	$2.50	$3.00
0-1	2.43	3.44	4.45	5.46	6.47	7.48
1-2	7.29	10.32	13.35	16.38	19.40	22.43
2-5	17.02	24.08	31.15	38.21	45.28	52.34
5-10	36.46	51.60	66.74	81.88	97.02	112.17
10-15	60.77	86.00	111.24	136.47	161.71	186.94
15-20	85.08	120.40	155.73	191.06	226.39	261.72
20-30	121.54	172.01	222.48	272.95	323.42	373.89
30-40	170.15	240.81	311.47	382.12	452.78	523.44
40-50	218.77	309.61	400.46	491.30	582.15	672.99
50-60	267.38	378.41	489.45	600.48	711.51	822.55
60-70	316.00	447.22	578.44	709.66	840.88	972.10
70-80	364.61	516.02	667.43	818.84	970.25	1,121.66
80-90	413.22	584.82	756.42	928.02	1,099.61	1,271.21
90-100	461.84	653.62	845.41	1,037,19	1,228.98	1,420.77

The Role of Vetiver Grass in Sustaining Agricultural Productivity.

Richard G. Grimshaw. Asia Technical Department, The World Bank, Washington, D.C. USA.

Introduction.

This paper summarizes the work to date in the resurgence of the use of vetiver grass, the most widely used species being *Vetiveria zizanioides*, as an important technology for sustaining agricultural productivity in the tropics and semi-tropics. As a result of an early initiative by the World Bank [1] vetiver grass was first introduced to development projects in India as a low cost vegetative system for soil and water conservation. This paper summarizes the findings of a growing number of independent scientists [2, 3, 4, 5, 6] and users [7, 8] of vetiver grass. Soil fertility maintenance and soil moisture availability are the two most important elements that are critical for assuring sustainable agricultural production. Vetiver grass provides a widely applicable technology that is practical, proven, cheap, and profitable. The Vetiver Grass Technology (VGT) is simply the establishment of a narrow (less than 1 meter wide) live stiff grass barrier across the slope of the land. When applied correctly the technology is effective on slopes from less than 1% to up to 100%. A well established vetiver grass hedge will slow down rainfall runoff, spreading it out evenly, and will trap runoff sediments to create natural terraces.

Methods and Materials.

The use of VGT is set out in a small handbook for farmers. The claims that were made for VGT under this and subsequent editions [9] were often disputed by scientists, and as a result, have and continue to be intensively investigated. This paper draws on this work and on field observation by the author.

Results and Discussion.

Claim # 1. A vetiver grass hedge is an effective measure for soil and moisture conservation. Research at ICRISAT, India [10] compared VGT with stone barriers, lemon grass, and bare ground (control) under natural (total rainfall 689 mm.) and artificial rainfall conditions. In all cases VGT was the most effective technology. VGT reduced rainfall runoff by 57%, and soil loss by over 80%. At CIAT Colombia [11], researchers compared vetiver to other vegetative systems grown in conjunction with cassava. At 11 months (rainfall 1240 mm.) soil loss was reduced from 142 tons/ha for bare fallow to 1.3 tons per ha. for vetiver. Rainfall runoff was reduced from 11.6% to 3.6%.

Claim #2. Vetiver grass will grow over a wide range of site conditions. Australian experiments under saline, sodic, and acid conditions demonstrated vetiver's tolerance to a wide range of conditions and will grow in pH levels ranging from 3.8 to 9.9. Other trials demonstrate its xerophytic and hydrophytic characteristics. Vetiver's cold tolerance limit is around -10 degrees C.

Claim # 3. Vetiver grass is non competitive with adjacent crops. All evidence indicates that vetiver does not reduce significantly adjacent row crops. Experiments demonstrate no yield loss reduction of cassava when grown with vetiver hedgerows. Similar results are recorded in India and Malaysia.

Claim # 4. Vetiver grass is not a weed, it is not invasive. There is no evidence of vetiver being invasive under upland rainfed conditions. There is some evidence of natural spreading under swamp conditions. Vetiver grass at a site in

Louisiana has not flowered in 25 years. In Zambia, vetiver grass hedges at Msamfu Research Station have remained intact for more than 60 years.

Claim # 5. Vetiver grass is extremely resistant to pests and diseases. There is evidence from India that when dead vetiver plant material is effected by termites that there may be an alleopathic reaction that effects the living part of the plant. Management by burning may eradicate this problem.

Claim # 6. Vetiver grass is not eaten by livestock. Where there are other more palatable grasses vetiver grass is normally ignored by livestock. It has been observed on many occasions, under farm conditions, that if the hedge is managed correctly regular harvesting of young leaves is possible, and that these young leaves provide a maintenance ration. In Texas, under irrigated conditions, production of dry matter at more than 100 tons per ha. per annum, equivalent to about 350 tons of fresh leaf, has been achieved.

Claim # 7. Vetiver grass can be used for structural strengthening of earth embankments, drainage lines, roads, and gullies. There is evidence to support the use of vetiver for embankment stabilization. There are positive reports of vetiver being used to reduce erosion in small dam spillways in Zimbabwe, gullies in Fiji, and drainage ways in Guatemala, South Africa, Malaysia, and Nepal. VGT can be used effectively for the stabilization of irrigation channels. VGT has been used in many countries as an effective means for gully control.

Claim # 8. Vetiver grass is fire resistant and repels rodents and other animals. Vetiver is well known for its resistance against fire in sugar cane fields that are burnt prior to harvesting. Vetiver is used to protect firebreaks from erosion. Young burnt vetiver under Malaysian conditions recovered fully in four weeks. There is conflicting evidence on vetiver's effectiveness to deter rodents and other animals.

Claim # 9. Vetiver grass needs no maintenance or management. Experiments have shown that management plays an important role in the efficiency of vetiver hedges. Just "sticking the grass in the soil and forgetting about it" is not a good technique. In India and the Philippines farmers who have understood the technology and manage it properly have effective systems.

Claim # 10. Vetiver grass is a low cost and economic system of soil and moisture conservation. Economic analyses compared establishing vetiver grass hedges at less than $30 per ha. with more than $500 per ha. for conventional engineered terraces. Economic rates of return for the latter are around 20% compared to more than 90% for vetiver. Short term crop yield gains have been demonstrated in India resulting in estimated Benefit Cost ratios of more than 2:1.

Conclusions

The foregoing establishes strong evidence that vetiver meets the requirements of a long term, low cost, vegetative technology for soil and moisture conservation. The proof not only rests in the above experimental results but also in an expanding group of users around the world, including the mass introduction of VGT in Thailand [12, 13]. Vetiver has special merit in its characteristics as a durable, relatively inert, and highly effective grass that when grown as a hedge halts sediment flows and reduces rainfall run off. Vetiver may prove to be a key technology for the sustainability of tropical and semi-tropical agriculture.

Footnotes.

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VETIVER INFORMATION NETWORK

SPECIAL BULLETIN DECEMBER 1, 1993

I have just completed a very interesting visit to Thailand, Hong Kong and China, and rather than wait until Newsletter # 11 (sometime next year), I thought I would send out this bulletin now so that you can share some of the pleasure and insights of my time in these three countries.

Thailand

Thailand in a very short time span (two years) is moving very fast in its use of Vetiver grass for soil and moisture conservation. In short Thailand's program is very good. A lot is happening, and a lot more is likely to happen in the future.

I had the honor to represent the Vetiver Information Network at the presentation of "The King of Thailand Award for Vetiver" to Dr. P.K. Yoon of Malaysia by His Majesty King Bhumibhol Aduluyadej at the Chidlada Palace, Bangkok, on October 30th, 1993. Dr. Yoon must be congratulated for his outstanding work and his contribution to the development of the Vetiver Grass Technology (VGT).

As many of you know, The King, having carefully studied VGT, initiated a special program in Thailand for the use of Vetiver grass some two years ago, and since then has personally been involved in the program. During this time he has actively encouraged Heads of State and senior Government ministers of other countries to take advantage of the technology. In recognition of his actions the Vetiver Information Network awarded His Majesty a special award, **"For Technical and Development Accomplishment in the Promotion of The Vetiver Technology Internationally".** The award is a specially commissioned bronze casting of vetiver grass and the soil that it protects.

The King wants quick and quality results. So his strategy has been to lead the effort with an aggressive field program backed by properly funded research. Research is very much "learning by doing". **You can never say you have failed unless you have tried first.** As a consequence, there is fast progress in Thailand.

The King places great emphasis on the production of high quality planting material - this means that any part of a nursery plant that has flowered should be culled (most nursery plants over four or five months have many flowering stems - unless cut regularly. These should not be transplanted). In line spacing, the plants should be as close as possible (if you can afford it). Aim for 10 cm. between planting stations. If you have a nearby source of water and can water the planting slips, then plant before the

onset of the rains. Don't use accessions that produce seeds that germinate. These are pretty simple specifications. Follow them, and you will have a successful program. Finally, use your common sense and act now. Perhaps we should call these "The King's Rules."

In the past two years, Thailand has made significant progress in the use of VGT. A fully coordinated nationwide research program has been established that is testing out various vetiver accessions at some 20 different sites from the brackish water coastal areas in the south to the high mountains in N.E.,Thailand. Over 30 different accessions of vetiver grass have been identified indicating a wide range of characteristics, and a start has been made to classify these accessions. In addition, another species of vetiver grass has been identified, *Vetiveria nemoralis*, an upland species, in contrast to *V. zizanioides* that is a wetland species. *V nemoralis* appears to have on average more tillers, and is blockier in shape. It looks good and deserves further testing at field scale.

Trials testing the use and effectiveness of vetiver hedges are undertaken country wide. These trials and pilot programs include the following:

• 20 centers throughout the country testing the growth and characteristics of vetiver at sites representing different ecotypes.

• Road cut and embankment stabilization (very large sections of up to 100 ft elevation over more than 1 km of new mountain road), **Doi Tung Development Project, Chieng Rai.**

• Shade tolerant experiments at two sites near Chiang Mai. **Chiang Mai Royal Development Project.**

• Vetiver grown under passion fruit (60% shade) as a conservation measure on steep slopes (30 to 40%) at Mai Tae. **Chiang Mai Royal Development Project.**

• Standard runoff small plot trials at Huai Hong Krai. **Chiang Mai Royal Development Project.**

• Trials with different vertical intervals between hedge rows (1, 2 and 3 meters, on very steep lands (up to 65 %). Very impressive - fully formed hedges within 14 months and significant terrace development behind the hedges. Mai Tae and Pang Da. **Chiang Mai Royal Development Project.**

• Vetiver hedge terraces on farm land, use of vetiver as mulch, with fruit trees, and with agro forestry. Mai Hair, Pang Da, Mae Tang. **Chiang Mai Royal Development Project, Doi Tung Development Project. Chieng Rai. Chantaburi.** also **Land Development Department.**

• Nursery technology and plant handling - Experimental Center - **Doi Tung Development Project. Chieng Rai.** Mae Tang Experimental Center - **Chiang Mai Royal Development Project.** Rayong Experimental Center - **Land Development Department.**

• Tissue culture propagation of

vetiver. **Doi Tung Development Project. Chieng Rai.**

• Pollution control - controlling fertilizer runoff from golf courses. Utilization on saline and acid soils. **Office of The Board of The Royal Development Projects.**

• Dam stabilization and reservoir stabilization and silt protection. **Chiang Mai Royal Development Project.**

• Use of vetiver as material for handy crafts, thatching etc. **Doi Tung Development Project. Chieng Rai.**

• Investigations are starting on the possibility of inoculating vetiver slips with mycorrhiza so as to improve performance under hostile site conditions.

His Majesty the King of Thailand and the staff of the Royal Development Projects are very willing to share their expenses. To this end:

• the network will devote the next newsletter #11 entirely to the Thailand experience, and vetiver users and promoters in Thailand will prepare articles for # 11.

• vetiver users and others are welcome to contact Thai vetiver users directly. In the first instance you should write to one of the following:

Dr. Sumet Tantivejkul,
Secretary General,
Royal Development Projects Board,
78 Rajdamnern Nok Avenue,
Bangkok, 10300.
Thailand.
Tel # 2806231
Fax # 2806206

M.C. Bhitsatej Rajani,
Director,
Royal Development Project Office,
Chiang Mai,
Thailand.
Tel # (053) 212204.
Fax # (053) 278997

M.R. Disnada Diskul,
Director,
Doi Tung Development Project Office,
Chieng Rai
Thailand.
Tel # (053) 767001.
Fax # (053) 767077.

Dr. Withoon Chinapan,
Vetiver Program,
Department of Land Development,
Phaholyothin Road,
Bangkok. 10900.
Thailand.

• Under the vetiver program more than 30 different vetiver accessions both of **V. zizanioides** and **V. nemoralis** have been identified and classified. Many have widely different characteristics. The following are currently recommended as being suitable for hedge development. Note those that have fertile seed characteristics are not included:

Vetiveria zizanioides - Accessions V4,V9,V23, V28. Indian Karnataka, Suratani.

Vetiveria nemoralis - Accessions V6, V7, V8, V13, V20, V22.

These cultivars and others are available from the Doi Tung Development Project, Chieng Rai, as tissue cultured plantlets (40 plantlets on

agar) in a bottle at approx. US $200 per bottle (including packing and shipping). If you are interested in getting hold of any of this material please get in touch with the Doi Tung Development Project. If you have special requirements such as saline, shade, or other specific types you should indicate your need. Incidentally, I was impressed by how the Karnataka and Suratani accessions performed over a range of conditions.

The Thais are eager to share with you their experiences, and welcome visits to Thailand to see their work to date. I recommend that you take an opportunity to see the wide range of work being undertaken there. It is the most comprehensive that I have seen, and in my view it is the best place in Asia to see a vetiver program in action. The Thais admit that they have a lot to learn yet, but they have a lot to offer the rest of us. If you want to visit Thailand's vetiver work, I suggest that you contact Dr. Sumet Tantivejkhul, Secretary General, The Royal Projects Development Board.

The following are some other interesting points that I picked up during the visit:

• To date some US $ 1.2 million have been allocated by the **Royal Projects Development Board** for research activities.

• At the **Doi Tung Development Project**, which incidentally is closely and actively watched by Her Royal Highness the Princess Mother (who is 93 years old), some 20 million vetiver slips have been produced and planted. At six months, 1 ha of nursery will produce a minimum of 1.25 million bare rooted vetiver slips, enough for about 42 km. of hedge (3 slips per planting station, each station 10 cm. apart). The farmer earns US $ 2,600 per ha. on the sale of quality vetiver slips.

• The total cost of production and planting of slips grown in polybags is approx. US $ .60 per meter.

• At **Doi Tung** 160 km of hedge has thus far been planted.

• Under difficult conditions a farmer can plant about 100 meters of hedge in one day. (In India under easy conditions, 200 meters a day can be planted by one person).

• Care needs to be taken. Better survival when slips are kept wet under wet sacking or between layers of cut vetiver leaves. If transported in a truck, avoid parking in hot sun, avoid cooking the slips(Dr. Yoon's advice).

• Humic acid has been used very successfully to induce root growth in young tillers. Tllers are soaked in bundles for three days in a tank (made from a large culvert ring) in 1:1000 part solution of humic acid and water. Strong rootlets appear from the culm after three days. This enhances growth of polybagged plants. (Perhaps it would enhance bare rooted field planting as well).

Incidentally the Thais are about to support some experimental work in Laos, and the Vetiver Grass Technology will be part of that effort.

Hong Kong

I met with **Ron Hill** of Hong Kong University and **Richard Webb** who is responsible for Municipal Landscaping. Both were testing vetiver on some pretty hostile landscapes. Ron Hill introduced the first vetiver grass to Hong Kong three years ago, and planted it on the University Research Farm in the New Territories. He has shown that the accession from Guangdong (China) grows well on some pretty hostile granitic soils that are subject to drought and fire in the dry season. Richard Webb's job is to revegetate the steep and eroding lands overlooking (and to the north) of the airport. We spent an interesting afternoon scrambling around these hills. Webb had planted his first vetiver two years ago, and had planted between the hedges *Acacia mangium* and other trees. The vetiver had grown well on granitic weathering material with virtually no topsoil. It had trapped the silt and other trash and had significantly improved the growth of the tree seedlings. Both Webb and Hill are now converts to the system. On the whole they had done a good job, considering neither had seen vetiver or the results from vetiver other than their own work in Hong Kong. If the 'King's Rules" were applied, the results would be even better!

Vetiver users passing through Hong Kong and who are interested in the stabilization and rehabilitation of hostile sites might like a walk in these hills and should conduct Ron Hill or Richard Webb (tel # (852) 9820703; Fax # (852) 98211452). I am sure good advice will be welcome.

China

Because of bad weather, I had to cancel my visit to Fujian Province where I would have seen the vetiver that was planted from 1989 onwards. In those days **Mr. Wang Zisong** frequently reported on progress there. On my return to Washington, I found a short report from **Mr. Shi Fu Qing** [Fujian Provincial Agricultural Department, #183 Gu Ping Road, Fuzhou, Fujian Province, China Tel. (0591) 813420. Fax # (0591) 852407]. He reports that since 1989, they now have vetiver planted at 39 sites with a total of 160 km. of hedge. They have sold 49 tons of planting material to other provinces. More recently they have planted chestnut trees protected by vetiver (one line of vetiver to three lines of chestnuts). He reports that vetiver grows well, and although he doesn't write it, we can assume that vetiver hedges are functioning successfully, since with limited resources, their program continues to grow. It will now accelerate rapidly with the start of the Second Red Soils Project (World Bank funded) when some 40,000 km. of hedge is expected to be planted in over 100 pilot watersheds in five provinces in China located south of the Yangtze River.

I was able, however, to visit Guangdong Province and travelled to Xingning and Wuhua Counties to see the large scale testing of vetiver on some very hostile sites. The work in these two counties is carried out jointly by the respective county Soil and Water Conservation Bureaus and the South China Institute of Botany. I visited three sites of interest. The first was on steep (15 - 20") heavily

eroded land that had been planted to vetiver and eucalyptus in 1991. Prior to revegetation measures, the site was virtually a moonscape devoid of all vegetation, and is locally known as the "Red Desert." The soils are lateritic red earths developed from purple arenaceous shales with a pH of 4.0. The treatment of the 40 ha site was successful. In this case, vetiver had been used to stabilize contour ditches and earthen gully check structures. The vetiver has not grown too well on the top of the banks, probably because there is virtually no moisture. On the other hand, where vetiver had been planted at the bottom of the structures, there had been good growth (in these cases relating to moisture availability). The use of structures to support vetiver in the early years of growth, under these conditions, seemed to be the right approach, because, as the check structure silted up, the vetiver hedge grows through the silt and becomes an ever-rising barrier. The experimental team that includes Mr. Xia Hanping (one of our prize winners this year) will look into the moisture stress aspects.

The site in Wuhua County was even more impressive. Here, a large catchment of at least 10 sq. km. was being studied and test sites treated. At a number of sites, vetiver was used to stabilize the sediment build up behind very small earth check structures (max. 15 meters long) located in steeply dissected gully areas. The vetiver, in these cases, was planted as a band of vegetation along the upside foot of the check structures. The results after two years were exciting - a stable structure, defused velocity flows above structures due to vetiver barrier, and excellent vetiver growth through the heavy silt deposits. Further up the gullies, there existed very good growth of other species - grasses and shrubs - due partly to the much improved soil moisture regime in the micro catchments concerned. At another site, vetiver rows had been established across a wide expanse of a seasonal river bed. These rows were about 50 meters long and covered an area some 60 meters deep. As a result, the river bed exhibited signs of stabilization and significant silt deposition within the vetiver area. River flow was being diverted over time to a restricted channel, and eucalyptus trees planted within this dense mass of vetiver were thriving. Vetiver showed no sign of stress from high volume flood water flows. Further down stream, vetiver had been planted to protect earth banks (bed bars) that were used for redirecting the water flow to dissipate hydraulic energy in a zig zag course down stream. The vetiver showed no signs of distress and the banks were in very stable condition. This work is the responsibility of **Zen Guo Hua** and **Jiang Lin She** of the Bureau of Water and Soil Conservation Experimental Station, Wuhua County, Guangdong.

The Forest Research Institute in Guangdong is doing some interesting work in reducing soil erosion in eucalyptus plantations using vetiver hedges. I did not visit the site, but from the photographs, it appears that good vetiver hedges have been established under eucalyptus, and that erosion has been reduced significantly over a two year program. Interestingly, very little else besides

vetiver will grow under eucalyptus. By the end of the second year, when the hedge was well established, soil loss had been reduced to 2.9 tons per ha. compared to 17.6 tons for the control which had no hedge (an 83% reduction). Vetiver hedges reduced rainfall run-off by 28%, and tree growth was improved by as much as 20%. These experiments are being continued, however, they do confirm what we are finding elsewhere. For those of you working in Vietnam, the potential use of vetiver for erosion control looks extremely promising, and a visit to Guangdong might be useful.

Those of you who require more information or who want to visit the work in Guangdong should get in touch with any of the following:

Prof. Liang Chen Ye.
Prof. Guo Zhenyan.
Mr. Liu Shizhong.
Mr. Xia Hanping.

The above are all of the South China Institute of Botany, Academia Sinica, Wu Shan, Guangzhou, China. 510650. Phone: (020) 7705626.

Also you can contact **Mr. Zhen De Zang** of the Tropical Forestry Institute, Chinese National Academy of Forests, Guangzhou, Guangdong, China.

Other News

On my return from this trip, I found many letters from vetiver users, some of which I quote from below:

Dr. G.M. Bharad, Professor of Agronomy and Watershed Management, PKV, Akola, Maharashtra, India, the recipient of vetiver awards for research in 1992 &1993, writes, ". .. we have introduced vetiver hedge technology on deep black saline belt of this region covering 3 lakh (300,000) ha area in this season. The results are encouraging. Other traditional technologies for soil conservation have failed in this region. The farmers are very much convinced with vetiver. In my opinion, vetiver hedge technology will be the main component for in-situ soil and water conservation ..." In another letter, he writes "....at this University farm, I have tried to develop vetiver hedges on lands under surface irrigation. Observations over a period of three years are encouraging in terms of convenience in layout preparation (border and furrow), uniformity in water application resulting in uniform crop growth over the entire field, minimum water losses especially at the tailends and very good crop yields. It appears even in [irrigation] command areas, we can give up costly and unnatural land shaping grading operation. During this Rabi [winter] and summer season we are planning to have quantitative monitoring of different aspects...." If anyone would like to take these matters further, you can contact Dr. Bharad at Punjabrao Krishi Vidyapeeth, PO Krishi Nagar, Akola, Maharashtra 444104, India Tel. 26840.

The Boucard brothers of the "American Vetivert Corporation" of Leakey, Texas (fax 210 232 5716) report a growing demand for vetiver plants. Their main problem now being how to ship live plants over long distances without high losses. Perhaps Dr. Yoon can advise. They

mention that Mr. Jano Labat of Zimbabwe - one of our key vetiver promoters there visited American Vetiver For those of you who may be new to the network the Boucard brothers have many years of experience in the mechanized management of vetiver.

The **Director General**, of the Department of Curriculum and Instruction Development, of Thailand's Ministry of Education, has sent me the published Thai translation of John Greenfield's, "Vetiver Grass: The Hedge Against Erosion", which is to be now part of the school curriculum in Thailand.

Mas'ud Panjaitan of CARE Indonesia,writing from Mataram, Lombok, says that the Karnataka (Indian) variety is growing very well and "...having seen the growth of vetiver and come across the local variety grazed by livestock at both Lombok and Wonogiri, I am sure that this grass will solve our fodder problem especially during the 9 month dry season...the combination of vetiver and tree legume leaf which have been growing on farmer's land will be the cheapest way to overcome the feed problem for cattle." Mas'ud is also working with forage amaranth and is reporting some good results for varieties D-881 and R -104. In my view forage amaranth (high yield of biomass and high levels of protein) would make an excellent feed if fed with vetiver.

Dr. K.V. Ramu, River Basin Adviser of the Ministry of Public Works in Indonesia writes that the Directorate of Rivers is making serious efforts to introduce vetiver as a biological engineering tool. Proposals have been prepared to carry out pilot studies in North Sumatra on the Batang Serangan River to protect the nght bank with vetiver spurdikes, on the Habil River Control Project to dissipate hydraulic energy using bedbars and vetiver hedges (basically the same as what is appearing to be a successful approach in Wuhua county in Guangdong), and at the Sirmonda River Outfall Control Project, Lake Toba, to stabilize the river mouth and river banks in a combination of gabbions and vetiver. Those of you who have an interest in these proposals or who may want to offer advice might want to contact Dr. Ramu directly at tel.(021) 739 1959 or fax (021) 520 4232.

John Greenfield has just visited southern Africa, we will report fully on his visit in the next news letter. However he found that a number of vetiver users were applying the technology incorrectly by using the grass to stabilize contour bunds - i.e. planting on the top of the bund. **This is generally a useless practice and does not take advantage of vetiver's ability to filter out sediments and spread water.** We can achieve better and cheaper results with vetiver hedges and no bunds.

Some special requests. There are a lot of you doing some pretty interesting things with vetiver, and the technology is spreading. Please write in and tell us your news, so that we can share it with others. Also remember that nothing we write is copyrighted, so I hope that you are copying these news letters and passing them on to other potential users.

Better still, translate them into your local language.

Finally, we seemed to have failed you by not being able to provide funds for start up operations, or for research and other experimental work. It appears that there are plenty of funds available for studies etc. but little for developing and disseminating a practical useful technology like vetiver grass technology for soil and water conservation. If anyone has some bright ideas on how to raise more money, or know of a source of institutional funding I would appreciate hearing from you.

New Year's Greetings to you all.

Dick Grimshaw.
December 1, 1993.

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(This is a new number).

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