VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER NETWORK
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CONSERVATION GRASS WINS MONSANTO'S "JOHN FRANZ SUSTAINABILITY AWARD"

ST. LOUIS, Oct. 22, 1996 — A nonprofit organization promoting novel uses for tropical grass for conserving soil and water and other environmentally beneficial applications was today named the winner of Monsanto Company's John Franz Sustainability Award. The winning organization — The Vetiver Network, headquarted in Leesburg, Va. — supports a worldwide network of 4,000 participants who use the technology to increase sustainable development in more than 100 countries.

Last December, Monsanto announced the $100,000 award to accelerate the development of new technologies and systems to improve world environmental and economic sustainability. The Vetiver Network was selected from more than 75 proposals as the most promising system for advancing global sustainability.

The announcement of the today's winner was made at a meeting of Monsanto's Sustainability Team, a group of more than 100 employees representing the company's 12 busi-

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Editorial *The Vetiver Network has come of age. It is now in a position to execute a comprehensive $500,000 program over the next two years that will not only provide information, but will encourage through the provision of financial assistance to vetiver user groups the promotion of the technology at regional, national, and local levels. It will reinstate its research and development awards program and it will provide new and up to date publications and videos about the technology.*

Our purpose in the last years of this century must be to continue to create, but at an accelerated rate, the awareness of the potential of vetiver grass as a unique and effective way of sustaining the worlds land resource, particularly in "tropical" countries. We have to also create the means to do this. The Vetiver Network cannot do this latter task alone. We invite governments, corporations and other institutions and agencies, however big or small, to take a serious look at the vetiver hedgerow technology, determine its usefullness, and then find the means to apply it.

During the next few years we expect to see Vetiver grass use expanded for bio-remediation and other puposes for cleansing the mess resulting from land fills, mine dumps, and other centers of toxic waste.

We also expect to see an expanded use of vetiver and other stiff grass hedges as a means of reducing nitrate and phosphate leaching to our natural water supply systems. This extraordinary grass, being a hydrophyte, has great potential asa component of a wetlands technology

We believe there will be an increased acceptance of the technology by engineers for use in embankment and other stabilization applications. It is an indeed an exciting plant and an exciting time to be working with the technology.

Earlier this year The Vetiver Network sent to many agencies a request for funding to enable us to expand our work. We thank those who responded, particularly The Royal Danish Government who gave us a generous grant. We would ask those who did not respond to reconsider, and provide us with funds. The Vetiver Network has no salaried staff and has minimal overheads. Thus funds go to where they can be effectively used -- in the field. We also ask vetiver users who can afford it, to contribute as well. Its your network, help to make it work!

We congratulate Jim Smyle and Joan Miller for establishing The Latin America Vetiver Network, and this year they have published two excellent newsletters in Spanish.

This Newsletter, #16 , has some interesting articles and deserves careful reading.

ness units who are dedicated to coordinating Monsanto's efforts to advance global sustainable development.

Monsanto received entries in the areas of resource conservation, technological innovation and educational programs from individuals, research institutions, and private and governmental organizations in 12 nations.

"The well-being of humanity depends on a healthy and sustainable planet," said Robert B. Shapiro, Monsanto Chairman and Chief Executive Officer. "Moving in the direction of sustainability will require new technologies and practices to spur the necessary innovation. We're working to develop some of these technologies, and we hope promising programs like the Vetiver Network will set a precedent for further advancement."

The winning proposal was selected by a panel of independent judges who are experts in different areas of sustainability. The panel of judges included Dian Cohen, the president of DC Productions Limited in Canada; John Hebblethwaite, the executive director of the Conservation Technology Information Center; Uma Lele, an Advisor in the Agricultural Research Department in the World Bankís Vice Presidency on Environmentally Sustainable Development; Manfred Wirth, the Director of Dow Europe's Environmental programs; and representatives from Interface, Inc., a company that provides high-quality, sustainable, commercial floorcovering products.

The Vetiver Network developed a method of using vetiver grass to conserve soil and water; to stabilize embankments, wastelands, landfills and mine dumps; and for flood control and groundwater recharge. The program is used in more than 100 tropical and semi-tropical countries through its 4,000-member communication network.

While effective in tropical climates, vetiver grass cannot survive extreme and continuous freezing temperatures typical of most of the continental United States.

Vetiver grass has a very deep and massive root system that extends more than five meters under the ground. Planted across the slope of the land as hedgerow, the Vetiver Grass Hedgerow Technology (VGHT) seems to be the most effective biological system of soil and water conservation.

Soil losses are reduced by 70 to 90 percent, while crop yields are increased by as much as 50 percent because of the preservation of sediment and nutrients on natural terraces. Vetiver grass is also tolerant to fire, drought, grazing, and high levels of toxic metals.

The advantages of VGHT, make vetiver grass a sustainable answer to many of the environmental dilemmas of the tropical world. For instance, highways in tropical countries are renowned as point source erosion sites that cause serious down stream contamination of water supplies. Used correctly, VGHT can virtually end forever sediment flows from such sites.

Other demonstration sites have proven vetiver grass as an effective means of stabilizing toxic dumps, controlling floods as well as a variety of other practical uses.

The Vetiver Network will use the $100,000 award to fund the continued operation and expansion of the project, including the preparation of educational films, publication of a new handbook and establishment of five regional networks to support further development of VGHT.

Monsanto is a science-based company involved in improving the quality of life through agricultural systems, pharmaceutical and food products and high performance chemicals.

The John Franz Award is named after the inventor of Roundup herbicide — which has contributed to agricultural sustainability worldwide through its use with conservation tillage systems. The announcement of the award in December of last year coincided with the 25th anniversary celebration of Roundup as a product.

VETIVER NETWORK FUNDED FOR 1997 and 1998.

The John Franz Sustainability Award to the Vetiver Network of $100,000, together with the generosity of the Royal Danish Government and the Amberstone Trust, assures that The Vetiver Network has sufficient funds to: support the establishment of Regional Networks (about $120,000), support NGOs in vetiver ventures (about $100,000), award prizes for good vetiver research and dissemination practices ($50,000), produce a new technical book on vetiver incorporating all we know ($50,000), produce new vetiver videos ($50,000), publish the newsletter, and continue the expansion of our home page on the World Wide Web. We are still short of some funds and look forward to receiving donations from vetiver users (especially those of you who are running profitable businesses using vetiver and the technical assistance that you have received though the network) and other donors who see the potential of vetiver technology in the mitigation of environmental problems. All donations should be sent to the Vetiver Network. More details under "ANNOUNCEMENTS page 10"

WHAT VETIVER USERS IN THE PHILIPPINES SAY

The following are testimonies by Vetiver (Vetiveria zizanoides) users given

during the Vetiver Users Workshop, May 24, 1996, Matalom, Leyte, Philippines. *Note in this part of the Philippines vetiver is known as "Mura" or "Mora".* Prepared by **Edwin Balbarino**, Program Field Coordinator, FARMI, ViSCA, Baybay, Leyte, Philippines. Email: v+visca@sat.vitanet.org

Leon Pen, *Barangay Chairman, Templanza, Matalom, Leyte.....*"I got my first Mura (Vetiver) planting materials from one of my barangay councilmen Jacinto Gerona. I planted Mura in my farm near my house. Mura is easy to plant with minimal maintenance. It grows very well and effectively controls the down flow of soil during the rainy season. At present, the contour plots of my farm have been leveled off. In addition, I am also using Mura to cure high blood pressure in my work as Tambalan (local medicine man). The only comment I have with Mura, is that my carabaos (water buffalo) do not like to eat it". *(If you cut your Mura regularly, say once a month, your carabaos will love it...Ed)*

Irene Pria, *Officer: Rural Women Association, San Salvador, Matalom, Leyte*..... "FARMI workers gave me the Vetiver planting materials in 1991. At the start (about the first 2 years of establishment) I did not practice trimming the Mura hedgerows. Then I found out that it is very strong and effective in controlling soil erosion. Now my Mura hedgerows are well maintained by trimming before flowering. Trimming the plant (during not before) is laborious because the stem is already hard. I placed the herbage along the upper portion of the hedgerows. This will help in trapping the soil during the rainy season. Other herbage is used as mulch for my sweet potato crop. I could also say that the wonderful contribution of Mura has ever given me is that it cured my thinning hair.

Note: Workshop participants and friends testified that Irene really suffer balding/serious thinning of hair before. She has the formula/technique of doing it which she will share to those who are interested. *("baldies" had better get in touch with Irene....Ed).*

Gertrudes Inderio, *67 years old woman-farmer, Altavista, Matalom, Leyte*..... "I was the first one to adopt the planting of Mura in my barangay (village). I noticed that my contour plots have leveled 3 years after I planted Mura. I really believe its effectiveness in controlling erosion. It is easy to plant and maintain. To maintain it, I just burn the hedgerows at the end of summer and in less than 5 days re growth is already visible. I have proven it myself that Mura grow in any type of soil. I have planted 6 lines of Mura in Anapogon (calcareous soil) and it is growing very well".

Note: Nang Itring's farm has a 25-40 degrees slope.

Photo 1**. Philippines. Lady framers sharing their Vetiver experience. **Photo Credit: Edwin Balabarino

Nemesia Purgatorio, *President, Women Association, Elevado, Matalom, Leyte.....* "My farm may not be as hilly as the farms of other farmers but still I notice how effective Mura is in controlling soil erosion. Once established, it is not easily killed by cogon grass (Imperata cylindrica) unlike other contour hedgerow species. Mura is easy to maintain. It does not grow anywhere except in the contour line where it is planted. I trim my Mura before planting corn or sweet potato or during land preparation. I am also using Mura as roofing materials for my Payag (animal shed)."

Rubelio Mazo, *Punta, Baybay, Leyte.....* "In my experience Mura is not effective unless we use the A-Frame in locating the contour line. Trimming is also very important. Mura should be trimmed before planting corn or camote to avoid "awong" (sunlight competition). If left untrimmed, there could be danger of accidental burning of the matured hedgerows when crops are still on the alleys. The herbage scattered along the hedgerow base also help in preventing the passage of soil during rainy days. Try to visit my farm, I am sure you will notice the difference between farms with Mura and farms without Mura hedgerows."

Santiago Llones, *Punta, Baybay, Leyte*..... "I like Mura because it is easy to establish and maintain. I do not practice trimming but instead burn my hedgerows because I observed that Mura grows more vigorously after burning. I do not believe that soil fertility is affected when Mura hedgerows is burnt. The effect of Mura could be seen in the healthy corn along the upper portion of the hedgerows. Mura does not compete with corn in sunlight and soil nutrients".

Norberto Inderio, *MAFUD President, San Salvador, Matalom, Leyte*..... "My contour farm is near (above) my small rainfed rice field. I have no doubt of Mura's effectiveness in controlling soil erosion. There was a big gully in my farm before but after 4 years of planting few lines of Mura that gully is no longer visible. The only thing that makes Mura unattractive to farmers is that it seems unpalatable to animals except during long dry season when grasses are scarce. During that 7 dry months in 1992 burned Mura was not able to recover. Mura

serves as a wind break of my rice and also serve as a nest for my hens. Mura should be trimmed to keep away the Maya birds from nesting on it."

Note: Maya is that small red-brown bird which is considered important pest by rice farmers.

Ronie Maso, Punta, Baybay, Leyte..... "I observed that farmers in the barangay who do not use Mura as a contour hedgerow frequently shifted farms. For me I have not shifted farms for already five years. The reason why they won't plant Mura is that they don't own the land they tilled. One observation I have with Mura is that it is easily dominated or overgrown by Kudzu especially if not well-managed." *(Development planners, please note the importance of land tenure, or lack of it, with regard to the uptake of longer term conservation technologies; also as we have mentioned before, vetiver hedgerows combined with other practices may be the answer to "slash and burn" problems. Ed.)*

Margarito Maso, *Punta, Baybay, Leyte.....* "I firmly believe that planting Mura grass is the most effective way to control soil erosion. I made a simple experiment on my farm by leaving a portion not contoured with Mura. In just few cropping seasons the difference in terms of soil erosion was already evident. I measured about 2 feet thickness of soil trapped at the upper base of the Mura hedges. Gullies are observed in the uncontoured portion."

Felipe Itallo, *Punta, Baybay, Leyte*..... "My experience with Mura is on paddy rice fields and not on upland farms. We have already been using Mura to stabilize rice field dikes several decades. It is really strong and lasts forever. It regrows even if covered with mud. Farmers just burn the Mura after harvesting to drive away rats and birds.

Bonifacia Gura, *Matalom, Leyte.....* "In the beginning we used rock walls as soil erosion control system in our farm. Along the rock walls we also planted Ipil-ipil (Leucaena leucocephala). After several years we eradicated the ipil-ipil because their roots are making land preparation difficult. During that time FARMI introduced Mura as contour hedgerows to control erosion. So I tried the grass as replacement of Ipil-ipil. We like Mura because it stays where it is planted. It is easy to establish and survives long droughts. One major characteristics of Mura that makes it an ideal control hedgerows is that it regrows or produces roots at the nodes making it effective as contour bands and riser stabilizer". *(This latter observation is execellent, and is exactly why Mura is such an effective stabilizer...Ed.).*

Concepcion Pada, *San Salvador, Matalom, Leyte*..... "I have not maintained (trimmed) my Mura hedgerows since planting because I fallowed my farm for 5 years. However, I noticed that the grass still exists after 5 years since it was planted. Now, my Mura hedgerows is already thick. I am planning to open my farm again and trim the Mura".

Nesias Galia, *Hitoog, Matalom, Leyte.....* "My farm is located below the barangay (village) road so that during heavy rains water is drained to my farm creating big gullies. As remedy, I formed contour bands and planted Mura and Napier along the bands. I observed that corn planted near the Mura produced bigger ears than those near the Napier. Napier roots runs through the alleys. The Mura hedgerows could be maintained by just cutting it at the base or stem regularly. It should be cut and cleaned regularly so that weeds such as Bokot-bokot (Micania cordata) can not dominate that would eventually kill it."

ORGANIZING VETIVER'S NEXT STEPS TO GLOBAL ACCEPTANCE

Presented at the First International Vetiver Conference, Thailand, February 1996 by Noel Vietmeyer, U.S. National Research Council, and Board Member of The Vetiver Network, Email: noelvi@aol.com

Introduction

For all its great merits vetiver has a major problem: it just isn't going to make many millionaires. Were it capable of creating lots of money for individuals, we vetiver specialists could retire to our laboratories, offices and test plots strong in the conviction that others would eagerly turn all our results and visions into practical benefits.

But the reality is that people of extraordinary conviction and vision, such as His Majesty the King, are the only ones going to dedicate their energies to moving vetiver upward and outward to its global destiny. As a result, we cannot go back to our research and expect that this immensely useful plant will advance into widespread acceptance by some sort of global osmosis. We vetiver champions must now shoulder the burden of selling the vetiver idea to people of influence worldwide.

And this brings up a second problem: vetiver is so good at doing so many things that our immediate challenge is an organizational one. Even we vetiver specialists become overwhelmed by the sheer breadth of the vision we see. And if we are confused, think about how baffling our story must be to those newcomers whom we must bring on board to achieve a successful global outcome.

To help bring some measure of order to our collective vision, as well as to boost the crop's advancement, I'd like to suggest that we move vetiver for-

ward by means of the following initiatives.

Soil Erosion Initiative, Extreme Soil Initiative, Water Management Initiative, Pollution Control Initiative, Farmer Support Initiative, Disaster Prevention Initiative, Basic Science Initiative.

These initiatives are more than just ways of thinking about the plant and its promise, they are compartments of practical progress, each distinct and selfcontained within itself. Of course there are overlapping borders indeed, a complicated chart could be drawn showing all the interrelations but for all that, each of these action oriented topics plays on different strengths of the grass and reaches out to different audiences. In addition, each requires a different approach from us as we shoulder our burden of locating partners for mutual support and for faster progress worldwide.

Let me see if I can explain this better by taking each initiative in turn.

The Soil Erosion Initiative

Of all vetiver's applications, controlling soil erosion is by far the best understood and furthest advanced. Probably 90 percent of all the work to date has been devoted to this initiative, and the fact that the plant stops soil loss is now abundantly clear. The effect is due largely to the strength of the stems in hedges placed along the contours of hill slopes.

I need not dwell on the details here, but I do want to note that this initiative must not be slackened. Soil erosion is arguably the worst global environmental problem, and for much of the world it was the least tractable until vetiver came along. All in all, this grass offers the first practical intervention with worldwide possibilities.

The Soil Erosion Initiative's next major challenge is to project existing knowledge to new locations and new people. In a sense, we must bring other nations up to the level of commitment and action achieved here in Thailand. If we can make perhaps 100 more nations as committed as this one, the global scourge of soil erosion would mostly be thwarted within our lifetimes. Of course, some nations are too frozen during winter to consider vetiver, but the United States is developing a complementary, vetiver inspired, grass hedge technology using cold climate species.

Bringing about the tantalizing vision of global success against erosion should be the Soil Erosion Initiative's aim. The existing vetiver publications are, by and large, adequate to the task. Farmers and foresters are of course the main audience, but we must reach out more to engineers and get them to take up vetiver routinely along roadsides, around construction sites, next to bridge abutments and along pipelines. Also we need to reach city officials so that vetiver gets put to use stopping erosion in the squatter settlements, storm water drains and other urban sites.

In addition, environmental scientists and conservation watchdog groups need to be made aware that vetiver is now a promising answer to the soil that washes into their natural preserves. They could, for example, push for the regional employment of vetiver hedges to reduce the waterborne silt that devastates coral reefs, fishspawning grounds and various other irreplaceable habitats. Three examples worth vigorous action are:

The Everglades. The delicate balance of this irreplaceable habitat in Florida is being upset by phosphate and other nutrients washing out of nearby sugarcane fields. To me, the solution lies in surrounding the canefields with vetiver hedges. Those hedges would trap the silt (along with the phosphate clinging to it) and absorb soluble nutrients before the water ever passes into the Everglades.

Lake Victoria. This large lake in the heart of Africa is suffering explosive blooms of water hyacinth. I'm informed that the problem has been linked to nutrient laden silt washing off the land and fertilizing the weed. A regional vetiver planting campaign in the watersheds serving the problem locations, might immeasurably benefit the lake, not to mention the watersheds themselves.

East Africa Coast. The grass might also prove useful in watersheds in eastern Kenya, where silt washing off the land is killing a priceless coral reef.

The Extreme Soil Initiative.

The primary challenge in this initiative is not erosion control; it is instead to make extreme soils productive, or at least more productive than at present. This is also an important challenge. Vast areas of the earth typically classified as "marginal lands," "wastelands," or "abandoned lands" are inadequately used because they are just too hard to harness for crop production.

A truly amazing aspect of vetiver is its ability to survive on sites so hostile toward plant life that people now universally write them off as impossible to cultivate. The relevant feature in this case has to do with the plant's root chemistry. We know from experiments and observations that vetiver grows in acid soil, alkaline soil, laterite, vertisol, toxic mine spoil, moderately saline soil, wetland and dryland soil, and even soils so dense they are likened, not inaccurately, to "concrete".

That vetiver can survive in such sites may at first sight seem just incidental, but having an adaptable and well behaved plant that stays neatly in place is probably the missing key to mitigating the harshness of many now barren lands. Vetiver hedges in this case would be deployed as vegetative shock troops to seize a botanical bridgehead on the

hostile site and open the way for other species to follow.

It seems likely that the lines of solid plant cover will indeed help get the restoration process started. Already the effect can be seen in many places. In Louisiana, for example, barren washes quickly fill with native vegetation after vetiver hedges stabilize the area. In northern India, sodic wastes were turned into luxuriant forests once vetiver hedges were in place. And in southern India, forests have been seen to colonize hillsides after vetiver hedges provided some protection.

This particular use of vetiver is hardly well known, and it deserves its own dedicated initiative. Research, testing and a comparison of experiences are all needed in a wealth of difficult sites. Globally important extreme soils to include from the beginning are vertisols, laterites, saline and sodic types. Get people excited about any of those and you'll really make a difference to vetiver and the world. The "laterite" that dominates the lowland tropics is an especially potent challenge. That particular type of soil red in color, very acid and high in soluble aluminum, a deadly toxin to most plants has long been considered beyond the possibility of highyield farming, but the fact that vetiver survives (even thrives) in laterite could turn out to be one of the great breakthroughs for tropical agriculture and forestry.

Combinations of vetiver hedges with appropriate leguminous cover crops that renovate infertile land between the hedges need especial consideration, That one-two punch, based on a natural succession of the vetiver pioneer and the nitrogen fixing successor, should open the doors to routine development of many now unusable sites. The combination with laterite tolerant leguminous trees, such as Acacia mangium, could also be a powerful intervention.

Taken all round the Extreme Soil Initiative is a way to "sell" vetiver to a new set of clients for whom soil erosion is not a main concern. Examples are landuse planners, international donors, economists, policy makers, government administrators and others worried over population pressures and immediate food supplies. In principle, hundreds of millions of hectares of now unused lands could be rejuvenated to support more people and more crops. Turning wastelands into farmlands would, in addition, be a way to save more natural forests from "slash and burn" destruction.

The Water Management Initiative.
The fact that vetiver hedges are dense enough to dam up water is yet another distinct feature. The effect is due to the plant's stems and myriad leaves, as well as to the soil and litter that collect behind a hedge. The effect is more sophisticated than people imagine; a vetiver hedge handles different depths of water in different ways. A modest, ground level runoff hitting one of those hedges gets ponded, but a rushing torrent passes through with increasing ease as it rises past the point where the leaves splay outward. An established hedge, seldom gets knocked down, and its variable filter feature damming up ground level flows but progressively passing more water the deeper it gets is an important one.

Professionals and policy makers involved in water issues are unaware that vetiver can help their efforts. This Water Management Initiative needs to reach out and show them what they have to gain. Things to highlight include the following.

Watershed Management. By holding silt and water on hill slopes, vetiver hedges should be able to protect entire watersheds the way the original forests did. This would not only reduce soil loss and river sedimentation, but by keeping water on the land, vetiver would recharge groundwater supplies. Work in Malaysia shows that by using plants raised in pots, the hedges can become functioning barriers within weeks of being planted out. This holds the possibility of creating "instant" working watersheds over vast areas at modest cost. It would also mean that people might be able to stay living on the watersheds without severely affecting the area's vital hydrologic importance.

Waterway Stabilization. Vetiver planted along streams, river banks, canals, drains and ditches can help keep out silt, maintain the flow and prevent the banks from being undermined. This means, among other things, that capital investments in water supplies will be protected and enhanced.

Reinforcing. This coarse grass with its roots like chicken mesh projecting several meters into the soil probably can strengthen earthen structures such as small dams and dikes. Following the disastrous Mississippi floods of 1993, it was reported that all levees protected by switch grass remained unbroken. Vetiver should do at least as well because it is endowed with a better root and stem architecture for the task.

Sediment Control. Waterside "walls" of vetiver hedge, grown on the banks of reservoirs, would provide ideal holding "pens" for dredge spoil. By allowing the water to filter back into the reservoir, these cheap, porous barriers would make it feasible to isolate the solids for economic handling by people or machine. Such self rising silt traps might help rescue reservoirs serving cities such as San Juan, Puerto Rico and Port au Prince, Haiti. Those reservoirs, along with many more in the tropics, are fast silting up and prematurely losing their capacity to hold water or generate electricity. Of course, the whole siltation process should be slowed with vetiver hedges on the watersheds.

Engineering Water Flow. Vetiver hedges can be employed not only to retard runoff but to direct water toward,

away from or through some given point. Hedges angled down slopes, for instance, would divert water away from sites such as unstable cliffs. For the cost of a few tillers and a planting effort, hydrologists and engineers could harness nature to achieve water shedding or water harvesting or other forms of water control.

Waste water Treatment. Probably there is no better species for stripping nutrients out of domestic (and perhaps industrial) wastewater. A native of a wetland environment, vetiver withstands long immersion. Hedges grown across or around manmade marshes would likely block the passage of solids, strip out dissolved nutrients and detoxify pathogenic microbes through aeration or detention. By providing simple, compact water treatment facilities that require no chemicals or pumps, vetiver could create a new and cheap form of tertiary wastewater treatment for the countries of the "Vetiver Zone." In return, these wastewater treatment facilities could become vetiver nurseries. Fertilized by the wastewater nutrients, the plants should throw off tillers in abundance. Employing human wastes to grow vetiver for planting where it can do good for people and the environment is a new and especially elegant notion of recycling.

In sum, this Water Management Initiative could elevate vetiver into a tool for providing more reliable water supplies, reinforcing earthen dams, protecting river banks, treating domestic wastewater and much more. In selling the idea to hydrologists, sanitary engineers, public health specialists and so forth, a few spectacular successes could make all the difference. The Panama Canal, for one, would be a great showcase. Today, ship wakes erode parts of the canal banks, but vetiver hedges would absorb the swells and allow ship traffic to speed up, thereby increasing the canal's throughput and economy. Moreover, contour hedges on the surrounding hills and mountains would retard rainfall runoff, recharge groundwater supplies and probably restore the Chagres River to high year round flow as in the days when those watersheds were fully clad in forest.

The Pollution Control Initiative. Although vetiver has many potential uses in pollution control, none is being vigorously developed or promoted. The initiative needed here, is to reach out to governments, environmental scientists, industry and organizations concerned over cleaning up messes people or their institutions have left behind. Also, vetiver might be employed to prevent future messes from occurring or at least from spreading. A few examples of what vetiver might help clean up are given below.

Underground Flows. Surrounding polluted sites with vetiver hedges may well be a way to keep toxic compounds from moving outward underground. The massive, curtainlike "hangings" of interwoven roots seem ideally structured to filter out underground contaminants. If the plant can keep deadly pollutants corralled and unable to move outward and contaminate new ground, vetiver will have earned a place in everyone's gratitude.

Soil. Paul Truong's magnificent work in Australia has shown that vetiver is tolerant of high levels of arsenic, cadmium, chromium, copper and nickel. The plant therefore seems highly suitable for rehabilitating and reclaiming lands contaminated by heavy metals, as well as perhaps by radio nuclcides and similar horrors resulting from mining, other industries, research facilities, landfills or other waste dumps.

Industrial Spills. No one has reported trying vetiver hedges against spills of industrial liquids, but it seems to me that a series of these very dense hedges would provide a cheap and probably effective backup protection against small spills at least. It would hardly matter if the hedge died, it could be easily replaced. Even crude oil might be held back. Indeed the oil soaked vegetation could be burned for furnace fuel.

Runoff. As mentioned above, vetiver hedges could block nutrient laden runoff. Such runoff from farms, industry, cities, landfills and even golf courses is a rising concern these days. Vetiver hedges could be especially useful as a "filtration barrier" around such sites, as well as around ponds and marshes built to contain or detain runoff. In the case of cities, contaminated stormwater is a particular concern.

Natural Waters. Hydroponics might be a way to use vetiver hedges to filter dangerous materials out of surface waters. This is a speculative and untested idea but, as noted, the plant is at home in watery conditions. In one form of hydroponics, the plants would be grown in an inert and highly pervious material through which the waters would pass. In another, vetiver might be grown with its massive roots dangling free in the water. This far out idea, which works for other plants, requires something (old tires perhaps) to keep the vetivers from sinking. Floating hedges might even be deployed across streams or canals to strip pollutants and dissolved nutrients out of the water passing by. This waterborne process might even prove a convenient way of growing vetiver roots for oil extraction (no digging needed, just clip off the root ends when they get too long).

Industrial Wastewater. I've already mentioned the possibility of treating human wastes in manmade vetiver filled wetlands. This nonchemical wastewater treatment also seem promising for cleaning waste products from aquaculture. It is already removing nutrients from trout farm effluent in trials at a U.S. Department of Agriculture research facility in West Virginia.

Taken all round, this Pollution Control Initiative opens up vetiver applications relating to some of the best fielded areas of research, with billions being spent in the United States alone. But the use of the grass is not currently a part of the experts' thinking. To correct that, vetiver needs to be tested widely in polluted sites, and fast. A success or two could launch vetiver into "big time" and well funded applications. In fact it would transform the world's appreciation of the plant overnight. In people's minds, a tool for removing deadly toxic hazards is something quite different from a tool to control soil erosion on foreign farms. A change of attitude like that would help everything.

The Farmer Support Initiative

Unless farmers deeply appreciate the plant and fully recognize that they are benefiting from it daily, we'll always have to struggle to get vetiver hedges on the land. So, while we're emphasizing grand global problem solving, such as those I've mentioned above, we've got to keep the farmers eagerly planting vetiver for themselves and for a surplus to sell. To assure this we need special efforts to get world wide appreciation for the benefits to growers. Many farmers won't plant anything new just for erosion control, but they will eagerly tend a crop that provides income or makes their lives easier or more secure. Here are some features of vetiver that provide salable products or a better life for farm families:

Handicrafts. Vetiver's bamboo like stems are ideal for making baskets and other small items.

Thatch. The leaves make one of the longest lasting and most beautiful roofs.

Supplementary Feed. Although not a great feedstuff, vetiver is better than many give it credit for.

Improved Crop Yields. Holding moisture back fosters better crop growth and helps keep wells filled.

Wildlife Controls. Pests such as rodents and Africa's graindevouring quelea bird might be kept out of crops. The birds, for example, like to roost in blocks of tall grass, and there can be trapped in the dark of night.

Mulch. The leaves create a long lived mulch that helps garden plants survive adversity.

Windbreaks. Standing up to 3 m tall, vetiver is ideally structured to resist the wind.

Boundary Markers. Several African nations recognize property lines demarked by vetiver because it stays in such a narrow band.

"Airconditioning". Mats woven of vetiver roots are placed over window openings and doused with water cool millions of India's houses. Breezes passing through are both chilled and perfumed. This could have wider potential than now imagined.

Ornamentals. In Miami, vetiver plants are being taken up for their beauty and good behavior in the landscape.

Screening. The tall, dense hedges are a way to provide a measure of privacy around houses, latrines, etc.

Animal Protection. Corrals and shelters for small creatures such as chickens seem a possibility.

Traffic Control. Vetiver can be employed to orient where people and animals walk and where vehicles drive. For instance, it can keep them off unstable banks.

Self Rising Utility Walls. Circles of vetiver might be used to enclose compost piles, trash heaps, farm gardens, fish ponds and more.

Weed Prevention. The hedges are said to prevent creeping weeds, such as Bahia grass, from invading gardens.

Making Steep Slopes Usable. Hedges across slopes make it possible to work where now even standing is difficult and everything washes away with the rains.

All of these farmer advantages need to be developed and exploited throughout vetiver country. They should be brought together in extension literature. In this case, the extension publications might mention erosion prevention, but their more immediate purpose is to stress benefits to the farmers' daily existence. In addition, commercial markets for vetiver tillers, handicrafts, thatch, "airconditioning" mats and other products need to be advanced. Rather than establish centralized nurseries, a commerce in farmer supplied planting materials should be encouraged.

The Disaster Prevention Initiative.

Given the deep roots, high tops and thick hedges, as well as the promise of practical largescale application, it seems obvious that this grass could play a role in mitigating (and perhaps preventing) various natural disasters.

This topic, speaking technically, overlaps water management and soilerosion control, but speaking in the political and humanitarian sense, the topic of disaster prevention takes vetiver into a different ministry and makes it of interest to different industries. Here the ultimate goal is not just to control water and retain soil, but to save lives and reduce property damage. The Disaster Prevention Initiative, then, is a way to reach out to governments, the worldwide insurance business, mortgage lenders and more. Here are some possibilities where vetiver might make the difference.

Mudslides. The stiff, strong tops of vetiver hedges stop mud and debris from passing by the massive underground walls of interlocking roots seem likely to stop slopes from slipping.

Floods. I've already mentioned how vetiver hedges may be planted in ways that rob floodwaters of the power to cause destruction, and that the hedges can hold rainfall on the watersheds.

Fires. In South Africa it has been found that burning off the hedges at the end of the wet season results in a flush of growth that stays succulent through the dry season. The forest insurance industry has accepted this band of green vegetation as an effective firebreak.

Droughts. By helping extend groundwater and surface water supplies (as mentioned above in watershed and reservoirs, for instance), vetiver should be able to benefit droughtprone areas.

Earthen Structures. Some (many?) earthen structures are in danger of collapse. A decade or two ago a dam in the hills above Los Angeles broke, releasing a deluge that caused immense property damage and some deaths. Vetiver appears to have potential to be an inexpensive reinforcing to strengthen such structures. Levees around New Orleans and along the lower Mississippi are likely candidates known to me. Were they to break, the devastation would be immense

We cannot be certain about vetiver's utility in any of these undertakings, but the authorities charged with disaster prevention should be given a chance to put vetiver to the test. Whatever is done to prevent disasters will have to be done over vast areas, and vetiver seems more suited than other possibilities, such as those employing concrete and steel.

This use of vetiver in emergency management would come clear to the appropriate authorities and businesses if it were employed on some high profile sites. An example might be Mt. Pinatubo in the Philippines where the massive landslides of volcanic debris are inundating towns and villages. In addition, disastrous mudslides have in the last few years caused deaths and/or destruction in Puerto Rico, Haiti, Leyte in the Philippines and Malibu in Southern California. All those locations seem ideal for vigorous vetiver growth.

In addition, the Mekong watershed might be tackled as an international vetiver planting test bed. The idea would be to keep silt out of the river and future floodwaters out of people's houses. Return the critical upland slopes to the hydrological state they enjoyed when fully forested, and perhaps Thailand's terrible floods can be a thing only of memory. A similar, but even bigger challenge, would be the protection of Bangladesh from Himalayan floodwaters. Such a mission might seem to be too vast to be possible, but vetiver would be a better place to start than anything else I can conceive of.

The Basic Science Initiative.

For all our experience, the truth is we still don't know much about how the plant ticks. Yet the workings of vetiver are what underpins everything. What makes it work so well at so many things? In this regard, how does it differ from other plants? These and many more question need answering.

In this Basic Science Initiative the audience is specialists such plant physiologists, microbiologists and (grass scientists). The topics here relate to pure science, rather than strictly to practical affairs.

Areas for basic science investigation include the following.

C02 Absorption. In this era of global warming scare, it is important to measure how much greenhouse gas vetiver stores in its massive roots.

C13 Absorption. Is vetiver, like corn, an accumulator of this uncommon isotope?

Taxonomy. What exactly is the relation between the sterile domesticated plants and the seedy wild ones?

Transaction of Oxygen. Rice survives in flooded paddies because it moves oxygen down into its roots. Vetiver also survives in paddies. Can it do the same oxygen transfer?

Heavy Metals. How well do pollutants move upward from the roots to the leaves? Is Vetiver a "superbioaccumulator"?

Disease Prevention. The plant is remarkably healthy, but let's get breeding and selection programs going so we don't got caught short if an outbreak occurs.

Mechanism of sterility. Why is the plant sterile? How reliable is that sterility?

Genetic Diversity. What are different types of vetiver? Are some better adapted for the various purposes than others?

Mycorrhiza. These fungi that colonize roots probably are one of the keys to the plant's survival in extreme sites. We need to know more.

Nitrogen Fixation. Does vetiver survive on barren sites because, like a few other grasses, it has a symbiosis with nitrogenfixing bacteria?

Cold Sensitivity. This is perhaps the biggest limitation for temper-

ate zone countries such as the United States. Can it be reduced or overcome?

General Tolerances. What are the theoretical limits to drought, water, and toxic conditions? What can be expected in practice?

Mechanism of Hedge Formation. Why do the plants in a hedge tend to interlock when most grasses stay in separate clumps?

Dwarfing. Can shorter hedges be obtained?

Root Growth. Just how strong are those reinforcings in the soil?

With topics such as these we need to reach out to scientists in the appropriate fields and show them how, through vetiver, their expertise can have a practical global importance. This is one area where vetiver specialists have the possibility of finding research partners likely to devote time and energy without much cajoling. This is because in the grass family vetiver falls between sugarcane, sorghum and corn, which means that it probably has much to contribute to the better understanding of those billion dollar natural resources. Researchers studying the basics of sorghum, corn, and sugarcane are natural allies of ours.

Conclusion

Breaking up the subject into these seven initiatives, can help generate funding, collaboration, innovation and new progress. More importantly, perhaps, it will inject backgrounds and special insights. No longer will vetiver be the exclusive of agriculturists; sharing our excitement will be environmentalists, chemists, engineers, hydrologists, and more. By this process of reaching out, vetiver champions can speak in seven voices, in seven forums, and stimulate outward momentum in seven directions. Also, it will give us feedback from seven different outlying visions that we now glimpse only vaguely, if at all. That will help us better use this immensely useful plant, and that will help the people of the world most of all.

VETIVER PROPOSED IN GHANA'S NEXT ACTION PLAN ON SOIL FERTILITY MANAGEMENT.

A major workshop on soil fertility management took place in Cape-Coast, Ghana from July 2. to 5. 1996 with more than 80 scientists, including agricultural and development economists, policy makers and selected farmers as participants. The main objective of this workshop was to come up with concrete proposals leading to the formulation of an Action Plan for Ghana towards the twenty-first century on the said subject matter.

The workshop was organized by the Ministry of Food and Agriculture jointly with their peers of Environment, Science and Technology; Land and Forestry. Assistance was provided by the International Fertilizer Development Centre, while Sasakawa Africa Association sponsored the workshop. CEDIA was invited by the sponsors in connection with the role vetiver can play as a component to such an Action Plan. In that perspective CEDIA made a befitting poster presentation on the use of vetiver under different conditions with various scenarios from many countries including Ghana, Malaysia, Thailand, India, Philippines and Fiji. The presentation, described as impressive, was possible thanks to the support of Dr.Tareke Berhe, Chief Agronomist from Sasakawa Global 2000, and Dick Grimshaw of The Vetiver Network.

According to the Minister for Food and Agriculture, this workshop was neccessary and timely because his ministry is currently reviewing the performance of the sector. The workshop's objective was to find ways of increasing food production in the country. Various presentations and reports of many working groups during the workshop acknowledged the importance and usefulness of vetiver grass, and proposed adoption of this hedgerow technology as a major component in land and water conservation and their management.

ANNOUNCEMENTS

CAMEROON WORKSHOP

A three day vetiver workshop, sponsored by Family Associationfor Rural Development (FARDP) will be held in north west Cameroon in the Mbingo-Belo-Kom area from February 6 - 8 1997. This workshop will be supported by The Vetiver Network, and the key resource person will be Mr. Alemu Mekonnen, Head of the Environmental Department, of the NGO Munchen f Munchen that operates out of Mettu in western Ethioipia. Interested persons should contact: Mr. Nwainmbi Simon Chia, Family Association for Rural Development (FARDP), PMB 42, Bamenda, Cameroon.

NEWLETTER #15 QUIZ WINNERS

Winners of the quizzes included in Newsletter #15 were: Mehari Abay, Ethiopia; Luttman de Vega, Brazil; and Bernard Byrnes, USA. Congratulations to you all and to all the others who submitted correct answers. The anwser to the quiz on page 15 is "a section of the vetiver woven grain store wall shown in photo 5 on page 10". The anwser to the quiz on page 30 is "a vetiver trial on the East-West Highway

in Malaysia". The anwser to the quiz on page 43 is "the distorted image of the vetiver water color on page 1".

THE VETIVER NETWORK SUPPORT PROJECT

The Vetiver Network has now raised sufficient funds, including a major donation from the Royal Danish Goverment, to enable it to proceed with the project through to the end of 1998. The project will:

- provide support to establish about five or six regional vetiver networks that would disseminate information on the vetiver technology reflecting local needs and languages (see details);
- provide support to key NGOs in developing countries to initiate or expand vetiver programs that would include training of other NGOs in the technology and the provision of vetiver plant material for propagation (see details);
- awards for innovative research and development;
- production of technical videos and handbooks;
- continued production of the Vetiver Newsletter;
- continued production of the Vetiver home page on the world wide web.

Support for the establishment of Regional or National Networks

The Vetiver Network (TVN) is prepared to assist in funding the establishment of regional and national networks. TVN could provide up to US$ 25,000 per network.

Networks would be expected to collect, produce and disseminate information relating to the vetiver technology in its use relating to soil and water conservation, land reclamation, embankment stabilization and for bio-remedial measures relating to waste management. The networks would disseminate information via newsletters, technical bulletins, videos, the world wide web etc. The networks would be totally independent non profit organizations, but would have informal linkages between other networks and TVN.

Eligibility Only existing or new (for the purpose of becoming a network) agencies that can demonstrate (through submitted evidence) a commitment to the technology and experience in use or promotion of the technology will be considered. The network must be prepared to share all available information with its network members and with other networks. At this time we are interested in establishing regional networks in China, the Pacific Rim and Oceana (PRO), South Asia, West Africa, Ethiopia (including other countries in the horn of Africa, South Africa and east and Central Africa. Networks already exist for Latin America and Europe. It would be important that networks have access to the Internet.

Funding TVN will fund the networks subject to the submission of: a "mission statement", detailed network proposals, both operational and financial to cover a period of two years. If additional funds are required over and above US $ 25,000 it will be important that the proposal sets out how such funds will be acquired. TVN will disburse the funds in two tranches. The first after the network has submitted evidence of its legal status as a non profit organization, and second 12 months later following the receipt of an annual report and statement of expenditure.

Vetiver Network Support to NGOs

The Vetiver Network is prepared to support eligible NGOs with funding up to $10,000 to initiate or expand vetiver technology for soil and water conservation, land reclamation, and embankment stabilization. Funds would be available for propagation of planting material, training materials, technical publications (in local languages), and for farmer support in field establishment.

Eligibility. NGOs officially registered as non profit organizations would be eligible for assistance from The Vetiver Network (TVN). NGOs would need to submit a "mission statement", evidence (photographs, work descriptions etc.) of previous involvement with vetiver (if any) and soil and water conservation, and a current statement of income and expenditure. NGOs that have previously worked with vetiver grass would generally have priority. Apart from carrying out their planned vetiver program, participating NGOs would be expected to run simple workshops to train other NGOs and interested agencies in the technology.

Each NGO would have to submit a simple "project plan", including plan activities and expenditures over two years (1997 and 1998), acceptable to TVN. TVN would expect the NGO to be able to provide some of its own inputs into the project including "inkind" elements.

Funding TVN would disburse its fund in two tranches. 50% at the signing of agreement with the NGO, and 50% 12 months later.

At the time of submission of its proposal the NGO would have to provide name of bank account, account number, and name and address of bank.

Reporting The NGO would have to submit at six monthly intervals a written statement of project progress, including photographs, copies of technical bulletins, evaluations etc. At the end of 12 months and 24 months a statement of expenditure would be submitted. The second tranche of TVN funds would not be released if progress reports and expenditure statements are not submitted.

Interested NGOs or agencies should contact: The Vetiver Network, 15 Wirt St. NW, Leesburg, Virginia 20176, USA. Fax: 703 771 1942 Tel: 703 771 1942. E.mail: vetiver@vetiver.org

Vetiver Network Awards for Innovative Research and Technology Development

The Vetiver Network is pleased to announce its second series of awards for advances in the understanding and use of vetiver technology. The intention is to reward activities by individuals or "project" teams that have increased the value of knowledge we already have, that have added to our current understanding, or that have promoted the use of vetiver technology. The deadline for nominations is June 30, 1998.(Information on the first series of awards can be found in Vetiver Newsletters 9 and 10.)

Award Themes

Awards will be given for initiatives in seven areas:

1. soil erosion
2. improvement of extreme soils
3. water management
4. pollution control
5. farmer-support and secondary uses
6. disaster prevention
7. basic science.

Vetiver Global Initiatives

The seven Vetiver Global Initiatives were proposed by Noel Vietmeyer of the U.S. National Academy of Sciences at the First International Conference on Vetiver in Thailand in February of 1996. Dr. Vietmeyer explained the purpose of these initiatives at the end of the conference in a speech entitled, "Organizing Vetiver's Next Steps to Global Acceptance":

These initiatives are more than just ways of thinking about the plant and its promise, they are compartments of practical progress, each distinct and self-contained within itself. Of course there are overlapping borders; indeed, a complicated chart could be drawn showing all the interrelations but, for all that, each of these action-oriented topics plays on different strengths of the grass and reaches out to different audiences. In addition, each requires a different approach from us as we shoulder our burden of locating partners for mutual support and for faster progress worldwide. ....

Breaking up the subject into these seven initiatives can help generate funding, collaboration, innovation and new progress. More importantly, perhaps, it will inject backgrounds and special insights. No longer will vetiver be the exclusive domain of agriculturists; sharing our excitement will be environmentalists, chemists, engineers, hydrologists, and more. By this process of reaching out, vetiver champions can speak in seven voices, in seven forums, and stimulate outward momentum in seven directions. Also, it will give us feedback from seven different outlying visions that we now glimpse only vaguely, if at all. That will help us better use this immensely useful plant, and that will help the people of the world most of all.

Eligibility

Awards may be given to anyone (scientist, technician, farmer, NGO, innovator) who has shown initiative in advancing the usefulness of vetiver technology. The awards themselves will be granted for efforts that have yielded new, innovative, and demonstrable results; that is, projects that do not duplicate earlier work, that take a novel approach, and that can be repeated in other places.

Amount of Awards

Twnty one Awards totalling $50,000 will be made at the end of 1998. There will be three awards granted in each of the seven categories: for categories 1-6, awards of $4,000, $2,000, and $500 will be given in order of merit; for category 7 (basic science) the awards will be $6,000, $3000, and $2,000. The total value of the awards will not be decreased; however, if additional funding for awards is found the award value may be extended and the number of awards may be expanded.

Documentation

There is no award application form. You can nominate yourself or others. Applications must stand on their own merit. Documentation can consist of any type of information (personal accounts, reports, photographs, articles, scientific papers, testimonials, etc.), but be as brief and clear as possible. Please provide the Vetiver Network with the following by June 30th 1998:

1. Your name and address (phone, fax, and email if possible).
2. Award nominee name and address (phone, fax, and email if possible).
3. Project information:
   - Location of project.
   - Description of project.
   - Accomplishments of project.
   - Importance of project.
4. Supporting documentation (optional but helpful).
5. Name of someone other than yourself or the nominee who is familiar with this project

Award Selection

Projects will be judged on the basis of their merit, relevance, innovation, and

application. Merit refers to the quality of thought and methods used to accomplish the project's goals. Relevance will be evaluated on the project's potential to protect the environment, lower costs, improve the quality of life, or other noteworthy benefit. Innovation can be originality in any sense, including using old ideas in new ways. Application refers to the demonstrated usefulness of the results.

Submissions will be evaluated by ad hoc award committees, who will make their recommendations to the Vetiver Network. Final selections will be approved by Directors of the Vetiver Network, whose decisions will be final. Winners will be announced in December 1998.

Topics

Any individual/project may be nominated in any topic area. The following are examples drawn from Noel Vietmeyer's Global Vetiver Initiatives:

1. Soil Erosion Projects: Probably 90 percent of all vetiver technology work to date has been devoted to some aspect of soil erosion, and the fact that the plant stops soil loss is now abundantly clear; a major goal is now to project existing knowledge to new locations and new people.

2. Extreme Soil Projects: The challenge is to make extreme soils productive, or at least more productive than at present - this topic embraces the area of land reclamation as a whole, including establishment of native vegetation.

3. Water Management Projects: The potential of vetiver on a landscape scale is little-explored; this topic area covers a broad range of watershed management, waterway stabilization, reinforcing earthen structures, sedimentation control, engineering water flow, ground water recharge, water flow management in irrigation systems, and wastewater treatment.

4. Pollution Control Projects: The goals are to demonstrate vetiver as a tool for removing toxic hazards in underground flows, soils, industrial spills, runoff, natural waters, and industrial wastewaters.

5. Farmer Support Projects: This area recognizes the need for special efforts to increase appreciation of the benefits that vetiver provides to growers by increasing income, or by making their lives easier or more secure through providing mulch, thatch, fuel, supplementary feed, improved crop yields, handicrafts, wildlife controls, boundary markers, ornamentals, screening, animal protection, traffic control, "air-conditioning" (both living and harvested plants), utility walls, weed prevention, making steep slopes usable, and similar "secondary uses".

6. Disaster Prevention Projects: Demonstration of the role vetiver can play in mitigating various natural disasters such as mudslides, floods, fires, droughts, and structural failure.

7. Basic Science Projects: The workings of Vetiveria zizanioides underpins everything else, but much remains to be learned about topics such as environmental tolerances and responses, pest and plague resistance, heavy metals accumulation, C02 absorption, C13 absorption, taxonomy, genetic diversity, mechanisms of sterility, root growth, translocation of oxygen, mycorrhiza association, nitrogen fixation, mechanisms of hedge formation, potential for dwarfing, and myriad other issues.

Please send nominations to:
The Vetiver Network
15 Wirt Street
Leesburg, Virginia 20176-2808

Nominations will not be acknowledged unless a self-addressed card is included.

VETIVER HOMEPAGE www.vetiver.org

With the help of Mark Dafforn and some winter time to spare we hope to reorganize the homepage. One addition is in the inclusion of a search engine which should make it easier for you to find specific items of interest. We welcome any suggestions as to how the homepage can be improved, as well as new items that you might like to be included. If you have an E.mail address that you would like to share. Please E.mail it to: "MarkDaffor"<VetNet@aol.com>. **Please note that The Vetiver Network's new electronic addresses are: E.mail: vetiver @vetiver.org and www.vetiver.org**

LIST OF VETIVER GRASS SUPPLIERS

We want to create a list of vetiver growers who have planting material available for sale. This list will be published in our homepage (www.vetiver.org) and also in the newsletters. Those of you who are interested please write to "The Vetiver Network" or E.mail to: vetiver@vetiver.org

INFORMATION ON VETIVER DEVELOPMENT. RECEIVE A FREE VIDEO

We need more information on what you are all doing with vetiver grass and its application. Particularly we need information on farmer feedback, engineering use (if applicable), area under protection, estimated total hedge planted (km), technical pointers and issues, and economic benefits. Those of you who respond to all the forgoing questions will receive a free copy of the video — Vetiver Grass A Hedge Against Erosion - in either Spanish or English, PAL or NTSC systems

(Please specify). Send your response to The Vetiver Network. This information will help us raise additional funds which one way or another will benefit you all.

VETIVER PARTICIPANT DIRECTORY

We will no longer provide a hard copy of the directory. An up todate list is available by country on the homepage (www.vetiver.org) and diskettes are available on request. Please indicate whether you want Dos or Mac format in "Word" or "Word Perfect".

REGIONAL NETWORKS

The West African Regional Network (proposed)

The West African Vetiver Network is underway towards its establishment in Accra, Ghana. This regional set-up will be formally launched next January and will serve both English and French language users in the West African subregion including Cameroon. The network will be managed by CEDIA with collaboration from the Council for Scientific and Industrial Research in Ghana. Formalities in that respect are on course. On another hand the support and cooperation pledged by the President of The Vetiver Network have galvanized CEDIA to put the scheme on track earlier than projected. In line with the objectives of the said regional network, CEDIA with support from Sasakawa Global 2000 has successfully completed the translation into French the vetiver green booklet: "VETIVER GRASS: The Hedge Against Erosion". CEDIA takes this opportunity to APPEAL for funds and assistance to produce the French version of this useful manual in sufficient quantity to serve not only a region with dominating number of French speaking states but also the rest of French users in many other countries.

Enquiries should be directed to:
Linus Folly, The Programme Coordinator, C.E.D.I.A., P.O. Box C-753 Accra, Ghana.
Tel. 233-21-775311 ext. 688, Fax. 233-21-774880/775421, E.mail:**Balme @ug.gn.apc.org**

The Latin American Vetiver Network (LAVN)

This Network, which has now just published its second newsletter in Spanish, is managed by Jim Smyle and his wife, Joan Miller out of Costa Rica. The newsletters in Spanish are available from **"James Smyle and Joan Miller"<hamilton@sol.racsa.co.cr>** or "La Red de Vetiver Latinoamericana, Apdo. 173-2020, Centro Postal Zapote, San Jose 92332, Costa Rica". This network is growing fast. Please encourage others interested in land resource management to join it.

The LAVN newletter will also be published on the Vetiver homepage at www.vetiver.org

The European Vetiver Network

This Network is managed by Marco Troglia and manifests itself as a web page that mirrors www.vetiver.org (when up dated!!!) at **www.siam.mi.cnr.it/Vetiver** . For more information contact: Marco Troglia at Email: "Tecnagrind s.l." <tecn agrind @iol.it>

The China Vetiver Network

We have agreed to establishment a new comprehensive network for China with the Agro Forestry Center, Institute of Soil Science, Academia Sinica, Nanjing, 210008, China. The network will start in November 1996. More will be posted about this network on our home page and in the next newsletter #17. The Network Coordinator is **Mr. Liyu Xu.** E.mail address: lyxu @ns.issas.ac.cn

The China Network will produce four newsletters a year and a series of vetiver fact sheets. It will also run workshops and set out practical demonstrations.

LETTERS TO THE EDITOR

From: **Ahmed Usman Ibrahim**, Bauchi State Agricultural Development Project, Nigeria.....

In Northern Nigeria we used to advise our farmers on mechanical soil conservation techniques to check soil erosion and conserve moisture; these mechanical techniques including terracing, check dams, gullies, gully concreting etc. We have now realized that these mechanical techniques are not only very expensive for the African farmer, but not easy to adopt.

In Bauchi State, Nigeria, since we got to know about vetiver grass hedgerow technology for soil and moisture conservation from the handbook "Vetiver Grass — A Hedge Against Erosion", the vetiver grass hedgerow planting for soil and moisture conservation started gaining popularity in northern Nigeria..

The Soil/Agroforestry Department of Bauchi State (a World Bank financed project) has pursued aggressively, since 1990, the dissemination of the following technical packages to the entire farming families in the State:

- vetiver hedge planting on farm boundaries;
- ridging on the contour across the slope;

- vetiver hedge planting around fish ponds;
- establishment of vetiver nurseries in areas where the grass (Vetiveria nigratana) does not grow naturally in the wild;
- other agroforestry plantings (windbreaks, orchards, alley cropping etc.)

These messages are being adopted by farmers in Bauchi State via the existing "Unified Agricultural Extension " through method demonstrations, adoption plots, posters, lectures, workshops, radio programs and village mobile cinema shows organized by the Bauchi State Agricultural Development Program (BSADP)

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From: **Ngwainmbi Simon Chia**, Medical Centers of West Africa, B.P.382, Maroua, Cameroon. Fax: 237-29-25-97, Tel: 237-29-25-79

The grass is very well known in Maroua, Cameroon. It has been here for many years, or can I say that it has been here since creation. The local name in Fulani is "saddordé".

It is used as land boundary marks in farms, home plots and whenever a new farm plot is sold or handed to a family member or visitor. It is also used for roofing homes. This is one of the best grasses to use in this area of Cameroon because insects (e.g. termites) cannot eat it up easily. It takes 3 - 5 years before the house roof is changed when roofed with Vetiver grass. The roots are used as medicines to treat bodily diseases locally. Also, it is used to produce caps known in the local Fulani language as "ndalaré".
This grass is very useful. However, my people did not know the importance, so, each year they cut and burn some of it. This is done in the dry season. As soon as the rains start, the grasses are back growing.
Anyway, the grass is now being grown in Bamenda, which is in the North West province of Cameroon, as introduced by me in 1990. It Is now used for soil erosion control and flood control for homes. In Maroua (Meskine village), many homes were flooded in 1994. I am now introducing the villagers to the uses of this "Miracle" grass to control floods.

Thanks to the Lord who is so kind and good to His people of Cameroon by providing this wonderful grass.

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From: **Paul Wolfram Alderson**, Senior Horticulturist, LandLab, 3801 West Temple Avenue, Pomona, California 91768, (909) 869-4380 E.mail wolframald@earthlink.net (Paul Wolfram Alderson).

I am honored to be part of the Network! The vetiver I am currently growing, propagating, and distributing at just about all my project sites is derived from one mother plant that was in the Los Angeles County Arboretum Herb Garden (I have been the horticulturist for the Herb Garden there for the last 2+ years.) This plant was probably introduced there by Jean Cozart, a member of the Southern California Unit of the Herb Society of America. Jean is one of the founders of the Herb Society and a bonifide Vetiver "Nut". Jean, in fact, first introduced me to the myriad powers of Vetiver. She wrote a great in-depth article about Vetiver in the Herb Society Journal and she is one of the nation's great ancient herbalists! If she did not introduce it, then my next suspect would be Jim Bauml, Botanist for the Arboretum. He is wonderfully quirky fellow who is constantly feeding my herb garden with new and interesting specimens. The Vetiver I have has never produced seed that I know of. I have never seen other varieties of Vetiver, so I am looking forward to being more educated in this regard.

I am using Vetiver as a soil erosion control plant on severe very dry shale/clay slopes at LandLab. LandLab is a 340 acre environment that includes a 170 acre landfill that is going to close by the year 2,000. There is a lot of potential for Vetiver use at LandLab as well as on Campus—if I can only convince some of the old school in the Horticulture and Agriculture Departments *(I feel for you, story of my life...Ed.)*. (I'm sort of a "cowboy" here on campus when it comes to "revolutionary" stuff like vetiver—I did not come up through the academic ranks. *...nor did I or most of the other vetiver users around the world!! I guess we all know something that the academicians don't know...Ed.*). I am using Vetiver at range of other sites and situations as an herb and as an ornamental. I also manage a compost demonstration site and garden where I am using it to soak up leachate and flooding during the winter—the garden there is huge and long (sort of a glorified windrow) on the perimeter of a 400 acre agricultural field. I am also fooling around with Canna lilies and Sugar Cane to solve the same problems..... I am also introducing it to the Regenerative Studies Center (which is part of LandLab)—they seem very receptive. Today, I dug up some specimens from the Arboretum for propagation purposes. They were located in a non-irrigated section and planted in a full-sun, rocky, sandy soil that was also filled with decomposed cement. The specimens were happy and healthy and seemed none or the worse for all the abuse they were taking! After an initial irrigation period, it appears that vetiver does quite well off the water grid. I have planted Vetiver in some extreme situations here at LandLab at Cal Poly Pomona and I am quite impressed. Like many of the plants I planted here, it went chlorotic (*all bare rooted slips do the same whatever the conditions, Ed.*) whatever on me during the initial period, probably due to the "moon like" shale/clay soil on the cut slope face that I planted it on. The specimens at that particular location are now thriving. I don't know of anyone else in my horticul-

tural circles that is using or studying vetiver.....*(Horticulturists get in touch with Paul, I think you would be in for an interesting time, lets see some serious work stabilizing California's mud slides with vetiver grass.....Ed.)*

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From: **Dr. Julio Aleare Orihuela**, Head, Agroforestry Programe ICRAF Peru, Yurimaguas, Loreto, Peru. E.mail: "Alegre, Julio" <J.ALEGRE@CGNET.COM>. Fax: 094352675

I am a Senior Scientist with the International Centre for Research in Agroforestry (ICRAF) working during the last 20 years in the Amazon Region of Peru. I receive the vetiver newsletter and recently the World Bank Technical Paper No. 227 about Vetiver grass for soil and water conservation, land rehabilitation, and embankments stability

I enjoyed reading all the benefits of this grass; also I was a little surprised because I have not seen any references about the use of Vetiver in Peru.

Before I received the first news letter about Vetiver I knew nothing about the grass, and then I started to search for this grass in Peru, but I was not successful. Then last year I went to Nairobi, Kenya, and I saw a lot of vetiver planted on canals borders and for embankment stability. Some researchers from my Institution (ICRAF) have planted a nursery for vetiver propagation, and I got 10 slips (bare roots) of *Vetiveria zizanioides* which I took to Peru. I planted them on very acid soil, 85% Al saturation and low in all nutrients) and in 6 months I had 10 large plants with many tillers.

I started to propagate vetiver in other areas, and now I have material for around 5,000 slips. I sent material for propagation to other parts of the Amazon Region and I think in one year we will have enough material to start trials for soil conservation and inclusion in Agroforestry systems on slopy areas. My idea is also to support the community with the planting of vetiver in areas of waste disposal to the rivers where there are a lot of problems with weeds and erosion.

When I sent ths material to Iguitos (Capital of the State of Loreto) the local people recognized the grass which is known as **PACHULI** (*Vetiveria zizanioides* (L.) Nash) and has been used by the native people for a long time. The roots are used as a medicine for dermatitis and control of fungus. Also for hemorrhoids, fever, rheumatism and neuralgia. The fresh roots (25 gm) are boiled for 10 minutes in one liter of water and then applied in the skin. The dry roots are used inside the shelves to protect against insects.

Also the roots are mixed with sugar cane alcohol, and after a maceration is used as a lotion on the head for hair care *(see farmer responses from Philippines....ED.).* The roots are sold in the markets for around half dollar for a package of 250 gm. I got this information from the a Biologist Elsa Rengifo who is working with the Instituto de Investigacion de la Amazonia Peruana. She has planted Vetiveria mainly for medicinal purposes.

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From: **Chris Backhaus**, Dambulla Road, Kurunegala, Sri Lanka. Email: dzp@sri.lanka.net"

If somebody in Sri Lanka wants to contact people having experience with Vetiver planting in the Dry Zone of Sri Lanka, please contact the "NWP Dry Zone Participatory Development Project. We could also help out with (small) quantities of planting material! *(Chris, How about writing us a note about your experiences in the dry zone, we can then share it around the world. .... Ed.)*

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From: **Borys Justavino,** Sustainable Agriculture Program, Cerro Punta, Amisconde Project, Panama.

I'm very grateful that you maintain me in contact through the Vetiver Newsletter and the Collection of papers and Newsletters compiled by the Vetiver Network. I will tell you how vetiver grass begun to be a tool for me in soil conservation. I saw the plant as a barrier in Honduras when I was working in the Kellogg's Foundation Rural Development Project at the Zamorano Panamerican Agriculture School.

When I came back to Panama, after seven years in Honduras, I started to work with AMISCONDE bi-national project involving Costa Rica and Panama in the communities around the International Park La Amistad in Cerro Punta, Chirigui Province. One of the goals was to control soil erosion on very steep slopes cultivated with vegetables and legumes, where the erosion rates were around 240 tons/hectare/year.

We planned the annual activities and I asked for funds to go on a trip looking for Vetiver in Chiriqui, we found plants (*Vetiveria zizanioides*) in the courtyard of some houses, but only one big plant used for medicine. We asked the owners of those plants if they could give seeds of "Valeriana", as they called the grass. They wanted to give us all the plant, but we left some in the ground, and explained how we would use the rest.
With this first material we planted 150 square meters in March 1994. During this time we received the mini book from you, "Vetiver, la barrera contra la erosion", that gave us invaluable information about the plant. The first three months every one that saw the plant said to me that those plants were dead, because they looked dry even though

I was irrigating, but I knew thanks to the book that they weren't dead, and in the fourth month the first new leaves appeared, and continued growing until we took planting materials to the farms to be planted as barrier hedgerows

The farmers didn't wait to reproduce Vetiver in small scale nurseries, but motivated me to look for more material in Costa Rica near to the border with Panama. I was traveling along to the area of San Vito Coto Brus, walking half day to find on the Farm "Hacienda Rio Negro", 200 hectares under contour lines plus Vetiver well established barriers. I told the manager our intention about the soil conservation practices and the use of Vetiver grass. He said that we could take all the material that we need only taking care to prune the barrier and covering any hole where the water could erode.

I returned to Cerro Punta one week later with two trucks of planting material which we treated with some chemicals against pests. We planted this on ten farms, today, two years later, they have well established barriers, and some of this material is now being used for starting vetiver practices on other lands. I didn't stay only with this, because I read about Vetiver reproduction in vitro in the Newsletter, and a friend of mine produced in vitrio plantlets in a laboratory at a cost of 10 to 15 cents per plant depending of the quantity to order. Perhaps you could investigate for me what sustenance material they use for Vetiver reproduction in vitro.

We have made an agreement with a government agency for reproducing more Vetiver to introduce in others areas not covered by Amisconde.

I hope to meet you some day and receive a bit of the knowledge that you have about Vetiver. I heard that the World Bank will be establishing a Project about soil erosion control with Vetiver in 1998 in Cerro Punta. Amisconde, where I'm working right now, will finish at the end of 1997 and it will be great if I can continue promoting the use of Vetiver through this Project .....*(Borys was the first person to use vetiver for soil erosion control in Panama. Most officials did not think that vetiver even existed in the country. For more details see article in Newsletter #15. ...Ed.)*

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From: **Marcelino Pita Rivera**, Coordinator of Riobamba Zone, Farmer-Forestry Development (DFC), Ecuador:

The Farmer Forestry Development (DFC-INEFAN/FAO) project helps farmer organizations of the Andes of Ecuador. In the Riobamba Zone, the communities are conserving their soils through "Slow Forming Terraces" (SFT) using "milín" grass (Phalaris tuberosa); but there are soils which are erosive and of poor quality where the milín doesn't grow well. With the information I have about vetiver hedges, I believe that this plant can be a good alternative for these soils.

Thanks to Mr. Robert Kirmse of the World Bank who visited our area, I received the green vetiver book, which motivated us to import some vetiver plants from India this past year (1995) for the DFC Project. In Quito, the plants were multiplied and then distributed to the project areas.

In the Riobamba Zone, which is in the center of the country, on February 12, 1996, vetiver was planted at different altitudes in community forestry nurseries in order to assess and make comparisons regarding its adaptability. In the community of Chauzán San Alfonso at 3580 meters (*must be an altitude record for vetiver...Ed) ...* there is a survival rate of 30%, the leaves have a reddish color and have developed little. In the Association Cantera at 3420 meters there is a survival rate of 75% with a greenish color and the devlopment of the clumps is better although the growth is insignificant. Community Panza Quirola at 2850 meters the survival is 100%, the growth and development of clumps is better and the leaves of some plants were eaten by sheep.

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From : **Dr. Marco A. Martínez Sosa**, Center of Investigation and Technical Assistance and Design of the State of Jalisco, Guadalajara, México.

We started propagating vetiver planting material to obtain the essential oil. The original planting material was brought from the State of Chiapas, and we have developed an experimental plantation that is about 1 1/2 years old. This plantation is located in the State of Jalisco near the city of Tuxpan. For about 10 years there has existed an experimental plot in the State of Veracruz in the El Morro de La Mancho Experiment Station for vetiver oil production. Our plantations have not been developed with environmental conservation in mind; our center and research is dedicated to technology transfer in the area of pharmaceutical chemicals and perfume.

Here in the State of Jalisco vetiver has adapted well at a state government-run experimental plot. This plantation is very small, but it has adapted well in that the plants are now almost 10 months old and have not received any fertilization and are healthy.

From: **Ing. Pedro Córdova Alva**, Institute of Research of the Peruvian Amazon, Tarapoto, Perú.

Recently we have been working with vetiver, thanks to a gift of some tillers from Dr. Julio Alegre, who works with vetiver in the city of Yurimaguas, Peru. With these tillers we have established a small parcel (about 50 m2) in which we are evaluating its behav-

ior in this part of the Amazonian jungle of Peru (the high jungle is more or less at 350 a.s.l. meters, rainfall of 1150 mm/year, and an average annual temperature of 26˚C). The preliminary results show that vetiver has adapted well, it has already grown well in a relatively short time. We will let you know of the results of our evaluation. ...this is the first time that this species has been introduced into this part of the Amazon Region.

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From: **Mark Dafforn**. National Academy of Science, Washington DC. E.mail : VetiverNet@aol.com

John Greenfield always says vetiver forms hedges so well because it is clonal and there are not "distancing" effects between separate plants, such as you might get with sexually reproduced materials. I've wondered a lot about the reality of that: It's obvious other plants (clonal or not) can be grown as a hedge without gapping, but it does seem to take more effort with sexual material (e.g. Miscanthus) than with clonal (Liriope)? Anyway, I came across the below lead. It doesn't deal directly with hedging ability, but it's related...vetiver vigor? Any thoughts?

"Stephen J. Tonsor of Michigan State University and Mary F. Wilson ofthe Forestry Sciences Laboratory in Juneau, Alaska, found that some flowering plants, such as pokeweeds (Phytolacca americana) and English plantains (Plantago lanceolata), grow faster when potted with full or half siblings than when potted with nonrelatives. If these kinship effects are widespread, they could be used to advantage in planting crops."*Extracted from Scientific American article on kinship".*

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From: **Linus Folly**, The Programme Coordinator, C.E.D.I.A., P.O. Box C-753 Accra, Ghana.
Tel. 233-21-775311 ext. 688, Fax. 233-21-774880/775421, E.mail: "Linus Folly" <Balme @ug.gn.apc.org>

After almost two years since CEDIA organised "Wonder Grass '94", things seem finally set for a real take-off towards a full program on vetiver in terms of research and development as one component with multiplication and propagation as the other. This came as a result of CEDIA's participation with a focus on vetiver grass in the Soil Fertility Management workshop in July this year.

The main problem with government bodies and other institutions is the usual non availability of funds, although they strongly want to adopt the grass and its technology; even the minimum to start with. May I suggest if it would not be too much for the President to take on The World Bank to reconsider its withdrawal in funding and supporting the Vetiver Network enough to back regional networks with their respective programmes. A suggestion of 5-10 years under the Bank's funded and supported extensive program could be ideal as well as helping tremendously solve the security problem in developing countries.

(*Ed. ... Unfortuneately, in Africa, the Bank funded extension programs are not very interested in Vetiver. Local pressure on MOAs would probably work better*).

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From: **Oscar S. Rodriguez P.**, UCV-Facultad de Agronomia, Departamento de Agronomia, Apdo. 4759, Maracay-Edo.Aragua, VENEZUELA

I am still happy about our big and interesting meeting in Thailand. I think it was a great success and a great opportunity for all of us to learn more about vetiver and its multiple uses through many interesting and enthusiastic people. I have sent two samples to Mark Dafforn for the vetiver identification program. I am enclosing for your use a copy of the botanic vetiver samples in the herbarium of our faculty (University of Venezuela). It is interesting to know that the oldest one is from 1953. In other reference 1942, also enclosed, vetiver is referred as rope material, insect control to protect clothes and for its essential oil in the surroundings areas here in Niaracay. So, it has been with us for a long time; but for erosion control, the technique has been used only to a limited extent. I have learned about its use only within two of the experimental stations that belong to the University where I work.

We are trying to start a small project with farmers in different agro-ecological zones of the Central Region of Venezuela and have initiated the high potential for erosion control within all lands. The project will be conducted through an NGO (Sociedad Conservacista Aragua) which has been involved in forest fire control and environmental education since 1973. We have received an offer of about US$ 1000 to do the job from the Secretary of Environment of the Aragna State. I have checked your proposal for a project in Panama and the estimated costs are high especially for technicians salaries as compared to the costs in Venezuela. Other costs are not far from reality. As you can see we are starting from a very small project but maybe in the future it can growth. At the moment the main bottle neck is plant material and sufficient funds to support the project. The starting point is to develop a nursery. I will tell you if the project goes further. If you have any idea on how to get financial support, please let me know.

We have also the idea to publish an small technical bulletin on vetiver. Are there many constrains about copyright from the newsletter and from other technical material. Please let me know where there is freedom and where is

not. *(Anybody may copy information on vetiver so long as the source of the material is cited and acknowledged. Ed.....)*

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From: **Legesse Seyeum**, PO Box 865, Awassa, Ethiopia

I'm one of your regular receivers of the Vetiver Newsletter, thank you very much for your up to date information. Regarding information about vetiver grass in my organization. Estate coffee nurseries produce millions of coffee seedlings**.** In the course of the nursery phase (about 8-10 months) these seedlings have to be protected from strong sunshine, high rainfall and hail hazards; for this purpose 75 cm long posts are erected to support wooden frames that are covered with vetiver grass. Since the grass flourishes throughout the year it is found to be cost effective and highly helpful. Vetiver is used for mulching purpose especially on pre-germination beds of coffee. On slopey areas new coffee seedlings are planted on the contour between vetiver grass hedges for a couple of reasons: first for erosion control; and second for provision of mulch for the coffee.....

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Photo 2*. Ethiopia. Finchaa Sugar Project. Diversification scheme. Vegetables and fruit trees planted between vetiver hedgerows.* ***Photo Credit: Shimelis Kebede***

From: **Shimelis Kebede**, P.O.Box 7016, Addis Abeba, Ethiopia

It has been some time since, I have written to you though, I have received your letter Sept 9 1995 after I returned back from Mauritius in Dec.1995. I was not in a position to participate Thailand Conference. I have recently received the compiled edition of the Vetiver Newsletter. Thank you very much. The establishment of the vetiver association of Ethiopia is not successful due to the bureaucracy and we have accepted your advice to avoid merging Vetiver with other associations. But, as to vetiver expansion some wise organizations (GOs NGOs) and individuals are using the best out of vetiver. My 3 ha demonstration field at Finchaa Sugar Project site has achieved great success and has been visited by various groups. I have successfully retained the soil insitu. And have 30 cm of soil behind the vetiver hedges in one season to form natural terraces.....

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From: **Mary Noah S.J. Manarang,** Officer In Charge, Bukidnon Forests Inc., NFDO Bldg., Department of Environment & Natural Resources, Visayas Ave., Quezon City, Philippines. Email: noah<joan @eiger.com.ph>

I've been to Thailand on a Vetiver grass study tour in December 1994. It created a big impact on me, as well as my companions, that I thought of making the seedling available to other Vetiver enthusiasts in the Philippines. As I discovered that it grows in my province (northern Philippines), I started a nursery based from what I learned from your technical papers and my exposure in Thailand. As of now, I have 30,000 two month old seedlings with 3-5 tillers. Maybe through you, other people interested in acquiring seedlings, should know about this nursery. I'm finishing the report regarding my own experiences in growing the grass in polybags and root trainers (which we are using for forest tree seedlings) and I will be sending one to you. I hope this would be of help to other Vetiver crusaders. As I still have to get my E-mail address this week, I could be reached through fax no. 00-632-7328462.Thanks so much.

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From: **Eduardo B. Principe,** Ph.D., (Forester, Ecologist & Environmentalist), Regional Technical Director for Environmental Management & Protected Areas Sector, DENR Region 13, CARAGA, Ambago, Butuan City, The Philippines. Email: "Principe Eduardo" <jfle@sun1.dost.gov.ph.>

Since the first time (in 1993) that I read the World Bank handbook entitled: Vetiver Grass: The Hedge Against Erosion, I have been an advocate of this grass in my personal, professional and official capacities. During that time, I held the designation from the Secretary of the Department of Environment and Natural Resources (DENR) as Project Director, National Forestation Development Office (NFDO) which oversees and coordinates the implementation of the National Forestation Program. This program was mainly funded through the ADB and OECF loans, amounting to about US$200 million. I found out that my three predecessors (the program started in 1989) had known about this versatile grass but were not able to evaluate nor test its potentials in this program. My first thoughts then (and until now) was that Vetiver is an ideal plant that may be able to solve many of the technological problems being met in typical reforestation projects such as in the Philippines. The first major problem then is how to obtain initial planting stocks, which was promptly solved through networking with col-

leagues and friends from other agencies such as the National Irrigation Administration (NIA). We were able to identify definite source of Vetiver from some Northern provinces of Luzon (Pangasinan, Zambales, and Ilocos Sur) where some farmers have been using Vetiver grass in their rice farm dikes and irrigation ditches since the Spanish colonial regime.

In the early part of 1994, NFDO had a remaining budget for about 1,200 hectares of watershed rehabilitation. I decided that this was a good chance to provide a pilot/demonstration in watershed rehabilitation through the main strategy of vegetative measures of Vetiver as an alternative way of reducing/eliminating the destructive effects of lahar in Central Luzon by massive hedgegrow plantings in the slopes and mountains around Mt. Pinatubo. This strategy could have lessened the cost of protecting the lahar-affected communities of Central Luzon and provide livelihood opportunities to these people. Through a community-based approach by awarding these rehabilitation areas for community contracts from planting of Vetiver followed by agroforestry development (by interplanting bamboos, fruit trees and agroforestry plants) once the mountain slopes had been properly stabilized and rehabilitated by the Vetiver technology.

Now, in my latest assignment as Regional Technical Director for Environmental Management and Protected Areas Sector (EMPAS) at the newest region, Region 13, CARAGA (Northern Mindanao) I am still promoting and prescribing the Vetiver grass technology to DENR clients engaged in mining and logging activities. My main concern is in the reduction of soil erosion in the uplands that are now extensively degraded because of the faster rate of deforestation. With the popularization of Vetiver, we may still have a good chance to recover from various impacts of soil erosion.

In the Philippines, there are no less that 10 million hectares of open and denuded grasslands that need immediate rehabilitation. These are all found in major watersheds of the country. The total area of the Philippines is 30 million hectares, where about half is classified as alienable or disposable, which means it is mostly in private ownership - under residential, commercial, industrial and farm cultivation uses. There are only about 5 million hectares remaining under forest areas (17%) mostly logged-over or the so-called secondary forest which are also in danger of disappearing because of tremendous population pressures. About 30% of the current total population of 70 million people are residing/squatting in the uplands. Now, given this setting, this country faces a massive problem and formidable challenges. We all know and realize that the government alone cannot solve this problem and I do believe, practically, that all sectors must pitch in and participate. But still, very few are aware and conviced that the Vetiver technology could provide the start of that technological solution in this problem. I am hoping that there might be a number people in this country who are already part of the Vetiver network willing to participate and share ideas in forming an action program that will be effective and widespread enough to create an impact against soil erosion, using mainly, the Vetiver technology.

Now allow me to start the ball rolling:

Step 1. Formation of National Volunteer Leadership Groups(s).

This group shall have the major role of promoting and creating awareness on the benefits of using Vetiver technology in erosion control and environmental rehabilitation, including recruitment and organizing of implementors and sponsor groups.

Step 2. Selection of project sites and training of communities or responsible implementor groups.

This will entail identification and delineation of proposed project sites in close coordination with DENR and Local Government Units (LGUís), and preparation of the specific management plan using community-based approach. Community participation of stakeholders should involve strongly in the planning, establishment, maintenance and protection and management up to sharing of project benefits.

Step 3. Installation of financial support services

A trust Fund shall be organized and instituted to provide the necessary financial and technical support services for every project site. Initially, it can be set up for the national level wherein financial sponsors are recruited to contribute in a pooled Fund, which, only the interest shall be used for operating initial/or priority projects. Financial sponsors shall be able to get back their capital contributions after a specific period of time, e.g., 5 years, for which they would be formally acknowledged for using Vetiver grass as its main anchor. Along with this, a shortened handbook/guidebook entitled: “Versatile Vetiver - for reforestation and watershed rehabilitation” was produced and distributed to all regions including the basic design of the pilot areas selected in the provinces of Pampanga, Tarlac, Benguet, Zambales, and Nueva Viscaya. The objective was to collect enough experiences and data on the performance of Vetiver in terms of its survival rates under various site conditions, including its effectivity in erosion control measures in the mountain slopes and in lahar-covered slopes affected by Mt. Pinatubo eruption.

However, in July 1994, I was given another responsibility as Deputy Director, National Watershed Development Program Office in response to the Water Crisis Act, which lessened my access to progress reports of the Vetiver Pilot areas. Nevertheless, I was able to visit once the Ambuklao Project site in

Benguet Province (about 1500 m asl) consisting of about 100 hectares which was contracted with local NGO. This was quite successful in terms of survival and growth rates and according to its latest report to NFDO, the Vetiver grass hedgegrows (4 m. apart between rows X 15 cm. within rows) have closed, vigorously growing, and firmly established despite some grass fires and drought experienced in this site. I have no doubts that the other sites will prove to demonstrate the versatility of this grass for erosion control in watersheds.

That is why I am also actively promoting the potential support that may be used for promotions or tax breaks of said sponsor institutions or persons.

Well, lets brainstorm on this further and please encourage everyone interested to participate so that we can evolve a workable conceptual framework which can effectively put more Vetiver plants on the ground to benefit people and their environment. For promotional purposes, I am also submitting a short article (Perennial Rice from Genetic Engineering!) dramatizing the possible use of genetic engineering on rice but actually focusing attention on the positive traits of Vetiver.

Please comment!

Thanks a lot for your patience on this long discourse and certainly will be glad to know if I can be considered part of the growing Vetiver networkers. Please reach out through e-mail: "Principe Eduardo" <jfle@sun1.dost.gov.ph.> *(Filippinos!! reach out to Eduado! He has a fertile and active mind, and his ideas are good. If you can put something solid together (networking, dissemination etc. perhaps the Vetiver Network can help you....Ed)*

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From: **Jim Smyle**, Costa Rica E.mail: "Jim Smyle and Joan Miller" <hamilton @sol.racsa.co.cr>

I found myself looking through somo photos and with time to play with my scanner. I am attaching 2 photos from our trip to Oaxaca. They were taken at La Soledad, Oaxaca where we planted the first demonstration hedge with SASO (Kevin O'Sullivan's group). Since it was a demo we wanted to be absolutely sure that we were putting in a good hedge. We thought it better to start with a no-risk spacing. We used "fists" as the spacing measure...say, about 10 cm between plants or 15cm centers...and used 3 tiller planting units. The pruned tops were then used to mulch the planting. Later, it was interesting talking to the 2 extensionists working with that community. They are two really good, experienced and dedicated guys who work during the week for an NGO and on weekends prefer to spend there free time with this community. They told me that they need to do this on weekends because it is the only part of their work which is personally satisfying. In working with government previously, and now with the NGO, they feel that they try to do too many things at once and so there is little impact. We talked about the World Neighbors philosophy of keeping things simple, identifying root problems and then concentrating on one or two messages at a time. Then keep pounding on those messages until everybody understands it and knows how to do it themselves. Then, see where you got to, re-prioritize and move on to the next message. They told me that they felt that this approach was missing from the way that technology transfer was normally done in their region and that this was how they should be working. They were going to keep vetiver as one of their messages...because in this community soil loss was identified by the community as their number one problem...and start talking with the people again to identify one more key message with them.

Photo 3. *Oaxaca, Mexico. It is very important to closely space vetiver slips at planting. Here is slips planted one "fist" apart as described by Jim Smyle in his letter.* ***Photo Credit: Jim Smyle***

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From: **Eduardo B. Principe**, Ph.D., (Forester, Ecologist & Environmentalist), Regional Technical Director for Environmental Management & Protected Areas Sector, DENR Region 13, CARAGA, Ambago, Butuan City, The Philippines. Email: "Principe Eduardo" <jfle@sun1.dost.gov.ph.>

PERENNIAL SUPER RICE FROM GENETIC ENGINEERING?.....As early as ten years ago, scientific breakthroughs were made in the field of genetic engineering, which are now producing entirely new sets of plant varieties, microorganisms, and even animals possessing genes coming from unrelated organisms. Therefore, to produce a persistent and perennial rice plant that needs NO INPUTS (i.e., fertilizer, irrigation water, and pesticides) is a clear and sure possibility. This

is peanuts, if one considers the fact that the earliest demonstration by genetic engineers/researchers have combined the genes from a firefly and a tobacco plant — producing a tobacco plant that glows in the dark!!! This is only to show that genes are the building blocks of living things and can be combined together from various unrelated organisms if it is so desired. It is already being put to practical use in many fields such as medicine, food processing, agriculture, and environmental protection. These are mainly involving the use of genetically engineered microorganisms such as those in the production processes using bacteria and fungi. But have you read about the super bull (cow), super mouse, and super trees in the science section of some newspapers or magazines? These articles point out that some outstanding or some selected traits (genes) have been incorporated, mostly from human genes, through the science of genetic engineering.

So what? You may say and shrug your shoulders. Well, based on the above existing premises, SUPER RICE is no sweat to produce in the laboratory. It only takes some will and a bit more creativity for our scientists, but surely, one has to gravely consider the political and economic impacts, which are negative and positive, that it may create. Nevertheless, lets look more closely at the positive side. Assuming that we really want to produce the SUPER RICE, which other plants(s) with desirable traits or genes can be combined with ordinary, expensive-to-produce rice? For those computer gurus/surfers, search in the INTERNET the words VETIVER GRASS!! Does it say or confirm the following?

- scientific name : Vetiveria zizanioides

- origin : From India, now pantropic, meaning, widely distributed in the tropics and sub-tropical climates. Further, it can be found in the Philippines!.
- local names : Khus-khus, Moras, Amoras, Anis (or Anias) de moras, Aniat.
- perennial grass with deep root system, up to 3 meters long.
- grows in any type of soil, even in toxic soils high with Aluminum, Sodium, or Iron.
- it tolerates both drought and waterlogged conditions.
- it grows even in high altitudes.
- it is fire resistant.
- it repels insects, rats, snakes, and other pests.
- it produces its own food by fixing Nitrogen and Phosphorous through its rhizobial and mycorrhyzal root associations.
- Uses : source of perfume called vetiver oil, leaves are for forage and roofing; erosion control, aquifer recharge, and site rehabilitation for watershed, agro-forestry, and reforestation projects; steep slope rehabilitation for road projects especially for ditches, waterways, embankments, and river banks; organic fertilizer; biological filtration system in settling ponds.

If and when SUPER RICE is finally produced, then our farmers will need less capital to produce our staple food. This means less irrigation water, with less or no fertilizer and pesticides, no more replanting every 3 months, and it can be planted almost anywhere including the lahar-covered Central Plains of Luzon and even in the slopes of Mt. Pinatubo!

Wishful thinking, a joke or pure hogwash? You may ask for confirmation from DOST if this is possible. Or better, lets dangle a couple of Billion pesos (save it from any white elephant projects) and challenge the PHILRICE .....to produce SUPER RICE in 5 years and then lets bet on it. If I lose, I'd go back to planting the poorest soils with Vetiver grass together with fruit trees, agro-forestry, and even ornamentals and still get back in return, a few million pesos. Now, dear readers, if you are an AQUARIAN like me, I might consider you a partner for this joint venture because its our turn to take over the world. Remember that now is the start of the Aquarian age! Thank you for joining me in this mind-surfing activity. Hope that it at least made your eyes open to the wonders of science and technology.

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From: **Mary Noah S.J. Manarang**, Officer In Charge, Bukidnon Forests Inc., NFDO Bldg., Department of Environment & Natural Resources, Visayas Ave., Quezon City, Philippines. Email: noah<joan@eiger.com.ph>

Hi, remember the big construction firm who was interested in using Vetiver in their project? Well,the First Philippine Holdings Company (FPHC) who is undertaking an 8 kilometer road construction in Subic has already started with their use of Vetiver. They wanted to hire Wik Wingramasinghe as a consultant but I think they were not able to fix his Visa requirements. Anyway, they asked me to visit their project 2 weeks ago together with a taxonomist from the University of the Philippines. The taxonomist was supposed to confirm if the planted grasses were indeed Vetiver and for me to look at their planting design. Well, the quality of the seedlings planted by their contractors were not up to standard as specified by P.K Yoon, and the planting design was if I may say, pathetic. It was scattered about like the style of planting rice. Even if I am not as knowledgable as Wik in terms of the engineering aspect, I did teach them the
plantation guide as I know them from our reference (Vetiver Handbook) and as how I saw them in Thailand during my study tour. I was thinking it was better than what they are actually doing. I also gave them a quality control guide in checking the seedlings that are being planted by their
contractors, again according to PK Yoon's specifications in his video and research results. Fortunately, they visited my small nursery, I think they liked

what they saw and FPHC required their contractors to get their seedlings from us, or at least follow the quality control specs. which I gave them. I think this is a test model for Vetiver in infrastructure project and I would really like to document it. By the way, I found some very interesting information about Vetiver in the Phils. Upon consultation with the herbarium of the University of the Philippines, I found a dried specimen of V.Zizanoides dated 1902! Dr. Lagunsad who is the taxonomist who went with me to the Subic project. is in charge of the herbarium and he believes that this is the earliest specimen of Vetiver in the Philippines.

I think there is a potential (active) network of Vetiver enthusiasts here in the Philippines, is there a network in Asia where we could individually link up (since there is no formal group in the Phils.)? And is there a way we could ask for some logistical support from these network if ever we document the ongoing Vetiver projects here in the Philippines (the Subic project for one)? With regards to my own report regarding my production of seedlings , I promised you this a long time ago but I want to include in my report the pictures of the plantable seedlings as delivered in Subic. I will send this to you as soon as I'm done (soon, I hope). Thanks so much for your support and I really wish to meet you in person.

(Mary Noah's point about "standards" is very important. There are a lot of contractors starting to use vetiver. It is essential that proper standards are used and that they are correctly applied. If they are not people will say that "the vetiver technology is no good - it doesn't work". The technology is fine, it is the users who time and time again fail to do things properly. ...Ed.)

Photo 4. *Oaxaca, Mexico. Hillside planting of vetiver in maize field.* ***Photo credit: Jim Smyle***

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From: **Jim Smyle**, Costa Rica. E.mail: "Jim Smyle and Joan Miller" <hamilton@sol.racsa.co.cr>

There is indeed progress on the ground in Central America but as always one only seems to get samples of it now and again. The EEC projects which are focusing on vetiver in Nicaragua, the NGO in El Salvador, the guy that wandered into my office last week because they want to do a big community vetiver program to protect their tourist trade on the Caribbean Coast (sediment building up from development activities and reef getting hit) and he had found the green book and one thing led to another. With these projects getting ready to kick off we will have the training courses to promote vetiver and project money to get it going...with LUPE having gotten Honduras going we will push it farther there with the project and get things moving in Nicaragua and Panama.

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From: **Tony Tantum**, PO Box 167, Howick, Natal 3290, South Africa. Fax 27 332 30 3000

Just a short note to fill you in on what is happening here in S. Africa. As you probably know Gueric Boucard (from Texas) came to SA to help with the first run of producing vetiver oil through the factory set up by Dickon Hall. The first oil was produced and appears to come up to the standards of the rest of the world. I believe Gueric enjoyed his trip and also learnt a few things about South Africa.

Based on the above findings Dickon Hall have committed them selves to putting up a factory which will handle 100 hectares of vetiver per annum. At present there is approximately 3 to 6 hectares bulked up for transplanting. By 1998 the factory should be in full production. This will now give us a lot of vetiver for the rest of the Country. The bio-mass from the crop will be crushed and protein added and sold as an animal feed. This will be pelletised. At last the whole plant will have been put to use. A first for South Africa.

Cedara Agricultural College has decided, because of all the inquiries they are now receiving with regards to vetiver and it's many uses, to test the grass in different uses. They will then be in a position to recommend vetiver provided it comes up to their standards. (I just hope they do not try to reinvent the wheel!! (*So do I....Ed!!*) I will be helping them as much as I can.

There is a student at Cedara who has done her thesis on the cost of re-establishment of land degregation using the vetiver system. At long last there is an Institution known to SA which is now prepared to go along with the use of vetiver. It has taken seven long years for this to happen and maybe now in the next few years it will be subsidised by Goverment for erosion control on farms etc. *(I hope not....Ed)*

Through Drs. Troung and Bristrow the Australian aid program is keen to do a vetiver project in SA. With a bit of luck I might be able to link Cedara and Paul Truong. He could oversee the project**.** Dr. Bristow and myself are trying to get Paul to SA to do a seminar for Australian aid to the various Goverment bodies. I have asked Sue Hart (NGO) to put forward a proposal for Australian aid to look at.

Photo 5. ***Portugal.*** *Antonio Vasco de Mello's lovely wife and his lovely vetiver!!! There is a huge potential for vetiver in southern Portugal, both on farms and for real estate stabilization.* ***Photo Credit: Antonio Vasco de Mello***

The Mocambique project (rehabilitation of wasted land at a gas drilling site) has a couple of weeks to run, and it will be finished. Once again vetiver has grown where other plant life has battled to suvive.....

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From **Joan Miller**, Costa Rica. E.mail: "Jim Smyle and Joan Miller" <hamilton@sol.racsa.co.cr>
... Finally, I heard from Jim, this morning, in Panama who said last week while in the Darien area of southern Panama at a little town he found a vetiver clump in someone's front yard. He got some good pictures and talking to the woman was told that everyone in town using the LEAVES for controllling their high blood pressure and everyone swears by it and that it's better than the medication they are given by doctors. They had never heard of using the roots for anything. Anyway thought you'd like the latest vetiver story.

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From **Antonio Vasco de Mello**, Rua 1.˚De Maio. 124, 1300 Lisbao, Portugal.

Please find enclosed two pictures taken a few days (October 9th) ago of the Vetiver planted in April this year. As you may remember, the plantlets came from South Africa - supplied by Tony Tantum. The lady in the picture is my wife; she is not really a tall woman - just a very nice and pretty one - but you can see nevertheless how the plants have grown well. This fall I am thinking of making a first division - maybe an average of ten plantlets out of each main plant - and if that again grows well, next year I will try to install the first 2,000 meter long barrier. I would very much like to have you visit us whenever you come next to Europe, and meanwhile I look forward to see your comments on my plans.

(Antonio, you are doing great, and are obviously as proud of your vetiver grass as you are of your wife!! I always thought that Portugal would be a great country to grow vetiver, and I suspect that there are many instances where vetiver would have a very useful function. when you have your first 2,000 meters all like your first few plants I will come and visit you - that's a promise. ... Ed)

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From: **Nang Kham Noam.** E.mail: Nang Kham Noam <nangkham @esuvm.emporia.edu>

.... "In Burma, we call vetiver grass, Myat Myit Hmway, the meaning is "an aromatic root grass." .....

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FIELD REPORTS

AUSTRALIA

Monto Vetiver by Paul Truong

The followings are updates of the results of works on Monto Vetiver in the last 12 months.

1. *Palatability:* Monto Vetiver is readily grazed by cattle throughout Queensland, particularly *in* the low rainfall areas of Western Queensland. Due to its drought tolerance Monto Vetiver is often the only green plant to have survived the drought in Western Darling Downs in the last few years. Monto Vetiver has a very high digestibility *(52%),* high potassium (1.31%), medium in N (1.10%) and low in P (0.08%).

2. *Seed Sterility:* Flower heads from Monto Vetiver plants established in wetland habitats, three from Cloncurry and one from Innisfail were collected for seed sterility tests. These four samples plus one from Katherine, Northern Territory, were again found to produce no caryopses. This is in contrast with MOA recently collected native Vetiver, which had 14% caryopses and 8% seed viability.

This series of tests shows that for seven consecutive years, Monto Vetiver has not produced any seeds under a wide range of climatic conditions - Cairns and Cloncurry in the north, Darling Downs in the south and Katherine in the west - and under wetland, dryland and irrigated farm land habitats.

3. *Disease and Pest:* Under field conditions Monto Vetiver has not been attacked by any diseases or pests, but under glasshouse conditions it was attacked by army worms when young.

4. *Sensitivity to herbicide and shade:* Monto Vetiver sensitivity to

glyphorate (Roundup) herbicide has been clearly demonstrated under field conditions when drift from spray from nearby weeds often killed well established Vetiver plants. Shading by broad leaf weeds, particularly vines reduced Vetiver growth severely especially at establishment phase.

P N Truong. E.mail: truongp@dpi.qld.gov.au

CHINA

Vetiver's Application for the Prevention of Highway Slippage in South China

Last year we collaborated with Guangdong Provincial Highway Administrative Bureau to stabilize road cuts with vetiver hedgerows. The result indicated that it was successful to apply vetiver to protect road slopes (See Vetiver *Newsletter* No.15). Both the Bureau and us were satisfied with the results and are willing to continue cooperating each other. We continued conducting the new technology on the First - Ring Highway of Guangzhou under the auspices of the Bureau. Two steep and easily-erosive road cuts were selected, they are picture 1 and 2, respectively. Picture 1 is below the road, called "down-slope". It is a tetrapezoid slope with an area of (30+60) 25/2 m21 and with a slope of about 100%. The second slope is above the road, called "up-slope" (Picture 2). Its shape is a triangle with a base line of about 130 m long and a height of 65 m and with a slope of approximately 50-60 m or so. The soils are both sterile and spongy lateritic red earth developed from granite. It is clear from the first two pictures that the erosion was very severe, especially down-slope. Since a large amount of soil had been washed away from down-slope, erosion resulted in the formation of a 6 cm wide crevice in the cemented road surface, and furthermore half of road surface near to this slope began to sink (Picture 3). Collapse in this whole section of the road was expected at any moment. The circumstances of upslope was no better than that of the down-slope at all. From time to time, there were mud-rock flows from the slope washed down to the road surface, which resulted in traffic jams and affected the safety of vehicles and pedestrians. All of this made the Highway Department very anxious.

The vetiver project began on March 26th. Vetiver hedgerows were planted along the contours of 2.5 m apart. There were 5 rows in down-slope consolidated with sand bags (picture 4), the up-slope was not sandbagged. Between the hedgerows were planted ten species of rapidly growing trees, such as *Eucalyptus* spp., *Acacia* spp. The total number of trees were approximately 2000.

Photo 6 *China, Guangdong Province. Highway embankment stabilized with vetiver hedgerows.* ***Photo Credit: Xia Hanping***

We made the first observation on May 15, and found that the survival rate of vetiver was over 95%, and the trees some 80-90%. The second observation was made on July 2nd. By that time vetiver had averaged 1.6-1.8 m high, and the mean tillers numbered about 15. They had almost formed into hedge lines and taken effect on stabilizing the slopes and the subsidence of the road surface had ceased. Storms in the first half of this year (1996), which were more than those of the same period of former years, **destroyed the drainage ditch on the down slope**, but the entire slope had little damage under the conservation of vetiver hedges (picture 1 and 2). This indicates the effectiveness of vetiver on protecting road slopes. Obviously, the growth of trees was not bad either, for example, the trees *Acacia magium* averaged up to 86 cm (picture 5) on August 23rd, whereas their mean height was only 40 cm when planted in the end of March.

The severe clrcumstances of up-slope have also been nearly controlled after three months. Vetiver hedges have begun to take shape, and the trees are thriving. However, since it has a steeper slope, a far larger area, a poorer habitat, compared to down-slope it was much more difficult to deal with. In a word, the eftectiveness of vetiver on this slope is not perfect, and further work remains.

Compared with last year's program, this year's is more successful, the reason being the establishment of lots of trees. We think there are at least four advantages when trees are planted among vetiver hedgerows:

1) they assist vetiver hedges to stabilize slopes; 2) the canopies of broadleaf trees can very effectively alleviate raindrop erosion, especially storm conditions; 3) the effect of trees on afforesting and beautifying the highways is much better than that of vetiver; and 4) they are capable of producing greater economic benefits. Therefore it would be best to plant trees amongst vetiver hedgerows.

Xia Hanping Ao Huixiu Liu Shizhong and He Daoqian (South China Institute of Botany, Academia Sinica, Guangzhou, China 510650)

COSTA RICA

A Tour of Costa Rica

During January 1996 we (Jim Smyle and Joan Miller) toured southeastern Costa Rica in order to locate a source of vetiver planting material for a project for the Government of Panama (GOP). The GOP wants to include the use of live vetiver hedges in their technologies which they are offering to hillsides farmers. In the upcoming months MIDE (?) will start to propagate vetiver in intensivley managed nurseries. They want to produce enough planting material necessary to start working in the field in 1997. The first nursery will be started by MIDE in the northwest of Panama near the Costa Rican border. The trip gave us the opportunity to visit other interesting places where they are using vetiver in Costa Rica.

Initially we visited an area near San Isidro del General where AMISCONDE, a binational NGO (Costa Rica and Panama) is working in the buffer zones of La Amistad Park. They are managing projects in agroforestry, community development and educational projects. On both sides of the border AMISCONDE has worked for several years with groups and rural communities in the region in soil and water conservation using vetiver grass. In Costa Rica, they have established vetiver grass plantings with a group of rural communities in the region. We visited one demonstration plot that was established by a farmers' cooperative (COOPEAGRI) with the help of CIAT. It was established about 5 years ago with the planting of 30 meters of vetiver. They tell us that they now have an area of 5-6 hectares protected by live hedges (with 8-10 meters between each hedge); or rather, 4-6 km of hedges — all planted with material from that initial 30 m hedge. The plot serves as a training and demonstration plot to display the advantages associated with the uses of vetiver.

Photo 7. *Costa Rica. Two year old vetiver plant on a Finca in south eastern Costa Rica.* ***Photo credit: Jim Smyle***

Speaking with some of the farmers working with AMISCONDE, we learned that an infusion of vetiver roots is used as an insecticide. They told us that they boil approximately 250 grams of vetiver roots in 1 gallon of water for 30 - 40 minutes. **The infusion is applied using a backpack sprayer on the soil below plants of coffee and sweet peppers. They say that this serves to control nematodes and "cochinilla". The Network had never encountered using vetiver as an insecticide**; as a repellent yes.. such as in closets for moths. It would be interesting to receive information from other users that have experience or knowledge of using vetiver as a biological control against insects or diseases. Perhaps someone could do some controlled experiments and send us the information to publish in the newsletter.

In San Rafael Jerónimo we visited a small coffee farm (finca) in the AMISCONDE project area. The owner of the farm had established vetiver hedges at the edges and within his finca. He was very enthusiastic about his vetiver hedges and could well explain to us how the technology worked in terms of slowing down runoff and trapping silt and organic material behind the hedges. He wants to continue establishing new hedges until his entire finca is protected by vetiver grass hedges. Recently he had started to plant some hedges not only in his coffee fields, but within his cornfield.

In the areas surrounding San Vito, close to the border with Panama, we found that the use of vetiver is common in coffee fincas. Driving along the roads we could see vetiver hedges planted in both small and large fincas. We were surprised and impressed to observe that a significant number of home owners had planted hedges at the top edges of their steep properties - apparently for conservation purposes.

We visited two of the larger coffee fincas in the area where vetiver had been established in hedgerows with very positive results. In the Finca Rio Negro, north of San Vito, vetiver has protected the roads for approximately 40 years! According to finca manager, Fernando Hernández, the coffee finca originally was owned and operated by a family from China or Taiwan. They planted vetiver along all of the major

Photo 8**. Costa Rica. Vetiver hedgerows used to protect coffee. Note the Arachis pintoii ground cover **Photo Credit.: Jim Smyle

roads running through the finca. Although they knew the value of planting vetiver along the roadside, they never transferred the technology to their coffee fields which were planted directly up and down the slope. Approximately 5 years ago the finca was purchased by an investment group from Switzerland and since then has been under local management. Luckily, the new manager (Mr. Hernández) identified the grass along the roadsides as vetiver. He had known about vetiver grass through the reading the World Bank's "green book" which he had received 6-8 years ago when he was working for the Costa Rican government. Subsequently in the rehabilitation of the coffee plantings during the past 5 years, vetiver grass hedges have been established and replanted in the coffee fields along the contours.

At first they used existing planting material from the roadsides of the finca to supply the planting material. The planting of the hedges used a "chicken foot" pattern; a triangular formation with 15-20 cm between plants. They say this allows the hedges to grow together more rapidly. The hedges were established along the upper edges of each drainage canal. Distances between hedges are 6 to 12 meters (depending on slope) and are pruned twice a year. Farm workers are paid 5-10 colones (US$ 0.02 to US$ 0.05) per meter of hedge established. This cost includes everything, with the workers obtaining planting material from existing hedges along the road and/or within the coffee fields This is equivalent to a cost between US$ 85/hectare (on the steepest slopes) and US$ 21/hectare (on lesser slopes) to establish the hedges.

Of the 200 hectares of coffee planted on the finca, approximately 60 hectares have been rehabilitated and protected by vetiver. The rest of the coffee fields will be protected during the upcoming years. Aside from the decreased losses of soil, they believe that there is an economic savings because there is little need to clear the drainage canals of sediment.

Photo 9 Costa Rica. Young vetiver hedge on steep land, prior to planting coffee. Photo Credit. Jim Smyle

One technical note from Mr. Hernández, administrator of Rio Negro...evidently when material is obtained from existing hedges, people want to remove entire clumps, rather than removing only tillers on the downslope side of the hedge. This practice of removing entire clumps is completely incorrect and damages the functionality of the hedge (See Technical Note: "How to Use Existing Hedges As a Source of Planting Material").

According to Waddy Villalobos, manager of Finca La China near the town of Sabalito (close to San Vito), they started experimenting with live hedges in May 1994. In an area where they were replanting coffee, they established vetiver hedges. In order to form the hedges rapidly they planted tillers every 10 cm. The follow year coffee was planted. We observed these hedges (18 months old) which were well formed, dense and apparently functioning very well. In the future they want to expand vetiver plantings where they will be replanting coffee. Also they have plans to mechanize the furrowing of the rows to reduce labor inputs for planting. Mr. Villalobos told us that for him, the ideal would be to always establish the hedges the year before you are going to replant coffee and during that year allow the weeds to grow. Thus, the soil is protected and you have the site pre-established for planting of coffee.

Also at Finca La China they have tried planting some areas with Arachis pintoii as a ground cover. They have 1 hectare of arachis planted between rows of coffee . They told us that after planting little time was needed for the arachis to cover the soil and decrease the need for weeding. They are planning to do an economic analysis of these systems (vetiver hedges with and without arachis); we hope that they will inform us of their results. At this time, they say that so far they are satisfied with the system although they are concerned that they could loose some coffee within the arachis during harvest time.

Joan Miller and Jim Smyle - Coordinators of the Latin American Vetiver Network. E.mail "Jim Smyle and Joan Miller" <hamilton@sol. racsa.co.cr>

ETHIOPIA

Report on Vetiver Workshop - May 1996 - Mettu, Illubabor, Ethiopia.

Debele Dinka, Deputy General Manager, Munchen f Munchen Mettu, Ethiopia

Introduction

Menschen fur Menschen (MfM) Foundation is very aware that soil degradation and erosion constitute a major regional and national problem, requiring effective management and long term conservation measures. MfM has also recognized the potential of vetiver grass as a practical and in expensive yet effective method for soil and water conservation.

With this in mind and to bring together experts, practitioners, government representatives from Illubabor, Western part of Ethiopia, MfM Foundation in collaboration with the Agricultural Development Department (ADD) organized a workshop on vetiver grass. The workshop was organized in honor of the Chairman of the Foundation, Mr. Karlheinz Bohm, who is the initiator, as well as strong supporter of the vetiver, for utilization for soil and water conservation in the region, under the theme "The strategy of MfM's soil and water conservation with particular emphasis of the role of vetiver grass (Vetiveria zizanioides) in Illubabor".

This workshop hosted by MfM Foundation was held at MfM Kerssa Training Centre, Metu, Illubabor , Ethiopia. From May 29 - 30, 1996. It was attended by about 58 persons, most of whom come from government organizations.

The discussions the following topics.

- Introduction to natural resources situation in Ethiopia in general, and in Illubabor region in particular.
- Vetiver morphology , physiology, and taxonomy
- Role of vetiver for soil and water conservation and its use for embankment and stabilization.
- Nursery development, field planting techniques and hedge management.
- Farmers' attitude towards vetiver uses for soil and water conservation in the region.
- Commercial uses and application of vetiver.
- The practitioners had also contributed their experience regarding hedge management.

A photograph and poster exhibition describing different MfM activities and vetiver multiplication and hedge management techniques and other uses of vetiver were displayed in a large hall.

Field tours

- Three sites were visited. These demonstrated:
- Techniques of propagation of vetiver grass.
- Techniques of planting out and loading of vetiver grass to the field.
- Uses of vetiver in degraded area.
- MfM strategy for promotion of vetiver grass for soil and water conservation and its efficiency (through discussion with the farmers).

After field tours open discussions, recommendations , quiz and quiz awards were made.

A closing speech was made by Mr. Adamu Legese, the Vice Administrator of Illubabor Administrative zone.

Excerpts from the statement made by Ato Debella Dinka. "This occasion is particularly historic as it marks the official launching of the vetiver network as a fully fledged inter institutional organization tasked to meet the region sustainable development need for up to date analysis of conservation measures technology trends."

Excerpts from the speech made by the Vice Administrator, participant of the workshop and member of the network. "From the lessons given to us, from what we had seen in the field and from the discussions we made with the farmers in the field, we can say that vetiver is really a miracle grass, which has got a multipurpose. Above all, it is the real soil and water conservation measures to alleviate the alarmingly taking place soil degradation without affecting farmers immediate needs. Therefore, we need to promote the use of vetiver in our region if we get technical and material support from the concerned agencies."

Recommendation and findings

- Since all the participants were enthusiastic to convince the farmers and to apply the technology in their respective areas, it was found indispensable to establish a Network. All the participants agreed to be member of the network. The members nominated a Network committee for immediate action.

- During the field tour, the participants found out that vetiver leaf

Photo 10. *Ethioipia. Farmers attending Mettu workshop visited field protected witrh vetiver hedherows. This area is typical of the eastern African highlands coffee zone.* ***Photo Credit: MfM***

Photo 11 *Ethiopia, Mettu. Vetiver is used often as a thatch in Ethiopia. It is long lasting.* ***Photo Credit: MfM***

is being used by the farmers for pest control in storage and for making rope.

- Since Oromiffa is the language spoken by the people of the region, the participants proposed to search a name for vetiver in Oromiffa.

- Finally the participants strongly insisted to search for a financial assistance to train technicians / developments agent on vetiver multiplication and hedge management techniques to promote the technology at an accelerating rate and have frequent and reliable feed back from the grass roots.

(Other groups wanting to run a vetiver workshop for the first time might be advised to follow the format of this workshop. I would add on other topic "farmer training methods and key points in a training program"...Ed)

GHANA

Vetiver Hedgerow Technology is catching up with Farmers.

Quietly but progressively on-farm vetiver hedgerow system is being adopted as a practical method of dealing with the century long problem of soil erosion on agricultural lands especially on slopes. A report from a recent survey carried out by CEDIA on a sampling basis within target groups has revealed this situation. Among the lots, two individual farmers have distinguished themselves and deserve commendation. They are Vincent Djarbeng of Kitase near Aburi in the eastern region and Bernard Kusiibuu of Tongo near Bolgatanga in the upper-east region; having used vetiver hedgerows in alley cropping; contour demarcation; and in agroforestry respectively.

Trials being conducted at an experimental site in Accra have shown so far Vetiveria zizanioides from Akola, India, and from Finchaa, Ethiopia are doing much better in producing more culms and within a shorter period of time. Vetiveria nemoralis ecotype Ratchaburi from Thailand comes next as far as number, size of culms and their production time are concerned. Observation on three different varieties of Vetiveria nigratana for the past three years has revealed that its root system is not as long, spongy, fibrous and dense as those of the V.zizanioides or V.nemoralis. Vetiveria nigratana is generally wilder and is not too disciplined in keeping in line on the rows which are mostly left with gaps; although the same planting interval (15cm) had been applied between the slips on each row for all cultivars regardless of species. Among the cultivars of Vetiveria nigratana in Ghana the overall performance classification goes in the following order: Zuarungu (Bolgatanga); Nyankpala (Tamale); Worawora (Kete-Krachi); Shai Hills (Dangme).

Linus Folly. E.mail: "Linus Folly" <Balme @ug.gn.apc.org>

(For Vetiver users in Africa it is important to move towards a program using 100% Vetiveria zizanioides. It is far superior to V.nigratana in many characteristics, not least it is not invasive. ... Ed)

MEXICO

A Visit By The Latin American Vetiver Network To Oaxaca, Mexico.

Jim Smyle

In the beginning of May (1996) we visited the State of Oaxaca, México by invitation of Kevin O'Sullivan of the group Soils, Water, and Seeds of Oaxaca (SASO); SASO is part of a group of NGOs and a Technical Committee who are introducing the use and application of the vetiver technology to communities in Oaxaca. Jim Smyle's visit was paid for by the World Bank as a donation of technical assistance due to the good work accomplished in Oaxaca. In very little time they have accomplished much and shown others what can be done when people work together with good determination and organization. It also gave us an opportunity to observe a successful program, and to become familiar with the needs of technical assistance and type information that we can provide as coordinators of the Latin American Vetiver Network.

Many people in the region are aware that loss of soil is threatening their survival and their culture. Vetiver grass is not yet widely known in Oaxaca, but there is much interest regarding its potential. During our visit we had the opportunity to meet with some of the groups involved with vetiver in Oaxaca to learn about the program. SASO was started in 1995 with the initiation of the Program for the Control of Erosion and Restoration of the Soils of Oaxaca (PCERS), an initiative aimed at the necessity for communities to consider simple and low cost natural methods to improve their soils and reduce erosion. A Technical Committee was formed in April 1995 to coordinate,

supervise activities and facilitate the institutional involvment. The Technical Committee has 20 member organizations which includes member communities, NGOs, research and training institutions and government. The Committee delegated the initial implementation of the program to SASO and the administration to the Oaxacan Commission for the Defense of the Environment (CODE).

In July 1995, the mother nursery was established on the property of the Technological Institute of Oaxaca (ITAO), who have the responsibility to multiply the vetiver grass to provide planting material for the regional programs. The ITAO nursery produced more than 200,000 tillers for planting in 10 months from an original 6000 plants brought from a coffee farm in Chiapas, Mexico. In September of 1995 another mother nursery was established in the Isthmus and in addition, eight smaller nurseries have been established in different regions of Oaxaca.

As of mid-1996, there were already more than 15 demonstration plantings of vetiver hedges (some communities with more than 2) and numerous small community nurseries. The future plans for the vetiver program in Oaxaca include the establishment of more nurseries and demonstrations in farmer's fields and public areas; increased field research with research institutions, communities and the farmers; and the initiation of a network of participants to establish centers of experience to distribute information of vetiver at the community level as well as identify and promote other grasses, shrubs, native trees species in each zone that are appropriate for soil conservation and erosion control. There is also an effort to promote the participation of indigenous women's groups in the planting and care of vetiver in small nurseries for use in their activities related to raising vegetables, fruits and flowers.

One day during our stay we attended a workshop which focused on experiences with vetiver grass in Veracruz and Oaxaca. The workshop, held at the Secretary of Agriculture and Forestry Development (SEDAF) was attended by 25 people — representatives of Federal and state government institutions, coffee growers, NGOs and the consulate of Canada. Dr. Victor Hugo Díaz (INIFAP, El Palmar Field Station in Veracruz) described his work with vetiver during the last two years (1994-96) in propagation and research on the impacts of vetiver hedges in agricultural systems on hillsides in Veracruz. Mr. Gabriel Narváez and Efrain Paredes (Autonomous University of Chapingo, Oaxaca) related their experiences with vetiver propagation and planting trials in the northern Oaxacan Isthmus. Jim Smyle of the Latin American Vetiver Network, shared experiences regarding the use of vetiver in other parts of the world.

Several days were spent in the field visiting nurseries and communites to provide assistence on nursery management and to assess the existing demonstration plantings and help identify potential locations for future demonstrations. We observed that many of the plantings did not appear to be particularly successful. It turns out that much of the planting was carried out under less than optimal conditions. That is to say were planted at a time when there was still threat of frost at night (i.e. it was too cold); before the start of the rainy season so there was inadequate soil moisture; planted in partial shade; and planted too shallow. One recommendation made was that plantings should not be made until the rains have started which is to say one should consider planting vetiver at the same time of year that corn is planted. In spite of the poor state of vetiver plantings, the people were still enthusiastic and optimistic about using vetiver in their communities.

A high point of our trip was a visit to a community in the Central Valley which was actually planting a hedge that day. Two technicians who work as volunteers in the community told us that the people were very excited and interested in trying vetiver grass, especially the women who had an erosion problem due to the heavy rains that wash away the soils of their communal vegetable garden. It was along the lower edge of this parcel that they wanted to plant the first hedge. The entire community was out in force to help prepare the vetiver tillers and participate in the actual planting. Jim Smyle gave a lesson on the physiology of a vetiver tiller and then explained and demonstrated how it should be prepared and planted. As a good sign, when the planting was done the first drops of rain of the rainy season started to fall to assure that the hedge would be well established.

Since our visit to Oaxaca in May, we have heard from Viky Díaz of SASO who brought us up-to-date on the progess of some of the demonstrations and nurseries that we visited. In Soledad, the community that planted their hedges during our visit on May 11, she informed us that "...its leaves are already an average of 40 to 50 cm high with 2 to 3 leaves per plant... in June they planted another 5 hedges (200 meters) along drainage lines of a plot belonging to the students in the community where they have planted corn and guava and also a small nursery (800 plants) was established along river banks. All is doing well and have received the recent rains". In Santa Maria Tlahuitoltepec (another indiginous community we visited in the Mixe Alta region), a demonstration plot was established in which six lines of hedge (240 meters) were planted in a field cultivated half with corn and half with wheat. Also a small nursery was established at the community nursery. In early July in the community of Sola de Vega, three lines of hedge (210 meters) were established in a field "...cultivated in corn and beans, and in this same plot they want to establish an experimental planting of annual crops, fruits, and medicinal plants...

Also they established 2 small nurseries with 2,500 tillers each."

There is no doubt that the progress of the soil conservation program in Oaxaca is very impressive. Before the initiation of the vetiver program, its use was not known. After only 14 months there now exist central and community nurseries, technical and training materials for local promotion and extension purposes, articles published about vetiver in newsletters, newspapers, programs on radio and television have mentioned the vetiver technology to control erosion and as a result many people in Oaxaca are interested and ask for vegetative material to plant in their fields. The successful promotion of vetiver on the State level has resulted in interest from the State Government to promote the use of vetiver.

There does exist concern that vetiver will not be successful at the higher altitutes, semi-arid zones and in the extremely degraded soils of Oaxaca. Without doubt, vetiver will withstand the cold in Oaxaca (minimum temperatures below 5ºC in the cold season and a 5 month warm season with termperatures up to 35ºC and 4 to 5 months of rains averaging 600mm); but only while it is correctly established. There exist places in Oaxaca where vetiver probably will not have much success or use, such as in the zones of calcarious rock where there is no soil and in areas with high concentrations of sodium in the degraded soils (receiving no additional fertilization). Nonetheless, vetiver will be of great interest in Oaxaca for the rehabilitation of degraded lands and during the coming years it is recommended that there be small trials for the extremely degraded sites. For the near future, it seems best to concentrate the majority of the efforts with vetiver grass on lands that are already productive and have value thus needing protection. There is no doubt that the lands where the farmers already are planting crops could be used to establish vetiver to minimize the loss of soils, water, and fertility.

We hope that Viky and SASO keep us informed of the progress in these communities and the program in general. One can see the enthusiasm and seriousness of the groups in Oaxaca... in very little time they have accomplished much and continue to advance. They serve as a good example for all of us.

TANZANIA

Vetiver Grass In Soil And waWater Conservation Experience Of Hima Iringa Project, Tanzania.

Iringa District's HIMA project started by 1990. It is a Soil And Water Conservation project based at IRINGA district. The project attempts to increase and improve agricultural and forestry production per unit area through raising of soil fertility status and reducing soil erosion. The latter is one of the major problems facing the farmers in the district. Most farmers refer to soil fertility as their major problem but a close observation reveals that in most cases soil erosion is the main factor causing poor soil fertility due to dislocation of top soil.

As such, soil erosion control was anticipated by the project as an essential technology to prevent further decline of soil fertility and reduce land degradation in general. The project adopted "farmers active participation approach" of the recipients in identification of the problem, planning, implementation and evaluation.

On Farm Soil & Water Conservation Measures. Since the commencement of the project in 1989/90 season, several soil and water conservation measures were tried in the villages. These included;

1. Biological and agronomical soil conservation methods whereby contour grasslines are planted with vetiver grass (*Vetiveria zizanioides*) and Makarikari (*Makarikariencis*). Farmers are also encouraged to plant Guatemala and Napier grasses. Uncultivated grass strips and trash on contourlines were also practiced in the project's villages.

2. Physical soil conservation methods such as Fanya Juu terraces (excavated contour bunds), cut-off drains and ridge farming were also tested. Others are gully protection measures, like the establishment of stone and brushwood check dams across gullies.

3. Integrated soil and moisture conservation methods combining two or more measures at the same time in the same area such as:

- establishment of contour trashlines planted with Vetiver grass.
- fanya juu terraces planted with Vetiver on the same lines.

Photo 12. *Tanzania, Iringa. Vetiver hedgerows on steep crop land in Tanzania's southern Highlands. Photo* ***Credit: HIMA Project***

- grasslines with trashlines and spaced agroforestry trees.

- for gully protection, gabions and Vetivar or Napier grass planting.
- leaving the gullies untouched to give room for natural regeneration.

Farmers Training And Subcatchment Protection. Before indulging in any soil and moisture conservation work, farmers in their respective villages are trained and are made aware of the erosion processes, effects of erosion and how to solve the problem by using simple and sustainable technology utilizing available materials. Farmers are becoming competent to layout contourlines and they know how to stabilize them.

Farmers' Adoption Farmers' response to training sessions were good while adoption rate of the technology is moderate. Todate there are more than 1600 farmers who have tried one or more of the different soil and moisture conservation measures covering an area of 530 Ha. having about 190,000 running metres of contour bunds out of which 85% are stabilised by Vetiver grass.

Soil And Water Conservation Measures Preferred By Farmers.
Biological and Integrated Soil and Moisture Conservation measures establishment of vetiver contour lines, trashlines planted with Vetiver grass, Fanya Juu terrace stabilised by Vetiver, Napier or Guatemala grass.

A simple evaluation made to assess why farmers have adopted these measures, farmers stated that they prefer them most, especially Vetiver hedges because the measures are simple to make, not labour intensive, the grasses form permanent protective hedge/barrier that will remain effective for many years and effectively reduces soil erosion. They also encourage improved infiltration rate as the hedgerows reduce runoff speed. Farmers claim the increase in production per unit area in well conserved farms.

Farmers mentioned that vetiver grows upright and causes none or very little disturbance to the crops; terraces are easily formed, reaching 30 - 40 cm in just two to three seasons; Vetiver grows well in even drought exposed areas; rarely browsed by livestock, and is used for thatching houses and therefore some farmers earn income by selling it to their neighbours.

Requirement Of Grass Planting Materials Amongst several grass species used for contour stabilization vetiver grass is preferred most by many farmers. Others grass species such as Napier and Guatemala are preferred by livestock keepers to stall-feed their animals.

In 1990/91 season 3 central grass nurseries (200m^2 - 400m^2) were established for Vetiver, Guatemala and Makarikari grasses. About 100,000 vetiver splits were produced and distributed. As farmers were interested in starting their own small nurseries the following season; in 1992/93 32 individual nurseries were established having the size of 10m^2 - 50m^2 producing from 800 to 8000 splits each.

As the supply of vetiver grass is less than the demand, HIMA project decided to collect some from Songea in Ruvuma region. About 55 tones of Vetiver clusters were collected and distributed to the villages in 1995/96 season. Despite of all these project efforts the farmers' demand was far to be reached.

The project expands from 27 villages in 1996 to 40 in 1997 the demand will also become extremely high, so individual grass nursery establishment is quite inevitable.

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THAILAND

Vetiver strips or leucaena hedgerows?

While discussing with farmers involved in the on-farm research programme for soil conservation in Chiang Rai Province, several interesting points were noted by the 'follow-up team'. It was encouraging to learn that farmers were satisfied with the experiments and had expressed their willingness to continue participating in the on-farm research programme.

The past agricultural season had not been very good due to excessive rainfall, so farmers had not been able to determine the impact on yields of the soil-conservation practices they had used (leucaena hedgerows, vetiver strips, or a combination of both). However, purely visual observations had indicated reductions in erosion rates, since the runoff was clearer and there was evidence of terrace formation between strips or hedgerows. Four farmers out of the six originally participating in the programme thought it would be a good idea to increase the area under conservation. One of them, although satisfied with the experiment, was not interested in increasing the area because his wife has recently left to be a factory worker in Taiwan, which means he will be short of labour for the next couple of years.

Three out of the four farmers want to increase the area they are using for soil-conservation experiments, and to test a different practice than the one they used in the first year of the project. This was surprising since the choice of technique during Year 1 was the result of a logical decision making process. Farmers had been asked to identify soil-conservation techniques that

they wished to implement, whether local or 'introduced'. Three techniques had been identified, and all of them had already been promoted by other projects: hillside ditches, alley cropping, using a mixture of leucaena and pigeon peas, and vetiver strips.

Most farmers initially wanted to dig hillside ditches, but the idea was eventually discarded because farmers thought that it would be too labour-intensive, and would also be inappropriate for most of the fields because the slopes were too steep. The second choice was vetiver strips, but after working for a whole day in one of the farmers' fields (tiller-planting), all the remaining participating farmers chose the leucaena + pigeon pea option (seed broadcasting).

For Year 2, two farmers using leucaena in Year 1 want to shift to vetiver, and the only farmer using vetiver in Year 1 wants to shift to leucaena. The reasons for these shifts are linked to soil fertility and labour requirements. Most farmers agreed that, although vetiver takes much more time to plant, the overall workload over an entire year, which needs to take into account both cutting and pruning, is less than the leucaena + pigeon pea option.

The second main argument was that vetiver is perceived as being more efficient in controlling runoff and soil loss. Two farmers, who either use fertilizers or who farm relatively fertile fields, are more interested in erosion control per se, and therefore would like to shift to vetiver strips. On the other hand, the farmer who already uses vetiver is farming on an infertile field. She is more interested in fertility improvement, and would therefore prefer to benefit from the organic material provided by leucaena + pigeon pea hedgerows.

It is clear that more research needs to be carried out by farmer before they take any final decision towards the adoption or rejection of the tested soil-conservation practices. If it is decided to increase the area under soil conservation within the framework of the on farm research programme, the three farmers mentioned above will have the opportunity of testing different practices at the same time. This should allow them to decide which of the practices is most appropriate for his/her production system.

Fabrice Renaud, Associate Expert, IBSRAM Newletter March 1996

USA

Vetiver A Miracle Herb

Extracts from Jean Cozart article published in The Herbarist #61 1995 , Herb Society of America.

"I am sure that everyone has seen the destruction caused by flood, drought, earthquake, pests, disease and fire in Southern California on TV. We have had five years of drought, then fires burning out of control and erosion and floods sliding houses down canyons 113 tons of mud plus all of the topsoil that cannot be replaced, with sandbags stacked everywhere. Now I believe that the herb VETIVER is the ideal solution to most of these problems. I'd like to explain why I have come to this conclusion. Several years ago it was decided to remove a huge clump of Vetiver Grass in the Los Angeles Arboretum Herb Garden to make room for other plants in the fragrance bed. This plant was five feet wide and six feet tall. It was very dense and tough to remove. We finally ended up taking an axe to take it out. Lately I read some literature on Vetiver Grass that concerned erosion control all over the world. Suddenly I realized that this herb, Vetiveria zizanioides, could be the answer to our dilemmas here in Southern California.....". "...The hedges act as windbreaks against our severe Santa Ana winds and the leaves chopped, are an excellent mulch, around citrus trees and herbs. It is suspected to have nitrogen fixing mycorrihiza so it will remain green with adequate water and thus look well in any location. Vetiver hedges can take the place of block walls and will remain to protect the ground from the onslaught of the next rains.

Fortunately, my block walls withstood our January 17th earthquake of 1994, although hundreds of walls were down all over the Santa Anna Valley. In my garden I put my vetiver in a large pot, the size of a half-barrel so I can lift out the roots and cut off all the feeder roots because these are die scented ones that I use for potpourri as a fixative. I don't need sandbags or vetiver hedges yet, around my home, although I understand from a news broadcast that my sandy soil could slide from earthquakes! After all the damage to the Los Encinos Historical Adobe buildings, several herb gardeners have decided to replace their downed walls with vetiver hedges. In certain parts of India, vetiver hedges are legally accepted as property lines. Here in America, we are accustomed to thinking there will always be more—more good soil, good water, good weather but each year we lose 3 millions of acres to erosion and another 3 million to development. We have toxified the soils of thousands of acres of prime California production areas. We are always short of water. However our winter rains can cause devastation so vetiver hedges would be a way to keep soil on our steep hillsides where it is needed and around buildings during construction, because more and more people are building up on the slopes and tops of mountains. Everyone wants a view! Vetiver has a remarkable ability to hold rain runoff. It can block the loss of top soil. This deeply rooted perennial is capable of catching the soil to keep it behind the hedges. A major project to reestablish roads and steep slopes destroyed by the 1990 earthquake in the Philippines is relying on Vetiver. All homeowners should learn about this herb, and

be motivated to protect their gardens, that are subject to drought and fire in our dry season "Vetiver works!" quotes one admiring homeowner. We have to convince the average person because they believe things are good only when they are costly but it would be an inexpensive way to have a fence that can do much. It can block the spread of weeds including couch and Bermuda grass from invading your herb garden. Using the trimmed foliage for mulch saves money too, when it is spread on the garden because it does not seed or take root. The vetiver needs to be cut regularly to keep it uniform as a hedge and neat appearing. *(the best way to trim vetiver hedges is with a nylon strimmer or bushwacker - does a very neet job...Ed.).* Vetiver tops, used as a mulch have considerable amounts of nitrogen, phosphorous, potassium and magnesium and will conserve moisture. In order to form a hedge, the plants may need a little fertilizer and water to get established. However in other warm states, where there have been floods, hedges take water logging. Vetiver is well adapted to Memphis silt loam of Southwest Mississippi and will control sediment deposits. It acts as a trap especially holding back moisture long enough to accumulate an amazing amount of soil, building up behind it. This will stabilize the flood levees. It will also prevent devastating gullies such as we had behind our home in Oxford, Mississippi....." ..... "".....It is definitely limited by cold and can not reliably withstand freezing. Here in Southern California, we only have a few days of cold or frost so it never has been a problem for us.

Vetiver is not shade tolerant so don't plant tall herbs next to your hedge or put it near shade trees It likes full sun and adequate water to stay green. It will survive any stress that nature hands it except shade and freezing. Vetiver grows only where people plant it so be sure to keep it in full sun. If you plant vetiver in containers, it needs to have loose, light soil because the roots are thread like strands that form lacy networks so in order to harvest your feeder roots that you plan to use as a fixative for potpourri or other crafts, you must be able to pull the plant from its container to cut the outer smaller roots, then replace the plant back into the pot. Be sure to get the largest container you can handle. Vetiver needs to be pruned monthly to keep it trimmed but do not cut below 2 and 1/2 feet. This does no harm to the plant since you will fertilize and keep it moist until it roots form again. The leaves of vetiver have sharp edges so it is best to keep it topped and trimmed. Use the trimmings for mulch.

Hedges may take three years or more to be effective under low rainfall conditions. It depends on the site, the climate, number and sizes of plants put in. The roots will not interfere with herbs planted next to the hedge and does not rob them of moisture or soil nutrients. The hedges arc seldom wider than 3 feet and therefore will take up little space from your herb garden. They can act as borders to separate the herbs that have different uses or water requirements, and will last for years. The crown of the plant is generally a few centimeters below the surface of the ground. It has a tangled knot of reverse rhizomes plus the thin roots grow downwards rather than sideways forming a curtain hanging in the soil so their roots interlock when side by side. Once it is planted, it will stay in place. It reaches moisture far below the depth of most herbs. That is why it is a survivor and can recover quickly.

For a plant that grows well on levees, vetiver's natural habitat may seem swamps and bogs in India. According (many book on *'FLORA INDICA* written in 1820, one variety, native to Northern India, was called *Andropogon squarrous,* found in Ceylon, which flowers and sets seed, spread out and swimming in pools of water. Whereas the one we know as *Vetiveria zizanioides* in Hortus Third is always erect, awnless, muricate, sterile and grows to 8 feet. This description matches the Southern India plant *"Andropogon "muricatas"* that is very common in every part of the coast and also Bengal on the banks of water sources. *A. muricatus* grows erect whether in water or on dry land. It will thrive growing in the direct path of salt spray under very wet conditions. The root of this plant is delightfully aromatic particularly when moistened with water. I have very alkaline, sandy soil, in my herb garden. My vetiver is very erect. In Flora Indica, the grass is also called "*Aristida setacea"* and grows in dry barren, binding soil. It is a root perennial with culms very erect, straight and about as thick as a crow quill at the base. The Telinga paper makers construct their frames of the culms. It also serves to make brooms and toothpicks. It is used for making screens called "tatties". For this purpose, it is spread thin on bamboo frames and tied down. These are placed on the weather side of the house during the hot land winds and kept constantly watered during the heat of the day, rendering the temperature in the house very pleasant compared to what it is outside. This is a primitive form of air conditioning. The thermometer outside in India exposed to the wind but not to the sun, will then be at 115˚F or more but inside it can be kept down (85˚ F with two to three rows of thin tatties and all kept well watered. The difference of the thermometer in the sun, rises from l3˚F to 40˚F. These tatties are used in Bengal and make it more tolerable to those inside. The Indian common name for vetiver in Bengali is Khus Khus The roots when dry are used to make large fans commonly called Vissarees and also to make screens which are used before windows and doors and are kept moist so the air that passes through is both cool and moist. There is strong evidence to suggest that the vetiver from North India is different species from the vetiver in Southern India which

appears to bear infertile seed, and is the same as our *Vetiveria zizanioides.*

Propagation is mainly by division or slip. They can be ripped off the main clump and put immediately into the ground. It does need care during the period after planting. Vetiver will establish itself without roots as the amount of roots serve no purpose. The slips will only grow after they put out new roots. Once the roots start then they will continue to grow rapidly. ....You must use vegetative material to propagate. Absolutely DO NOT PLANT SEED. Otherwise it would become a pest. Most vetiver grown in the United States is the sterile variety. We insist avoid the use of seed. Seed when viable will only germinate under a narrow range of conditions and would create problems. Vetiver's tolerance to salt is high although it prefers slightly acid soil. The best soil is loamy sand although it is able to grow in any the type of soil regardless of fertility or alkalinity. It is also an acid tolerant herb. Phosphate and nitrogen together is very beneficial. I use bonemeal, bloodmeal, or fish fertilizer. I plant my slips in sand and newspaper pots set on black plastic in trays in full sun. I make the pots from strips of newspaper 2 and 1-2 inches wide, cut lengthwise and wind the strips into 2 and 1/2 inch pots then tape the ends. They are easy to make and the plastic keeps the sand from falling out the bottoms. The overhead mister does not deteriorate the pots as they are thicker from the layers of paper. You can make the pots any size or width you need, the same way.

Vetiver has been recorded as a medicinal plant in the Ayuveda era. It has a special use as a tea for curing hangovers and calming the nerves of people and horses in Honduras. In folk medicine, it is used to induce sweating and as a stimulating agent. Herbalists appreciate vetiver for its fragrant roots and as an insecticide or as oil for perfume. We weave the roots into baskets, mats, fans, sachets and ornaments. Oil from the roots is used perfumes because of its ability to take along time to evaporate from the skin, therefore perfumer combines it in soaps and scents to give them "persistence". That is why we use vetiver as a fixative in our potpourris. Vetiver can be made into hairbrushes to scent the hair, and basket weavers say that the stems hold paint and keeps its color better. It can be used to replace tree fuel. Vetiver can be harvested any time of the year. It is not a seasonal product. It has been used for ropes and for stuffing mattresses, it prevent bedbugs. Herb gardeners can plant vetiver in garden-size plots to use for herb craft and herb fairs. Some of the crafts include clothes hangers covered with vetiver roots and bound in ribbons They are thick and soft for hanging clothes on and look very special besides giving your closets a wonderful long lasting scent. One girl uses khuskhus grass with balsam for weaving distinctive baskets. Others make wall hangings, lampshades and hats. The vetiver can be relied upon to keep moths out of closets during hot summers. It is effective for two years. Vetiver oil is obtained by steam distilling the roots and is used in soaps, lotions, deodorants and other cosmetics. I have distilled rose petals at home and plan to do the same with vetiver. It keeps the more volatile oils in potpourri from evaporating too fast. It has a woodsy, earthy, musky scent and can dominate a perfume but it provides the base for potpourri. Vetiver was introduced to the perfume industry of Grass in the south of France. It still exists there and survives the Mediterranean winter. The oil will repel flies, cockroaches and other pests. The grass can be used as a pulp for making writing and printing papers or strawboards The roots are used as an important curry seasoning, in Malay. In Vietnamese and Thai food Khus-Khus is a flavoring for desserts, sherbets and canned asparagus. It is used with other extracts of Jasmine, Osmanthus, Pandan, and Lichee in Agar-agar and Sweet Rice.

Vetiver plants are grown by the Boucard Brothers, American Vertivert Corporation in Leakey, Texas. The Texarome Inc. also of Leakey, Texas has a standing offer to purchase roots for *$350* a ton. A company in Sunshine, Louisiana will ship plants of Vetiver. Also here in California, vetiver plants are being grown in Woodland in a small backyard by James E. Eagan of Esparto, California. He has been amazed at the survival rate after experiencing very hot and adverse conditions with water, a serious problem with sparse irrigation due to the past drought conditions and then after a serious freeze. In 1990, he found all but a few plants showed signs of new growth. It is truly a miracle herb."

TECHNICAL NOTES

How to Use Existing Barriers as Sources of Planting Material

(By **Jim Smyle** - Director of the Latin American Vetiver Network. E.mail. "Jim Smyle and Joan Miller" <hamilton @sol.racsa.co.cr>

We found on our tour (in January in south-eastern Costa Rica) two interesting practices that people are using to obtain planting material for establishing new vetiver hedgerows. One of these was to remove an entire section of a hedge to obtain the planting material. Then the removed section is replanted. The other practice is to remove entire clumps (one every couple of plants) and either replant the gaps or wait for the plants on either side to grow together and fill the gaps. In the first practice, (the removal of entire sections) they told us that previously when they removed only tillers from the hedge the remaining parts were damaged and died, leaving gaps in the hedge. This is the first time we

had encountered this problem. The practice of removing tillers from the existing barriers is common. In many other places and projects one "removes half" of the hedge to obtain vetiver tillers. We have not previously received reports of this phenomenon where the clumps have died from removal of individual tillers. For example, the LUPE project (in Honduras) and in the Finca Rio Negro (in Costa Rica) they have obtained planting material from existing hedges for years without damaging the hedges.

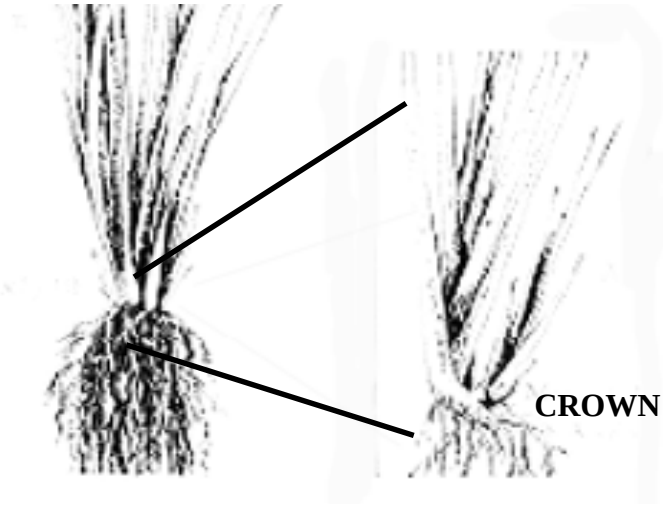
This practice of removing entire sections of the hedge and afterwards replanting or removing entire plants does not seem to be a recommendable practice (See Figure 1). Furthermore it damages the ability of an established hedges to function and can cause a significant increase in soil loss. We would like for those of you who have experience with the use of established hedges as sources of planting material to write us so we can report how you have done it and what are the results.

HOW TO PLANT VETIVER *by* ***Jim Smyle***

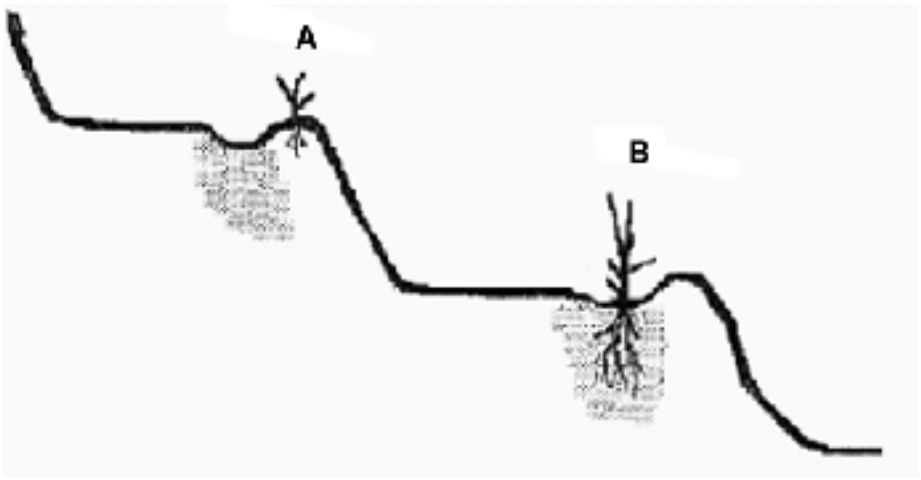
In the planting of vetiver one must take into account its physiology and the consider the effects resulting from one 's management of the plant:

First: When the plant is dug up, it must be kept in the shade with adequate moisture; treated in this manner the plant can be stored for a week or more between the digging up and planting. But, it is always recommended to minimize the time between excavation and planting. In order to minimize the mortality rate, plan on planting the same day the vetiver was dug out. If left in full sun, without shade or moisture the plants will wilt and dry out and lose any stored moisture; a significant loss can be expected in only a few hours if nc treated properly.

Second: The point c growth on vetive grass is in th "crown", which i found in the part im mediately above th roots - that is, th area between th leaves and the roots One can identify thi zone for its white/ye lowish color. Whe clumps of vetiver ar dug out of the nursery, the existing roots have a tendency to die out, and usually die anyway from the digging out and the pruning of the leaves prior to planting. After planting new roots start to develop from the crown allowing the plants to establish and to start growing. Thus, **when planting you must assure that this area of growth (the crown) is planted completely below the surface of the soil.** It is recommended that each time someone demonstrates how to plant vetiver, they dig up a tiller and remove all the leaves so that they can show and explain to people that it is from this zone with its incipient leaves and "buds" where the roots and new leaves are produced. Finally, upon planting, the crown needs to be covered by well compacted soil around the plant in order to assure good contact with the soil and moisture. If the soil is not compacted, the plant dries out and cannot survive.



Third: A mistake often made by vetiver users is to plant vetiver on the edge of a terrace or in other micro-sites that are extremely dry and therefore are not acceptable. Another example is planting on the lower, downhill side of a furrow. For example in the drawing, tiller 'A' was planted on the lower edge of the terrace. In this micro-site evaporation is high, and, furthermore it is planted on an elevated spot so that water drains from the site instead of being captured. One must avoid planting in these micro-sites because they are extremely dry. On the other hand, tiller 'B' was planted on a micro-site



where it is most likely to capture the maximum amount water, therefore the establishment and development of the plant is better than 'A'. These are small differences, but small details determine success and failure. In dry and semi-arid zones, planting as in 'A' could be fatal to the survival of the plant.

Know Your Hedge Vetiver: Environmental Concerns About *Vetiveria zizanioides*

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Introduction

Thanks to the generous sponsorship of King Bhumibol, we here at the International Conference on Vetiver Grass have seen the scientific proof that vetiver is a "miracle grass". But in 1989, when we at the U.S. National Academy of Sciences first heard of it, vetiver sounded too good to be true. Erosion has been recognized since ancient times as the enduring enemy of human works, and the inevitable power of water against rock is a metaphor in every culture. Agriculture in particular, with soil laid bare to the rains, is a paradox: the very action that feeds us ruins us. We must clear the earth to plant, and the earth is swept away. Our tools against erosion - traditionally earth or stone - are almost all expensive, and almost always temporary.

In 1989, two World Bank veterans of tropical agriculture, John Greenfield and Richard Grimshaw, were claiming to have a simple, natural answer to soil loss and moisture control. They based their beliefs on what they had seen in traditional sugarcane agriculture. A contour hedge of grass, dense with stems at ground level, slows water enough that it drops sediments, layering behind itself a self-leveling bench terrace from which water flows gently and smoothly. Between the hedges can run fields, roads, canals, and other features of the "built" and natural environment. They declared that this biological system of erosion control, particularly using a ubiquitous tropical grass called vetiver (*Vetiveria zizanioides*), could be effective almost anywhere.

The Academy Vetiver Study

My colleague at the Academy, Noel Vietmeyer, with whom I've worked for ten years as a research associate, and I were skeptical to say the least. The purpose of the National Academy of Sciences, founded in 1863, is to "advise on matters of science and technology" through its National Research Council (NRC). Since 1970, our small NRC program has reported on technology innovations with the potential to help developing countries. During this time we have heard of hundreds of "breakthroughs" which might feed the world, or produce abundant fuel, or remedy any of a dozen of humanity's crises. Most solutions are impractical and would cause more problems than they solve. On the other hand, some ideas have true merit, and our program has produced over forty studies highlighting the potential of under exploited crops, fast-growing trees, and little-known animals. Almost all the innovations have been based on natural resources already important to some people at some time in some place: "lost" crops, "micro" livestock, "firewood" trees. Our job has been to draw on the best knowledge available to evaluate and explain whether these "new" resources truly had the potential to improve the quality of life and, if so, to make this information widely available with the endorsement of the National Academy of Sciences. In a sense, we put into practice the English saying, "The proof of the pudding is in the eating.": after all is said and done, does something work?

By 1989, John Greenfield and Richard Grimshaw had been very successful promoting vetiver hedges in World Bank projects in several countries. The U.S. Department of Agriculture (USDA) was exploring the idea of grass hedges for use in the United States, and had even sent an exploratory team to visit vetiver projects in India. The U.S. Agency for International Development (USAID) saw the potential of the vetiver system in many of its "sustainable agriculture" projects. But prudence dictated that before those agencies promoted the vetiver system, it should be investigated for both its strengths and weaknesses. Given other experiences caution was wise, for there seems to be a "law of unintended consequences" which states that the unexpected outcomes of our actions are often more costly than the anticipated benefits. So the World Bank, USDA, and USAID contracted for the National Academy of Sciences to "... assess the state of knowledge, the promise, and the possible limitations of vetiver use, as well as research that might be needed before vetiver can be deployed rationally and safely.".

As in all studies, we assembled a panel of supporters and skeptics. It was chaired by Norman Borlaug, whose high-yielding wheats had averted unprecedented starvation in the 1960s, for which he received the Nobel Peace Prize in 1970. The other panelists were Rattan Lal, author of several standard texts on erosion (including Soil erosion in the tropics: principles and management, and Soil erosion research methods); David Pimentel, a developer of integrated pest management and systems agriculture; and Hugh Popenoe, a senior authority on tropical agriculture and land-use systems.

It was David Pimentel who recast our task as "scientifically validating a traditional practice". This was made clear as we learned that vetiver hedges had long been used for erosion control. Vetiver was standard agricultural practice in places such as Fiji, Mauritius, and St. Lucia. We found that much of our background work had

been done by farmers and colonial agronomists: vetiver is not only well-known for the essential oil produced from its roots, but vetiver erosion-control hedges had often been recommended in the literature. Our task was not to create new or hypothetical knowledge, but largely to assemble and evaluate the wealth of existing experience and bring it to global awareness. We gathered agricultural and botanical information from around the world, eventually contacting in our quest for positives and negatives over 500 people (plus soliciting experiences from the then -1000 members of the World Bank's Vetiver Network). After four years, a mass of information was distilled into the peer-reviewed study Vetiver Grass: A Thin Green Line Against Erosion, in which the NRC panel unanimously reported that vetiver hedges were a cheap, safe, and effective technique to slow erosion and retain soil moisture. Vetiver could be used with confidence, but much remained to be learned. We should increase our knowledge of the system to the level known about engineered erosion structures, and of vetiver to the level known about other plants such as rice or wheat.

Doubts About Vetiver

This study was unique for Noel and me in that none of our other reports had touched upon the resolution to something as basic and widespread as erosion; it became clear that vetiver truly was an innovation of the first importance. The objections to vetiver were more unimaginative. Skeptics often seem to fall into three categories: traditionalists, innovators, and generalists. In this case, the traditionalists felt that proven technologies were the best immediate answer to the erosion problem: engineered structures were expensive to build and maintain, and it was difficult to get people to construct and maintain them, but they worked and what was needed was more investment and more education.

The innovators felt that there were many other ways to combat erosion, using contours and bunds and stone and vegetative debris and dammed ridges and trees and swathes of grass and scores of other techniques which largely depend on local conditions and local initiative and continual upkeep. The generalists themselves often acknowledged that vetiver worked wonderfully, but that the law of unintended consequences precluded its use: there was too little known and there had been too many blunders in the past. It was better where it could be afforded to stick with what was already proven, and elsewhere to suffer unchecked erosion rather than try the unfamiliar. Although vetiver was well-known to many in the tropics, status quo and risk aversion are strong inhibitors of innovation.

The first two types of objections, those from the traditionalists and the innovators, can be answered objectively. Quantifiable scientific data can show the relative costs and benefits of vetiver hedges. The amazing outburst of research and application catalyzed ten years ago by Grimshaw and Greenfield, and the great advances in knowledge documented by participants at this conference, have clearly demonstrated that vetiver hedges are a fundamental advance over both traditional and innovative erosion control methods. Vegetative grass barriers are an insight which is qualitatively different from most past approaches!... it is what Noel Vietmeyer calls "nudging nature". The vetiver system uses a natural process that grows stronger and more stable with time, rather than weaker and more vulnerable as do most other erosion-control techniques.

The now-obvious insight into the workings of a vetiver hedge has been in front of humans for centuries, in the soil built up along fence lines running across the contour, the silted debris-dams in contour rowcrops, even in dirt built up behind grass growing in the cracks of sidewalks. We have just been unaware about what was happening in front of our eyes. We lacked the insight. As John Greenfield is fond of saying, "we looked but did not see!". Today, the basic concept of the vetiver system is itself proven, and now the minutiae of soil, shade, rooting, and many other factors are being documented in ever-greater detail. Propagation, planting, and management techniques are nearly mature. Standards and specifications are evolving, combining engineering and agronomic principals. This blossoming of agroengineering is exciting. Such results as epitomized by this conference and now a part of the scientific literature were summarized by our panel: Vetiver hedges are cheap … and effective. There are circumstances in which other approaches are appropriate, but even then they are usually improved upon by incorporating a hedge as a key component of the system.

But during our study the generalists asked the more difficult question: Is vetiver safe? Unlike the misgivings of traditionalists and innovators, this fundamental question can not be completely answered objectively, for it is part value judgment and part null hypothesis. Just because we know no fatal flaw, we can not prove one does not exist. The question "When do we know enough" is one of the most vexing in science, and is often answered "never". Scientists are famous for always needing more research, more data, before they can give a final answer. But just as the emergency physician rarely has all the information needed to make an absolute diagnosis and so is forced to rely on past experience, scientists are forced to make recommendations based on incomplete knowledge. It is a balance between perceived risks and perceived benefits. For this reason, the techniques of risk-assessment have evolved to evaluate the unknown. The physician often makes quick decisions based on incomplete information because life is immediately at risk; the mathematician often develops elabo-

rate proofs over many years. The considered judgment of the NRC Vetiver Panel that vetiver was "cheap, safe, and effective" fell somewhere in between. The line of reasoning is that erosion is the number-one problem in agriculture and vetiver is a well-known plant occurring throughout the tropics whose wider use shows no cause for immediate alarm ... further research is prudent. Ethically logical but unprovable.

There is no final answer to the question "Is vetiver safe?". It will always be a value judgement based on past experience and new information. The "generalists" have three particular - and very valid - questions which will require vigilance as vetiver is planted on a massive scale:

1. Does vetiver harbor some pest or plague? is it a "vector"? which will ravage some crop or the environment?

2. Is vetiver itself vulnerable to some pest or plague which will make it unusable or, worse, cause a collapse of the vetiver system, leaving tracts of land unprotected by any erosion control mechanisms? This is especially worrisome if one vetiver clone is used as a monocrop across vast areas.

3. Is vetiver a weed, a plant which can invade and naturalize on its own?

I will briefly discuss the first two questions together, and deal with a framework for vetiver's weediness in greater detail. But let me point out some basic precepts to be kept in mind. First, ignoring concerns will not make them go away. Every country has plants which have run rampant or become a reservoir of disease or pest. Second, belittling the risks will only antagonize; that's human nature. Third, bombarding people with one-sided information will only confuse and, if just one fact is incorrect, the whole body of knowledge is made suspect. And fourth, steamrollering over people's objections will only strengthen their determination to oppose.

A passing word on "miracle" plants. The word is used among the smug as a snide or pejorative term, but I believe it was chosen for this conference, "Vetiver: A Miracle Grass", as a challenge. There are those so jaded or cynical that they forget we are surrounded by miracle plants!... those special plants that allow us to live as "domesticated" humans. Rice, wheat, maize, tell me these aren't "miracle grasses"! Bamboo. Beans. Pine. Potato. I'd say there are at least a hundred miracle plants for which we humans should be eternally grateful!... so vetiver would now make it one hundred and one. Vetiver seems destined to become a "global grass".

Pests and Plagues

The main pest-and-plague problems reported with vetiver have been few: fungal dieback from *Helminthosporium* and *Bipolaris,* bacterial leaf blight from *Xanthomonas*, sooty molds such as *Meliola*, stem borers and white grubs, maize cyst and root-knot nematodes, termites, and rats. The genus is susceptible to smuts from *Tilletiaceae* and from Ustilaginaceae. There is even an ascomycotina fungus called *Phyllachora vetiveriicola* indigenous to Gorakhpur, India, although I know nothing about it except that members of the genus cause leaf-spotting (black spot, tar spot) and they may be genus specific (there are species named *P. sorghi, P. sacchari, P. maydis, P. eucalypti, P. ficiuum,* etc.).

None of these pathogens have caused a failure of vetiver in the field, nor is there evidence of transfer to other crops. There are no reported cases of vetiver serving as a reservoir for pests or plagues, even when infected plants grow next to hosts. Vetiver has been cultivated on a large scale as an essential-oil plant for centuries, generally in association with our other economic plants. Its vulnerabilities and their treatments are well-covered in the literature. Each of the pests, even the stem borers, is harbored by many other species, so vetiver is not forming a unique refuge. Proper maintenance reduces or eliminates them as problems. Extension officers in Fiji, where there is the longest scientific field experience with vetiver hedges, have pointed out that under a proper maintenance program all known problems can be adequately overcome.

Vetiver seems unlikely to become a devastating vector nor itself catastrophically vulnerable to pests and plagues, no more than other crops planted on a vast scale. Sorghum, maize, and sugarcane are all close relatives which have survived intensive monocropping for centuries. It is of course a constant contest between agriculturists and nature, which thus far we have won with most crops in most places. During an early NRC strategy meeting, I believe Erik Arrhenius of the World Bank pointed out that, "Without doubt, sometime vetiver will be hit hard by something somewhere. It's only a matter of time".. This of course is true, as it is for all our crops.

Pandemic disease is a fact of life in modern agriculture. The same will be true for vetiver, and somebody had better be ready. Thankfully, agronomy is today a discipline in which both theory and practice excel. That is why vetiver should now be considered as a primary plant resource of humanity, receiving the same intensive research focus and development as our other major crops. I believe that if adequate scientific, economic, and political attention is given to vetiver, we have no more to fear than we do from the many other "miracle" plants which feed, house, and cloth us humans, we who after all are the most evident "monoculture" on the planet.

Weediness

So vetiver seems a miracle. Will some vetiver become a weed and tarnish that image? I think

most definitely not, if vetiver users continue to exercise the judgement and care in the selection of germplasm which they have shown in the past. The vetivers used in hedges do not have rapid reproduction, nor produce vast numbers of indeterminant seeds, nor have creeping rhizomes, nor possess most of the other technical characteristics ascribed to weeds. The two primary "weedy" characteristics shown by good vetivers are their ability to grow in a wide range of habitats and to be unusually persistent where planted. Yet vetiver proves easy to eradicate if desired.

By the way, many people seem to equate "weed" and "exotic", but the correlation is very weak and some of the worst weeds are "home-grown". Almost any weed scientist will tell you that 99% of introduced plants - especially domesticates - will never be weeds (look anywhere at fruits and vegetables, grains, legumes, trees, and ornamentals...most are exotics). Of the remaining 1%, 99% of them can be predicted as weeds; they have that combination of characteristics that cry out "Danger, Warning, Probable Pest". What concerns weed scientists, exotic plant committees, and other professionals is that obscure 1-in-10000 plant which seems well-behaved but which shows unexpected vigor and fecundity in some new environment. Regrettably, much of the clamor against "exotics" comes not from professionals but from armchair generalists. One of our duties is to provide them with field-proven evidence about our well-known vetiver, which has long been grown in every country and clime of the tropics. Nonetheless, it is important to point out our awareness that some members of the species and its congeners certainly do have the potential to be pestiferous, nor do I recall anyone ever denying this possibility.

The genus Vetiveria belongs to the Tribe of grasses called the Andropogoneae [Andropononeae]. One of the worst weeds in the world is an andropogon. *Imperata cylindrica*, widely known as cogon, lalang, and, in Thai, yaa kha, dominates several hundred million hectares of Asia, where it is native. It has little forage value, is persistent, and precludes land from useful purposes. About the only cost-effective way to recover the cogon lands is to battle it with one of those stubborn acacias, *Acacia mangium*, which has the ability to establish in the tangled mass of grass and eventually eliminate it through its dense shade. Mangium is nitrogen-fixing, fast-growing, and provides an excellent timber. It seems a real innovation in our struggle against cogon, and we hope some day to issue a report on this from the National Academy of Sciences. Incidentally, there is a diminutive form of imperata grown in the United States for its red leaves. Called "Japanese Blood Grass", it does not set seed around Washington but scientists in the South, in Mississippi, have shown it seeds abundantly there. Big cogon is already loose in the South, and I have fears about this pretty little ornamental further north.

Also closely related to vetiver is sugarcane. Another member of its genus is Saccharum spontaneum, infesting nearly every nook and crannie of perennial fields in its Asian home, not to mention roadsides, ditches, and waste areas. It is not as robust as sugarcane, but is much more feisty.

The closest generic relative of vetiver is sorghum (along with Chrysopogon, a widespread brush and lawn grass). Another member of the genus, *Sorghum halepense* (called Johnson grass in the United States after one of its early promoters), embodies the worst characteristics of a weed. Johnson grass was purposefully introduced in many areas because of its actual value for forage. It proves pioneering, invasive, and persistent; it produces both abundant seed and long, burrowing rhizomes, each of which can produce a new plant; it can be grazed, burned, dug, poisoned, and plowed, yet come back year-after-year to form impenetrable canebrakes; seasoned leaves develop prussic acid, which turns to deadly hydrocyanic acid in animals; and, worst, it has apparently borrowed some genes from its fellow sorghums which allow it to mimic them in seasonality, growth, habit, and reproduction. It continues to evolve, and there seems to be a genetic continuum between Johnson grass and sorghum, including even the shattercanes which slash yields in almost every field of sorghum in America. Thus, *Sorghum halepense* has become even more of a pest because of its association with agriculture than it ever was as an unaltered wild plant. Because of this history it is illegal to perform research, at least in parts of the United States, on transgenic sorghum. If one needs examples of undesirable plants, look no further than the andropogons.

If one needs examples of desirable plants, look no further than the andropogons. Most andropogons are perennials, which have a lesser need for seediness; the above examples are exceptions. The entire genus is noted by botanists and physiologists for its tendency towards sterility, surprising, given maize and sorghum. But none of the three most famous and useful andropogons, maize, sorghum, and sugarcane, can reproduce on their own in nature (this is common in domesticates; neither can wheat, rice, cassava, peppers, etc.). The seeds of maize, an unusual plant, are embedded in a cob and encased in a husk through which germinating seed can not penetrate; maize exists solely through human intervention. Grain sorghum has been bred to produce abundant seed, but because the plant throws its weight behind seed production rather than vegetative persistence, the plants themselves can not compete with other plants, especially other grasses. The ditches next to fields of sorghum in Africa, Asia, and America are not filled with sorghum for it can not survive with-

out the disturbance of cultivation. Sugarcane, which like vetiver is not grown for its seed, so rarely flowers that it was only at the end of the last century that seed-producing tricks were discovered that allowed selective breeding to begin. Sugarcane grows where humans plant it; feral plants are vanishingly rare or nonexistent.

Where does vetiver fall between these extremes? Different types seem to approach both ends of the spectrum. Wild forms of *Vetiveria zizanioides* from Pakistan to the South China Sea produce abundant fertile seed. They are a dominant grass in many areas of the Ganges Valley, and are usually called "North India" vetiver. Two points are important to remember about North India vetiver: 1) it is not very useful as an erosion control plant, for it is fairly lank and weak-stemmed, and 2) it is not reported as a weed in places where it has been introduced. Nonetheless, outside its native region, it should not be mentioned in the same breath as hedges.

On the other hand, there are forms of vetiver that for centuries have been selected and cultivated in South Asia and elsewhere for their essential oil. Most rarely flower and many have never been known to set fertile seed. These are usually called "South India" or "nonflowering" types (though they occasionally flower). Like sugarcane, they are extremely well-behaved. Some genotypes have full pollen sterility and/or full embryo abortion. It seems these are the types which were spread throughout the tropics in the last century, both for oil production and because they were used to protect the edges of sugarcane fields from erosion, as we discovered during the course of our study. The old essential-oil types are grown in every tropic soil and clime, and have never been reported to invade or naturalize. They are exceptionally persistent however, sometimes growing in the same row for a hundred years or more. This is why they are legal as boundary markers in parts of Africa and Asia. It is also this quality which helps make them premier hedge plants: they will stay where they are put, but they do not wander.

South India vetiver is also genetically distinct from North India vetiver. One study by Steve Kresovich of the U.S. Department of Agriculture has shown that three essential-oil genotypes from different countries are genetically almost identical, while all three are vastly different from wild North India vetiver. But elaborate tests are unnecessary to tell them apart in the field. They can be visually assigned by overall morphology to either the North India or South India "complex". In addition, leaf width and pigmentation, internode length, and several other measurable characteristics set them apart. Further, their oils vary chemically, they rotate polarized light in opposite directions, they smell differently, and are treated separately in commerce. Their taxonomy is tangled.

Incidentally, in the past few decades several countries - particularly India - have had breeding programs to improve the oil content of vetiver root. These efforts have naturally been based on fertile plants. These hybrids look like North India vetivers, but neither these nor the seedy North India types are widespread outside South Asia. It has almost always been the traditional essential-oil vetivers of the Indian Ocean region that show up in other countries. But these days, just because a plant is called an "essential-oil vetiver" does not mean it is a "non-flowering" vetiver.

Germplasm

Past generations were admirably efficient at introducing high-quality vetiver to new environments, and today it is unlikely that one country has "better" vetiver than another. Good-quality vetiver is found nearly everywhere, so people do not have to introduce new germplasm. Indeed, it is fortunate vetiver hedges have come into pantropical use without facing the hurdles of phytosanitary quarantine that slows introductions of new plant resources.

So far as I am aware, members of the Vetiver Network have been as well-behaved as their vetivers; people haven't been sticking plants in their pockets and carrying them to other countries. Now is not the time to start smuggling germplasm! There is no practical need to exchange uncharacterized or uninspected planting material, the risks of introducing new pests or plagues are very high, and that is why unauthorized plant introductions are illegal in most if not all countries. For now, stick with the germplasm you or your neighbors have. Remember that vetiver's global reputation could still pay the consequence for one individual's negligence.

The few international exchanges that have occurred have been among official government programs, and strict quarantine and phytosanitary regulations have been followed. So far as I know, no introductions have entered into hedge use, for the local vetivers have always been as good if not better than the introduced material. If you are looking for vetiver, locate it in your own area or ask your national agricultural service. The Vetiver Network has identified suitable cultivars in almost every country and will be glad to help newcomers find starting material.

It is our duty as vetiver users to ensure we are using good-quality vetiver for hedges. Although seedy vetiver does not make good hedges and vetiver seed has rarely been used, to my knowledge, to establish them, seedy vetivers have been reported in a few countries outside South Asia, such as Colombia and Haiti. (Seed is always so much easier to introduce than vegetative material.) As I said, these are not reported pestiferous. The vetiver species endemic and widely used in Africa, *Vetiveria nigritana,*

is also fertile, as is *Vetiveria nemoralis* in Southeast Asia. Do not exchange seed outside areas of origin. We must stay on guard that our vetivers are not becoming problems, and we must ensure that new users, as well as skeptics, are aware of the risks and, more importantly, that we know and they know what kind of vetiver we are using.

Knowing Our Vetiver

How can we know our vetivers? There are two complementary paths. The first is to record as much as we can about the history and characteristics of the clones we are using for erosion control. How far back can this plant be traced? Was it used for oil production? Has it flowered? Set seed? Invaded or naturalized? The more we can describe our individual genotypes the better. Name your cultivars and characterize your germplasm, keep records of what you've planted, where, when, in what types of soils and with what kinds of associations, document and publish your experiences, and, especially, report unusual observations to the Vetiver Network.

The second path is to join with others in uniting our knowledge of vetiver. This task has been performed honestly and admirably by Richard Grimshaw and the Vetiver Network. Through this same Vetiver Network, I now hope to establish what Noel Vietmeyer calls a "Basic Science Initiative", in this case a "Vetiver Identification Program". Using classical and modern techniques of plant morphology and genetics, scientists should be able to unravel the taxonomic, systematic, ecological, molecular, and reproductive biology of vetiver. Because the profile of vetiver is rising in tropical agriculture, several researchers (with access to facilities and funding) have volunteered to assist in understanding the floristic, numerical, and cladistic taxonomy of vetiver, to test and document its ecology and physiology, and to perform DNA fingerprinting using RAPDs, RFLP, and FISH analyses. This is all for the good.

Here at the conference I am handing out accession, descriptor, and DNA forms to help accomplish these goals; these are also available on the internet at www.vetiver.com, by E.mail at vetivernet@aol.com, and by mail. We hope to soon be able to relate any unknown vetiver to all other vetivers, and to clarify genetic relationships among wild, cultivated, and hedge vetivers. The next steps will include physically linking genetic sequences with morphological characteristics such as rooting, tillering, flowering, and drought, cold, and chemical tolerances, and perhaps to unravel the many travels of vetiver. Perhaps most important, we may discover that some vetivers lack altogether the genetic ability to reproduce.

This is not as unlikely as it seems, and could be accounted for by one of two explanations. The first is that some vetivers may be naturally sterile. Low fertility and low seed-set are considered an evolutionarily advanced characteristic in andropogons, as shown by sugarcane and many of the grasses of my native Kansas prairie. However, if this is the case, there is always the possibility of genetic reversion to more primitive (fertile) states, or that introgression from fertile vetivers or other related grasses would create a reproductively active hybrid, as happens with Johnson grass.

The second explanation is that the essential-oil vetivers are domesticated plants, and having been selected for something other than seed (in this case oil in the roots) they have lost the ability to sexually reproduce, much like potatoes and sugarcane. In preparing this talk, I spoke with Jack Harlan, the USDA plant explorer (he collected vetiver in the 1950s) and geneticist who was elected a Member of the National Academy of Sciences for his contributions to understanding the origins and evolution of cultivated plants. He told me:

The wild vetiver is weedy; it's a seedy plant that has fertile pollen and normal meiosis, and it gets around on its own. I think the [traditional] oil-type vetiver is domesticated; it is not fit for survival in the wild. Because of pollen sterility and irregular meiosis in the South India type, I see no objection to calling it a domesticate. How does this sterile plant get by? Humans have made the sterility persistent by intervention. One could make the claim that it is a cultigen. (1/22/96)

If this is the case, and I believe it is, then it is possible that the best oil vetivers are also the most completely infertile: indeed, some essential gene necessary in the reproductive cycle may have been lost forever. A genetically certified sterile vetiver would be the best answer to the weediness question, and such clones may be found to be common through DNA analysis. On the other hand, if domestication is the cause of sterility it is likely that a gradient of fertile-to-sterile vetivers exists, and this too does seem to be true, so we must not forget the example of other domesticated root-crops. Radish and carrot come to mind. A few seedy plants among thousands of sterile plants have allowed persistent and pernicious "allied weeds" to become established and evolve wherever the cultigens are grown. Do not let this happen with vetiver! Remember the King's Rule to destroy any plants with seed (see below). Remember, our ancestors were cautious and only introduced the best. It seems likely - and we will soon know for sure - that Jack Harlan is right: most of us are working with domesticated germplasm.

Vetiver seems to have had two main paths of introduction to new areas. First, it formed part of the "economic botany kit" of the colonial powers; the finest germplasm was selected for introduction to possessions. Incidentally, much of the vetiver now used in hedges

came from botanic gardens. The second path was through indentured cane workers, particularly from southern India, who apparently carried vetiver with them to sugar tracts in Mauritius, southern Africa, the Caribbean, and elsewhere. A third, undocumented, route was perhaps via the Moors to Iberia and on to the New World. The biogeography of vetiver, reinforced by DNA analysis, will prove a fascinating story when someone takes up the challenge.

Hedge Vetiver

No matter the origin of the vetivers we use in erosion control, we must always adhere to King Bhumibol's Rules of Vetiver:

1. Use only high quality planting material, and destroy any plants with seed.
2. Plant vetiver as close together as possible.
3. Maintain your hedges.

Follow the King's Rules: the vetiver system will thrive and skeptics will continue to join us. How can we make it clear to others that we are adhering to the first rule? I recommend we adopt the term "hedge vetiver" for planting material in which we have documented confidence. This phrase would be reserved for plants we would be proud to publicly present to national leaders as examples of well-behaved vetiver. It is too early to establish firm practical standards for hedge vetivers, but here are some things to look for: the ideal is robust, dense and erect, with deep roots, wide adaptability, and nonseeding (though perhaps occasionally flowering).

It seems likely that most "hedge vetivers" will prove to be elite essential-oil types, but that is not clear as yet. Also unclear is whether we are talking about genotypes (vetivers sharing genetic characteristics) or phenotypes (sharing physical characteristics). We know that most vetivers out there are "good", but there are few records of the types of vetiver each of thousands of users are planting. By analyzing the characteristics of many different vetivers, we should be able to establish acceptable standards and unambiguous terminology to clearly and easily identify hedge vetivers. Comments and suggestions are welcome to help establish a grading system to ensure the phrase Hedge Vetiver is synonymous with top-quality planting material. If we promote the use of hedge vetivers, weediness will not be a concern. Establish the concept and practice the use of hedge vetiver.

The Hedge Vetiver Challenge

As you can see, I believe the best way to handle skepticism of the vetiver system is to act responsibly and to understand and share the persistent and irresolvable concerns of the "generalists". We must work with them, for they have useful and important perspectives. We as individuals must be especially familiar and confident with the particular cultivar of vetiver we're using in our own work!... nothing can be more important both to success in the field and to success in the public's mind. Today, because of workers like you, the vetiver concept is infinitely more secure and robust in the thinking of scientists and bureaucrats than it was ten years ago, but we have only begun to awaken the awareness of the public. And for every inch of vetiver hedge now in existence I envision a mile (I'm sometimes not too metric). Imagine a grass hedge on every two-meter interval in every field in the tropics. This, colleagues, is a major ecological intervention. We must know our vetivers.

At about sunrise the day before the conference, I sat and talked about vetiver with my colleague and friend Jim Smyle of the World Bank's Vetiver Network. We did some quick calculations and conservatively estimated that more than a billion vetiver slips have been planted these past ten years!... it's probably closer to five billion. If vetiver becomes the standard conservation method throughout the tropics, being used in cotton and banana and maize and sorghum and cassava and the other crops, and to protect roads and waterways and civil engineering and watersheds, Jim and I speculated that within our lifetimes vetiver could become one of the most common plants on earth. Perhaps we were carried away by the intensity of this conference, but it demonstrates how serious is the challenge.

We must be prepared to meet that challenge. Although I believe we have the requisite skeleton of information, much remains to flesh out understanding. This exercise could be one of the great untapped adventures for vetiver champions: it gives each of you the golden opportunity to add new wisdom to the world body of scientific knowledge. Many of you are working with this plant every day, and many of you have specialized training to evaluate it. Take up this challenge. There are abundant opportunities for publications and theses on vetiver botany, physiology, pathology, entomology, agronomy, ecology, anthropology!... the list of -ologies goes on. If you tie your findings into these broader disciplines you'll contribute both to the advancement of vetiver and of science. It might even get you a promotion.

Vetiver is becoming a global resource. "Outside" scientists are increasingly willing to donate their time and resources to work with us and understand this new innovation. Vetiver's rising prominence in erosion control is not the only lure: its central but unresolved taxonomic position in the midst of the andropogons - among maize and sugarcane and next to sorghum - only reinforces the desire of scientists to unravel its nature. At the same time, more and more people are hearing of vetiver, and that means, always, more and more skeptics. The same objections will be raised again and again, the same poorly informed objections which occurred to Noel Vietmeyer and me

back when we first heard of the vetiver system in 1989. We must maintain our patience in honestly explaining the vetiver system, and we must maintain our commitment to improving our knowledge of it.

My commitment, as a scientist working only with paper in Washington, is to initiate the Vetiver Identification Program, and to coordinate accession and genetic records until a qualified team of scientists assumes long-term responsibility. I ask each of you who are using vetiver to document your clones, send copies of your records to the Vetiver Network, and to submit samples for DNA analysis. By participating in this effort you lose nothing while you help us all understand the environmental adaptations of vetiver genotypes, their vulnerability to pests and plagues, their origins, and much more. Hopefully, such results will allow us to quickly understand important agronomic and genetic information about clones, will shorten the time needed to evaluate new vetivers, and prevent much of the germplasm duplication which currently exists.

Using modern analytical DNA techniques, we will also be able to measure the "genetic vulnerability" which exists in hedge vetivers. In any given place most or all vetiver is genetically identical. If a pest or plague can harm one plant, it can harm them all, so it is useful to know how much genetic variety exists, and where. Steve Kresovich has already shown that three "different" hedge vetivers are genetically almost identical. This is one illustration of what a hundred analyses will uncover. It should be possible to group vetivers into a small number of types whose qualities are well-understood. Such an understanding is essential for efficient research, for confidence in planting hedgegrade materials, for insuring adequate genetic diversity in the future, and for answering questions from those unfamiliar with vetiver.

I pointed out earlier that we can never prove vetiver will never be a pest. All is not lost, however; other null hypotheses are that the sun will not rise tomorrow, that we will live forever, and that the government will eliminate taxes. All are possible, but don't count on any of them. Nor do I anticipate that vetiver, properly selected and installed, will ever create an environmental difficulty. I still stand four-square behind the conclusions of our National Academy of Sciences' panel: that vetiver is a cheap, safe, and effective way to slow erosion and increase soil moisture.

The Vetiver Network, lead by Richard Grimshaw, has performed admirably in bringing together and distributing this knowledge. What has been achieved in ten years is epic. The research presented at this conference, sponsored by the King of Thailand and bringing together 200 researchers from more than 40 countries, has provided hard evidence that vetiver hedges are indeed a robust innovation. So is the fact that just last week, after only six years of independent research, technical specifications for grass hedges were published by USDA researchers. It seems likely grass hedges will be approved in the "Farm Bill" currently before the U.S. Congress as the first legal alternative to engineered terraces for conservation compliance [Ed.-This has since been approved.]. You see, grass hedges are now considered by some authorities to be "accepted practice"; our goal is to make them "standard practice" around the world.

We here today have the good fortune to know vetiver and to know what it can accomplish for agriculture, civil engineering, and the environment. It is our responsibility to spread that knowledge conscientiously, honestly, and thoroughly. I believe we have an historic opportunity to show what a dedicated group can achieve when given the right tool, the right organization, and the right goals. We are building a knowledge base, and in time the concerns will fade. We will stay ahead of the "law of unintended consequences". In the meantime, with Hedge Vetiver, we will change the face of the tropics.

The original version of this paper was presented at the International Conference on Vetiver Grass held in Chiang Rai, Thailand, February 4 - 8,1996.

RESEARCH

Vetiver Workshop Australia

Research, Development and Application of Vetiver Grass for Erosion and Sediment Control in Queensland *Wednesday, 6th November 1996.*

Overview of Research, Development and Application of the Vetiver Grass System in Queensland and Overseas. *(Dr P Truong, Principal Soil Conservationist, RSC, Indooroopilly)*

The Hydraulics and Sediment Trapping of Vetiver Hedges on Steep *Slopes.(Professor Rod Smith, Head Agricultural Engineering, University of Southern Queensland).*

Use of Vetiver Grass for Engineering Purposes in Malaysia with Particular Reference to Slope Stabilisation and Erosion Control. *(Mr Diti Hen gchaovanich, CEO, EROCON, Kuala Lumpur, Malaysia).*

Application of Hydraulic Characteristics of Vetiver Hedges in Stripcropping on the Floodplains.(*Paul Dalton, Agricultural Engineer, University of Southern Queensland)*

Application of Vetiver Grass in Soil Erosion and Sediment Control in the Dar-

ling Downs. *(Clive Knowles-Jackson, Land Conservation Officer, Oakey).*

Strip Cropping with Vetiver Hedges - A Landholder View Point *(Mark Hensel, Prairie View, Jondaryan).*

Research, Development and Application of Vetiver Grass System in Thailand. *(Mr Sam Rajani, Director, Highland Development Office, Chiang Mai. Dr Vitoon Chinapan and Mr Chaicharn Chalothorn, Senior Research Officers, Department of Land Development).*

Vetiver Grass for Erosion Control in Forest Plantation. *(John Grimmett, Senior Research Scientist, Forestry Research Institute, Gympie).*

Vetiver Grass for Erosion and Sediment Control in Pineapple Farms. *(Cyril Ciesiolka, Senior Soil Conservationist, Toowoomba).*

Rehabilitation of Degraded Pasture - A Landholder View Point. *(Bevan MCleod ex Monto).*

Vetiver Grass for Erosion Control and Land Stabilisation in the Wet Tropics. *(Darryl Evans, Land Conservation Officer, South Johnstone*).

Vetiver Grass for Erosion and Sediment Control in Canelands in the Mackay Area. *(Frank Mason, Land Conservation Officer, Mackay).*

FIELD TRIP
Strip Cropping: Prairie View, Aubigny; Gully Stabilisation; Mechanical Planting Demonstration.

(If any person wishes to receive copies of the original papers please contact **Paul Truong**, Natural Resource Management, Queensland Department of Primaty Industries, Meiers Road, Indooroopilly, Queensland, Australia. E.mail: "Truong, Paul" <TruongP @prose.dpi.qld.gov.au>)

Vetiver Grass for Rehabilitation of Acid Sulphate Soils

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Introduction Vetiver grass (Vetiveria zizanioides L.) is being widely used overseas for soil erosion and sediment control (Truong, 1993). Research in Queensland showed vetiver is highly tolerant to drought and water logging, frost (-11˚C), heat (>45˚C), extreme soil pH (3.3 to 9.5), sodicity (ESP=33%), salinity (17.5 $mScm^{-1}$ for *50%* yield), Al toxicity (>68 Al/CEC%), Mn toxicity *(>578* ppm). (Truong *et al.,* 1996). Vetiver is also highly tolerant to a range of heavy metals such as As, Cd, Cu, Cr and Ni (Truong & Claridge, 1996).

Field trials in Queensland have shown that vetiver is highly effective in the stabilisation of steep slopes and rehabilitation of degraded and eroded lands. Vetiver is non invasive, only spreading by tillering. From the fertile vetiver cultivars in Australia, only a sterile line was selected and registered in Queensland as Monto vetiver.

Tolerance to low soil pH and high soil Al A strongly acidic soil with very high Al and Fe content was used in a glasshouse experiment to assess the performance of vetiver grass. Table 1 shows that when adequately supplied with essential nutrients, vetiver produces excellent growth under highly acid conditions (pH = 3.8) with extremely high level of soil Al (68% of CEC). Vetiver can not survive at an Al saturation of 90%. These trials did not assess the critical level of Al but observation during the trial indicated that vetiver growth occurred at level much higher than 68% Al saturation, as young leaves emerged and remained green for three weeks after planting in a soil with 87% Al saturation.

The critical Al level of vetiver is between 68% and 87% showing vetiver as extremely tolerant to high soil Al concentrations. These results were supported by overseas findings where vetiver has been satisfactorily established on soils with Al between *50%* and *85%* saturation (CIAT, 1992). Thus, vetiver is more tolerant to Al toxicity than some of the most tolerant crop and pasture species such as rice (>45%), corn (30%), wheat (30%), soybean (20%), lucerne *(15%)* and cotton (10%) (Fageria *et al.,* 1988).

Acid sulfate soils have severely affected sugar cane growth in north Queensland (Reghenzani & Hayson, 1986). Erosion of drainage channel banks of acid sulfate soils on an old cane farm near Babinda was persistent and severe. Several attempts in the past to stabilise these banks with various plant species have failed due to plant death and the land holder has resorted to using rocks to stabilise the most severe erosion on the banks. Vetiver grass was planted along the banks of these channels late in 1995 and after 8 months, although it is not fully mature, vetiver has successfully stabilised these banks during the last wet season. Table 2 indicates an actual acid sulfate soil exists and all samples analysed have high to very high potential to become acid sulfate soils. Vetiver was successfully established on these soils without any fertiliser and reached a height of 80cm after 8 months. Much more vigorous growth occurred when DAP (300kg/ ha) was applied at planting. These results confirm earlier glasshouse findings that vetiver tolerates very high levels of soil Aluminium and acidity.

Conclusion The above results indicate that vetiver grass, with its very high tolerance to extremely acidic pH's and high Al level, is suitable for the

Table 1: **Soil pH, Al, Mn and yield of Vetiver of a Glasshouse Trial.**

Treatments	pH Modifying Agents	Planting			Harvesting			DM Yield
		pH	Al Sat%	Mn ppm	pH	Al Sat%	Mn ppm	gm/pot
Control	Nil	3.9	61	1.6	4.0	58	2.0	29.0
1*	S	2.3	87	22.0	2.2	99	22.0	0.0
2	Nil	3.8	66	2.1	3.8	68	2.0	47.5
3	CaCO3	4.3	38	1.4	4.4	36	1.0	47.4
4	CaCO3	4.9	10	1.3	4.8	11	1.0	49.4
5	CaCO3	5.4	2	1.0	5.5	2	1.0	46.5
6	CaCO3	7.4	T	T	7.6	T	T	46.9

* Treatments 1 - 6 received basal fertilisers (N = 184 Kg ia; P = 04 Kg/ha and K = 144 Kg/ha). T = Traces.

Table 2: Acidity and Aluminum Levels of the Acid Sulfate Soil at Babinda

Location	Depth cm	Initial pH	Oxidised pH	TAA mole H+/T	TPA mole H+/T	Al meqib0g	AVCEC %
Drain	0-5	4.0	3.5	36	272	2.4	21
	5-15	4.0	3.6	33	256		
Flat	0-10	4.0	3.5	33	312	2.9	20
+Fertilizer	0-10	3.7	3.0	51	410	3.0	21
	10-20	3.5	2.8	9.3	535	8.7	62
-Fertilizer	0-10	3.7	3.4	58	400	4.5	49
	10-20	3.7	3.3	85	426	7.8	71

TAA=Total Actual Acidity; TPA=Total Potential Acidity

stabilisation and rehabilitation of acid sulfate soils.

(References not included due to space constraint. Please contact authors for full paper..Ed)

An Assessment Of Strength Properties Of Vetiver Grass Roots In Relation To Slope Stabilization

Diti Hengchaovanich and Nimal S. Nilaweera Erocon *Sdn Bhd, Malaysia*

Abstract: The root properties of vetiver grass affect beneficially on the surficial and mass stability of soil slopes. In this process, the strength properties of vetiver perform a very important role by means of its very strong, prolusely grown, and deep penetrating fibrous root system. When compared to the root tensile strengths of many hardwood species, the vetiver roots are very strong with an average tensile strength of about 75 MPa. Experiments on vetiver root permeated soil shearing reveal that the abundance of fine, strong and vertically penetrating roots of vetiver grass increase the shear strength of soil considerably throughout the depth of root penetration. The root tensile strength of vetiver along with the root area occupied on a potential shear surface can be used to estimate the shear strength increase in soil due to the penetration of vetiver roots.

Introduction. Vetiver grass *(Vetiveria zizanioides)* has been utilized to reduce soil erosion in many countries throughout the world for a long time. It is well understood that the root properties of vetiver grass can help reduce soil erosion and strengthen slope stability when planted properly on soil slopes. Vetiver hedgerows cultivated across soil slopes can block the passage of soil particles and develop terraces in between the hedges enhancing the slope stability. Some previous studies on vetiver plant have elaborated the root morphological properties and their significance on erosion control and slope stabilization qualitatively (Grimshaw, 1994; Yoon, 1994). They emphasize about the early developed deep penetrating (sometimes up to 3.5 m) fibrous root system of vetiver and its capability of anchoring firmly into slope soil profiles. However, the

strength properties of vetiver roots, which also play an important role in terms of erosion control and slope stabilization by means of their influences on the shear strength of slope soil has not yet understood adequately. When a plant root penetrates across a potential shear surface in a soil profile, the distortion of the shear zone develops tension in the root; the component of this tension tangential to the shear zone directly resists shear, while the normal component increases the confining pressure on the shear plane. Therefore, it is essential to determine root tensile strength properties in the process of evaluating a plant species as a component of slope stabilization.

Recently, in Malaysia the vetiver hedgerow technique starts to gain popularity in erosion control and slope stabilization. It has been and will be used to stabilize several road embankments of the East-West Highway and some other road projects. Simultaneously, attempts have been made to analyze the effects of vetiver grass roots on slope stabilization and erosion control. This paper discusses about root tensile strength of vetiver grass and its contribution to soil strength through experiments on root tensile strength determinations and root permeated soil shearing, which are a part of an ongoing research work specially design to assess both root strength properties and root morphological parameters in relation to slope stability and erosion control.

Root Tensile Strength of Vetiver Grass

For the determination of root tensile strength, mature root specimens were sampled from 2-year-old vetiver plants grown on an embankment slope. The specimens were tested in fresh condition limiting the time elapsed between the sampling and the testing to two hours maximum. The unbranched and straight root samples about 15 - 20 cm long were connected vertically to a hanging spring balance via a wooden clamp at an end while the other end was fixed to a holder that was pulled down manually until the root failed. At failure, the maximum load was monitored. Subsequently, the mode of failure was examined for each sample and the results of end sheared samples and those with unusually altered rupture points were discarded. To calculate the root tensile strength, the root diameter without bark was used since the bark failed before the root due to its weaker strength properties, and eventually the total tensile stress transferred to the root core. About 30 vetiver root specimens of different diameter classes varying from 0.2 to 2.2 mm were tested and the results were interpreted as the ultimate tensile force and tensile strength in relation to root diameter without bark.

The ultimate root tensile force against the root diameter plot for the vetiver roots is presented in Fig. 1. The power regression analysis of the relationship between the ultimate root tensile force and the root diameter provides the best fit with equation

$$F_t = 46.93 d^{1.4217}$$

where, *F1* - ultimate root tensile force; *d* - root diameter

This power regression relationship can be used to predict the ultimate tensile force of a vetiver root with known diameter. A comparison of tensile resistance of vetiver roots with those of some hardwood vegetation is illustrated in Fig. 2. The ultimate root tensile forces versus root diameter relationships for Japanese ceder, *Dipterocarpus alatus,* and Rocky Mountain Douglas-fir were obtained from early works of Abe and Iwamoto (1986), Nilaweera (1994), and Burroughs and Thomas (1977) respectively The comparison clearly indicates that the tensile resistance of vetiver roots as high as the hardwood vegetation, sometimes even higher, in contrary to being a grass species.

The tensile strength of root is defined as the ultimate root tensile force divided by the cross-sectional area of the unstressed root. If the root tensile strength is constant for vetiver roots, the ultimate tensile force, F_t should be proportional to d^2 . According to the relationship given by Equation (1), F_t is proportional to $d^{1.4217}$ implying that the root tensile strength decreases with the increase in root diameter. Figure 3 illustrates the actual relationship between root tensile strength and root diameter. The root tensile strength, $T_{5,}$ decreases with the increasing root diameter, *d,* following the power regression relationship.

$$Ts = 59.80 d^{-0578}$$

Similar relationships were reported from many previous works on hardwood roots. This phenomenon implies that stronger finer roots provide higher resistance than larger diameter roots with comparatively low tensile strength for a given root cross-sectional area of a species. According to Fig. 3, the tensile strength of vetiver roots varies from 180 to 40 MPa for the range of root diameter 0.2 - 2.2 mm. The mean tensile strength is about 75 MPa at 0.7 - 0.8 mm root diameter which is the most common diameter class for vetiver roots. Compared to many hardwood roots, the average tensile strength of vetiver grass is very high. Even though some hardwood roots provide higher tensile strength values than the average tensile strength of vetiver roots in the root diameter class of 0.7 - 0.8 mm, their average tensile strength values are lower since the average root diameter is much higher than that of vetiver roots.

Direct Shear Tests on Vetiver Root Permeated Soil

Roots of trees and other vegetation provide a reinforcing effect to soil through tensile resistance and frictional or adhesional properties. The reinforcing effect or the shear strength increase in soil due to roots can be quantified by conducting in situ direct shear tests

on root permeated and root free soils at the same location. The difference between shear strength values of root permeated soil and root free soil sheared under the same conditions gives the shear strength increase due to the roots. In order to determine the root reinforcement effect of vertiver grass, a large scale direct shear tests were performed in a slope soil profile of an embankment vegetated with vetiver. The test apparatus comprised a shear box, a hydraulic jacking system, a proving ring and dial gages. The shear box was made of 8 mm thick steel plates capable of holding firmly a soil block of 50 cm x 50 cm x 50 cm in dimensions. Hydraulic jacking system with capacity of 10 tons produced the shear load through the proving ring of 3 tons measuring capacity which controlled the shear force while four dial gages were measuring the shear displacement (Fig. 4).

The test plants were selected from a 50 cm length of a vetiver hedgerow that usually includes 3 plants planted with a spacing of 15 cm. The soil surrounding the plants was removed leaving a 50 cm x 50 cm x 25 cm root permeated soil block centering the hedgerow. Subsequently, the shear box was set so as to cover the soil block and the loading and displacement measuring systems were assembled. The soil block with 25 cm height then sheared horizontally towards the slope direction under the stress controlled condition. After shearing, the shear surface and the orientation of failed roots were examined carefully in order to estimate the shear distortion during failure. It was observed that the average shear distortion during failure was about 300. The total root cross-sectional area on the shear plane and the bulk weight of roots in the sheared soil block were measured in order to determine the root area ratio and the bio mass, respectively. This procedure was followed for each 25 cm depth under the vetiver hedgerow length 50 cm up to 1.5 m depth. For each depth level of shearing, a root free soil profile adjacent to the root permeated soil profile was also sheared under the same shearing conditions. Each soil block was sheared under the self weight as the normal load. The bulk density of test soil was determined before each test for the comparison of the normal load on root permeated soil block with that on the counterpart root free soil block. Each pair of test was made under equal normal stress condition.

The test results were processed in order to obtain the relationship between the shear stress and shear displacement for each test. Figure 5 presents the shear stress versus shear displacement curves, each plot representing the relationships for root permeated and root free soils for each 0.25 m depths up to 1.5 m of root penetration. The difference between the maximum shear stress of root permeated soil and that of root free soil at a particular depth is defined as the shear strength increase in soil due to the presence of vetiver roots (Δs). According to the test results, it is obvious that the penetration of vetiver roots in a soil profile increases the shear strength of soil significantly. For each test depth, the shear strength increase, the corresponding root cross-sectional area, and the bulk root weight per unit volume of soil were determined and tabulated in Table 1. The Δs value decreases with depth from 8.92 kN/m^2 at 0.25 m depth to 1.82 kN/m^2 at 1.50 m depth depending on the number of roots penetrating through the shear surface. A comparison of the variation of Δs and the root cross-sectional area on the shear surface is elaborated in Fig. 6 for the depth of root penetration. The vetiver root penetration of a 2-year-old hedgerow with 15 cm plant spacing can increase the shear strength of soil in adjacent 50 cm wide strip by 90 % at 0.25 m depth. At 0.50 m the shear strength increase is about 39% and gradually reduced up to 12.5% at 1.50 m depth. The shear strength increase due to 1 cm root area (As) is calculated for each test depth and presented in Table 1. The As value varies very slightly with an average of 5.1 kN/m^2 for the analyzed root penetration depth.

Table 1 Shear Strength Increase in Soil Profile Due to Root Penetration of 2-Year- Old Vetiver Plants with Spacing 15 cm in a Hedgerow of 50 cm length

Depth (m)	D_R (kg/m3)	A_R (mm^2)	A_R/A x 10^{-4}	Δs (kN/m^2)	%Δs	ΔS (kN/m^2)
0.25	1.522	331.0	3.31	8.92	90.2	5.39
0.50	0.701	176.2	1.76	4.17	39.3	4.73
0.75	0.521	137.8	1.38	3.46	34.6	5.02
1.00	0.378	106.8	1.07	2.61	26.3	4.89
1.25	0.181	71.2	0.71	1.94	19.0	5.45
1.50	0.135 `	51.6	0.52	1.28	12.5	4.96

D_R - bulk weight of root in unit soil volume, A_R - root area on shear surface, A - area of the shear surface, Δs - shear strength increase in soil due to roots, Δs - shear strength increase in soil due to roots 1 cm^2 root area.

Discussion Theoretically, the average tensile strength of roots can be used to compute the shear strength increase in soil due to the penetration of roots across a shear plane. The computation adapts the simple model of root reinforced soil subjected to direct shear (Wu, 1976). According to this model, the tensile force that develops in the roots when the soil is sheared can be resolved into a tangential component which directly resists shear and a normal component which increases the confining stress on the shear plane. The model simply assumed that the roots penetrate perpendicular to the shear surface and the tensile strength of the roots is fully mobilized during shearing. The mobilized tensile resistance in the roots translates into a shear strength increase in the soil as expressed by the following equation:

$\Delta s = t_R [\cos\varnothing \tan\phi) + \sin\varnothing]$

where: $\varnothing$- angle of shear distortion
ϕ - angle of internal friction
t_R - average tensile strength of roots per unit area of soil

The average tensile strength of roots per unit area of soil can be determined by multiplying the average tensile strength of the roots (T_R) by the fraction of the soil cross section occupied by roots or root area ratio (A_R/A).

Using T_R = 75 MPa, ϕ = 300 and $\varnothing$ = 300, the shear strength increase in soil due to vetiver roots were calculated for each test depths and tabulated in Table 2 with experimental results.

The computed Δs values are about 3 times as high as the values obtained from the field experiments. The disparity between Δs values obtained from experiments and computation can be attributed to the assumptions made in the root reinforcement model and the nature of root specimens used in the tensile tests. During shearing of root permeated soil, the tensile strength of each and every root was not mobilized completely as assumed in the model.

Table 2 The Experimental and Computed As Values with Depth.

Depth, m	Δs, kN/m^2 (Experimental)	Δs, kN/m^2 (Computed)
0.25	8.92	24.83
0.50	4.17	13.20
0.75	3.46	10.35
1.00	2.61	8.03
1.25	1.94	5.33
1.50	1.28	3.90

Some roots were pulled out completely or partly by a rupture at a finer point below the shear surface providing a lower resistance to shearing than expected. Even though the root penetration of vetiver is generally vertical as assumed in the model, some root orientations oblique to the shear surface can give rise to lower shear strength increase in soil. In actual conditions, the root crookedness, jointing and the presence of young roots yield lower Δs values than those are expected from straight, unbranched and mature roots which are more stronger than the former.

Though the adaptation of the root reinforcement model does not compute the shear strength increase directly, an estimation of shear strength increase can be made by dividing the computed values by factor of 3 for vetiver root permeated soil with the angle of internal friction 300. Furthermore, the correlations of Δs with the root area ratio and the bulk root weight per unit soil volume clearly indicate linear relationships which can be used to predict the shear strength increase in soil due to vetiver roots (Fig. 7). The value Δs increases linearly with the root area ratio in the order of 2.7×10^4 for vetiver grass. The relationship between the Δs and bulk root weight per unit volume of soil indicates some positive intercept of shear strength increase owing to the nature of roots and root penetration with depth. At shallower depths, the fractions of root weight given by obliquely oriented roots and by the roots terminated before the shear zone are higher than those at deeper levels. Therefore, at shallow depths the root weight is not directly proportional to the As value. As a consequence, a positive intercept in the relationship between the As value and the bulk root weight per unit area of soil appears though the intercept should be theoretically zero. For a known root area ratio or a known bulk weight of roots per unit volume of soil, these relationships can be used to predict the As value instead of doing rather difficult and expensive direct shear tests. Carefully extruded root systems of vetiver plants by water jetting can be used to determine the root area and the root weight at different depths of root penetration.

At present study, the shear strength increase in soil by the root penetration of a vetiver hedgerow at different depths up to 1.5 m was determined for a 0.5 m wide strip of soil across the slope. In general, for a 1 m wide hedgerow spacing these As values can be used directly at relevant depth intervals throughout the slope. However, for greater hedgerow spacings the As values should be corrected according to the pertaining areas of influence. It was unable to investigate the influence of vetiver roots on the shear strength of soil below 1.5 m depth due to the difficulties encountered during excavation and setting up testing equipment. Field evidences indicate that a gradual and slow decrease in root penetration

with depth after upper 0.5 m where a rapid decrease in root penetration occurs. According to the trend of the As decrease with depth it can be predicted a shear strength increase of about 1 kN/m^2 at 2 m depth below the vetiver hedgerow.

Conclusions

The root tensile strength properties of vetiver grass in association with its inherited root morphological characteristics improve the resistance of soil slopes to shallow mass stability and surficial erosion. The tensile strength of vetiver roots is as strong as, or even stronger than, that of many hardwood roots which have been proven positive for root reinforcement in soil slopes. The root tensile strength of vetiver decreases with the increase of root diameter as in the case of hardwood roots. Compared to hardwood vegetation, smaller average root diameter of vetiver furnishes very high mean tensile strength (75 MPa) indicating that the vetiver grass is more effective in the mechanism of root reinforcement in soil slopes. The penetration of fine and strong vetiver roots in a soil profile can increase the shear strength of soil significantly at shallow depths. The shear strength increase in soil due to the root penetration of a 2-year-old vetiver hedgerow with plant spacing 15 cm varies from 90% at 0.25 m depth to 12.5% at 1.50 m depth. The shear strength increase in soil due to vetiver roots can be approximated by using the average root tensile strength and the existing root area occupied by vetiver roots on a potential shear surface at a certain depth or by using the relationships of shear strength increase in soil versus the root area ratio or the bulk weight of root per unit volume of soil.

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(Figures not included, full, paper availble from authors.....Ed)

MALAYSIA

A seminar on vetiver grass technology was sponsored by the REAAA Malaysian Chapter, Institution of Engineers, IHT (Malaysian Branch) on August 17 1996. The seminar, under the Chairmanship of Dr. Ir. Wahid Omar, Director of Roads, JKR Malaysia, comprised a number of presentations and case studies of the Malaysian experience with vetiver grass technology. Readers interested in learning more about the seminar and its outcome should contact Dr. P.K. Yoon, 69 Jalan SS/3/39, University Garden, 47300, Petaling Jaya, West Malaysia. The presentations included:

Overview on the use of vetiver grass for erosion control and soil stabilization - P.K.Yoon.
The Malaysian Experience - Case Studies. Ir. Neoh Cheng Aik.
Slope stability design incorporating vetiver grass technology - Mohd. Asbi Othman.
Research and Development in Vetiver Grass Technology - Encik Mat Barhan Harun.
Prospects of advances in Vetiver production - Ismail Hamzah

THAILAND

Farmer Participatory Selection of Vetiver Grass as the Most Effective Way to Control Erosion in Cassava-based Cropping Systems In Vietnam and Thailand[1]

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Abstract

Research has identified various effective ways to reduce erosion in cassava-based cropping systems, including the use of vetiver grass contour hedgerows. However, few of these practices are presently used by farmers. To enhance the adoption of soil conservation practices by cassava farmers, a Farmer Participatory Research (FPR) methodology was used in two pilot sites each in Thailand, Vietnam, China and Indonesia to test and select the most effective practices. Farmers in Thailand and Vietnam selected vetiver grass contour barriers as one of 4-5 treatments they wanted to test on their own fields. After harvesting all trials and discussing the results, farmers in all three villages in Vietnam selected the vetiver grass treatment as the most effective in increasing income and reducing erosion. Although in one site in Thailand the vetiver grass treatment did not result in high cassava

yields or income, farmers in both sites selected the vetiver grass treatment as the most useful. In both countries, participating farmers, after seeing the benefits of vetiver grass barriers, requested additional planting material to plant on their fields.

Introduction Cassava *(Manihot esculenta* Crantz) is the third most important food crop grown in southeast Asia, both in terms of area planted and production of dry matter, following rice and either maize or sugarcane (FAO, 1993). In Thailand the crop is grown mainly for the production of dry cassava chips and pellets, as well as for that of cassava starch. The former are mainly exported while the latter is used for both domestic consumption and export. Cassava is generally among the three most important agricultural export products of Thailand. The crop is grown mainly in the northeastern and eastern part of the country in rather infertile lighttextured soils and under unpredictable rainfall conditions.

In Vietnam cassava is grown mainly for on-farm feeding of pigs, for direct human consumption, and for production of starch, maltose, noodles, cakes etc. Most of the starch is produced by small-scale family units, but in the past few years some large-scale search factories have been established in South Vietnam. Cassava is grown by small farmers throughout the country, but especially in the hilly and mountainous areas of North and Central Vietnam, on light textured and infertile soils which are very susceptible to erosion. Chemical fertilizers are seldom applied, but many farmers apply pig manure to maintain soil productivity.

Cassava is known to grow well on poor soils and under low rainfall conditions, but also has the reputation to exhaust the remaining soil nutrients and to cause serious erosion when grown on slopes. Research has shown that cassava extracts large amounts of soil nutrients only when yields are very high, but that per ton dry matter produced the crop extracts less N and P, and similar amounts of K as other crops (Howeler, 1991). Whether or not the crop causes more erosion than other crops depends largely on the soil and climatic conditions as well as on its management. Under the soil and climatic conditions of Thailand, Putthacharoen *et al.* **(**1992) found that the planting of cassava caused about twice as much erosion as that of mungbean, and three times as much as that of maize, sorghum or peanut grown only once a year. However, Wargiono *et al.* (1992) and Howeler (1995) reported that cassava grown in southern Sumatra of Indonesia produced similar amounts of soil loss as peanut and slightly more than maize or upland rice. Because of its wide spacing and slow initial growth, cassava plants leave considerable soil surface exposed to rainfall impact during the first three months after planting, and this can lead to serious erosion when the crop is grown on steep hillsides. However, the fact that cassava is often grown on eroded hillsides does not necessarily mean that the crop has been the cause of the erosion. It may also be that the growing of this crop is the result of erosion, since cassava can still be productive on degraded and eroded soils where other crops can not grow anymore, as shown by recent research in Colombia (CIAT, 1996). In any case, numerous erosion control trials, conducted both in Colombia and various parts of Asia, have shown that soil erosion in cassava can be reduced substantially by good management. Many management practices have been identified that can reduce soil erosion, such as minimum or zero tillage, mulching, fertilizer application, closer plant spacing, intercropping, as well as the growing of contour hedgerows of grasses, legumes or multipurpose tree species (Howeler, 1987 and 1994). The effectiveness of vetiver grass *(Vetiveria zizanioides)* contour hedgerows in reducing erosion losses in cassava fields in Colombia has already been reported by Laing (1992) from work done by Ruppenthal *(1995).* Similar trials conducted in Nanning, Guangxi province of China **(**Table 1**)** again showed that among various soil/crop management treatments, the planting of vetiver grass contour hedgerows produced the lowest amount of soil loss due to erosion as well as the highest cassava yields.

Many of the practices shown to reduce erosion, however, have certain advantages and disadvantages as they may require additional capital, labor or land, and thus may or may not increase the net income for farmers (Table 2). Since most cassava farmers are poor, and their main concern is to feed their families, they will not adopt soil conservation practices unless they themselves are convinced that these practices bring immediate benefits as well as protect their soil from long-term degradation (Fujisaka, 1991). Which management practices are most effective and beneficial is very site-specific and depends very much on the local soil and climate, the farmers' socio-economic conditions, as well as the traditional production practices. The testing and selection of the best management practices can thus best be done by the farmers themselves, in close collaboration with researchers and extension agents.

The Farmer Participatory Approach to Soil Conservation

The adoption of new technologies, such as new varieties or management practices, is often limited because the recommended practices were developed by researchers, who may not always know the farmers' specific needs and limitations. The recommended technologies may thus not fulfill the farmers' needs or may not be adapted to fit the local conditions. Farmer Participatory Research (FPR) methodologies have been developed by CIAT in Colombia (Ashby *et al.,* 1987) and Rwanda (Sperling, 1992), and were shown to increase substantially the adoption of new bean

(Phaseolus vulgaris) varieties. A similar approach is presently being used to improve the efficiency of cassava variety selection (Hernandez, 1991) as well as to enhance the adoption of better integrated pest management (IPM) practices for cassava in the northeast of Brazil, and that of better soil conservation practices in Colombia (CIAT, 1996) and southeast Asia (Howeler, 1996).

In 1993 the Sasakawa Foundation in Japan (now known as the Nippon Foundation) decided to fund a 5-year project, with the objective of enhancing the adoption by farmers of more sustainable management practices in cassava-based production systems in Asia, through the development and use of an FPR approach to soil conservation extension. The approach is based on the following basic principles of soil conservation:

1. Soil conservation is not an end in itself, but an integral part of good soil and crop management, including effective agronomic practices as well as the use of more productive germplasm.

2. Soil conservation must be done through a bottom-up program, planned and executed with the full knowledge, cooperation and participation of farmers.

3. Any proposed soil conservation practices must offer short-term benefits to farmers in order to be accepted, and must be suitable for the local soil and climatic conditions and fit the local cropping patterns.

The Sasakawa Foundation FPR Project The project started in 1994 with the organization of an informal consortium of collaborating research and extension institutions from the four participating countries, i.e. Thailand, Vietnam, China and Indonesia. In Thailand the project is conducted with participation of the Field Crops Research Institute of the Department of Agriculture, the Rice and Field Crops Promotion Division of the Dept. of Agricultural Extension, and the Thai Tapioca Development Institute (TTDI). In Vietnam the project is conducted in collaboration with the Agro-forestry College in Thai Nguyen, Bac Thai province, and the National Institute for Soils and Fertilizers in Hanoi. After the training in FPR methodologies of participating researchers and extensionists from the four countries, the project started with the conducting of Rapid Rural Appraisals (RRA) in potential pilot sites, so as to select the most appropriate sites and learn about the bio-physical and socio-economic conditions as well as the current production practices in each site; these data were used to identify farmers' needs and constraints. From the results of these RRAs, two pilot sites were selected in each country, based on the present and future importance of cassava in the region, the seriousness of soil erosion, and the interest of farmers to. participate in the project. Table 3 shows that the selected pilot sites differ markedly in terms of soil, climate, cropping systems and farm size.

Before the next planting season started, farmers from the selected pilot sites were invited to a farmers' field day to see demonstration plots that had been established by researchers on a uniform slope, usually at an experiment station, with a large number of soil and crop management practices. Soil losses due to erosion had been determined in each treatment by weighing at monthly intervals the sediments collected in plastic-covered channels at the bottom of each plot (Figure 1). Farmers could see with their own eyes the amount of soil that had eroded into these ditches as a result of each treatment. Farmers were asked to discuss the advantages and disadvantages of each treatment and to score the treatments in terms of general usefulness, based on yields of cassava and intercrops as well as effectiveness in reducing erosion.

Table 4 shows the ranking of the management practices considered most useful by the farmers of each pilot site. It is clear that farmer preferences vary greatly between countries, and even between sites within the same country, depending on the local conditions, farm size, and traditional cropping patterns (see Table 4)**.** The use of vetiver grass hedgerows was the first choice among farmers from both pilot sites in Thailand, possibly because of their knowledge about the interest of His Majesty the King, King Bhumibhol Adulyadej of Thailand, in this "miracle grass" as an effective means to reduce erosion. Vetiver grass hedgerows was also among the first three preferences of farmers in the two pilot sites in Vietnam. It was not a preferred option in China and was not even used in the demonstration plots in Indonesia, as researchers considered that farmers would reject it as unsuitable for feeding their cattle, and would therefore prefer to plant elephant-grass barriers instead.

Upon return to their village, the farmers that were interested in conducting FPR trials met with researchers and extensionists to decide on the 4-5 most useful practices that they wanted to try in their own fields. In Vietnam, farmers in Pho Yen district of Bac Thai chose four common treatments (including one of intercropping cassava with peanuts and establishing permanent vetiver grass contour hedgerows) and one "farmer's" practice consisting of their individual current practice. In the other site, in Thanh Hoa district of Vinh Phu, seven farmers each planted two replications of one selected treatment in adjacent plots on 40% slope; one treatment involved cassava/peanut intercropping with vetiver grass contour hedgerows. In Thailand, farmers in both Soeng Saang district of Nakorn Ratchasima province and in Wang Nam Yen district in Sra Kaew province chose 2-3 common practices (among which vetiver grass hedgerows), the farmer's current practice as well as a farmer selected practice. The latter was

the farmer's individual choice of what he/she considered a most useful practice. This sometimes included cassava intercropping with sweet corn or pumpkin, the use of dry grass mulch, or contour barriers of mulberry bushes for feeding silkworms. Besides soil erosion control trials, those farmers having mostly flat land participated in the project by conducting trials on varieties, intercropping or fertilization practices **(**Table 5**)**. The FPR teams, consisting of researchers and extensionists, helped the participating farmers select the most suitable site for each type of trial, to set out contour lines, stake out the plots and construct the plastic-covered erosion channels at the bottom of each plot in the erosion control trials (Figure 1). Planting material of new cassava varieties and the selected hedgerow species, as well as fertilizers for the trials were usually provided by the project, but farmers were responsible for the planting, weeding and maintenance of their own trials. FPR team members visited the trials regularly to see the progress, discuss any problems and try to find solutions. They also helped the farmers collect and weigh the eroded soil sediments in each erosion channel, and to take samples of these sediments to be dried and weighed to determine the moisture content, in order to calculate soil losses on a dry weight basis.

Results of FPR Soil Erosion Control Trials

1. Thailand

In both pilot sites, erosion was particularly severe in 1995 due to unusually heavy rain. In Soeng Saang district, where cassava is planted as a monocrop on gentle (5-10%) but very long slopes, large amounts of rain water ran down the slope along natural drainage channels. This caused the formation of small gullies and washed out and exposed cassava roots. The diversion ditches and bunds constructed above each trial were often inadequate to stop this deluge, and sediments brought in from outside the plots often filled the erosion channels, making it impossible to accurately measure the effect of each treatment on erosion. In Wang Nam Yen district, slopes tend to be steeper but shorter and the clay-loam soil has much greater aggregate stability, which resulted in less serious erosion and less problems of sediments from outside the plots filling the erosion channels.

Cassava as well as the vetiver grass hedgerows grew well in both locations. Other hedgerows, like sugarcane (for chewing) or mulberry bushes did not establish so well and left wide spaces between plants, causing water to run unimpeded down the slope. When asked what practice they considered most effective in reducing erosion, almost all farmers in both pilot sites mentioned the vetiver grass barriers. Some, however, considered sugarcane or mulberry as attractive alternatives, since these crops can provide additional income. One farmer also mentioned that mulch of dry grass was more effective in reducing erosion than his vetiver grass barriers.

At the time of harvest, in each site a field day was organized to harvest together, farmers, researchers and extensionists, the various FPR trials, to determine in each treatment the average height of plants, and to pull out ten plants to weigh the fresh roots and determine starch content using a Reihman scale. The results were tabulated and written on large paper sheets to present to and discuss with the farmers.

Tables 6 and 7 show the average results of six FPR trials on erosion control harvested in Wang Nam Yen district and nine trials in Soeng Saang district, respectively. Since only *4-5* treatments had adequate replication, only those will be considered. In both locations cassava yields and starch contents were quite high (yields were about twice the national average), while soil loss due to erosion was low to medium. However, the latter are only rough estimates of erosion losses due to treatments, as some "additional" sediments that were believed to have come with runoff from outside the plot (as discussed above) were excluded.

In Wang Nam Yen district (Table 6) highest cassava yields and net income were obtained with the "farmers' practice" of up/down ridging; however, this practice also resulted in the highest soil losses due to erosion. Contour ridging produced slightly lower yields but significantly lower erosion losses. Vetiver grass hedgerows produced still lower cassava yields (partially due to space occupied by and competition from the hedgerows) and net income, while being only intermediately effective in reducing erosion. In spite of this, farmers overwhelmingly selected the vetiver grass as the best treatment, probably in the expectation that once the grass is better established,the hedgerows will become increasingly more effective in reducing erosion, while a better infiltration of runoff water will reduce fertilizer loss and result in better soil moisture during the dry season, while the mulching of vetiver leaves on the soil surface will help control weeds and erosion and also conserve soil moisture, which may lead to improved yields. Thus, farmers hope that the use of vetiver grass leaves as *in-situ* mulch, will give benefits similar to those obtained in the grass mulch treatment (T7), but without the hard work of carrying grass mulch onto the field from elsewhere.

In Soeng Saang district (Table 7) the "farmers' practice" of up/down ridging produced the lowest yield and the highest erosion losses. Although this practice is cheaper than any of the other practices tested, it still produced the lowest net income, clearly showing to farmers that this practice is counter-productive. The vetiver grass hedgerows produced the highest cassava yield and a high net

income, while being the most effective in reducing erosion. Contour ridging and planting sugarcane hedgerows were also quite effective in reducing erosion and increasing net income. Based on these results farmers from Noon Sombuun also overwhelmingly selected the vetiver grass as the best treatment, with contour ridges and sugarcane hedgerows as second and third best, respectively.

Most farmers were very interested in continuing the trials next year and requested additional vetiver planting material to plant in their cassava fields outside the FPR trials. That is probably the best sign of spontaneous adoption of the vetiver grass technology. However, it still needs to be seen how extensive actual adoption is, because farmers also mentioned that tractor drivers contracted to plow their cassava fields charge considerably more for plowing along the contour than for plowing up and down the slope, even on gentle slopes of less than 10%. This will be a deterrent for any farmer who wants to establish contour hedgerows to control erosion. Thus, the benefit of contour hedgerows, including that of vetiver grass, must also be conveyed to contract tractor drivers that often determine the method of land preparation for cassava farmers.

2. **Vietnam**

Field days were also organized in Vietnam to harvest and discuss the results with farmers in three pilot sites, i.e. in Kieu Tung village of Thanh Hoa district in Vinh Phu province, and in Dac Son and Tien Phong villages of Pho Yen district in Bac Thai province. During the field days, farmers looked at and discussed the amount of sediments in the erosion channels of each treatment (sediments had been collected from the channels only during the first two months, in order to let farmers see the erosion losses during the rest of the year), and pulled up at random ten plants in each plot and weighed the roots to estimate cassava yields.

Table 8 shows the results of total soil loss due to erosion, yields of cassava and peanut, and the gross and net income from each treatment in Kieu Tung village. Soil losses did not vary much among treatments, but were highest in those treatments with cassava monoculture, or where cassava was intercropped with peanut, but without fertilizer application. Soil loss was lowest in the treatment of vetiver grass barriers and cassava/peanut intercropping. This treatment also provided the highest cassava and peanut yield and thus the highest gross and net income. When asked, farmers overwhelmingly selected this as the best treatment and requested additional planting material of vetiver grass to plant in their own fields outside the trial plots. Similar results were obtained in Dac Son and Tien Phong villages of Pho Yen district in Bac Thai province **(**Table 9**)**. In both villages, the treatment of cassava/peanut intercropping with vetiver grass hedgerows produced the lowest amount of erosion and the highest or second highest net income. Based on these results, farmers from both villages in Pho Yen district voted overwhelmingly for the cassava/peanut intercrop with vetiver hedgerows as the most effective treatment to increase their incomes and protect the soil from erosion. They too requested additional planting material of vetiver grass for planting on their cassava fields next year.

During the course of the year, non-participating farmers from the village and those from neighboring villages often visited and talked about the FPR trials. Several asked to join the project in the coming year. It is hoped that when farmers themselves develop the soil conservation technology that is most suitable for their particular conditions, and they are able to see with their own eyes and through their own work what effect each practice has on. crop yields and erosion, that they are more likely to adopt those practices considered most effective. In the case of both Vietnam and Thailand this included the planting of vetiver grass contour barriers to slow down run-off, enhance water infiltration into the soil and thus reduce erosion.

Once farmers are convinced of the need to reduce erosion and committed to use soil conserving farming practices, they will show their neighbors and teach their fellow farmers about the best soil conservation practices for their region. We believe that through a bottom-up approach and farmer participation in the development of effective soil conservation practices for a particular region, farmers become more aware of the problem of erosion and the need for soil conservation practices. Farmers are the stewards of our soil resources - so essential for present and future food production - and thus should be the ones directly involved in the development of practices that maintain the soil's productivity for future generations.

(Tables, acknowledgements and references not included due to space constraint. Please contact authors for full paper..Ed)

INDIA

Fungal Endophytes of Vetiver.

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Many grass species all over the world have endophytic fungi without expressing any symptoms. Endophyte associations are known to confer certain advantages to the grass hosts such as - tolerance to drought and insect pests (Clay, 1994; Siepl & Bush, 1994). The endophytes, particularly *Acremonium* species, are also known to cause toxicosis in animals grazing infected grasses (Clay, 1994). We screened

vetiver for the presence of fungal endophytes, especially since it is remarkably free of diseases — National Research Council,1993).

Materials and Methods Leaf blade, leaf base and root bits of *0.5* cm length were cut froin South Indian Vetiver and were surface sterilized by immersing in 70% ethanol for 5 seconds, and then shaking in a solution of sodium hypochlorite (0.5% available chlorine) for 5 min. (Latch & Christensen, *1985).* Such tissues were plated on Potato Dextrose Agar medium containing antibiotics (100µ/ml penicillin and 100µ/ml streptomycin). The tissues were slightly pushed below the agar surfrce and incubated in darkness for 15 days at 30˚C (Latch & Christensen,1985).

Results and Discussion The tissues of vetiver did not have *Acremonium* as endophyte. However, other fungi were observed. Leaf and root had *Curvularia lunata,* the leaf base showed the presence of *Nigrospora oryzae* and *Ramularia sp*. A comparison of the fungal endophytes of some forage grasses such as *Panicum maximum, Cenchrus ciliaris, C. setigerus* and *Pennisetum purpureum* revealed that vetiver has a restricted numuber of fungi as endophytes.

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(References not included due to space constraint. Please contact authors for full paper..Ed)

NIGERIA

The Effect of Nitrogen Fertilization on Growth and Root Yield of Vetiver Grass *(Vetiveria nigratana)* in Nigeria (Preliminary Study)

Vincent 0. Imoh *Bulletin of the Institute of Tropical Agriculture, Kyushu University, Vol 15, December 1992, pp.49-54*

Abstract

An evaluation of the effect of nitrogen fertilization (0 kg N/ha, 60 kg N/ha and 120 kg N/ha) on the growth and root yield of vetiver grass (Vetiveria nigratana) in a clay loam soil was carried not in polybags at Imo State University, Okigwe, using a completely randomized design.

Parameters measured were the number of tillers per plant, plant height, root yield (dry) and total dry matter production (TDMP). The data which were analyzed by analysis of variance showed that an increase in the level of nitrogen led to significant increases in the number of tillers per plant, plant height, root yield and total dry matter production. Application of 60 and 120 kg N/ha gave plant height values of 96.73 cm and 103.20 cm and tillers per plant of 10.13 and 12.73 respectively, compared with 80.20 cm (height) and 6.06 (tillers) for plants that received no nitrogen (0 kg N/ha) after three months growth. Similarly, values of root yield (dry) per plant of 13.67 g (379.72 kg/ha, calculated on the basis of 60cm x 60cm plant spacing) and 18.15 g (504.17 kg/ha) and total dry matter production per plant of 34.30 g (952.78 kg/ha) and 48.53 g (1348.06 kg/ha) for 60 and 120 kg N/ha, respectively, were significantly greater than the values of 9.96 g or 276.67 kg/ha (root yield) and 19.44 g (540.0 kg/ha TDMP) produced by 0 kg N/ha plants. The number of tillers per plant and total dry matter production in vetiver grass showed greater response to nitrogen treatment than plant height and root yield.

On the basis of the results of the trial, it is recommended that for optimum vetiver grass production in clay loam soil, a high level of nitrogen nutritients should form part of an agronomic package.

SPAIN

The Introduction, Early Results And Potential Uses Of Vetiver Grass Hedge Row (VGHR) In Mediterranean Regions[1] .

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Introduction

In this project, an attempt was made to test the establishment, growth and potential uses of Vetiver grass hedgerows (VGHR) in the hostile aerial and edaphic environments of Murcia, Spain. Two sites were selected for testing , viz. El Chopillo (Latitude 38˚ 22' 08'' N Longitude 10 48' 06'' E) and Lorca (Latitude 37˚ 42' 36'' N Longitude 37˚ 37' 28'' E). The climatic conditions consist of a long dry summer with absolute maximum temperatures reaching of 42˚C in Lorca and 47˚C in El Chopillo, and a cold winter with absolute minimum temperatures of - 4˚C in Lorca and - 14˚C in El Chopillo Precipitation is low with averages of 27.51 cm per annum in Lorca and 40.45 cm per annum in El Chopillo, and with few rainy days. The relative humidity is consistently low with high evapotranspiration. Negative water balance occur over 6 months in El Chopillo and 10 months in Lorca. The soil type is quite calcareous, mostly clayey but sometimes alluvial with negligible nutrient. Hilly topography is common with serious yearly erosion rates of more 5,000 Tm / Km^2. The aim of the project is to use VGHR to minimise soil erosion and to enhance soil moisture. If successful, it will be tested as a means to improve crops, protect high-

way slopes and other embankments, as a source of biomass production and other applications.

Materials And Methods

Planting Materials used for Various Look - See Trials

i. Planting Materials for El Chopillo. A small consignment of 300 bare-root tillers was obtained from Malaysia and sent directly to El Chopillo in May 1994. They were raised in 12.5 cm x 17.5 cm polybags in a glasshouse for 11 weeks before being planted into the ground in El Chopillo on 29 July 1994.

ii. Planting Materials for Lorca
Large consignments of tillers were obtained from Malaysia in June 1994 and America in July 1994. They were planted in plastic planting trays of 37 x 30 cm; with 20 containers, of 22.5 cm deep and each container holding 800 cc of standard potting mixture (Composition 25% peat + 65% pine bark and other forest materials + 10% rice husk. Fertilization Osmocote 1.5 kg / m3, 16-8-12-2, 6-8 months). The plants were kept in a glasshouse near Barcelona with the controlled environment maintained at 18° C to 35° C and 60% - 80% R. H. Plants were irrigated for 5 to 10 minutes with a overhead mist for 1 - 3 times per day depending on the prevailing climatic conditions. They were also flooded with nutrient solution of "10-1 0-20-oligoelements" at a rate of 0.5 gm./1 once every 3 days. The bare-root tillers produced roots within 2 weeks. After 3 1/2 months, the roots had enmeshed the core of the potting mixture with the tops having 2 - 5 tillers newly produced in-site. The plants were cut to. 20 cm height before sending it to Lorca (Photo 1). They were then reconditioned in an open air container nursery (Photo 2). These container plants were used in all the field trials in Lorca.

Irrigation and Fertilization System Used In The Look - See Trials.

In Phase I of the project, the main concern was to ensure establishment of the Vetiver plants in the hostile environments of Murcia. It was therefore decided from the onset to reduce the stresses from water deficit and low nutrients by adequate supplies. Irrigation and fertilizer were applied as follows

i. Ground Nursery in El Chopillo. The plants were drip-irrigated every 1, 2 or 3 days depending on the season. Water consumption was equivalent to 6,670 m3/ha from February to October 1995. Soluble fertilizer was distributed regularly through irrigation water; from February to October 1995; the total amount used was 170 kg/ha KNO_3 + 70 kg/ha H_3P0_4 75% + 500 kg/ha $KN0_3$ 59%.

ii. Container Nursery in Lorca**.** Irrigation was supplied by overhead sprinklers at a rates of 2 l/m^2 day to 9 l/m^2/day, adjusting it according to the climatic conditions. Fertilizer was applied at rates of 0.156 gm./m^2/day, KNO_3.

iii. Ground Nursery in Lorca. Irrigation was by flooding. The amount of water used was equivalent to 700 m^3/ha over 10 occasions from February to October 1995. Fertilizer was applied by adding the equivalent of 500 kg/ha N15P15K1, before planting; and 500 kg/ha KNO_3 distributed with the irrigation water over the 10 applications.

iv. Highway Slope. Irrigation was by drip-irrigation at rate 4 l/hr/m of VGHR. The total amount of water applied from February to October 1995 was 948 l/m of hedgerow. Fertilizer was through the irrigation pipes, using a total of 151 gm/m KNO_3 over the recorded period. This area was not linked to the farm's irrigation system. The pipe system was connected to a mobile tank of 6,000 litres placed at a higher level. Drip-irrigation was by gravity, at a rate of 4 l/hr/m of VGHR. The amount of water used was about 500 l/m from April to October 1995. Fertilizer, at a rate of 180 gm/m of KNO_3 was distributed in the irrigation water over the same period.

Design For Look - See Trials.

Our main concern at the beginning of the project was the establishment of the Vetiver plants; we were not even sure whether the plants would grow!! Thus only observational trials were set up.

i. Ground Nursery in El Chopillo
204 polybag plants were planted in a single block of 4 rows on 29 July 1994. The planting distance was 1 metre between rows and 0.33 metres between plants.

ii. *Ground Nursery in Lorca.* The total trial consisted of 2 blocks of 2,917 and 2,478 plants of Malaysia Accession, and 3 blocks of 2,587 ; 2,685; and 2,745 plants of American Accession. They were planted into the ground nursery on 5 - 19 December 1994. The block size was about 0.1 hectare and the planting distance was 0.33 metres with 1.00 metre between rows. Because the blocks were of irregular shape, the number of rows varied from 12 - 16 per plot and the number of plants per row varied from 150 - 200.

iii. Highway Slope. A trial was undertaken to test the effect of VGHR to prevent soil erosion on the Highway slope of 12 m vertical height and with 320 gradient. The slope construction used a rocky gyspic base covered with very irregular, unstable, not consolidated, clay soil. 3 blocks of 20 metres width were selected with the outer blocks planted with VGHR and the central block as control. Vetiver container plants were planted at 5 cm between plant distance and the VGHR were at 1.0 metre vertical intervals . 12 full length VGHR were planted in each block and the total plants used were 10,258. The VGHR were planted on 4 - 9 January 1995.

v. Almond Plots**.** Three VGHR of 90 metres length were planted between blocks of four almond rows on 7 April 1995. The between-plant distance was 5 cm and a total of 6006 container plants were used.

Observations Made.

i. Serial photos of the container nursery in Lorca were taken weekly, while for all the other ground trials, photos were taken at approximately monthly intervals. Qualitative assessment of plant performance were from examining these collections of photos.

ii. Quantitative count of tiller production and dry weight production were done by harvesting the tops as follows:-

a) Ground Nursery El Chopillo 4 groups of 6 - 8 plants each were cut at 20 cm from the ground. The fresh weight was measured and numbers of tillers of each top were taken. Subsamples were taken to obtain oven - dry weights.

b) Ground Nursery, Lorca To remove boundary effect, the boundary rows were topped by a mechanised grass cutter to facilitate sampling in the immediate adjacent rows. 3 groups are randomly selected and the plants were cut manually at heights of 20 cm. For the Malaysian Accession, 15 plants were sampled per group per row of each of the 2 blocks. For the American Accession, 10 plants were sampled per group per row of each of the 3 blocks. The fresh weight and tiller number of each top were noted in the field. Sub - sample's were taken to obtain oven - dry weights.

iii. Root Examination. Excavations to examine the root systems were carried out in September 1995. A backhoe was used to dig a large pit next to a group of plants ranging from 4 plants in El Chopillo to 7 plants in Lorca. To ensure the roots were not damaged, a gap of at least 20 cm were left between the hole and VGHR. A pressure pump, linked to a water tank, was used to wash away the soil and expose the roots.

iv. Meteorological Data were obtained from the official stations near the trials sites. For this paper, we concentrated on the maximum and minimum temperatures and rainfall as given in Appendices 1 and 2.

Results

1. Establishment and Growth of Plants in Ground Nursery, El Chopillo. This was essentially our first observation block. The 11 week old polybag plants were transplanted into the ground in July 1995 in the warm weather of summer with very good transplanting success of 99.5%. Growth was good between August - September 1994 (Photo 3) with very vigorous growth from October to early December 1994. Subzero temperatures occurred between 23 - 28 December 1994 and the frost killed all the exposed tops. However, the buried crown-portion survived and by early February 1995 new tillers started to emerge. (Photo 4) From then to May 1995 there were rapid tiller productions. A census taken in June 1995 showed that 81.8% of the plants have fully recovered from the winter frost. Good growth was observed in June 1995 (Photo 5) followed by very vigorous growth rates from August to November 1995. (Photo 6)

Harvesting of the tops were carried out on two occasions. (Photo 7a) . The differences between the dry weights obtained in the 2 harvests suggested rapid biomass production in autumn 1995. This was confirmed by the very rapid regeneration of the cut tops. (Photo 7b + 7c).

Excavation showed the root system to have reached 2.6 metres deep, with very dense root mass on the first 0.5 metre depth. (Photo 8)

2. Establishment and growth of Container Plants in Lorca. The plants in planting trays, in the glasshouse in Barcelona, were cut back to 20 cm height and transplanted on 2 occasions viz.: 27 October 1994 and 10 November 1994, to a open air container nursery in Lorca (Photo 2). The plants transported well with no sign of transporting shock and practically no casualty. They stayed a healthy green colour but with little growth; the young tillers barely increased in height over the next few weeks. With the decreasing cold temperature in December 1994, the matured green leaves became bleached, turned yellowish and finally after sub-zero minimum temperature over 7 days in end December; they were killed and turned straw colour. Throughout this period, the young tillers continued to retain the green colour and turned dull green only after the sub-zero minimum temperature. On site examination showed that, whereas the matured leaves were killed, the young tillers and the crown region was alive. The dull green colour of the young tillers persisted through to March 1995, when, with the warmer weather, a healthy green colour was re-attained and growth resumed. Then, new tillers were also noted. Container plants were taken out for planting at various times, into the ground starting from 5 December 1995 and ending 7 April 1995. Towards the end, each container plant had a few actively growing tillers. The overall establishment success of field planting 32,498 container plants was 95.9 %.

3. Establishment and growth of plants in Ground Nursery, Lorca. At the time when the container plants were taken out, the cold weather had already turned the matured leaves to bleached yellow colour, but the young tillers were still green. After the transplanting and after the frost

in late December 1994, the matured leaves dried up into straw colour (Photo 9a); even the young tillers turned a purplish-green to straw colour. This condition persisted into the cold period of January - March 1995. With warmer weather in April 1995, the young tillers regained a healthy green colour and there were new tillers. By May 1995, there were good tiller production, followed by growth in June and July 1995. Very rapid growth was observed from August 1995 onwards (Photo 9b + 9c). Census taken on 4 July 1995 showed the overall establishment success to be 89.1 %. On two occasions, assessments of growth were carried out by topping the plants (Photo 10a)

The dry weights between the 2 harvests were substantially different indicating vigorous growth. Observations of rate of regeneration of cut tops confirmed this view (Photo 10b). Excavation of roots were carried out. The roots of the American Accession has reached a depth of 1.7 m while those of the Malaysian Accession was 2.1 m (Photo 11). However, the main and pronounced root mass was in the upper 0.4 metres, and there was no apparent difference between the 2 accessions.

4. VGHR to protect Highway slope. Planting was done on 13 - 17 January 1995, at which time the plants in the containers was suffering from the cold December weather; the mature tillers were dead and the young tillers were dull green in colour (Photo 12). However by late March, the young tillers had turned a healthy green colour and by April / May, new tillers were being formed. Very rapid tiller formation and good growth occurred between April and July followed by vigorous growth from August 1995 onwards (Photo 13). The overall establishment success was 98.8%. Observations in late September 1995 showed that the VGHR had effectively reduced soil erosion in the planted plots (Photo 13). Severe erosion had occurred in the control plots despite the low rainfall of 740 mm over 24 days since the establishment of the trial (Photo 14a + 14b).

5. VGHR to improve Almond Plots. At the time of planting in April 1995, the container plants had fully recovered from the frost injury; the young tillers were actively growing with healthy green colour and there were also new tillers being formed (Photo 15a). The plants established very fast with a good success of 99.3 %. From the beginning of transplanting new tillers were produced and by July, useful hedgerows had been formed. Growth from August 1995 was rapid (Photo 15b). In this trial, it is hoped that the VGHR will serve to slow down the surface rain wash thus improving infiltration and conserving moisture. There were also plans to cut the tops of the VGHR to mulch the almond plants. The effect of VGHR on almond production will be studied using the 2 adjoining plots as controls.

6. General Field Observations. In the field, some interesting observations were made

(i) Both the Malaysian and the American Accessions had not flowered though plants had many morphologically matured culms with distinct nodes.

(ii) The morphology of the Malaysian Accession in Spain seemed to be different from the same Accession in Malaysia. The culms of plants in Spain were clearly bigger and taller than the same Accession grown in Malaysia. However, the internodes were surprisingly shorter. In addition, there were very few culm-branches in the plants grown in Spain.

(iii) Plants in the boundary of blocks of Vetiver grass tended to be less vigorous and showed more stress symptoms of dying of the leaf tips, when compared with plants growing in the centre.

Discussion And Conclusion

There do not appear to be any documented record of Vetiver grass having been successfully grown in Mediterranean climate. Dr. Francoise Dinger reported his failed attempt to grow Vetiver in Draix (Haute-Provence Alps, France) in the Vetiver Newsletter #6. We are happy to have successfully established Vetiver grass and to be able to study the performance of VGHR in Murcia.

Field Establishment of VGHR Under Mediterranean Climate. Due to various logistic requirements, the large number of container plants were transplanted to the ground beginning 5 December 1994 and ending 7 April 1995. This, fortuitously, allowed the study of plant development stages on the transplanting success, establishment and growth under different weather conditions. It also permitted observing container plants over a longer period. Observations from the various trials in Lorca showed that new tillers were largely produced in May regardless of the time of the first transplanting into the field. The same time of new tiller production also occurred in the container plants. In addition, there was a distinct trend that plants taken out during the warmer weather have better establishment success. This ranged from 89.1% in the Ground Nursery (planted December 1994) through 98.8% in the Highway slopes (planted January 1995) to 99.3% in the Almond Plot Trial (planted April 1995). Therefore, it would appear that plants should not be taken out too early. In addition to better establishment success, the plants would be easier to irrigate and maintain in the container nursery. Based on this first set of results, it appears that the best time to take out container plants may be in the spring months of March / April. However, this gain in ease of management and less water

usage must be weighted against the advantage of winter planting with its least competition for labour; spring planting is normal for the main crops.

Growth and Biomass Production A most interesting field observation was that the plants in the boundary rows were smaller than those in the central rows and showed more stress symptoms. This occurred in all 5 ground nursery blocks and in the 2 Highway slope blocks. This is different from observations noted in the tropics where the central rows consistently performed poorer because of the shade sensitivity of Vetiver. This new observation may be due to the high solar intensity and the long sunlight hours during the growth period of May - September 1995 and the negative stress effect of low relative humidity. If so, moisture and water stress have become a stronger limiting factor when compared with light effect. Due to the growth pattern, biomass determination of the tops were not done until the plants have gone through some months of the active growth period. Active growth of plants in ground nurseries started in May 1995 in El Chopillo, but commenced in June / July in Lorca. This difference was most likely due to the different times of planting. Though the El Chopillo plants were damaged by winter frost, they already had an established root - system, and plant growth can take off faster. On the other hand, plants in the ground nursery in Lorca were only transplanted to the ground just before the winter 1994-5 and the plants will take time to establish first. Harvesting of plant tops in El Chopillo produced 1030 gm and 1388 gm per plant after 14 and 15 months respectively. For the same 2 periods, the number of tillers per plant were
55 and 67 respectively. In reality, as the tops of plants were killed during the frost of winter
1994-5, this biomass production was over a growth period of 5 and 6 months. These values
were high and showed good growth of the Vetiver plants.

In the ground nursery in Lorca, the Malaysian Accession produced 45 and 47 tillers after 9 and 10 months growth respectively. Over the same periods the dry matter were 305 gm and 489 gm per plant respectively. The American Accession yielded 377 gm with 79 tillers and 560 gm with 65 tillers after 9 and 10 months respectively. After deducting for establishment time, the growth periods were only 4 and 5 months. It would appear that the American Accession was more vigorous than the Malaysian Accession but it must be noted that the trials were not designed for such comparisons; also the plants were rather variable as there were no stringent selection of container plants used for field planting.

In both El Chopillo and Lorca, the cut tops regenerated rapidly confirming the good growth of Vetiver grass m autumn. Whether the impressive growth during the growing seasons is sufficient to compensate for negligible growth during the dormant and sustenance seasons to give good annual biomass production, will be the subject of future investigation.

The good growth of Vetiver grass and the rapid regeneration of cut tops point to potentially abundant in-site mulch to improve the main crops; this will be tested in the almond plots. Also the toppings may be considered for fuel, fodder, animal bedding, etc. The fast establishment of quality VGHR could be used to prevent surface soil erosion, as was clearly demonstrated in the observation trial on Highway Slopes.

Root System And The Need For Irrigation. Excavation to study the root systems showed that the roots of the plants in El Chopillo had reached a depth of 2.6 metres after 14 months in the field. In Lorca, the Malaysian Accession and the American Accession had produced roots reaching down to 2.1 metres and 1.7 metres respectively after only 9 months. However, m all 3 cases the massive root system was at the top 0.4 - 0.5 metres. The root Systems observed were not inferior to the condition experienced in Malaysia. In this project, there was an attempt to grow Vetiver grass in the Mediterranean climate of Murcia. Vetiver grass originated mainly from the humid tropics and it will therefore be most challenging to try to establish it in such an alien and hostile aerial conditions. For the first Phase of the project, Vetiver grass was irrigated to allow it to have a better chance of establishment so that its growth performance may be studied. However, irrigation is expensive and m certain locations, water may not be readily available. The ultimate economic success may ultimately be determined by its tolerance to water stress.

With the good root system produced, the plants may be able to tap into the sub-soil moisture during drought and that VGHR, once established, may be tolerant of dry weather conditions. This is a very important speculation as the need for continued irrigation may make VGHR not economically viable. Therefore, more experience is needed in order to confirm this key aspect of the project. Phase II Trials will be targeted to achieve this objective.

Plant Response to Climatic Conditions. Since there is no easy nor economical way to modify the temperature in the field, we decided, in Phase I of the project, to concentrate on studying its effect on the establishment and growth of Vetiver plants. The responses of the plant to the seasonal weather conditions showed very interesting results. With plants established in the ground in El Chopillo, frost killed the tops but the crown-portions were not injured. With the coming of the warmer weather, new tillers were formed. In the Container Trial in Lorca, the cold winter killed the matured tillers but not the newly emerged ones. This recovery from cold damage was not surprising as the Vetiver Newsletter had carried such

observations made in China, U.S.A., South Africa, Zimbabwe, etc. The plants in El Chopillo recovered from frost injury and cold weather much faster and produced tillers earlier than the plants in Lorca. The main reason may be, that the plants in El Chopillo were well established with a good root system while the plants in Lorca were being established in the field or were in containers exposed to the aerial environment. The depth of root in the warmer ground could be of importance in the plant's tolerance to cold as well as water stress. These observations, documented by serial photos, suggest that there seem to be distinct plant performance periods (at least under irrigation) viz.

- Frost injury and dormancy
- Awakening and tillering (regeneration or multiplication)
- Rapid growth and biomass production
- Slow growth or sustenance period.

The last period need to be verified during the coming 1995 - 6 late August to early winter months. If these observations were correct, the tropical to subtropical Vetiver Grass is behaving more like a temperate plant, adapting to the prevailing climatic conditions. This adds on to the documented great range of adaptabilites of Vetiver Grass, a very unusual plant indeed. It also points to the possibility of using VGHR in the Mediterranean regions as well as up in the cold highlands of the tropics and sub-tropics.

GHANA

Adaptive Research Collaborative Programs.

Linus Folly - *CEDIA, Ghana*

An adaptive research package is being worked out between CEDIA and the National Agricultural Research Project (N.A.R.P.) of the Council for Scientific and Industrial Research (C.S.I.R.) on vetiver grass in the area of Research and Development covering among others:

- collection of clones;comparative study and germplasm analysis;
- classification of ecotypes to march soil types and agroecological zones;
- selection of suitable genotypes for development, multiplication and propagation;
- research on pest, entomological and other related issues;
- setting-up of a data base ...

Another collaborative package on the drawing board is a Training, Application and On-Farm Trials program between CEDIA and the Department of Agricultural Extension Services (D.A.E.S.) of the Ministry of Food and Agriculture.

The Land and Water Management Unit of the Crops Services Department (C.S.D.) of the same ministry has also shown interest to include the use of vetiver grass in the syllabus for its training programs.

Other departments such as Irrigation Development Authority; Animal Production; and Fisheries Department are all targets of the package. Sectors like mining; roads and highways; land and forestry; environment, science and technology are becoming abreast with vetiver grass. Mining companies, such as Bogosu Billinton and Teberebie goldfields, are showing among others good examples of how to rehabilitate mine spoils, slime dumps and to restore vast areas of land with vetiver grass.

The last component of this package is the projected collaborative program between CEDIA and the Department of Parks and Gardens. This department had already given CEDIA a substantial quantity of polybags for the multiplication of vetiver slips on trial basis.

It is worthy to know that the binary section of Ghana Atomic Energy Commission (G.A.E.C.) has both the human and the technical capacity to produce the requisite quantity of vetiver slips by tissue culture production and multiplication techniques for CEDIA whenever a comprehensive agreement is reached between the two parties.

USA

Streamside Buffer Strips Improve Water Quality and Provide Wildlife Habitat

Richard Schultz *Iowa State University. USA*

Bountiful production of corn and soybeans can cause pollution of streams and groundwater. Along many miles of Iowa streams, row crops are grown down to the stream edge or cattle are grazed in narrow bands of land that include the stream and its flood plain. Before European settlement, Iowa had many more miles of streams that carried cleaner water than today. Floodplain forests, prairies, and wetlands along the streams regulated water flow and quality and provided wildlife habitat. As these plant communities were cleared and laid fallow for part of each year, and as many fields were tiled and stream channels were straightened, large amounts of soil and chemicals were carried to the streams. Streams carried more water after rains, which collapsed streambanks and caused them to erode deeper into the landscape.

Concerns about water quality and an interest in reestablishing forests, prairies, and wetlands in Iowa and the Midwest led the Iowa State Agroforestry Research Team (IStART) and the Agroecology Issue Team of the

Leopold Center for Sustainable Agriculture to develop a streamside management system. The multispecies system uses trees, shrubs, and prairie plants as a buffer strip along a stream. The basic model consists of four rows of trees planted along the stream edge, followed by two rows of shrubs and then a strip of prairie plants planted along the edge of the crop field. This plant community provides a frictional surface that "stops" surface erosion and causes most of the nitrate contained in the tile water. Microbes attached to sediments and decaying plant material use the nitrate molecule in place of oxygen to provide them air to "breathe" while releasing harmless nitrogen gas into the atmosphere.

The streamside management system, in concert with upland water and chemicals to soak into a "living filter" made up of soil, plant roots, microbes, and soil animals. Water moving through this filter is cleaned and slowly released to the stream channel. Many variations of this model, with widths from 50 to 100 feet, can be planted depending on the landscape features and landowner objectives. The rich soil along the stream edge can support many species of trees, shrubs, and prairie plants. The key is to get this plant community rapidly established. To accomplish this, fast-growing trees such as willow, poplar hybrids, and silver maple are usually planted in the two rows closest to the stream. The other rows may consist of fine hardwoods such as black walnut, oaks, and ash. Many species of shrubs can be planted to diversify the habitat for wildlife. This system has been shown to reduce chemicals and surface erosion by as much as 80%. Four times more bird species use this system than use the straightened streams where corn and beans are grown to the edge. If planted as a short-rotation woody crop or biomass energy system, all of the woody rows can be planted with tree species such as willow, poplar hybrids, or silver maple. The switchgrass strip provides an herbaceous energy crop.

Another important component of this system is the use of willows and certain shrubs to stabilize the streambanks themselves. As much as 50-60% of the sediment carried in streams can come from the collapse of streambanks. Woody tree and shrub species that are able to produce roots from stem segments are pounded or pushed into the conservation practices such as minimum tillage, grass waterways, and terracing, can effectively reduce pollution produced by agriculture. At the same time it can provide diversified products for the landowner and a diverse habitat for improved wildlife and aesthetics. Native trees and shrubs together with prairie ....streambank, where they hold the soil in place once they have rooted and grown tops. The amount of work needed to assure success of this procedure depends on the height and shape of the streambank. Where streambanks are less than four feet high, it is possible to simply push or pound two rows of willow posts, large cuttings up to 4-5 feet long, along the bottom of the bank. Higher up the bank, smaller cuttings are pushed into the bank. If the banks are 4-10 feet in height, the toe of the bank must be specially stabilized with rock or red cedars to reduce the chance of undercutting and collapse of the streambank. Willow posts and cuttings are planted between the cedars or rock. Where vertical streambanks are 10 feet or more in height, equipment is used to produce a gentler slope (2:1). Grass may be seeded and a fiber mat staked down before the willow and shrubs are planted. In this case, stabilizing the toe of the bank with cedars or rock is even more important. These streambank bioengineering techniques can effectively stop erosion along critical streambanks and protect such structures as bridges, buildings, and fences that may be threatened by channel erosion.

The last component of the streamside management system is a small constructed wetland built within the buffer strip where a field tiledrains into the stream. A shallow depression, no deeper than 2 feet at the center, is excavated and planted with cattails, bulrushes, and other wetland plants. Such wetlands, when properly designed and maintained, can remove plants can help improve water quality and protect the long-term sustainability of Iowa and Midwestern farmland.

(in "warm winter" areas of the US vetiver coul;d be easily worked into such systems and would be very effective ... Ed).

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AQUACULTURE SLUDGE REMOVAL AND STABILIZATION WITHIN CREATED WETLANDS

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Introduction Removal of solids or nutrients from the effluents of fish farms is often required because of priority and regulations given to minimizing the effect of the discharge on the environment (Ewart et al., 1995). Aquaculture systems offen have two separate discharges, and solids and/or nutrients in both, if left untreated, can have a negative affect upon receiving waters. When systems have two separate discharges, the effluent of largest volume usually contains comparatively low levels of solids and

nutrients, particularly nitrogen and phosphorous. A second effluent, generated during clarifier backwash, is comparatively small but contalns high levels of concentrated organic solids. The settleable fraction of solids are often removed with settling basins to produce a siudge that is about *5%* solids. Many states in the US classify and regulate aquaculture sludge as an industrial or municipal waste, because the sludge is a residual product of wastewater treatment; however, other states consider the sludge to be an agricultural waste, because it is composed of manure and uneaten feed and is thus considered to be a non-toxic nutrient source (Ewart et al., 1995).

Aquaculture effluents such as these, however, do not have to be considered liabilities, because these effluents can be used as inputs for production of other products and used to improve overall facility sustainability. To better achieve sustalnability in aquaculture, *The Conservation Fund's Freshwater Institute* has been working with the *USDA/ARS Appalachian Fruit Research Station* on a project titled, "Aquaculture Linked to Plant Culture: Products and Processes." Research has been focused on developing technology to treat nutrients or biosolids in aquaculture effluents while producing other valuable products such as high-value fruits and vegetables (Adler et al.,1996 a; b; in press a), grass turf (Adler et al., in press b), and organic composts (Adler et al.,1996b). Although reuse of effluent streams is always worth considering, it is sometimes difficult to develop the technologies and markets required to support reuse as a form of effluent treatment.

The two most common methods used to recycle solid wastes from aquaculture facilities are land application and composting (Ewart et al., 1995). According to Ewart et al. (1995), land application of manure and other organic wastes (including wastewater) to fertilize agricultural crops is governed in most states by guidelines or regulations that limit the amount of pathogens, heavy metals, and other contaminants and the land application rates. In particular, application rates are based upon nutrient content, soil type, and plant nutrient uptake characteristics to prevent runoff or groundwater contamination (Chen et al., 1991; Ewart et al., 1995). Odor problems can also limit land application in populated areas. Sludge transport from the facility to another point of disposal or reuse is a major factor in the costs of sludge management, because the thickened sludge is greater than 90% water (Black and Veatch, 1995; Reed et al. 1995).

Depending on an aquaculture facility's location and the local regulations, an aquaculture facility may have only limited and costly options avallable for sludge disposal. If land application is not available adjacent to the facility, on site treatment of the concentrated solids discharge with an uncomplicated, low-maintenance plant-based system could reduce solids disposal costs (Outwater, 1994).

Created horizontal flow wetland (HFW; i.e., overland flow wetland) systems have been used with some success to treat high-strength aquacultural wastewaters (Pardue et al., 1994) and other agricultural, municipal, or industrial wastewaters (reviewed by Reed et al. [1995]). HFW systems are usually operated with a hydroperiod to produce cycles of inundation and dewatering. However, HFW systems typically are not loaded with thickened sludges.

On the other hand, constructed vertical-flow wetland (VFW) systems have been used, over the past 20 years to treat thickened sludge (1-7% solids) produced in the clarifier undefflow at wastewater treatment plants (Hofmann, 1990; Lienard et al., 1990; Nielson, 1990, 1993; Riggle, 1991; Outwater, 1994; Reed et al., 1995). VFW wetlands are generally referred to as "reed beds" because they are often planted with reeds. When used for municipal treatment, these wetlands are loaded with 7-10 cm of 2% solids approximately once every 7-21 days (about 30-60 kg/m2/yr). During operation, a series of vegetated beds receives sequential batch applications of sludge. The sequential batch applications are such that the more recently flooded VEW cells are dewatering, wffile beds with older sludge applications are drying. Intervals between sludge addition allow for dewatering and drying. Plants facilitate dewatering by conducting water along their stem and root paths through previous sludge layers and by removing water through evapotranspiration (Outwater, 1994; Reed et al., 1995). The plants also increase biological stabilization of the solids by transporting oxygen to their root zones. Reed bed treatment system have been reported to have a useful lifetime of up to 10 years (Outwater, 1994; Reed et al., 1995).

Aquaculture sludges are good candidates for use in both crop or created wetland. However, if transportation costs make sludge disposal on crop land uneconomical, disposing of the sludge on-site within created wetlands might be the next best alternative. The objectives of the work reported in this paper were to investigate disposal and treatment within created wetlands of an aquaculture sludge produced during clarifier-back-wash. This research focused on the variables controlling capture and stabilization of solids within created wetland systems. Solids removal and stabilization were investigated within two types of created wetlands where water flowed either: (1) vertically, down through a porous substrate; or (2) horizontally, over soil and through hedges. These two wetland types differed in both physical characteristics and in hydraulic distribution and collection.

Both created wetlands types were planted with vetiver grass *(Vetiveria zizanioides).* Vetiver grass was selected

because it is tolerant of a wide range of environmental conditions, and has been proven to control soil erosion throughout the world (Becker, 1992) when planted as narrow hedges, the dense vetiver shoots act as a filter, allowing water to pass through while holding soil back to settle by gravity, thereby preventing erosion.

Vetiver also has an extensive and deeply growing root system that would help malntains the bed's hydraulic conductivity and contribute to oxygen transport into the bed.

Methods Sludge used in these studies was collected from the recirculating trout-production system at the Freshwater Institute (Heinen et al., 1996). Sludge originated from the clarifier backwash and was collected and thickened to about 5% solids in a septic tank before it was pumped to the greenhouse where the wetland cells were located. However, the manner in which the sludge was collected and pumped from the septic tank to the equalization tank within the greenhouse diluted the sludge to about 0.75% dry solids by weight. Sludge pumped from the equalization tank was thoroughly mixed before it was applied to the wetland cells. Solids loading onto both horizontal and vertical wetland types was about 30 kg/m/yr. About 60 l of sludge was applied 6 times daily per wetland cell, approximately evety day from May 12, 1995, until February 18, 1996. No draln and dry period was provided for either type of wetland. However, on three occasions, flow to the HFW cells had to be discontinued for several days to prevent water levels from over-flowing the vessels. Flow rates to each wetland were checked three times per week. Occasionally, a plugged distribution pipe kept sludge from being applied to a given wetland cell.

Six 3.7 x 1.2 x 0.8 m (L x W x H) wetland cells were used to provide three replicates for both types of vetiver beds.

The VFW cells (Figure 1) are sand drying beds planted with vegetation. The VFW cells consisted of a 10-cm layer of sand and three layers of increasingly larger gravel to support the sand over a flow collection pipe (Figure 1), based on criteria provided by Cooper (1993). Sludge was distributed across the top of each VFW cell through a 2.5-cm inside diameter pipe (Figure 1). Solids were trapped on and within the sand as the flow passes vertically through the bed. A 7.5-cm inside diameter drainage pipe at the bottom of the bed collected and carried the flow from each VFW cell. Each VFW cell sloped 2% down to the point where the draln pipe exited the tank. Vetiver tillers were planted at about 15-cm intervals across the entire top of each VFW cell.

The HFW cells (Figure 2) were designed to have the flow travel overland, passing horizontally along the tank's long axis, from one narrow end of the cell to the other. The HFW cells were loaded to a depth of 51 cm with a local topsoil. Rooted vetiver shoots were planted close agalnst each other in three 35-cm wide rows; each row was oriented perpendicular to the long axis of the vessel, and each row was about 61 cm apart (Figure 2). About the same number of vetiver tillers were planted in a HFW cell as in a VFW cell. Sludge was distributed at the upper end of the tank onto a brick to disperse the energy of the flow. The flow passed through the vetiver hedges in the process of traveling from one end of the wetland to the other (Figure 2). The dense shoots of mature vetiver hedges were expected to enhance solids removal by straining and settling. After passing horizontally through the wetland cell, the flow was collected in a perforated draln pipe placed at the end of the cell's long axis and buried under sand and three supporting layers of gravel. Each HFW cell sloped 2% down to the point where the drain pipe exits the tank.

Data was collected on influent and effluent concentrations of total suspended solids (TSS), total volatile solids (TVS), total and dissolved chemical oxygen demand (COD), nitrate, dissolved phosphate, total nitrogen, and total phosphorus. Data was collected on 11 separate weeks from June through February. TSS and TVS were measured using standard methods (APHA, 1989). Total and dissolved COD were measured using a Hach spectrophotometer test kit (Loveland, Colorado). In water samples, nitrate and phosphate were quantified by ion chromatography (APHA, 1989) as described by Adler et al. (in press b). After chemical digestion, total kjeldahl nitrogen (TKN) and total phosphorus were determined by ion chromatography as described by Adier et al. (in press b).

Sludge depths and sludge samples were also taken from each wetland at the end of the 1-yr study and were analyzed for percent volatile solids.

Results And Discussion Results indicated that sludge removal and stabilization occurred within both wetland types (Tables 1 and 2). The VFW and HFW cells, respectively, removed 98 and 96% TSS, 91 and 72% total COD, and 81 and 30% dissolved COD (Table 2). Because little dissolved COD was expected to be removed by physical mechanisms, the increased removal of dissolved COD within the VFW cells was likely due to better anaerobic digestion occurring within the sand and gravel layers of the VFW cells. Both wetland types removed most, 82-93%, of the dissolved phosphate, total kjeldahl nitrogen, and total phosphorus (Tables 3 and 4). Nitrate was produced in both wetland types; however, there was much more nitrate in the effluent from the VFW cells than from the HFW cells (Table 3). Particulate phosphorus were the major form phosphorus in the treated effluent from both wetland types (Table 3). Nitrate was the major form of nitrogen leaving the VFW cells (Table 3).

Nitrate production (Tables 3 and 4) indicates that there was some aerobic bacterial activity (e.g., nitrification) in both types of wetland cells. Although the saturated regions of both VFW and HFW cells were mostly anaerobic, localized aerobic conditions may have been created within wetlands through either root transport of oxygen or by aeration of the flow as it trickied through cells than in the HEW cells, probably because oxygen was transferred from the atmosphere as the flow trickled through the aerated gravel-support layers. Denitrification probably accounted

Table 1. Mean (±standard error) concentrations of TSS, TVS, percent volatile solids, total COD, and dissolved COD fed to and within the effluent of two wetland cell types.

Wetland type	TSS (mg/L)	TVS (mg/L)	Volatile solids (%)	Total COD (mg/L)	Dissolved COD (mg/L)
Influent	7,860±1849	6,204±362	82.8±1.6	6,855±125l2,	173±110
Effluent					
Vertical flow	156±29	93.3±14.4	572±2.3	539±134	419±68
Horizontal flow	229±30	147.51±17.9	65.l±1.5	1,761±289	1,486±136

Table 2. Mean (± standard error) percent TSS, TVS, percent volatile solids, total COD, and dissolved COD removed across two types of wetland cells.

Wetland type	TSS	TVS	Volatile solids	Total COD	Dissolved COD
Vertical flow	97.2±0.8	98.0±0.4	3041±3.6	91.3±1.9	81.0±3.0
Horizontal fiow	95.8±0.9	96.8±0.6	21.1±2.7	71.9±4.2	297±7.6

Table 3. Mean (± standard error) concentrations of nitrate, phosphate, phosphorus fed to and within the effluent of two wetland cell types,total kjeldahl nitrogen, and total kjeldahl phosphorous fed to and within the effluent of two wetland cell types.

Wetland type	Nitrate (mg/L as N)	Phosphate (mg/L as P)	Total kjeldahl nitrogen (mg/L as N)	Total phosphorus (mg/L as P)
Influent	0.057±0.009	1061±7	234±20	238±19
Vertical flow	4541±8.7	7.07±1.38	269±3.5	309±3.2
Horizontal flow	0.381±0.14	8.96± 1.72	32.5±28	422±3.4

*only a few data points were avallable.

Table 4. Percent increase of dissolved nitrate and percent removal of dissolved phosphate, total kjeldahl nitrogen, and total phosphorus across two types of wetland cells.

Wetland type	Net nitrate production	Phosphate removal	Total kjeldahl nitrogen removal	Total phosphorus removal
Verticalfiow	80,000	93	89	90
Horizontal flow	570	92	86	82

the gravel-support layers within the vertical flow wetlands. The lower gravel layers were not saturated with water due to the large void spaces between large pieces of gravel. However, much more nitrate was produced in the VFW for the removal of some nitrate from both wetland types, but the low level of nitrate in the effluent from the HFW cells may have been due to both insufficient oxygen transfer for nitrification, and to anaerobic conditions that

caused rapid denitrification of nitrate when it was produced.

At the end of the study, depths of accumulated sludge in each wetland averaged 11 and 8.1 cm in the VFW and HFW cells, respectively. Although the density of the accumulated sludge was not measured directly, the sludge that accumulated within the VFW cells was less dense than the sludge that accumulated within the HFW cells due to the presence of large voids (air pockets) within the sludge from the VFW cells. Additionally, these sludges contained an average of 43 and 37% volatile solids, respectively. In comparison, the fraction of volatile solids in the sludge that was treated was about 83% volatile (Table 1), and it was 57 - 65% volatile in the treated wetland effluents (Table 2). Therefore, considerable mineralization occurred in the accumulated sludge.

Resistance to water flow through the wetland cells was greater within the HFW cells than in the VFW cells, as indicated by deeper water ponded above the HFW surface (on average 12-18 cm deep) than above the VFW surface (on average 5-12 cm deep). Additionally, we suspect that most of the water flowed horizontally above the soil and across the HFW cells and then filtered through the sand layer covering the collection pipe at the end of the cell. The distance the sludge had to flow horizontally and the thickness and number of hedges in the HFW cells were probably inadequate to physically remove most of the solids. These conclusions were supported by observations of the vetiver hedges and the sludge distribution across the top of the HFW cells at the end of the experiment, which indicated that the three hedges planted across each HFW cell did not develop stem and root masses thick enough to trap most of the solids. Performance may have been enhanced by allowing hedges to thicken more before application of sludge began. Therefore, we think that the similar and favorable particulate removal found in both the HFW and VFW cells were largely due to the sand layers that cover the effluent collection pipes within each wetland cell.

In this research, solids were loaded onto both horizontal- and vertical-flow wetland cells semi-continuously at a rate of 30 kg/m2/yr. Sludge was loaded on the wetland cells at about the same rate as others have recommended for wetland drying beds (Hofmann, 1990; Lienard et al., 1990; Nielson, 1990, 1993; Riggle, 1991; Outwater, 1994; Reed et al., 1995); however, sludge used in this experiment was relatively dilute (0.75% dry solids) when compared to the thickened sludges (1-7%) these same others reported. Additionally, the semi-continuous application of sludge in this experiment meant that only a small volume of sludge was distributed at any given application. Over a two-week period, the more dilute sludge concentrations applied (i.e., higher water content) resulted in a higher hydraulic loading rate than others generally applied to VFW cells (Outwater, 1994; Reed et al., 1995). After the first few weeks of operation, the hydraulic loading used in this experiment always maintalned a flooded condition. Maintaining surface flooded conditions was our original intent when we selected semi-continuous applications. We expected that, when flooded, the sand layer of the VFW and the soil within the HFW would make effective anaerobic filters, which proved true. This hydraulic loading strategy was contrary to conventional wisdom, as others have recommended altemating flooding and drying intervals to enhance plant growth and sludge stabilization by air- and photo-oxidation (Hofmann, 1990; Lienard et al., 1990; Nielson, 1990, 1993; Riggle, 1991; Outwater, 1994; Reed et al., 1995). It is generally held that an aerobic environment helps to minimize odors, breaks down organic matter more rapidly, and makes phosphorus less susceptible to leaching than would anaerobic conditions. However, it is also generally believed that an anaerobic environment stabilizes sludge to its minimum solids mass and requires less energy (e.g., trickling filter height, blower/aerator power) than an aerobic environment. Additionally, this study showed that the the anaerobic-sand filter proved effective at removing dissolved organic molecules.

At the conclusion of the experiment, root growth was observed when all material was removed from the wetland vessels. Root growth was thick below the vetiver all the way to the base of the 51 cm sand and gravel or soil media. Roots had even grown into the bottom drain pipes and had surrounded the bottom layers of large gravel suffiently to make manual gravel removal much more difficult.

Vegetation played an important role in dewatering the sludge, as evapotranspiration accounted for 12-20% of the water balance across both types of wetland cells during the summer months as others have also reported (Outwater, 1994; Reed et al., 1995). Plant growth was vigorous from spring until fall, when all but the base 20-25 cm of plant stem was cut and removed from all wetland cells. Much of the vegetation senesced through the winter, but shoot growth was occuring in portions of the wetlands by the end of February, 1996, when the experiment was terminated. It was apparant from the pattern of uneven shoot growth that occured in all three VFW cells, however, that some factor had limited plant revegetation within the lower third of each HFW cell. There was a total lack of vegetation in these regions. It is uncertain why revegetation did not occur in the lower regions of the VEW cells. However, because both the sand surface and the vessel base of each wetland cell had been sloped 2% down to the drain, an additional *5* cm of ponded sludge (when flooded) had accumulated at the lower end of each cell. It is possible that the additional sludge, along with the continuous

anaerobic digestion, ammonia production, and flooded conditions were critical factors that limited revegetation in the lower regions of the VFW cells. Therefore, in future studies we hope to investigate the impact of hydroperiod on revegetation and solids removal and stabilization within created wetlands.

(References not included due to space constraint. Please contact authors for full paper..Ed)

Vetiver Identification Program: General Information and Research Update

The Vetiver Identification Program is a plan to investigate the botany and genetics of vetiver. Research is carried out by independent scientists using their own funds; The Vetiver Network helps facilitate the flow of information. The Vetiver Identification Program is coordinated on a volunteer basis by Mark Dafforn, a professional staff member of the U.S. National Academy of Sciences who was research associate for their 1993 report, Vetiver Grass: A Thin Green Line Against Erosion.

Currently, scientists are investigating vetiver taxonomy, DNA, and oil chemistry in an attempt to make sense of what we see in the field. Other topics will be included as the opportunities arise. The knowledge to be gained from such research is a foundation for everything we do with the grass. Many questions remain about genetic relationships, biogeography, diversity, and similar topics. We cannot dependably document physiology, adaptability, pest or plague resistance, hedge formation, and similar characteristics without knowing what vetiver we are using. Initial observations from DNA research, described below, give a good example of the usefulness of this type of information.

Following the Summary is more detailed information on Vetiver Accession Forms, Taxonomic Research, DNA Research, and Oil Research. Each section is divided into Background and Importance, Status, Results, and What You Can Do to Help. As more results from the Vetiver Identification Program become available, they will be posted on the World Wide Web at www.vetiver.org and summarized in the next Vetiver Newsletter.

Summary

About 50 vetiver users have provided Vetiver Accession Forms. These are currently being compiled by the Vetiver Identification Program into a database from which it is already obvious that rooting depth varies enormously (is this genetic?) and that some vetivers die back after seed maturity. Other patterns are emerging but more Accession Forms are needed!

Taxonomic studies of the genus Vetiveria are underway at the Rijksherbarium in Leiden, The Netherlands. This involves examining a large number of plant specimens that are currently kept in herbaria scattered around the world, so it will be some time before results are published. It seems likely that there will be revisions in what is considered a member of the genus, but that *Vetiveria zizanioides* will remain a valid species.

Over a hundred vetiver users responded to the call for DNA samples. One group of specimens was tested in May and a second will be done in December, after which all results will be analyzed and published. Even without analysis it is clear that earlier distinctions between wild, seedy vetiver and essential-oil vetiver hold true. However, it was a surprise that almost all vetiver specimens from outside South Asia proved to be exactly the same clone. Accession records show that two of these have been on separate continents at least 60 years. Full analyses should be ready in time for the next Vetiver Newsletter; if you supplied a DNA sample but did not complete a Vetiver Accession Form, please use the blank one in this Newsletter! It is hoped that oil chemistry can be used to separate different types of vetiver and perhaps to help unravel its history. These efforts are just getting underway, but researchers will be able to draw upon an enormous amount of previous industrial work on vetiver oil.

Vetiver Accession Forms

Background and Importance: Record keeping is as important with plants as it is with livestock and banking. It is important for vetiver users to maintain basic collection, ecological, and descriptive information about their genotypes. This is useful not only for their own records, but The Vetiver Identification Program can use these forms when analyzing taxonomic, genetic, and chemical tests. In fact, the key interpretive data for our program comes from the Vetiver Accession Form. In the future, we hope to be able to find obvious morphological characteristics that will allow users to easily identify the kind of vetiver they are using.

Status: We are still in the data-collection phase, and relay upon your cooperation. We do not yet have enough Forms or data to perform statistical analyses, but DNA results should show correlations with some physical characteristics.

Results: One unexpected variable has already shown up. Many users report that vetiver foliage dies back at seed maturity; many users report that it does not. This may be environmental or genetic or meaningless, but it could be an important agronomic factor. Rooting depth also varies widely (from .8 to 6 meters), as does leaf width, erectness, and several other characteristics.

What You Can Do to Help: If you are a vetiver user, begin record keeping today (a blank form is in this Vetiver Newsletter). Whenever you make a new observation about your vetiver,

update your form. If a category does not exist, create one. And please, share copies and updates of your form with The Vetiver Network.

Any information on the history of your material would be very helpful.

Please also pay close attention for foliage die-back at or after flowering or seed maturity. Does any nonfertile vetiver die back at or after flowering?

Do nonfertile clones drop their "seed" upon maturity?!

If any characteristic you think is important does not appear on the Vetiver Accession Form, please let us know.

Taxonomic Research

Background and Importance: *Vetiveria zizanioides* is now used throughout the tropics for erosion control. In South Asia, several native vetiver species are grown in hedges; in Africa, the indigenous *Vetiveria nigritana* is sometimes used. Even in these regions, however, *Vetiveria zizanioides* is the most commonly used species. Almost everywhere, these vetivers have been collected from gardens or the wild. It is crucial to be able to compare the physical and environmental characteristics of these plants with their botanical identity. Years have been spent accomplishing this with other grasses such as rice, wheat, and maize.

Most members of The Vetiver Network know there are two general types of *Vetiveria zizanioides:* a cultivated type (traditionally used for essential-oil production) that is vegetatively propagated, and a wild seedy type. The cultivated type is dense, erect, and has deep roots. It is the most desirable hedge grass of all; that's why there is a Vetiver Network! The wild seedy type is more open and lank, so it is less useful for erosion control. It also could colonize outside its native range. It is especially important to develop ways to distinguish these different types of vetiver.

The most recent taxonomic examination of the genus Vetiveria was by Eduard Hackel in 1889 (Hackel, E. 1889. Monographia andropogonearum, in A. de Candolle, Monogr. Pl. 6:1-716). Hackel was revising the Andropogoneae, the grass Tribe to which vetiver belongs. He agreed with many taxonomists before and since that the genus itself merited more detailed attention: its boundaries are unclear and delineation of its species is confused.

There are, however, far more species of plants in the world than there are botanists, so they have not been able to pursue every interesting scientific path. Since the source of vetiver roots and oil is usually elite cultivars of *Vetiveria zizanioides*, until now there has been no reason for botanists to spend their time scrutinizing the entire genus. But thanks to members of The Vetiver Network, the plant is now taking on far greater importance: understanding vetiver now has economic as well as scientific significance.

Status: J.F. Veldkamp, in collaboration with other botanists and institutions, is currently examining the genus Vetiveria using classical (morphological) taxonomic techniques. He is a botanist at the Rijksherbarium in Leiden, Holland and works with their Flora Malesiana, a long-term project begun by Cornelis Steenis in the 1940s. The Flora's goal is to document plants in Indonesia, Malaysia, the Philippines, Papua New Guinea, Singapore and Brunei Darussalam.

Plant biogeography and phylogenetic analysis are a focal point for Rijksherbarium research (taxonomy classifies plants and animals into groups; phylogeny attempts to ensure these groupings reflect evolutionary history). Dr. Veldkamp is the Flora Malesiana author for grasses, which are currently under revision for the project. Malesia is a region of diversity for the genus Vetiveria (it contains many of the currently recognized species), so part of Dr. Veldkamp's work involves documenting what has been studied before and what remains unknown about vetiver taxonomy.

Results: It will be some time before analyses are complete, but it is interesting to note that Dr. Veldkamp is examining some vetiver specimens that have not been looked at for nearly two hundred years, as well as some that have never been examined. He also believes that much valuable information is contained in older classifications (*Vetiveria zizanioides* itself has been listed under at least five different genera and a dozen different names [*Editor note: Dr. Veldkamp now reports 8 genera and 17 names!*]). Earlier authors felt some species of Vetiveria might belong in Chrysopogon, and that some other Vetiveria species should be recombined into different groupings.

Generically JeF Veldkamp believes he can clarify the close relationships between Vetiveria and its sister genus Chrysopogon; specifically he hopes to better delineate our familiar old domesticated essential-oil (hedge) vetiver, *Vetiveria zizanioides*. The Vetiver Identification Program will report results as they become available.

What You Can Do to Help: Please contact The Vetiver Network if you would like to collect voucher specimens for this study. Dr. Veldkamp would particularly like to examine variation in the Malesia region (see above), as well as Southeast Asia (Vietnam, Cambodia, Laos, Thailand, and Burma). Especially needed are botanical vouchers (and Vetiver Accession Forms) for naturally occurring nemoralis from the Southeast Asian mainland.

DNA Research

Background and Importance: DNA is a very simple molecule that performs a very complex op-

eration: its chemical code controls the functioning of life. That code is different in every living thing that reproduces sexually, and it is what confers the genetic nature of an organism ... in a plant these are things such as disease resistance, cold tolerance, and flower color. The code is carried by only four different chemicals, but the four appear in molecular strands that can contain millions of sequences of code. A fundamental belief in biology is that the more similar these sequences, the more closely related the organism. Humans and plants share less than 50% of their DNA; humans and chimpanzees share about 95%; you and I share more than 99%, you and an identical twin would share 100% of your DNA sequences.

The ability to compare the similarity of DNA samples is one of the most powerful tools to arise from biotechnology. Several different techniques have been developed to analysis DNA but, generally, they do one of four things: 1) they can tell whether a certain piece of DNA is in a sample, 2) what its code is, 3) physically where that piece is on the gene, or 4) what it does. In time, The Vetiver Network hopes that each type of analysis will be performed for many different characteristics on many different vetivers, but most of these techniques are still in the developmental stages. Many are quite expensive and scientists are only now learning how to read the results; such research has scarcely begun in rice and rats, much less vetiver.

One of these techniques has been used on vetiver. Called RAPD analysis, (pronounced "rapid", for Randomly Amplified Polymorphic DNA), random chunks of specific DNA code a few hundred sequences long are chemically multiplied until there is enough of it to be measured. It is a yes/no test; either that specific sequence exists in a sample, or it doesn't. By running RAPDs from different samples on several different sequences of DNA, scientists can run a number of statistical analyses to get a good measure of relatedness. RAPDs have been run on organisms from many different kingdoms — bacteria, fungi, plants, animals — so there is a general idea of how much variation exists in life.

Almost everyone using vetiver in hedges is using plants found locally. Unless we propagated the plants ourselves, we did not know if two plants growing side by side were identical or different. By using RAPD DNA analysis, we can measure the variation in our planting materials, ensure we maintain as many different types of vetiver as possible, and — most important — combine our knowledge for plants that prove to be genetically the same, even if they were collected in different places.

Status: Two series of RAPDs have been completed, and a third is underway. The first was by Steve Kresovich of the U.S. Department of Agriculture, whose results were reported in Vetiver Newsletter 14. He demonstrated that DNA from three essential-oil genotypes (collected in different countries) were essentially identical, while all three were quite different from wild, fertile North India vetiver. Then, at the First International Conference on Vetiver in Thailand this year, Pattana Srifah, Nitsri Sangduen, and Vinitchan Ruanjaichon of Kasetsart University presented results of RAPD classification and identification of vetiver collected from different areas. Their results showed that RAPDs are a "simple, quick, and reliable alternative to identify 9 Vetiveria grass ecotypes" in Thailand.

Robert Adams of Baylor University in Texas has volunteered to perform a third series of RAPDs for The Vetiver Network. Dr. Adams has long worked with essential-oil plants; his specialty is juniper but he has been familiar with vetiver in Haiti for years. We all owe our thanks to Dr. Adams for devoting laboratory time and resources to vetiver research! Thanks Bob!

Results: At the Vetiver Conference in February 1996, a hundred kits for collecting vetiver DNA samples were handed out to participants, and in April another 100 requests were mailed to Vetiver Network members. The Vetiver Identification Program received nearly one hundred vetiver samples before May 15, 1996. These included 70 samples listed on Accession Forms as *Vetiveria zizanioides*, as well as five other species: *V. nigritana* (but see below), *V. elongata*, *V. filipes*, *Chrysopogon fulvus* and *C. gryllus*. Specimens were received from 19 countries. About another 30-40 samples have been received since the deadline; many of these fill crucial gaps and thankfully will be tested in another round of RAPDs later this year.

From the first round of samples, Dr. Adams' laboratory was able to extract DNA and perform RAPD analyses on about 60 specimens. Once all RAPDs are complete, data will be correlated using statistical tests to group the samples into clusters ... these will be compared with the physical descriptions on Vetiver Accession Forms and with botanical vouchers. In the near future Bob Adams will be performing RAPD analyses on some of the remaining material received after May 15. We need Southeast Asian samples! Once analyzes are complete, results will be available in tabular form by Vetiver Identification Number - with commentary. Results should be available in time for a full report in the next Vetiver Newsletter. In the meantime, some unanalyzed data are available.

Notice: The following discussion should be considered as speculation. Full analyses could dramatically change some of the following possible relationships!

These are raw results and NOT for Scientific Reference or Citation! They are provided as interim information for

the many members of The Vetiver Network who contributed time and samples to make this testing possible. If you do not find your Vetiver Identification Number below, your submission was either not analyzed in the first round of testing or the DNA had deteriorated beyond recovery.

Below is one way to look at the raw results of the DNA testing. This simple test compares the amount of variation of every sample against each sample in turn (obviously done by computer!); this is called "best-fit" or "nearest-neighbor". discussed below is the one scheme (of about 4000) that had the least overall variation. This result is not a scientific proof; it is a philosophical test stating that the simplest explanation is probably the best explanation. This test is called "Occam's Razor", and translated from the Latin states "A plurality should not be posited without necessity" (William of Occam, 1285-1347). Using this principal, the computer found that uncultivated specimen VET-K-Pnb-2 from Orissa, India was a representative sample against which all others could be compared most simply. The choice is not surprising, for this sexually reproducing clone is one of 12 closely related, carefully documented specimens collected in the heart of Vetiveria zizanioides distribution.

Using this simplest measure of variation, the samples fell into four general groups: 1) wild, seedy types of *Vetiveria zizanioides* from Northern India and Bangladesh; 2) cultivated, low fertility, oil types of *V. zizanioides* collected from cultivation; 3) other Vetiveria species; and 4) Chrysopogon, the "sibling" genus. In this respect, these initial results are a reflection of current botanical and agronomic knowledge. There are several puzzling samples using this scheme, however, and the following must be viewed as tentative.

Group One: This group includes wild, seedy types of Vetiveria zizanioides from Northern India and Bangladesh. The representative specimen VET-K-Pnb-2 (from Orissa, India) is quite similar (0.90) to two other Orrisan samples (VET-K-Brk-8 and VET-U-Bdm-12), with this cluster in turn closely similar to VET-K-Dtp-1 (as well as VET-K-Dnk-3, VET-K-Blp-9, and VET-U-Gsg-11). (Note: The measures of similarity, such as 0.90, given in this discussion are not a measure of overall variation; the tests are designed to emphasis difference not similarity). These three samples (seven specimens) share about 0.85 similarity with VET-U-Nlg-10 from Orissa and VET-USDA-U1 from the Punjab (USDA PI 196257). Also in this group is a clone from Bangladesh (VET-BANG-B001, as well as the nearly identical B002, B003, and B004). Like the Orissan plants, these Bengali plants form a distinct, closely related subcluster such as could be found in locally collected sexual material that is vegetatively propagated. (This paragraph is full of examples of how DNA fingerprinting can help researchers eliminate duplicate germplasm.) Overall, these "Ganges" vetivers could be representative of the widespread, homogenous, sexually reproducing population of uncultivated "North India" *Vetiveria zizanioides* mentioned so often in the literature.

Group Two: This group includes cultivated, low fertility, oil types of *V. zizanioides* collected from cultivation, mostly outside South Asia. The members of this group are distinguished in the raw analysis not by their great genetic "distance" from Group One, but by their internal uniformity and behavior: these are apparently all oil vetivers and most are growing outside the native range of *Vetiveria zizanioides*. Variation from the wild, seedy baseline plant (VET-K-Pnb-2, above) used in this particular analysis ranged from about 3-15%; internally this group varied less than 2% (remember, subject to further mathematical analysis!). The group included one accession from Australia ('Grafton'; VET-PT-1C), one from Malawi (VET-ISV-AGA, see below), one from Nepal (VET-01-CWDS, which originated "in a tropical climate" outside the area), and twenty-five (25!) identical (>0.99) clones that came from around the world! Grafton is reported to have very low germination (<3%), the Malawi clone is free flowering with tillers dying back after flowering (seediness is not reported), the Nepal clone has not set seed.

Twenty-five identical DNA samples from around the world is a very surprising result. The DNA samples were sent from Australia, Costa Rica, Haiti, Hong Kong, Malawi, New Guinea, Panama, South Africa, United States, and Venezuela, as well as from Aneitym, Atui, Efate, and Mangaia in the South Pacific.

These clones are genetically identical; none have been reported to seed: VET-DEKN-1001, VET-DEKN-1002, VET-DEKN-1003, VET-DEKN-1004, "VET-GVB-001", VET-IMZ-AGA, VET-MRD-0001, VET-MRD-0002, VET-MRL-0001, VET-OSR-VV-7729, VET-PT-1A, VET-PT-1B, VET-PT-1D, VET-PT-1E, VET-RA-F1-7747, VET-RA-F2-7748, VET-RA-H1-7659, VET-RA-H2-7660, VET-RA-H3-7661, VET-RA-H4-7662, VET-RA-H5-7663, VET-RDH-0002, VET-RGG-CR-A, VET-RGG-PA-A, and "VET-MR-VAL1". These accessions include, among others, the cultivars 'Monto' (Australia), 'Sunshine' (United States), and 'Vallonia' (South Africa).

The history of a few cultivars is well-enough documented to know that they did not come from any one single plant within the last 60 years. In particular, 'Monto' has been in Australia since the 1930s; 'Vallonia' ("Charmoy") was brought to South Africa from Mauritius around 1920. From this, it seems likely that at some time prior to the Second World War, this single, very desirable clone of an essential-oil

vetiver was purposefully spread far and wide.

The unexpected result that one particular clone is so widespread has both good and bad aspects. The good news is that we now know much of the vetiver research in Australia, South Africa, the United States, and elsewhere has been performed using a single genotype. Therefore, research results from many different countries can now be combined and compared to form baseline data, at least in terms of germplasm response. What a bonus to be able to exclude this uncertainty from analyses of topics such as disease resistance and fertility! Further, given that in these tests more than 90% of the *Vetiveria zizanioides* from outside South Asia proved to be one single genotype, it seems likely this will be the clone found in use many other countries as well. This genotype is dense, erect, deep-rooted, and forms beautiful hedges. Now planted by the tens of millions, it is not reported to have seeded in any habitat. It is a superb hedge vetiver. This is all for the good.

The bad news is that we are now aware that there is a great deal of genetic uniformity in the vetiver we are using: the same clone is widely used and anything that harms one plant can harm them all. This is called "genetic vulnerability", and is a warning that we need to uncover further variability within the species, and to conserve it as a genetic reserve for the future.

Group Three: This group contains other Vetiveria species. Two specimens of *Vetiveria elongata*, a "narrow-leaf" type (VET-PT-2A) and a "broad-leaf" type (VET-PT-2B), that were recently botanically identified are clearly distinct from each other; both are equally distinct from *Vetiveria zizanioides* (.85 to the baseline VET-K-Pnb-2).

Two samples labeled *Vetiveria filipes* were also tested. One (VET-PT-2C) was recently collected and botanically verified. Like the *V. elongata* specimens, the degree of similarity to other vetivers (0.77 to VET-K-Pnb-2) is as would be expected taxonomically. The second sample (VET-FP-7734), however, is very different from VET-PT-2C as well as from all the other vetivers tested (0.67 to VET-K-Pnb-2). In fact, it differs more from *Vetiveria zizanioides* than does one sample of Chrysopogon, vetiver's sibling genus.

The plant from which came this seed sample (VET-FP-7734) was botanically identified in the 1950s. It was collected in Queensland, Australia by the Commonwealth Scientific and Industrial Research Organization (CSIRO) as Q269, and received by the USDA National Plant Germplasm Service on May 25, 1959, which gave it the Plant Introduction Number PI 257810. This unusual genetic result may be because of a true miss-identification; it also seems possible that it represents one of the recently named Vetiveria species described by B.K. Simon or a miss-identified species of Chrysopogon, or possibly (though unlikely) a new species. This sample would not make a good hedge plant and was included in the DNA fingerprinting for comparative (genetic) purposes. Nonetheless, hopefully someone in Australia will grow out samples of this seed and clarify the mystery identity.

The fourth sample in this group, from Panama (VET-RGG-PA-B), is another mystery. It varies from the baseline VET-K-Pnb-2 slightly more than the *Vetiveria elongata* and slightly less than the verified *Vetiveria filipes*. In form and habit, it can be confused with *Vetiveria zizanioides*. Coming from Latin America, it merits special attention (see below).

Group Four: This group includes *Chrysopogon fulvus* (VET-CFP-7769; USDA PI# 219579) from Pakistan and Chrysopogon gryllus (VET-CG-777; USDA PI# 383762) from Turkey. Results for both plants are what is to be expected from a separate genus: the latter sample shows the least similarity (.65) to the baseline *Vetiveria zizanioides* (VET-K-Pnb-2) of any plant tested. Interestingly, however, this distance is less than is "normal" for intraspecific variability, thus demonstrating how closely allied are the genera Vetiveria and Chrysopogon, and thus how genetically close are their constituent species. Further, in this "slice of the Razor", there is a smooth gradient of variation running from the baseline into Chrysopogon, rather than a gap between the genera as would be expected in two clearly differentiated taxa These relationships will be greatly clarified when other genera (such as Sorghum) are included in the next round of testing.

Falling between *Chrysopogon gryllus* and *Chrysopogon fulvus* in Group Four is the above-mentioned 1950's putative sample of *Vetiveria filipes* (VET-FP-7734).

Two samples from Bangladesh (VET-BANG-B005 and VET-BANG-B006) provided another surprise by having an intermediate variation between the chrysopogons and the vetivers (the two samples were distinct from one another, and showed equal variation compared to our baseline sample). These are probably two varieties of a different species. Our assumption prior to testing these samples was that these were from Vetiveria zizanioides. This was based on recent botanical surveys in Bangladesh that found V. zizanioides to be the only vetiver species in the country. This unexpected result could be explained in several ways. The submitters may have provided Chrysopogon or other samples; the specimens may have been miss-identified (though this seems very unlikely); it may be they are truly *V. zizanioides* and we have only begun to understand the genetic variation in the species; it may be that the current characteristics

used to classify *V. zizanioides* are invalid and that some second species is actually "masquerading" as V*. zizanioides*; it could merely be that in this simple text the Razor sliced the results incorrectly. However, to this author, it seems highly likely that the submitters of these samples (known for their sense of humor) have slipped in a test of the testing! Unfortunately, Vetiver Accession Forms are not available for these samples (hint).

What You Can Do to Help: Lack of diversity and genetic vulnerability is a true risk. Because we have discovered there seems to be limited genetic variation in nonfertile vetiver outside South Asia, it is important for everyone to maintain as many different kinds of vetiver as they can, and to describe them on Vetiver Accession Forms. This is especially important for clones that do not set seed. This means to maintain the clones you have; do not import new germplasm because the risk of disease to vetiver and other plants is simply too high!

We need one general name for the one genotype that is so widespread. John Greenfield — who first popularized the vetiver system — observed long-ago that most vetivers outside South Asia looked the same. He suggested calling them "Vetiveria ubique", Latin for the ubiquitous vetiver—the vetiver that is everywhere. Scientists won't accept such a Latin phrase unless it is used to describe a separate species, nor do the Botanical Rules of Nomenclature allow cultivar (cultivated variety) names to be Latin, so we can't just call it "ubique" — although UBK would probably be acceptable to the taxonomic community! We can name this vetiver type (it is technically a cultigen) almost any other way we choose, so please send us your suggestions! (By the way, Monto is a small town in Queensland, Sunshine a small town in Louisiana, and Vallonia a sugar estate in South Africa.)

We desperately need DNA samples from Southeast Asia (Vietnam, Cambodia, Burman, Laos, Thailand, Malaysia, and Indonesia). We learned from the first round of testing that no specimen preparation is necessary! Simply clip about 5 cm of green leaf, wipe it dry, and mail it with a Vetiver Accession Form to The Vetiver Network.

The Nepalese VET-01-CWDS should be closely evaluated and its history documented. Germplasm should be duplicated in other sites for safekeeping. It may represent important genetic diversity. It would be very helpful if a full botanical voucher could be provided to The Vetiver Network.

The Malawian VET-IMZ-AGA was submitted to the Vetiver Identification Program as "probably *Vetiveria nigritana*", although the accession form noted that it had many characteristics of *V. zizanioides*. It seems likely that it is the latter species; in any event it represents very interesting genetic variation. If it does not have viable seed, it could represent an important source of biodiversity. Although apparently abundant, material should be duplicated at other sites for safekeeping. It would be very helpful if a full botanical voucher could be provided to The Vetiver Network.

The Panamanian VET-RGG-PA-B should not be used as a hedge plant until it is collected, maintained, identified, and a detailed accession record begun. If it flowers, a qualified botanical identification should be made. Does it set fertile seed?! If it seeds after thousands of clones have been planted out, it could become a pest. On the other hand, if it is sterile it could be a very valuable addition to our arsenal of germplasm. In the meantime, until more is known about the plant, use the Panamanian VET-RGG-PA-A, which is the nonfertile hedge type of *Vetiveria zizanioides* (see above). It would be very helpful if a full botanical voucher could be provided to The Vetiver Network.

The Bengali mystery of samples VET-BANG-B005 and VET-BANG-B006 should be clarified. The Vetiver Network will gladly assist in authenticating. If they are botanically authenticated as *Vetiveria zizanioides*, there is something seriously wrong with this slice with Occam's Razor — or with the current taxonomic classification of the species.

Oil Chemistry

Background and Importance: Vetiver has been important for centuries because of the fragrant oil in its roots. Perfumers distinguish two kinds of vetiver oil. Oil from the uncultivated, seedy "North Indian" type is technically called Khus Oil; oil from the cultivated "South Indian" type is called Oil of Vetiver (this is the vetiver oil of international commerce). The two types (perhaps mirrored in the above first-two groups) consistently yield oils that vary chemically, have opposite polar rotation, and smell differently. Much basic oil research has been performed in India and elsewhere.

One puzzle is the hypothesis that selection for maximum root mass gave us the dense, erect, heavily rooted, and sterile clones we have today. If this were true why would their oils be so dependably different? Does anyone know other species where two different genotypes consistently yield two different oils from the same tissue?

By answering questions about vetiver's oil chemistry, we may learn clues as to the origins of vetiver, could solidify DNA results (oil is a different "Razor"), and could possibly develop tests for distinguishing different types of vetiver in the field.

Results: This is an area in which several Member of The Vetiver Network have expressed interest but research is just getting started. Robert Adams has reported that a group

of scientists in Berlin is planning to do a complete analysis of Oil of Vetiver. They will surely be assembling world literature on vetiver oil; we will make every attempt to convince them to include Khus Oil in their analyses. Dr. Adams' own lab is also equipped for many types of analyses.

What You Can Do to Help: The ideal research would be based on oils that could be traced back to specific clones on which DNA fingerprinting had been performed and for which botanical vouchers and descriptions exist. Oil producers please help! This is an potential opportunity for you to receive no-cost, state-of-the-art analyses of your oils and germplasm while helping farmers and others throughout the tropics! None of this testing requires living tissue. Please let us know if you wish to contribute.

We would also appreciate oil or root samples from other vetivers, particularly those described as of interest above. Nepalese VET-01-CWDS, Malawian VET-IMZ-AGA, Panamanian VET-RGG-PA-B, and Bengali samples VET-BANG-B005 and VET-BANG-B006 merit particular attention At the moment Khus Oil is also needed for preliminary analyses. Please send well-packaged samples (and as much background information as possible) to The Vetiver Network. Please contact The Vetiver Network for further details.

The Future

The goal is to reach a point where this type of research will no longer be necessary! Our level of knowledge is rapidly increasingly, and many of the questions of 1990 are answered. Two sophisticated genetic techniques, coupled with new taxonomic clarity, may help us further along this path.

RFLP (Restriction Fragment Length Polymorphism) molecular analysis would allow study of the evolutionary and reproductive biology of vetiver. These tests could permit us to identify genes that influence morphological traits such as rooting, tillering, flowering, and seeding in vetiver. Once these are identified, new-found clones would not require lengthy field testing to determine their genetic characteristics. Plans are underway to initiate RFLP analysis of vetiver.

FISH (Fluorescence In Situ Hybridization) is an advanced cytometric technique for analyzing genetic location. Once RFLP has identified genetic sequences, FISH will allow us to locate its appearance[s] on vetiver chromosomes. Plans are underway to initiate a FISH analysis of vetiver.

Many thanks to all of you who have cooperated with the Vetiver Identification Program. We are open to suggestions for any other research ideas that may help answer questions about the identity of vetiver. Please contact The Vetiver Network with your ideas.

STUDY ON VETIVER GRASS IN BANGLADESH

Comprehensive Study. Bangladesh National Herbarium
by Matiur Rahman et al.

Summary

Vetiver is a versatile grass with unique characteristics. There is world wide evidence to support the use of Vetiver as an effective means of soil stabilization.

A project proposal was submitted to Danida by the Bangladesh National Herbarium to conduct a reconnaissance survey on Vetiver in Bangladesh in order to explore and identify the distribution and location of Vetiver, identify the different species and ecotypes of Vetiver, and its existing indigenous uses. The proposal was approved by Danida in April 1995.

The survey was conducted by a technical team which consisted of 5 persons (Annexure 2). The team leader, who is an agrostologist, and three taxonomists/botanists formed the core team while a sociologist was attached to the team for a shorter period.

The survey work was for a one year period starting from June 1995, with an extension of further three months. The study period was broken into two parts. The finding of the first part of the study was presented in a one-day workshop in February 1996 with 30 invitees. The workshop assessed the progress of the work and recommended future possible steps to be undertaken during the second part of the study.

The survey work was carried out in all the 64 districts of Bangladesh. The distribution and locations of Vetiver were explored and identified through numerous field trips by the members of the technical team. Each site was visited more than once and the technical team collected a total of 375 samples of Vetiver plants during the field trips. They made field notes and recorded information on individual collection supported by photographs of the habitat, the Vetiver colony, and the extent of the stands. The collected plant samples were processed, preserved and examined at the Bangladesh National Herbarium. Full botanical descriptions were prepared on the basis of the collected samples.

The investigations made in the survey revealed that there is a wide occurrence of Vetiver in Bangladesh including a number of large areas covered extensively by Vetiver. Some of these areas may be the largest populations of Vetiver ever seen in the world. It has been established that Vetiveria zizanioides (L.) Nash is the only species that occurs in Bangladesh. Three botanical 'forms' of Vetiver have been identified to occur though no ecotypic variation was found.

The study conducted by the sociologist revealed various past and present indigenous uses of Vetiver in Bangladesh including thatching, fencing, handicrafts, medicine, fodder, and in festivals and religious functions.

The present findings suggest that Vetiver grass has a great potential for use as a vegetative means for protection of river and coastal embankments in Bangladesh. Vetiver which is commonly found in Bangladesh will be most suited for this activity. Apart from its traditional use as a thatch grass, its use in handicrafts can also be expanded.

(The full report is available from the National Herbarium, Dakkar, Bangladesh).

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FOR SALE

Video Films: Vetiver Grass - A Hedge Against Erosion. 28 minute video comprising 128 scenes of vetiver technology. Available in English or Spanish, and in PAL or NTSC formats. Price US $25, including shipping.

Slide set: (65 transparencies) of vetiver technology + write-up in English. Price US $65 including shipping and handling.

Available from The Vetiver Network.

MOST WANTED

We need to know whether *Vetiver nigratana* has oil in its roots. Also people with knowledge of *Chrsopogon spp*. please smell/bite the roots to see if they have oil any oilor other odor. Please pass information to Mark Dafforn.

VETIVER PHOTO GALLERY

Australia, Queensland, from Paul Truong's collection.

Vetiver zizanioides (Vetiver Monto) grown in Queensland on acid sulphate soils to protect eroding field gully. **Paul Truong**

Same scene a year after planting with crops. **Paul Truong**

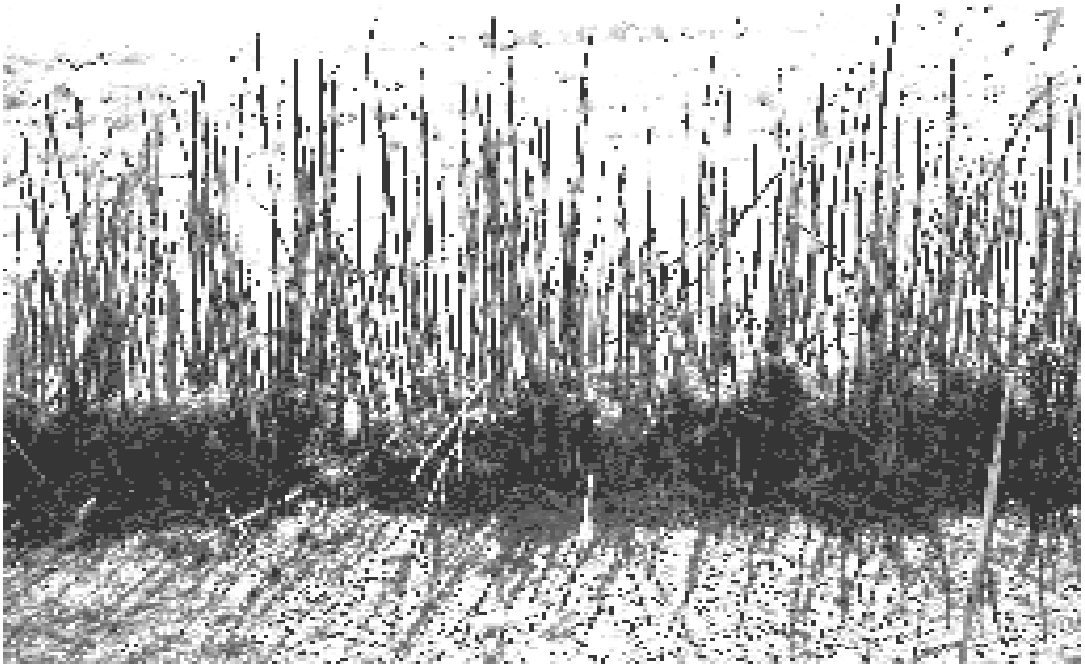
Vetiver grown on acid sulphate soils to protect a drainage channel. Note on the far side of the ditch the palm tree roots are unable to stop erosion and the bank has been temporarilly stabilized with sand bags, The vetiver has stabilized the near side very effectively, and for ever. **Paul Truong**

A deep flow of water of about 1.3 meter in a drainage depression flattened the native grasses, but not the vetiver. Note the stable, non eroded drain bottom. **Paul Truong**

The same flow as the previous photograph. Note the debris collected on the head rod. **Paul Truong**

Vetiver does not burn well even under windy conditions. **Paul Truong**

Above: Vetiver was burnt to get rid of the mice which hide in the hedge during winter and attack the corn. Below: Vetiver after burning, It remains erect, and green shoots and leaves are still visible (in the color photograph). **Paul Truong**



When protected with vetiver, the vetiver hdge farmer can plan the whole area, thus increasing productivity by at least 30%. Note the depression in the field above will be filled up over time and will become level. **Paul Truong**

Above: Typical strip farmer cropping layou on the Darling Downs. Normally at least 30%of the land is underbare stubble fallow. **Paul Truong**

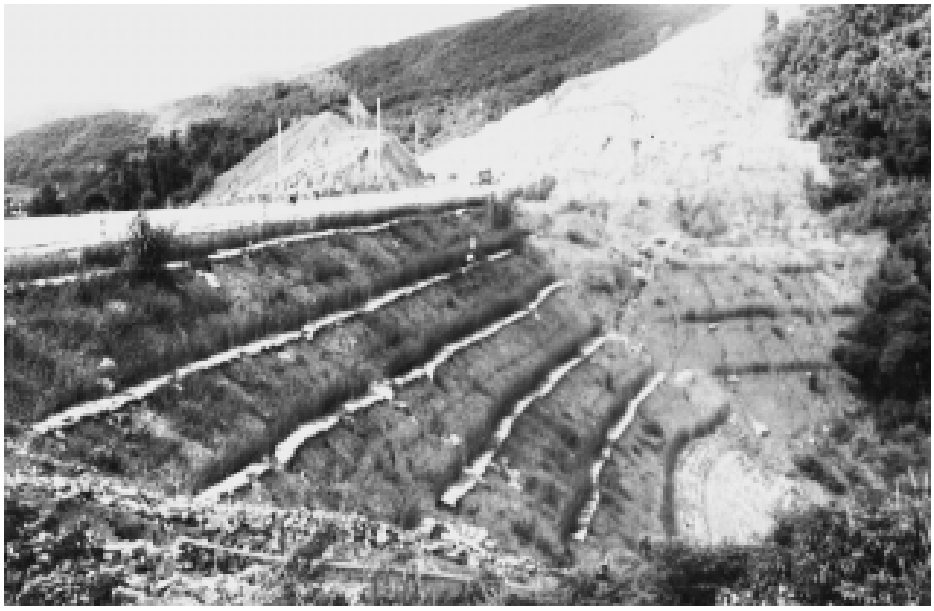
Below: Vetiver used to stabilize a land fill area in Queensland. **Paul Truong**

China. From Xia Hanping's Collectiion

The following photographs relate to the article on page 25

Above: Cracking pavement on a new highway in Guangdong Province due to an unstable embankment. **Xia Hanping**

The cracking in the pavement was due to the unprotected embankment shown above. **Xia Hanping**



Above: The embankment now stable 6 months after the vetiver grass was planted.

Below: The cut slope protected by vetiver. About another three months was required to reach reasonable slope stability. Note the Acacia mangium **planted between the rows of vetiver. Xia Hanping**

Costa Rica. From Jim Smyles Collection

Vetiver plantedon a steep slope to protect coffee plantings. The leaves of the vetiver can be cut and used for mulching the coffee. **Jim Smyle**.

Vetiver used as a protective boundary hedge around house and garden.

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Vetiver hedgerows intercropped with banana in NE Thailand, Chiang Rai. ***Photo Credit: Dick Grimshaw***

Vetiver hedge rows intercropped with vegetables near Cebu, Central Visayas. Phillippines. Photo Credit: Edwin Ballabarino.

THE VETIVER NETWORK
Vetiver Identification Program

Vetiver Accession Form

(If you wish to help identifyb the vetivers that you work with, please fill in this form and either copy or cut along dotted line)

This form records basic collection, ecological, and descriptive information about a single vetiver clone. Make copies for multiple genotypes (we'll supply blank forms if you need them); use additional sheets if needed. Form should be kept updated. Distribute this form to others with different vetivers. Please send copies--or other accession records--to Vetiver Identification Program, 15 Wirt Street NW, Leesburg, Virginia 20176, USA; 703 771 1942; fax 771 8260; write, or check The Vetiver Network (www.vetiver.org) for new information.

Identification Number: #VET-_____-_____

Assign this number to one single plant (genotype)
(suggested format: VET-Your Initials-####).
Use this number on all information supplied to the Vetiver Information Program. We will use this number in correspondence with you and in presenting research results. As we trace the relationships of vetiver, identical clones will receive reference numbers and cultigen names; information will be made available through the Vetiver Network. Please indicate at the end of this form if you do not wish your name to be released without permission.
Date:

Your Name and Address:

Part I: Recording Your Vetiver
Everyone please complete Part I. This allows us to track distribution and to contact you with information about your plants. If someone else is maintaining records on the "foundation stock" of your vetiver clone (see Part II), this is all we need.

By what name do you call this clone?

Other type/cultivar/clone names:

Other accession numbers:

Genus/species, if known (botanically authenticated?):

From whom/where did you receive this clone? (Sample responses could be: "This is 'Sunshine' vetiver." or "Acquired from John Doe of the Elbonian Agricultural Service, [address].", or "My family brought this plant from Elbonia in 1935."):

Location of your clone (be as precise as possible, with latitude, longitude, and elevation if available):

How long have you had this clone?

How widely planted (thousands of plants, if known) is this clone (by you, and by others if available)?

Please reference others working with this clone:

Is this genotype duplicated in a national germplasm collection? ___ No ___ Yes; Where?

Have you prepared herbarium vouchers for this clone? ___ No ___ Yes; Where?

Have you submitted this clone for DNA RAPD testing? ___ No ___ Yes

Have you submitted this clone for DNA RFLP testing? ___ No ___ Yes

Are you a member of the Vetiver Network? ___ No ___ Yes

Part II: Documenting Your Vetiver

Complete Part II (and Part III) if you curate vetiver "foundation stock", that is, you maintain a particular vetiver genotype for use in hedges (especially if you have distributed the clone to others), or--if not a member of the Vetiver Network--you have a plant you'd like to know more about. If you keep accession records in another format it is not absolutely necessary to complete Parts II and III of the form, but please supply us with Part I and a copy of your records.

Original collection date and season, if known (when was this plant first collected as an accession):

Original collector name and contact information (if not you):

Original collection location of clone, if known (be as precise as possible, with latitude, longitude, and elevation if available):

Permanent location of clone, if different from above (be as precise as possible, with latitude, longitude, and elevation if available):

General description (erectness, density, flowering, abundance, etc.):

Ecological and habitat information (including soils, rainfall, moisture, and drainage regimes, temperature averages and extremes, seasonality, associated species, etc.):

Origin (any details you may know, including history either known or reputed):

Local or traditional uses:

Please explain any experience you have with this clone (please reference or attach copies of articles, letters, documents, or other papers discussing your work):

Special characteristics (including oil data):

Comments (use additional sheets and attachments if you wish):

Part III: Describing Your Vetiver

Part III lists simple physical characteristics visible to the naked eye. Some traits may seem obscure but, at some time, someone working with vetiver thought them important. Although the questions are designed to emphasis these points, they have not been tested: feel free to add anything you think is relevant. Provide as much information as is currently available; keep forms updated.

Plant Habit

Overall height (cm):

Crown density (tillers per unit area):

Crown diameter (cm):

Plant vigor compared to other accessions (1 = weakest, 9 = strongest):

Vegetative spread rate (one season; 1 = caespitose, 9 = 1 meter or more):

Dry weight = dry weight/wet weight:

Stems, Tillers, & Leaves

Erectness (1 = procumbent, 3 = sprawling; 5 = open; 7 = upright; 9 = erect):

Stem strength (1 = soft; 2 = average; 3 = stiff):

Stem adherence to crown (year-old culms) (1 = firmly attached; 2 = loosely attached; 3 = detached):

Last internode length (cm) (1-year plant):

Third internode length (cm) (1-year plant):

Number of tillers (1-year plant):

Number of leaves/main tiller (1-year plant):

Leaf color (1 = light green; 9 = dark green):

Pigmentation pattern (Regular/Intense to Irregular/Feeble):

Leaf length (cm):

Leaf width (cm):

Forage quality (if possible, give in vitro dry matter digestibility calculated by NIRS):

Forage yield (forage yield/ha at first harvest):

Flowering Characteristics
When (if) this clone flowers, please preserve specimens for botanical identification.

Number of panicles (1-year plant):

Flower length (cm):

Flowering habit (botanical type; 1 = determinate; 9 = indeterminate):

Female-infertile spikelets:

Awned glumes (length, if present):

Seed abundance:

Percent seed set (fertility):

Germination:

Aggressiveness:

100 seed weight (gm):

Seed retention (relative degree of seed shattering; 1 = shattering; 9 = retention):

Leaf senescence at seed maturity (1 = dead leaves; 9 = all green):

Chromosome number (somatic chromosome number):

Physiology

Acidity tolerance (1 = little tolerance; 9 = very tolerant; or pH):

Alkalinity tolerance (1 = little tolerance; 9 = very tolerant; or pH):

Salt tolerance (1 = little tolerance; 9 = very tolerant; or dS/m or mho):

Drought tolerance (1 = little tolerance; 9 = very tolerant; or min.):

Moisture tolerance (1 = little tolerance; 9 = very tolerant; or max.):

Poor drainage tolerance (1 = little tolerance; 9 = very tolerant; specify):

Cold Tolerance (1 = little tolerance; 9 = very tolerant; min):

Heavy metal tolerance (1 = little tolerance; 9 = very tolerant; specify):

Other tolerances:

Roots

Depth of roots (deepest):

Root yield (gm/plant) (1-year plant):

Diameter of roots (cm/largest) (1-year plant):

Root color:

Has this plant been used for oil production? ___ No ___ Yes

Other root/oil observations:

Please provide any information on adaptability, pests, plagues, or other characteristics which may be important to understanding your vetiver genotype.

Part III is based largely on the “Descriptor List for Grass” used by USDA’s Germplasm Resources Information Network (GRIN), with other characteristics of special interest to vetiver researchers. Many were drawn from Ramanujam and Kumar’s 1964 paper, “Metroglyph analysis of geographic complexes in Indian vetiver” (Indian Journal of Genetics & Plant Breeding 24:144-150), as well as from various keys separating Vetiveria species. Other sources included the Smithsonian’s “Collection Reference System Data Standards” and the USDA’s “Preparing Herbarium Specimens of Vascular Plants”. Thanks to Rusty Russell, Je.F. Veldkamp, and John Wiersema.

For those with a deeper interest in recording their vetiver, additional information is available on the World Wide Web at www.vetiver.org and from the Vetiver Identification Program

Updates: __/___/__; __/___/__; __/___/__; __/___/__; __/___/__; __/___/__.
(Please circle new information on updated copies sent to the Vetiver Network)

Nondisclosure request: If you do not want us to link your name with this clone, sign here:

X_____

If you are looking for vetiver, we’ve identified suitable cultivars in almost every country and will be glad to help you find starting material; please contact the Vetiver Network.

Ver 2.0t Oct/96