VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER NETWORK
NUMBER 14 SEPTEMBER 1995

Editor's Page

This newsletter is rather long. It contains a lot of feedback from users around the world - thank you all for the time and efforts that you put in preparing the material. It contains two long articles on vetiver that I consider useful. The first is an article written in 1949 about the world wide production of vetiver oil. A number of network members are interested in producing vetiver oil, and this article may help (but beware the market is pretty thin). It also gives a good insight to some field practices and other aspects of interest. The second article is the Spanish translation (thanks to Kevin O'Sullivan) of a paper that your editor presented at the World Soil Congress in Mexico last year. We have a growing number of users in Spanish speaking countries and this paper should be useful to them. In this regard the newslettter is prepared to publish articles in Spanish and French so long as the editor receives an English translation and that the topic is considered relevant and useful.

This newsletter also breaks from tradition and includes two articles on non vetiver technologies. The first describes a new plough used in Niger for the creation of in field micro basins. This technique has been used before with some success (in Australia for example) and helps to improve insitu water conservation on large scale agricultural and forestry operations in very dry areas. The second describes an offset disc that can be attached behind a large farm tractor for reforming road shoulders. In many developing countries, roads are the key to economic development in rural areas. Road maintenance is critical, roads often fail on the shoulders, and shoulder and surface materials end up in the side drains. This piece of equipment could be used in every district of developing countries for returning the road material to the road surface and for reforming road shoulders at minimum cost. Furthermore the equipment could be used by local farmers (owning tractors) under contract to the district administration. If you want more information please write to the manufacturers directly, mentioning the Vetiver Network.

SEE BACK PAGE FOR TABLE OF CONTENTS

We have had a few generous contributions from some of our members to help keep the network in operation. These donations have meant that we have been able to send technical material (videos slide sets etc. to those of you who can't afford them or cannot get foreign exchange. Some of the money will be used to make a professional technical video of the vetiver system using slides and photographs that many of you have generously sent me over the years. This 20 minute video should be completed by mid October and will be available in PAL or NTSC at about US $ 20 each.

We need more support from those of you who can afford to help. You will see from this newsletter that readers really appreciate the information that they receive through the network.

Photo 1. *His Majesty The King of Thailand with Her Royal Highness The Princess Mother viewing some quality vetiver planting material at Doi Tung.*

NGOs in particular are moving the technology fast. See the articles from David Connors, Kevin O'Sullivan, Shimelis Kebede, Alemu Mekonnen, Simon Ngwainmbi, David Harvey, Charlie Inggs, Bob Mann, and others. These NGOs need financial help. They obviously know how to use their scarce resources. If you can influence donor agencies, I suggest that you point them in this type of direction.

The Vetiver Network sadly has to report the death on July 18 of our oldest vetiver user and promoter, Her Royal Highness The Princess Mother of Thailand, at the age of 94. She was a great woman and much loved by the people of Thailand. She was famed for her establishment of the Flying Doctor Service. She did much for the socially poor, for those with leprosy, and for the crippled. She had great concern for the Hill Tribe people in the North East of Thailand and for the related environmental issues. During her last few years she took a great interest in vetiver grass, and had her own

development project at Doi Tung, near Chiang Rai, where vetiver was vigorously promoted. Her project will be the site for the "Vetiver: A Miracle Grass" conference — A befitting tribute to a great lady. I am sure that all Network members will join me in our condolences to the Thai Royal Family.

The Royal Development Projects Board of Thailand has announced that the International Conference on Vetiver grass "Vetiver : The Miracle Grass" plannned to be held in November 1995 has been postponed to the 4 - 8 February 1986. I hope that those of us who planned to attend the conference in November will be able to attend in February. I am sure that the Thais will put on a very good conference. They have a lot to show us, and there will be much exchange between participants. I believe some 300 "vetervites" will attend with at least 100 from overseas. We hope that the Board will publish a "proceedings' of all the works contributed to the conference, and that the proceedings will make it available to all network participants.

Once again I would remind you that your contributions and feedback are essential to our progress, those of you who have something useful to contribute to the next newsletter please write before by the end of January 1996.

Letters to the Network

From: **David Connors**, Project Manager, St. Joseph's Family Farm Project, Catholic Mission (Bwiam), P.O. Box 165, Banjul, The Gambia. Ph/Fax: 220489050

Thank you for the information you forwarded to me on the hand held site levels. They seem to be exactly what we want for our extension agents in the field to set out the contours on the farms. We are also training the farmers themselves to set out the contours using the 'A' frame.....We are a grass roots organization, working directly with the rural families. Our primary concern is in addressing the environmental issues which will, in time, lead to an increase in food production. We do this by educating the people at the grass roots because, after all, they are the people who count.

We are a charity organization relying on outside assistance for the operation of the project. But I think we are putting it to good use! Currently we have funding from the EC and the Irish government which will take us up to the end of 1996. Beyond that it is uncertain at this point. If you know of any organizations who are interested in funding environmental projects I would appreciate it if you could put me in touch with them when you have time to do so. I realize the Vetiver Network also seeks funds from donors, from reading your January '95 issue, and so I am certainly not asking you for anything in monetary terms. Your vetiver newsletters more than suffice in that respect. They make excellent reading and provide much needed technical information to interested people. We may even be in a position to make a small donation sometime.

We, at this project, realize the importance of vetiver grass in preventing soil erosion and have submitted a proposal to the National Environment Agency in The Gambia (Funded by United Nations Development Program) to establish about 15 vetiver nurseries in our area, which is about 70 km by 10 km. The planting stock will be provided to any farmers who practice contour farming.

I am enclosing a copy of that proposal for your interest and to let you know that vetiver is being promoted in West Africa. We are not sure how much vetiver there is in the country but apparently a lot of women have been using it in their rice fields for a long time. We plan to locate this local vetiver (don't know the technical name) and propagate it in nurseries. We already have 5 vetiver nurseries established, here at the project site and in schools (Vetiveria zizanioides, I think). How is it possible to determine the actual name / type of the vetiver?

We also want to establish a local vetiver network here in The Gambia and I will write to Jim Smyle to get the information from him about that.

That's about all I have to report. We are new to the Vetiver Network, and only heard about it late last year. We are delighted that such a network exists, which is a great assistance and support to us, and we will aid in getting this information to the people who matter, i.e. the farmers and rural people.....

From **Teoh Cheng Hai**, Golden Hope Plantations, Malaysia (fax 03 261 8221) ..... you will be pleased to note that the use of vetiver has become a standard management practice now. Although we produce vetiver planting material by micro propagation, it is mainly for in house use. However we have limited quantities available to people who are interested to evaluate vetiver...

From **Shimelis Kebede**, Finchaa Sugar Project, PO Box 101915, Addis Ababa, Ethiopia ..... After returning from Ghana (Wonder Grass Conference November 1994), I have continued planting vetiver grass on a 3 ha. vegetable farm for demonstration purposes, and the grass is silently doing its work ....The establishment of a National Vetiver Committee is in the pipeline ..... I have already submitted the draft statutes of the association to the Science and Technology Commission of Ethiopia. I have recently conducted a press conference about vetiver and our proposed Association. The Ministry of Natural Resources Development and Environmental Protection has promised further research and cooperation following my complaining to one of our newspapers! .....

From **Mr. Poul Richardt Jensen,** Royal Danish Embassy, Bangladesh ..... the National Herbarium of Bangladesh has been funded by Danida to under take a study on Vetiver in Bangladesh. The team leader is Dr. Matiur Rahman, Director of the Herbarium and grass specialist. The study will be in two parts, the first part will be completed this year and will be followed by a workshop in December .... *(Ed. We look forward to receiving news of the preliminary find-*

ings)

From **David Harvey**, Coordinator, FSP, Shiwa N'gandu, Mpika, Zambia .... My family has been involved in agriculture in northern Zambia for over 70 years. My father John Harvey imported vetiver from Madagascar in the hope of using it for essential oils ... I have planted out several hedges to see the results. Have been impressed, and am starting up some small nurseries, and so will have some vetiver for sale. The small NGO that has been set up to assist farmers within our area hopes to start a soil conservation component, particularly those who are farming on slopes of more than 15% *(Ed. I hope on slopes of less than 15% as well!!)*. We have also found that dairy cattle will graze it down in the dry season .....

From **Murray Fergusson** CEDEC, Casilla # 196, Sucre, Bolivia. Fax 591 64 32628 .... As part of my work I will be trying to promote the use of vetiver grass in this part of Bolivia and, if it proves successful, expand the use of the grass in coordination with CEDES' existing programs .... Here in Sucre I have made contact with Sn. Cresencio Callapino who is working with the NGO called Accion Cultural Loyola (ACLO). His address is in the network mailing list (page 7). ACLO has been working with vetiver since 1991 and currently has a nursery with several million slips for planting out and active projects in at least three communities. They have also produced 1000 copies of a 40 page cartoon booklet in Spanish on the use of vetiver in Bolivia called Protejamos Nuestros Suelos Usando Pasto Vetiver: Manual de Educacion Ambiental No. 2, 1994. It has good illustrations and seems to be aimed at a level somewhat between a technico and campesinos.....(*Ed ..... Murray, could you please let us have more about this program since I believe you visited ACLO. Thanks)*....

From **Ndong Joseph to Simon Ngwainmbi,** C/O PMB 42 via Bda, Mbingo Baptist Hospital, Mbingo, N.W Province, Cameroon .....I seize this opportunity on behalf of the Nbingo II Mens Group of the church to appreciate your efforts to supply us with books about vetiver grass. We have planted over 100 hedges of vetiver. After reading the booklet (Vetiver Grass A Hedge Against Erosion) members, who were reluctant, are now so impressed and are ready to transplant more of the vetiver around their compounds ..... I am appealing for more booklets for members who did not receive the first series that you sent. I am planning to introduce the vetiver grass to the Mens group of the association of churches as a special project.....*(Ed. Note the power of well written material, and proper training of farmers)*....

From **Glenn Allison,** Box 1481, Lilongwe, Malawi. There is keen interest in vetiver here. I have linked up with Francis Mbuka of the World Bank and Stephen Carr at Zomba. Implementation is very slow to date so I am endeavoring to establish commercial nurseries to bulk up planting material for faster than hitherto .... I like the comment from Fiji about the necessity for hedge maintenance seems to me to be a *sine qua non*! Most of the material available so far is Vetiveria nigratana . We are working towards bulking V. zizanioides.....

From **Charles Inggs**, Eastern Highlands Round Table No 35, PO Box 225, Chipinge, Zimbabwe ..... As an individual Table we have over the last two years been planting *(Ed. vetiver I presume)* the severely eroded Tanganda River catchment (a sub-catchment of the Save River), and are now gathering a tremendous response from the peasant plot holders. We have also successfully established vetiver nurseries at 10 schools in our District, supplied various agencies in ours and neighboring districts, and assisted in planting mine slimes dams. All this was done with voluntary donations of vetiver grass from **large scale commercial farmers**, with transport, labor and publicity costs financed by charitable contributions... *(Ed... when I visited Central American countries in 1993 I suggested that commercial farmers could help campesinos in this same way as is being done by commercial farmers in Zimbabwe, I wonder if anything came of it??)*..... Our Association has now adopted this project and at least 10 Table Clubs in Botswana and Zimbabwe are keen to, or have already started nurseries in their areas .....

From **Carlos Alberto Potes Roldan**, Decano, Fac. Ing Recursos Naturales y Medio ambiente, U. Central del Valle del Cauca, Apartado 303, Tulua-Valle, Colombia ..... I have received some planting material from Dr. Karl Mueller Seeman of CIAT and there are now four small propagation nurseries around the city of Tulua. The new Government of the city is interested in developing a vetiver program as a priority, for this, its agricultural extension and our local university is planning to make a special teacher and student project...

From **W.A.V.Wickramasinghe**, Ritz Towers, Ayala Avenue, Makati, Metro Manila, Philippines. ..The Department of Public Works and Highways is establishing a pilot project using vetiver. We plan to implement it as follows: (i) to popularize the technique of using vegetative measures to arrest erosion and stabilize unstable road embankments, and (ii) to establish the proper procedures and techniques into a standard item of road maintenance / rehabilitation works to be adopted in future projects executed on contract.....

From **S.R.Chalise**, ICIMOD, PO Box 3226, Katmandu, Nepal ..... We have introduced vetiver in a very degraded community forest land at an altitude of approx. 950 m a.s.l. in East Nepal on acid and hot/dry "red soil" area. The performance of vetiver is being monitored. We would be interested to hear from anyone who has tried vetiver in similar conditions. *(Ed.....The red soils of southern China are somewhat similar, similar altitude, rainfall of about 1,000 mm. year, long dry season, high summer temperatures, cool winter temperatures, pH of about 4.5... vetiver is doing very well under these conditions. For that matter vetiver grown in Karnataka, India seems to have some what similar conditions)*....

From **Bob Mann**, The Methodist

Church, 1 Central Buildings, London SW1H 9NH, UK. Fax 01717992153) ..... It is essential that all possible assistance be given to the people in Musiyo (Gwembe Valley, Zambia). and through out Gwembe South to help halt erosion and reclaim degraded areas. This is where the GSDP Agricultural Program has taken a step in the right direction encouraging people to start their own nurseries for vetiver grass....to stop erosion and give crops a better chance of survival in times of drought. There are presently some 31 farmers in the Musiyo area who have started vetiver nurseries

..... Mr. Lungu says that vetiver is a tough grass, drought resistant, and can tolerate grazing when once established .... The vetiver grass nursery established by John Jamanklwala in Siabaswi village was grazed down by livestock only a few months after planting, but the roots had become sufficiently well developed in that time to provide adequate anchorage for the vetiver clumps. The grazing has not damaged the nursery plants but had in fact improved the tillering and subsequent growth of young vetiver clumps ....

At Siabaswi village there is a good vetiver grass nursery started during the last rains by John Jamankwala, and in spite of the drought has grown well. In March 1995 the vetiver appeared to be under attack by termites, so Mr. Lungu made up a solution of crushed Neem leaves in water and sprayed part of the nursery as a trial. Two months later it is clearly seen that termites have left that part of the nursery sprayed with Neem-leaf solution.... *(Ed... great news, vetiver users in dry parts of Asia and Africa that have had problems with termites might want to try this use of Neem)*.

Samuel Kuwandira of the Lungwalala Irrigation Scheme (Zimbabwe) showed us where they have used vetiver grass in the drainage channels to successfully stop erosion. There used to be gullies 1 meter deep, they planted vetiver in lines at intervals between 3 - 5 meters across the drainage channels and that prevented erosion and repaired the channels. Farmers then cut the vetiver and found it good for thatching. They have also found that it can shoot again without any problems if accidentally burnt by a bush fire. In the green stage vetiver grass has been found a palatable fodder for donkeys and oxen.....At Fambidzanai (Zimbabwe) vetiver grass is also being cut for mulch on garden beds and around trees, and it is also cut and mixed with Leuceana and Sesbania as a fodder for livestock. Cattle have been observed to eat vetiver in the green leaf stage in preference to other tough bush grasses.

From **Mark Dafforn** (mdafforn@nas.edu@INTERNET) .... Vetiver DNA profiling .... Great news! Robert Adams who used to work with NPI (now AgriDyne) is planning to do DNA fingerprinting of the entire genus Vetiveria! I've put him in touch with Steve Kresovich, who did the earlier work. I may ask you'all to put me in touch with people with different kinds of vetiver, but we've got some time. Adams' address is: Robert P. Adams, Plant Biotechnology Center, Baylor University, PO Box 669, Gruver, Texas 79040. Tel: 806 733-5558; fax 806 733-5606. rpadams@aol. com. *(Ed... anyone wanting to cooperate with Mr. Adams should contact him on Mark via Internet. I would imagine that he will be pleased to receive plant material from world wide sources).*

From **Norman Jones** - World Bank forester. ..... I have been meaning to contact you about an interesting chap who came to my office talking about Bioponics. In his brochure there are pictures of plants with absolutely vast root systems. The system recycles water (mixed with some chemical concoction) and plants just grow. It is used for raising vegetables in dry areas in the Western USA and I believe in one or two Middle Eastern countries. However, it struck me that anyone interested in the oil from vetiver roots could install one of these units and prune away to his hearts content without serious debilitating the plants. The price for these units range from $55,000 for a 20 sq. ft. adequate for 100,000 plants to $405,000 for 2,160 sq. ft. for a million plants (and a lot more for more!). The company is Bioponics International, 32 Galli Drive, Novato, California 94949 (Tel 415 883 3474; Fax 415 883 3776) .

From: **Alemu Mekonnen**, Head Ecological Dev't Dept. Menschen Fur Menschen (MfM), P.O. Box 45, Mettu, Ethiopia.... As you know, MfM, a local NGO, working in the South Western part of Ethiopia, is the only organization currently involving in vetiver grass promotion on a larger scale at farmers' level in the whole of the region and to that extent in the country. The success and the result in the transfer of vetiver technology is encouraging and appreciable. Today it is becoming very difficult to satisfy the increasing growing needs of farmers in the project area and outside the project as well. Currently we have 6 large nurseries (1-2.5 ha) established for vetiver grass propagation. Beside these we have also established four farmers' nurseries. Even these were not enough & farmers in the project areas are now propagating and planting from the already established hedge rows. All in all since the start of the project 1992, 811 ha. of land was treated & covered with vetiver hedge rows. Beside moisture & soil conservation, we have observed farmers are using the grass for: thatching material for huts; as mulch for vegetable beds; to cover the root zone of newly planted perennial crops (coffee & fruit); irrigation canal side stabilization; for coffee ceremony; on-farm grazing during off seasons & dry periods; and ornamental plantation in gardens etc. Further more, our project tried to introduce and supply the planting stock & technical support to government & non government institutions such as:- Japan voluntary service (NGO); Soil conservation research project (NGO); German Agro Action (NGO); Farm Africa (NGO); Ministry of Natural Resource & Environmental Protection; Ministry of Agriculture; and the Ministry of Tea & Coffee.

From **James Smyle & Joan Miller** (hamilton@sol . racsa . co. cr@INTERNET) ... I received a letter from a man in Guatemala: P. Agr. Romulo AlbrtO Ramirez G., Cordinador Regional, Proyecto

Conservacicn de Suelos, DIGESA Region II, Norte, Codigo postal 16801, Coban, A.V,Guatemala ..... points of interest are:

- the project has been working for 4 years with vetiver. They are also promoting green manure cropping, compost, agroforestry, and introduction of earthworms;

- their experience has been very positive with vetiver, especially since they have been promoting it as a multiple use grass barrier. They find that it works very well for: grass roofs, woven rugs, fans, brooms and supplemental cattle feed;

- they have 0.75 ha of nursery and currently about 20 ha of fields protected with vetiver. This covers 24 different areas and about 120 farmers are involved. They plan to expand the nurseries this year; and

- they are starting to do fertilizer trials (inorganic fertilizers) for nurserying of vetiver establishment in order to have a better understanding for proceeding with the promotion of vegetative propagation of vetiver.

Research topics

As I recall you had mentioned that you were interested in knowing some of the areas in which research on vetiver was yet needed for Central America. I can think of several, and will list them in no order of priority:

- We know very little about the vetiver populations in the region. There has been no collection of accessions, no genetic characterizations to establish similarities and differences, no physiological comparisons, etc. etc.. Obviously this makes it somewhat difficult to look at improving performance;

- Zamorano Ag. College in Honduras is now is bulking up an accession of the "Karnataka" or "farmer-selected" vetiver from India. We think that it is better quality fodder. Dr. Yoon in Malaysia found that it tended to out perform the other 8 or so accessions that he compared it against, in terms of characteristics desirable for rapid hedgerow formation. From reports we have had from our contacts in Honduras, while Zamarano has some interests in vetiver, it is apparently not yet fully committed to putting an effort into bulking up and testing this accession either for fodder value or for performance relative to the locally available accessions. Some cooperation with them on this might provide a needed incentive. *(Ed. note. Could those of you at Zamarano interested in vetiver give the above some thought, from all accounts this grass is becoming important in Central America),*

- Regional governments are beginning to heavily cut back on support (even little as it is now) to small farmers on so-called "marginal" lands or lands of "forestry vocation" Their technical criteria for doing is not very realistic and does not recognize the presence of some very good technologies available (such as vetiver) for hill slope farmers, which can sustain basic grain (beans & corn) production at a financially viable (and socially valuable) level. Empirical data with which to convince policy makers is missing. It is also missing to provide guidance to technicians on the conditions (slope, rainfall, soil depth) when more traditional hedgerow species (e.g. lemon grass, napier grass) no longer are technically desirable.

- Among some other soils, ultisols are a major problem within current small farmer technology menus as seemingly most extension efforts fail to recognize phosphorous deficiencies, and given the heavy emphasis on organic methods, they do not coincidentally have any significant impact on the problem. Given that maize is as yet the most common hills slope crop and that maize is quite sensitive to P deficiencies, yields are extremely low. Low yields translate to low input cropping, which translates into no soil conservation and higher erosion rates, etc. etc.. Given that the soils thus tend to be in pretty poor shape (biologically, chemically and physically) after a decade or two of such treatment, it would if possible that one part of the solution is to look at the mycorrhizal populations on maize crops. In Vetiver Newsletter #7 there is an article on "Mycorrhiza and Vetiver - Rehabilitating Degraded Lands" where the authors found that AMF commonly occurring on maize roots significantly increased vetiver growth under P deficit conditions and hypothesized that AMF inoculated vetiver hedgerows could serve as a reservoir of AMF for crops on degraded lands. *(Ed..... Readers any other research topic suggestions would be welcome)*

From **Richard Webb**, Hong Kong ..... A small part *(of the land reclaimed through the use of Acacia mangium and Vetiver — Ed)* was burned last year, but the vetiver grew away strongly after the fire, and after being released from the shade so that it quickly did its job before the Acacias leafed out again. The vetiver planted in the single rows, while providing some erosion control in the first year, did not thrive and is now dying back. I think that the "soil" is too poor, but Ron Hill at Hong Kong University is doing some soil nutrient tests, which may throw some light on the subject. However, I am not discouraged as the grass did an excellent job and improved the establishment of the trees ....

From: **S.P.Yadav**. Community Development and Welfare Society, Katmandu, Nepal. .... Some information about Vetiver on our farm at 6,000 ft. We started with few (7) seedlings of Vetiver in July 1992 out of my personal interest in it after hearing about its soil binding and erosion controlling characteristics. It was planted for fun in the worst location without any care and management. Observing its capacity to withstand even the worst condition and no management and still having the growth (vertical and horizontal) we planted it on terrace bunds in July 1993, but still limited in number. n July 1994 we counted the number of plants in a clump. On an average it has multiplied 38 times in a year having a maximum of 46 plants in a clump. 300 shoots were planted in three different terrace in July 1994. The multiplication count done on 24th July 1995 is 48 per clump. The number has grown

to 75 this year in a clump planted in July 1993. The plant height above the ground is around 110 cm. and the root length is 45 cm. We are still using it in our farm prominently to control the soil movement during the heavy rains. It looks quite appropriate planting material in order to check the soil erosion and land slides in the steep hill slopes and therefore we are multiplying the stock to be distributed to the farmers in our project area initially and later to others as well. The farmers coming to our farm for training and visits are being exposed to the importance and characteristics of Vetiver as it appears in our farm which has quite positive impact on the farmers and there is increasing interest for this material to extended in the larger areas. Let us see how it works in the days to come.

From: **Christoph Backhaus** (GTZ Team leader), North Western Province Dry Zone Participatory Development Project (DZP), New Secretariat Building, Dambulla Road, Kurunegala, Sri Lanka. Tel/Fax: 0094137122554+22203 writes .....After such a long time I am not sure whether or not you might still remember that we once met in Northern Thailand a few years ago (about 1991), where we had a good time together while you were visiting our project area (the Thai German Highland Development Program). In the meantime, I have started to operate as a team leader for a new GTZ-Project in the Dry Zone of Sri Lanka, which among other components is mainly focusing on Rainfed Upland Farming. We are adopting a "Participatory Technology Development Adaptation" approach, but are also increasingly involved in dissemination activities. The project (funded by FAD and GTZ) is working with small farmers in the Dry Zone in order to assist them in improving their self-help capabilities and upgrading their living standard and in developing and adopting natural resource management systems which are in a sustained balance with their natural environment.

Vetiver plays an important role in our program, as one of the most prominent species which we are offering to farmers for soil and water conservation purposes. We are determined not to promote anything, but just offer the chance to farmers to test some new technical options and incorporate them into their existing resource management systems. The response has been quite good so far, in each of the 30 villages where we are working so far (the project is only operating for 2 seasons yet) some farmers have picked up Vetiver, though on a small scale, and they are observing and comparing it with other S&WC options, such as alley cropping (mainly with Gliricidia), physical bunds etc. While the first Vetiver lines are closing and thus show what kind of effect they may have, some (but not all) farmers have indicated that they consider Vetiver as one of the more promising options for S&WC. In addition, we have trained the operators of private small-scale multipurpose nurseries to multiply Vetiver and they are doing a good job already. In the coming years the challenge for us will be to further develop the technologies in a way that they become manageable for the farmers, and to disseminate them through a farmer to farmer extension approach on a fairly large scale. The project is supposed to extend its services to 500 villages (in 7 years).

Photo 2. *Natal, South Africa. Well established and stabilized water course on sugar estate. Note the vetiver hedges on the contour in the sugar field*.
Photo Credit Maxime Robert.

From: **Maxime Robert**, Vallonia Sugar Estate, P.O. Box 56, Umblali, Natal.4390.South Africa ..... Due to the good rains experienced in the months of March, April, and June, 1995 I am still at present planting vetiver even though we are in the middle of our winter season. The vetiver clumps have being dipped in water and planted immediately using 3-5 slips per station. Vetiver is an unbelievable plant that can take up to three months before growth is noticed especially during the winter months, but in the summer will show growth after only one week. The better the quality of the plant material the higher the survival percentage will be. The advantage of planting in winter, provided there is moisture in the soil, is that except for harvesting of sugar cane during this period, our labor force can be given alternate work with the vetiver program *(Ed. note that in the Himalayan region of India and Pakistan winter or early spring planting*

Photo 3. *Natal, South Africa. Four year old vetiver hedges in a sugar cane field in Natal. The sugar cane is 18 month plant cane. Note that there is virtually no damage caused by cane harvesting and transporting sytems*.

Photo Credit. Maxime Robert.

snow melt is feasible and would reduce competition for labor).

The problems experienced are very limited compared to summer planted vetiver where newly planted material can he washed out after the heavy summer rains and even staking of clumps will be required. Gaps in the vetiver hedges are best planted using up to 10 slips as this will ensure no further replanting. Harvesting of sugar cane between the hedges using a tractor together with a side loader does not cause a problem. Where the tractor and trailer are forced to drive over the vetiver hedge, it is then advisable to cut the damaged hedge down the ground level as this will promote regrowth.

The negative aspects of vetiver that I have experienced are very limited: (i) mature vetiver burns quicker under dry conditions, and unless water is available can cause a problem; and (ii) around the laborers quarters, where soap detergents are constantly used and thrown over the grass, and compaction occurs, the grass will die. Therefore washing facilities and pathways are required to prevent this problem.

On the positive side the advantages far outweigh the negative aspects. The vetiver system is easy to implement, it is not expensive and not difficult to maintain. It will eventually increase crop yields and the overall farm management will be made easier and less expensive.

The vetiver system is a system that I believe in, found that it looks after itself, and found it most rewarding to work with.

From: **Paul Truong**, Queensland Australia. ..... I agree wholeheartedly with Dr Yoon on the high quality and standard of planting materials needed for stabilization of engineering projects as replanting is very expensive and sometimes impossible. However I wish to point out that we must not lose sight of the main reason that the Vetiver System is so widespread and popular is that it is a very practical, simple and low tech means of soil and water conservation. This is particularly important in developing countries and also under extensive land use systems.

To me the bare root planting should be the ultimate aim in general as it is the simplest and cheapest method of establishment. I have successfully used bare root method at many sites in Queensland, the critical requirements are: (i) fresh planting material, should be planted preferably on the same day of digging, but no more than 2 days maximum; (ii) slightly larger slip size, at least 3 green tillers; (iii) planting into wet soil or that to be irrigated within a couple of hours after planting with enough water to soak the soil around the roots; and (iv) keep soil wet for at least 2 weeks after planting.

As watering is often a limiting factor, timing is very important, plant only during the wettest part of the year if watering is not available. A small application of fertilizer or manure will promote early growth and better chance of survival later. These are my limited observations, and I think this is a very important area on which we need to focus. I am presently working on the clay dipping method where bare root slip are dipped into a mixture of bentonite clay, dried out, and then planted. Clay dipping is a common practice in forestry to plant bare root pine seedlings here in Queensland *(Ed..... and in China)*

From: **Mark Dafforn,** National Academy of Science, Washington .....on the "non-weediness" of vetiver.

Mark Dafforn was research associate for the 1993 National Research Council report, "Vetiver Grass: A Thin Green Line Against Erosion". The following comments are drawn from some of his early correspondence on potential vetiver seediness and pestiferousness.

Vegetative hedges have shown great results controlling erosion in field agriculture, as well as in civil engineering, landscape stabilization, rehabilitation, and the re-establishment of native vegetation. The potential invasiveness of the species was an initial concern in our study.

This diminished considerably as we

learned more about the plant. The vetiver used in erosion control is an essential-oil grass from South India, where it seems known only in cultivation. It is increasingly clear that most vetivers outside South Asia are these low fertility, essential-oil types that are never invasive and are unlikely to become pests. This domesticated form of vetiver has long been grown as a field crop for its oil, which is used in perfumes. For this reason the grass has been carried from place to place for centuries. It is now pantropical—in nearly 100 countries. Extensive experience and literature exist on the plant, and it is not considered a weed.

When selecting germplasm for erosion control, fertility should be monitored on a case-by-case basis. There seems a strong correlation between oil yield from the roots and what is termed "nonflowering". Thus, the most desirable plants for propagation and further introduction have also tended to be the most infertile. This selection pressure may explain why viable seeds (caryopses) are scarcely reported from elite cultivars. This is a common characteristic of plants domesticated for purposes other than seed production, such as potato and sugarcane (a close relative of vetiver). The sterility (due to various factors such as pollen sterility and embryo abortion) seems total in many vetiver genotypes, but of course cannot be absolutely proven. "Nonflowering", by the way, is a misnomer: inflorescences occasionally occur but they are sterile.

One conjectural ancestor of the cultivated essential-oil vetivers is the seedy vetiver from north India and adjacent areas. This is not widely disseminated but it has been introduced to South India and a few other places. Morphologically the two types are quite dissimilar: the North India phenotype is lax, weak stemmed, and shallow rooted (and thus unsuitable for forming hedges). These traits hold true regardless of where the plants are grown.

The oils vary chemically, they rotate polarized light in opposite directions, they smell differently, and are treated separately in commerce. Technically, the north Indian is "Khus Oil"; the South Indian, "Oil of Vetiver".

The two types also differ in flower structure. The differences fall within specific limits of the taxon, so the two are not at present considered separate species. The North India vetiver is fully fertile, as are other species of the genus. Since the time of Linnaeus, it has been proposed that the wild north India vetiver and the essential oil south India vetiver are separate species; this has not been separately examined. It should be noted in passing that, as a convenience, taxonomists have long lumped unassignable cultivated plants with nearby relatives. Nearly all vetivers with which I am familiar can be handily assigned to either the north India or south India group. The last treatment of Vetiveria was about 90 years ago, and systematists seem to agree the genus merits revision. Incidentally, 2 - 4 new Australian species have recently been described.

Initial DNA fingerprinting (RAPD RFLP) of several genotypes has shown north India seedy material to be quite heterozygous and genetically quite distinct from the south India materials. By comparison, the three "nonflowering" clones tested thus far are unusually homozygous among themselves. These were traced back as far as Louisiana, Guatemala, and—quite possibly—Jamaica. They are virtually identical by any genetic standard (as well as quite distinct from the seedy types of vetiver from northern India). Homozygosity such as this over a broad geographical area seems to indicate a long history of clonal propagation without sexual reproduction. None of these three accessions has seeded in more than 50 combined years of field growth.

The "vetiver system" is an innovative concept of great promise. Hundreds of people are now working with vetiver hedges in every clime; the knowledge base is exploding, still without signs of potential vetiver pestiferousness. Since our report, many locations have been found with very old vetiver hedges. None show signs of spreading either nearby or far downslope; they persist but have not naturalized. Watchfulness is, of course, called for. Experience also shows that, if desirable, vetiver is easy to eliminate either mechanically or chemically. Perniciousness is not a problem. Importantly, even seeding north India types are not reported invasive, although they are co-dominants in fluvial Ganges grasslands.

Other plants besides vetiver can be used in a vegetative hedge system; the concept of slowing runoff and dropping sediment remains the same. The drawback is that nothing has been found that does the job as well as vetiver."Analogues" have been less effective, or required more maintenance, or been more competitive with neighboring crops, etc. On the other hand, if mandated in critical areas, native grasses—given sufficient management—would probably work well enough.

I ask members of the Vetiver Network to contact me with their insights on vetiver's physiology, morphology, and ecology and—particularly—to correct misconceptions I may have. Mark Dafforn, Office of International Affairs, National Academy of Sciences, Washington, DC 20418; 202 334-2692; fax 202 334-2660; email mdafforn@nas.edu.

Newspaper Reports

Khus used to check erosion - The Times of India News Service SHIMLA, May 15 1995: **.....** The agricultural department here has found that the fragrant tropical grass, vetiver (KHUS), used for cooling rooms, is a good soil binder. The grass, which can be grown without the risk of turning into a menacing weed, has proved to be an inexpensive and practical solution for combating erosion - a chronic problem in the state (Himachal Pradesh). It can be successfully grown both in tropical and semi

arid regions. The agriculture department planted the grass in rows on the slopes in Sirmour district. The grass grew quickly forming narrow but dense hedges which not only blocked the passage of soil and debris from being washed away but also gave a better chance for the rain water to soak into the soil rather than run down the slope. Besides, once the grass hedges were formed, they did not spread and become a pest. As a result terraces arose as the soil accumulated behind them. The once fragile erodible slopes - were converted into stabilized terraces fit for cultivation or forestry. This has proved to be a boon for Himachal where a few hours of torrential rain can wash away major chunks of top soil from the land ..... According to an official spokesman, successful demonstrations have been given in and around the Shiwalik Hills region. These have motivated farmers to recognize, understand and adopt the grass along the periphery of their orchards and agricultural lands.

Photo 4. *Darling Downs, Queensland, Australia. A typical strip cropping layout on the flood plain, a sequence of different crops (corn, sorghum, cotton, sunflower and fallow) designed to protect crop/fallow from flood erosion. If proven, only one Vetiver hedge is needed to protect five of these l9 m strips.*

Photo Credit Paul Truong.

Vetiver Grass Being Trialled On Flood Plains Sunday Mail. Dec 18 1994. .....Vetiver grass hedges are being assessed for their effectiveness in spreading flood flows on flood plains by two Darling Downs landcare groups. Overseas studies have shown Vetiver grass to be effective in spreading water and conserving soil and water on sloping land. Trials in Queensland have shown it to be highly drought, heat, cold and salt tolerant and able to be established on a wide range of soil types. Vetiver's suitability is now being assessed on flood plains as a supplement to or, in some cases, an alternative to strip cropping, which at times provides little protection from erosion. This is particularly so during drought or when low stubble producing crops such as sunflower and cotton are grown in alternate strips. The Myall Creek/Blaxland Landcare Action Group and Jondaryan Landcare Group have initiated two Vetiver trial field sites. These have been set up by Paul Truong (Natural Resource Management Unit. DPI) and Rod Smith (Agricultural Engineering Department. Southern Queensland University). For the Myall Creek/Blaxland Group, Vetiver hedges were established across shallow gullies and depressions to supplement existing strips at Ken McRae's property. These hedges should spread flood flows and trap most of the eroded soil moving down the slope, gradually leveling the gullies and depressions. For the Jondaryan Landcare Group, Vetiver hedges were established at approximately 90 m intervals down a strip cropped slope on Mark Hensell's property on Evanslea Road. Flume tests on the site, conducted by Paul Dalton of the Agricultural Engineering Department, University of Southern Queensland, found that when fully established, the Vetiver hedges should provide adequate spreading of flood waters over the 90 m spacing, which is equivalent to five strips at this particular site. Stubble mulching would still be required to maximize erosion protection. If proven successful, the incorporation of Vetiver hedges as an alternative to strip cropping on flood plains should result in more flexibility, more easily managed land, and more effective spreading of flood flows in drought years and with low stubble producing crops. An added benefit is that the area cropped at any one time could be increased by up to 30%.

Vetiver Developments in Mexico. What two men with a mission can accomplish

Your Editor first heard from Kevin O'Sullivan less than a year ago. We have never met, but he is obviously a dynamic person with a mission in life. He got interested in Vetiver, and found it growing in Chiapas Region of Mexico. People often ask me how one can get a vetiver program started in a country. Kevin's approach is interesting and appears to create many initiatives. His story of how he is spreading the technology in southern Mexico is worth pondering and follows below:

From: **Kevin O'Sullivan. Mexico** Tel: 52

951 464 90 ..... A brief update on the status of vetiver in Oaxaca and other Mexican States as of the beginning of August 1995.

1. Institutions.

Instituto Tecnologico Agropequarto De Oaxaca (ITAO): Member organizing committee. - Ing. Francisco Marini. Now have a Vetiver nursery in Oaxaca. Approx 7000 tillers were brought from Chiapas, 6000 of which were planted in groups of 3 tillers, 30 cm. X 40 cm, unfortunately, under far from optimum conditions. ITAO has micro propagating facilities and is very interested in getting information on micro propagating techniques for Vetiver. Who would be the best people to approach ? *(Ed. I believe some of the best micro propagation work has been done in Thailand at the Doi Tung Royal Development Project at Chiang Rai).*

Centro Regional Universitario Sur (Crus Chapingo) Suelos Aguas Y Semillas De Oaxaca (SASO.Ac). Member organizing committee. - Ing.Efrain Paredes, Ing.Gabriel Narvaez. Efrain and Gabriel have been taking care of the plants I brought from Chiapas in January and the accessions we received in February from the Botanical Gardens, Jalapa, Veracruz. Both were very slow to start but with the advent of the rains, warmer temperatures and a little more care, sprang vigorously to life!!! They appear to be different varieties. The grass from Chiapas has grown very well. It has put out between 20-30 tillers since May with a strong, erect: habit; that from Veracruz has produced 15-20 tillers, is a lighter green in color, more "weepy" and looser in habit. We will get botanical identification as soon as we can. They have also taken 1000 tillers from our latest batch from Chiapas which they have planted in polybags. *(Ed. Kevin you might want to send your different cultivars to Robert Adams for DNA testing. See letters to Editor above).*

Instituto Politecnico National. Centro Interdiciplinario de Investigacion para el Desarollo Integral Regional. CIDIR - IPN - U. GAXACA. Ing. Cirenio Escamiros. Your slides are proving very useful. Efrain and I gave a presentation to a group of agronomists from ClIDIR. They were very enthusiastic. They are working with communities in the Mixteca Region, one of the most eroded parts of Mexico, if not of the world! They were curious to know if vetiver would grow faster under greenhouse conditions given the elevation (1500m.) and a cooler climate. Very keen to start a nursery.

Instituto National De Investigationes Forestal Y Agropequarto INIFAP. CEFAMOAX (Nochixtlan). - Ing. Efrain Cruz Cruz. Ing. Efrain Cruz has been working for some years with grasses, shrubs and trees in this very eroded area of Oaxaca. He is very well informed about the virtues of Vetiver but did not know it existed in Mexico. We will meet with him next week.

Universidad De La Mixteca. Member organizing committee - Ing. Juan Manuel Garcia. ..... Very keen to start a nursery for research purposes.

2. NGOS and Committies in Oaxaca:

Estudio Rurales Y Asesoria. AC. (ERA) Member organizing committee. - Ing. Carlos Vilchis. ERA has been working with Union Zapoteco Chinanteco - (UZACHI) on sustainable forestry for a number of years. UZACHI are very keen to use vetiver as part of their erosion prevention program. The nursery would be based at CAPULALPAM DE MENDEEZ. Region: Sierra Juarez. I am really impressed with their tecnicos; very keen and very committed to their work. The elevations 2400m.

Asesores Para El Advance Sociales. SC. (AAS) Member organizing committee. - Ing. Ricardo Diaz.AAS have been working on integrated projects (agriculture, health, education) in the region of the Mixteca Alta. They are keen to start vetiver nurseries in the area of SAN MARTIN PERAS on the border with the state of Guerrero, one of the most eroded parts of Mexico.

Santa Maria Tiltapec. Region: Mixteca Alta. A very interesting community in the valley of Nochixtlan where prehispanic forms of erosion control still survive. Two campesino friends, Don Betto and Don Saul, are very keen to try Vetiver both as an adjunct to and possible replacement for the very laborious but very effective traditional methods of check dams and terraces. They are also interested in Vetiver as a forage grass. Ing. Efrain Cruz has worked with this community for a number years.

Santa Maria Chilchotla. Region: Sierra Mazateco. This is a coffee producing area on the border with Veracruz. The people here are seeking to minimize their dependence on a monocrop. They had heard about vetiver oil and were looking to the plant as a generator of income. They obtained 3 or 4 slips from a campo experimental in Guadalajara, Jalisco. The campo experimental seems to have a few Vetiver plants as specimen/ornamentals as does the botanical gardens in Veracruz. The people of Chilchotla, having got their plants and didn't really know what to do with them. We gave them what literature we have in Spanish and explained our approach to Vetiver. This is a tropical, subtropical humid region of very steep slopes. Erosion is an increasingly serious problem. The two community representatives who came to see us will get in touch with us around the middle of August with their ideas for a Vetiver program.

La Esmeralda. Region: Isthmus of Tehuantepec. Gabriel and Efrain (CRUS) have been working with communities in this area for a number of years using the mucuna and canavalia beans as green manure/cover crop/ weed inhibitor. It is a tropical humid zone with deep rich soils. We would like to start a nursery here. We reckon the plants would reproduce rapidly under the nearly ideal conditions of good deep soils and good soil moisture throughout the dry season.

3. Vetiver In Other States.

Tabasco.

Centro De Capacitacion Agropequarlo Y Forestal. Macuspana, Tabasco. Dr. Arturo Romeo. Dr Romeo got in touch with us by telephone. He and his group are working with agroforestry programs on steep slopes on the Tabasco/Chiapas border. He is well informed about vetiver but was not able to identify it in Mexico. He tried importing vetiver from Guatemala (through SHARE, I think) but it did not survive. He was delighted to know that vetiver is available in Mexico and is very keen to work with it. We will exchange visits later in the month.

Veracruz.

Jardin Botanico. Jalapa, Veracruz. Biologist Mayte Lazcurain. This botanical garden has some well established vetiver plants as specimen/ornamentals. We obtained about 20 tillers from them in February. Comparing it with our accessions from Chiapas it appears to be a different variety. We will soon have botanical verification.

Inifap Campo Experimental El Palomar. Cordoba Veracruz. Ing. Victor Hugo Diaz. Ing. Victor Hugo has also been in touch. with us. He is working on slope agriculture and obtained 5 slips of vetiver from the botanical gardens in Jalapa which he hopes to reproduce. He was very pleased. to know other groups are beginning to work with Vetiver and more ample supplies might be available. I will visit him in the near future.

Jalisco.

Centro De Investigacion Y Asistencia En Tecnologia Y Diseno Del Del Estado De Jalisco. AC. (CIATEJ) Dr. Marco A Martinez. We know very little about this group except that they have some vetiver, apparently as specimens/ ornamentals. They also have micro propagating facilities. CIATEJ provided the vetiver slips for the Union de Santa Maria Chilchotla but very little information. We will get in touch with this group very shortly.

Tlaxcala.

Carlos Vilchis of ERA. AC. (Oaxaca) tells me of communities in the state of Tlaxcala who are working with grasses for erosion control. He thinks they might be using vetiver. I will visit this area with him around l4th -l 5th August. It seems that in Mexico, there is vetiver (possibly 2 varieties) in at least 4 states, if in very small quantities. Our most plentiful source still seems to be the finca La Paz in Chiapas. Our main problem is and will continue to be lack of plants.

The vetiver program is linked into at least three of the major agricultural research institutions of the country. We are now hoping that some bright eager researchers will grasp the possibilities. Unfortuneatley, none of these institutions seem to have any money at all for research at present.

As for the small farmers, I believe that if we have enough material to do adequate demonstration by the beginning of the rainy season 1996, farmer acceptance of vetiver grass technology will speedily follow.

The question I am most frequently asked is, "is vetiver a good forage grass ?". Here is an immediate topic for research and development. Most farmers I know would jump at a technology that has dual benefits: a technology that not only conserves soil and moisture but also doubles as a forage or has some other economic benefit would be irresistibly attractive. *(Ed. ..... there are lots of examples in this news letter showing that vetiver is very much used as a fodder).*

At the end of the month I intend to go back to Chiapas if the finca La Paz is still in the hands of my friend Ricardo, to bring back as much vetiver as I can. We will distribute this to the interested groups and communities in the various regions and zones of Oaxaca with the aim of propagating the grass for regional demonstrations next year. We will also provide Tobasco and Veracruz with enough to plant their own nurseries. We are also considering starting a nursery in the deep soils and tropical humid zone of the Isthmus to insure safe supplies for the very uncertain future.

Very little funding has materialized so far but: some agencies are beginning to blow warmer and others have gone ice cold. UNDP and FAO seem to be really interested in the long term development (and perhaps amplification) of a Vetiver program. We certainly could do with a healthy injection of cash. There is an enormous amount of work to do and only two of us to do it.

David Leonard's advice from Honduras is, "propagate, propagate, propagate! The grass will then promote itself!!". He also sent us a magnificent volume on "sustainable soil management practices for slopes" which will be enormously useful here because it is largely based on campesino experience. I also visited very briefly David Arrivillaga of SHARE Guatemala. Unfortunately, I arrived at the beginning of a four day holiday so I wasn't able to any demonstrations; nonetheless, it is a useful contact for the future.

This is more or less the vetiver story so far here in Oaxaca, perhaps in Mexico. I find it quite surprising. First Chiapas, then Veracruz, and now Jalisco. In the next weeks or months perhaps more sources of vetiver will turn up and we won't have to be so anxious about losing our source in Chiapas. It does seem though, that with proper organization, sufficient personnel and adequate financing we could be at the beginning of introducing a major new technology. I guess we need to find a Mexican Dr. Yoon. There is so much to be explored. In particular given the Frequency of the question about forage. Are any groups actively researching this? I came across a reference to "hybrid 8" in the newsletter but much to my chagrin, I can't find it again! (*Ed. ..... Hybrid 8 is supposed to be a high yielding oil cultivar developed in India)*

We will be very appreciative of any ideas/advice you might have for us.

Thank you again for all your help so far.....

Accelerating Vetiver Developments In Africa

Ghana. Some feed back from the November 1994 Wonder Grass Conference

Billiton Bogosu Gold Ltd.

The Billiton Bogosu gold mining area in the Western region of Ghana, initiated a few years ago an intensive rehabilitation of mine dumps. In this process a wide range of grasses and plants were tested to see which of them are suitable as conservation measures. One of the main characteristics for this exercise is how to handle the soils with very low nutrient content. Vetiver grass is among the grasses being tested, both local and imported species are being grown. At the present stage nurseries have been set up to provide planting material. Vetiver has so far performed very promisingly compared to other plants, such as e.g. Leuceana sp., due to its strong root system which is very effective in the process of stabilizing slopes. Comparisons of the performance of the local species *(Ed. probably Vetiveria nigratana)* with the imported one (Vetiveria zizanioides) indicate that the latter is more suitable.

Establishment Of A Local Vetiver Grass Planting Material Base

Upon request for solutions from farmers facing serious erosion problems, the local species of vetiver grass has been established at the Crops Research Institute in Kumasi for further experiments and at the same time providing a planting material base

Agroforestry In The Volta Lake Area

In an attempt to solve the siltation problems in the Volta lake by the Akosombo dam as a result of serious erosion problems on the hilly sides surrounding it, an assessment of a possible use of agroforestry measures along the Volta river was carried out. In the process vetiver grass was identified as one of the possible means of preventing erosion and local species were discovered in various parts of the country including the Shai hills in Eastern Region and the Northern parts of the Volta Region.

Demonstration Of Erosion Control Measures At Bompata In The Ashanti Akim Ditrict

In connection with the celebration of the Africa Scientific Renaissance Day on 30th June, 1994, the Soil Research Institute (SRI), Building and Road Research Institute (BRRI), Crops Research Institute (CR1) and Forestry Research Institute of Ghana (FORIG) decided to address the settlement erosion problem affecting many communities in Ghana. The aim was:

- to adopt measures which could be implemented to check erosion problems at Bompata at the most economic level, and

- to implement some of these measures as demonstration exercise for the 30th June celebration, 1994.

Bompata being one of the major towns in the Ashanti Akim District is located in the moist, semi-deciduous zone with annual average rainfall of about 1200 mm. occurring usually in torrents. Soils are generally deep agricultural soils classified as sandy clay loams and clay loams. Control measures with special emphasis on vegetative cover were embarked upon in 1975, but due to health inspectors discouragement , considering it a malpractice encouraging weedy and insanitary surrounding of the town, the grasses were hoed out. Roads and houses are oriented along the slope with no drains, and rills and gullies dominate the landscape. The ground slope is around 20% on upper slopes and 2-5% on lower slopes where a lot of sand deposits have accumulated. The erosion problem has left many buildings, especially older ones, virtually hanging or sitting on pedestals and many are collapsing; even the newer buildings are being undermined gradually. Erosion in the area is a result of the soils' high susceptibility to erosion, heavy rainfalls, lack of land use planning creating pedestrian access roads facilitating further erosion as well as socio-economic factors. A number of measures were implemented around the houses such as:

- slowing down and diversion of velocity of runoff using bamboo, sticks, boulders/stones and sandbags;

- biological stabilization of the surface soils including the use of various grasses and fast growing trees

Vetiver grass was one of the grasses being test planted at the toe of a slope in order to arrest the movement of eroded soil. Preliminary results showed that the grass formed a very effective barrier sieving runoff and thereby causing soil particles to be deposited behind. Further studies are yet to be carried out to look at the grass' performance in the long term. **Some of the inhabitants of Bompata have however already started planting vetiver grass hedges around their houses in an attempt to control erosion.** *(Ed. It would seem that the potential users are already convinced, researchers should work with them and speed up the process of adoption).*

A Practical Look At Vetiver And Its Uses As Applied In The Republic Of South Africa

Tony Tantum, South Africa

It is not known when vetiver was first brought to South Africa from the East. The grass has been grown in the Transvaal since 1892. It was apparently brought from the Cape by a Voortrekker family, and was used for scenting kists (Meredith, 1955) .

Mine Dump Rehabilitation - Anglo-American Gold Tailings Slimes Dam. Vetiver hedges were planted in May 1992. The experiment showed that:

- the vetiver plant managed to establish itself prior to winter with a minimum of water;

- Vetiver survived the winter, but it also survived the hot winds of spring in the hostile environment of the slimes dam with a pH of approx. 3.3.

Not only did the vetiver hedges survive with no maintenance or fertilizer/watering but three years later they were still in-situ. The year 1993 was a bad drought year in the area, but over the three years a mortality rate of only 18% had been experienced. Through this experiment Welkom Mines have written vetiver into their specifications for the mines slime dam reclamation work over the next 15 years.

Kimberley (De Beers diamond mine dumps)

The vetiver hedges established easily on the dumps, and have also enabled (because of improved soil moisture) the local grasses to establish themselves between the hedges. The dumps range from rainfall areas as low as 300 mm. up to 1000 mm. Once again the droughts in South Africa have not affected the vetiver grass significantly. In any mining situation in areas where the rainfall is low and especially in Gold Tailings where pyrites are acid forming, irrigation is essential. Vetiver hedges planted across the slope then vegetates. A detailed plan on how this is done is available from Tony Tantum.

Road Stabilization

A road pass, called Oliviershoek, in the Drakensberg mountains in the region of Natal was stabilized by the Road Department. As an experiment, a portion of the pass was planted with vetiver grass. The objective was to see how the vetiver grass stood up to, and could be compared to the norm of guniting the slope (blowing concrete onto the slope). Three years after establishment the gunite was clean and intact where the hedges had been planted above, whereas the gunite was breaking down where there was no hedge protection. The gunite was full of holes and within a few years is expected to be replaced at a very high cost. Where gabions have been put in place mud slides are prevailing and the slope often collapses. Vetiver hedges at a much smaller cost could have done the job in the first instant with no subsequent maintenance.

If a little trouble is taken to establish vetiver hedges on any slope or gully prior to the rains there is no doubt the area concerned will be stabilized. No maintenance will be required. The establishment of vetiver hedges across waterways will stop silting of dams. In South Africa it has been proven that wherever vetiver hedges are used and no matter the circumstances, as long as it is properly established, the system works. Presently the plant is also being used for the following in South Africa: oil from roots; resale of crowns as planting stock for new planting; and for thatching, weaving and briquettes for cooking.

As one can see there are many uses of vetiver. Not only is vetiver a "Wonder Grass"; but it has become a household name especially in government and district country circles. If people in power are serious in their attempts to give people a sustainable living at the grass root level then a serious and positive look should be given to the "wonder grass" called vetiver.

Vetiver Grass As A Tool For Consideration In The Forestry Erosion Management Program. - Tony Tantum et al. South Africa.

While the erosion problems have largely been overcome within the forest plantation, the areas adjacent to the plantations have been overlooked. These areas include firebreaks, road cuttings, and drainage systems. Vegetative barriers of vetiver grass were planted on firebreaks and show much potential as a tool in the erosion management program. A suitable site was chosen on Bloemendal experimental farm where bands of vetiver grass were planted across a firebreak to test the grass' ability to filter out the sediment and retain it, in situ. The firebreak has a slope of 15% and is 9 m. wide. It is hoed clean. In October 1990 vetiver grass tillers were planted 5 cm. apart across the firebreak at 30 m. intervals perpendicular to the slope. Seven months later the grass had started to form a hedge and was effectively filtering out much of the sediment. A terrace had started to form from the filtered sediment above the hedge and the development of a gully which had started to form below the hedge was halted. It is expected that with time, the hedge will grow thicker and become more effective at filtering out sediment. To satisfy fire insurance requirement the grass must be burnt before the first season. Attempts were made to burn a hedge of vetiver grass in June 1990, but a satisfactory burn could not be obtained. It was then sprayed with a contact herbicide (Gramoxone) and two weeks later a satisfactory burn was obtained. The grass has subsequently recovered and new tiller development has been encouraged by burning. By devegetating firebreaks the erosion process is encouraged. The advantages and possibilities of vegetating firebreaks with fire resistant ground covers require further investigation. Ideally the ground cover should be frost resistant, competitive but not invasive, indigenous and of low growth habit. Certain succulent species have been identified and are presently being investigated.

The grass has fulfilled all expectations and observations made thus far are impressive. It has the potential for replacing mechanical methods of controlling erosion on forestry firebreaks. It is more cost effective than mechanical methods and requires less maintenance becoming more effective with time as the hedge grows thicker. It does not produce viable seed, and will not become a weed.

Prospects And Problems Associated With The Use Of Vetiver Grass As A Biological Mean Of Soil And Water Conservation In Lesotho Lowlands And Foothills
- By A.B. Chaudhry, M. Petlane (Agronomist & Programme Coordinator, soil and Water Conservation and Agroforestry Programme (SWaCAP)), and N. Mota

(Chief Conservation Officer, Soil Conservation Division, Ministry of Agriculture, P.O. Box 24, Maseru 100, Lesotho).

Summary: Vetiver grass (Vetiveria zizanioides) was introduced into the farming systems in Lesotho lowlands and the foothills during 1990/91 summer season. Observations thus far have indicated that Vetiver grass has gone through the process of acclimatization and displayed its potential as a biological mean of soil and water conservation. Contrary to the earlier beliefs, Vetiver grass is palatable to the livestock and has survived below freezing point (around - l0˚ C) winter temperatures. However, the traditional practice of livestock grazing, and Vetiver grass' failure to withstand over grazing and compete with neighboring Bermuda grass (Cynodon dactylon) as well as Kikuyu grass (Pennisetum clandestine) seems to seriously restrict its scope for successful integration into the farming systems. *(Ed. ..... this may be a premature conclusion. In other countries vetiver will withstand very heavy grazing, and if planted at the right time will actually act as a preventative barrier to the afore mentioned creeping grasses)*.

Introduction: Lesotho's agro-ecosystem is characterized by wide spread erosion, shrinking land resources, low pH, biomass disequilibrium, and as a consequence, declining agricultural production (UNICEF, 1991, Harrison, 1989). There are over 30,000 gullies occupying 4% of the total arable land and millions of tonnes of top soil have been lost through erosion (Hall and Green, 1989, Harrison, 1989). An average rainfall of 740 mm should normally sufficient to ensure successful farming, however, with erratic rains the crop failures due to the drought conditions are a common phenomenon. Lesotho farming systems are based on comprehensive terracing which are more than 50 years old. Unfortunately most of the terraces at the moment are poorly aligned and in some cases banks have been slashed by the plough to be just rudimentary lines (*Ed. ..... also many of the waterways that take surplus runoff from the terraces have become major gullies due to concentrated water flows. It is my opinion that Lesotho's conservation systems are a classic case of systems that have actually enhanced the removal of scarce water resources from the land, and have contributed to furthering "drought" conditions and reduced ground water levels).* Farmers are generally not too keen to upgrade their terraces due to the physical drudgery and controversial land tenure system. Under prevailing circumstances physical soil conservation structures need to be supplemented by appropriate biological means to effectively contain the situation. In this regard Vetiver grass was introduced from the Republic of South Africa (RSA) during 1990/91 summer season to ascertain it suitability for the existing farming systems in Lesotho.

Methodology: Vetiver planting material was imported from the RSA during December, 1990 at very high initial cost. In all >60 farmers were selected through consultation with the District Conservation Officer (DCO), Extension Agents (EAs) and the Village Development Committees (VDCs) to contain rill erosion in their farm lands. Sufficient material was provided to each farmer to establish a line or so across the run-off routes. Vetiver grass was used to establish border lines, measuring about l00 m, to protect a cut-off drain in the communal area. In addition Vetiver grass was tried in the agroforestry experimental plot for soil and water conservation. All the planting took place during December 1990/ January 1991.

Establishment of Vetiver grass nurseries: Part of the planting material was planted on an area of 0.40 ha for observation and multiplication. A research element was also introduced by employing two tillage systems i.e. traditional plough-plant system (control) and rip-line system, where in addition to ploughing, pre-planting rip-lines were established and necessary soil amendments, notably compound fertilizer 2:3:22 @ 100 kg/ha and farm yard manure @ 2t/ ha were applied on the rip-lines. Ripping was carried out to eliminate the plough-pan. Later during 1993 another nursery was established on an area of 0.20 ha. For the first nursery, an arrangement has been made with a farmer having a cow and a heifer to monitor the fodder potential of Vetiver grass. The farmer regularly cuts the green fodder and feeds his animals. Necessary data is being recorded periodically using a questionnaire.

Propagation: During 1993/94 summer season efforts were made to establish Vetiver grass lines using bare root slips with disappointing results. At present the planting material is first time being planted in polybags to be transplanted in the field, later following the planting of field crops.

Observations:

On-farm observations: During 1990/91 summer season, out of 8543 Vetiver grass stands 56% successfully established. However, following 1991/92 harvesting of summer crops, the grazing livestock relished the fresh regrowth so much that they grazed it to extinction. It was more so because Vetiver grass puts up an accelerated growth at the inception of fall and pre-spring period, when in the fields nothing else is green. In the cut-off drain situation Vetiver grass initially put up a wonderful growth but it was soon over powered by the Bermuda and the Kikuyu grasses. The following year its token presence was felt and later it disappeared completely. In the agroforestry experimental plot Vetiver grass grew well and established in a short while. Half moon circles planted around some fruit trees for in situ water harvesting did not provide any evidence of competition between the trees and the grass. Vetiver grass hedges were trimmed twice a year, once before Fall and then in Spring. The hedges acted as windbreaks.

Establishment of Vetiver grass nurseries: The first Vetiver grass nursery was established during January, 1991 for a close observation. The plants responded to rip-line system (improved husbandry) favorably in terms number of slips/ clump and dry matter production. On an average there are 17 and 28 slips/ clump for traditional plough-

plant system (control) and rip-line system, respectively. The number of slips/ clump directly contributed towards the dry matter production.

Fodder production: The information regarding the Vetiver grass fodder production and utilization has thus far indicated that Vetiver grass did provide green fodder for supplementary feeding of the farmer's cow and a heifer. He reduced grazing time to four hours/ day and cut four sacks of green fodder daily. Vetiver put up an accelerated growth during prefall drop in temperature as well as early spring. Plant growth always slowed down during the extremes of winter and summer. Winter chill also led to a usual bronzing of vetiver foliage. Vetiver fodder reduced farmer's dependence on alfalfa hay selling at US$ 4-5 per bale. Farmer cut fodder assisted by his family. Despite the fact his cow was at the end of lactation period, he has been recording on an average 300 liters of milk/ cow/ month to be sold at US$ 0.50 per liter. He found one cut of 0.40 ha Vetiver grass plot sufficient to feed his cow and a heifer for up to 60 days, especially during the rainy season and recorded very minimal wastage on Vetiver grass fodder during stall feeding. Finally on palatability issue he pointed out that another farmer's cattle refused to eat Vetiver grass fodder, indicating that cattle have to develop a taste and get used to the new fodder. Otherwise frequent cutting of fodder strengthened the clumps and increased the number of slips/ clump.

Propagation: Bare root plantings displayed a modest success of around 60%. The gaps within the line rendered the hedges ineffective to successfully intercept the run-off. The planting of Vetiver grass slips in polybags seems to be the appropriate way to economize on the planting material and insure a uniform establishment (*Ed. ..... under farm conditions polybags are expensive. I would suggest that you look more carefully at bare root planting. Two points should be especially noted: (i) time of planting when the soil is wet after a good rain, and (ii) in India we have found that survival rates drop significantly if planting is done more than 24 hours after lifting the plants from the nursery).*

Discussion:

Lesotho according to Harrison (1989) is facing an environmental crisis of "massive proportion". There is no way how conventional, physical soil conservation structures alone could rescue the situation. The only way out seems to be an integrated approach. In this regard Vetiver grass has been proclaimed to be not only right, but indeed the only plant suitable for long term control of soil erosion and promoting in situ moisture conservation (Greenfield, 1988). With most soils in Lesotho being acidic. Vetiver grass' tolerance to low pH and particularly aluminum toxicity (Truong, 1993), makes it the most appropriate biological mean of soil and water conservation.

There is always an acute shortage of fodder in the country, as the carrying capacity of the range-land is extremely low. Vetiver grass is palatable. Its nutritive value has been reported to be between Napier grass (Pennisetum purpureum) and fresh corn stover (Vetiver Newsletter, 1990) *(Ed. .....if cut at regular intervals in the young green leaf stage)* In the light of the above facts, it is expected that Vetiver grass hedges within the farm land, around the gullies and even within the range land might be an answer to the current overstocking (Hall and Green, 1989, UNICEF, 1991). However, the socio-cultural tradition of livestock grazing is a big obstacle in the way of this positive development and has in fact been causing a havoc (Hall and Green, 1989).

Better Vetiver grass performance due to rip-line system is associated with the fact that most Lesotho soils are the victim of compaction of various degree. These observations are in line with other field crops' response to the rip-line system (Chaudhry, 1994). Vetiver grass planting material is scarce and extremely expensive, and with the erratic rains, planting of Vetiver grass in polybags seems to be a right approach.

Australian Pilot Programs Steam Ahead Under the Guidance of Paul Truong

Effectiveness Of The Vetiver Hedges In Soil Erosion And Sediment Control In Queensland. by Paul Truong, Queensland Department of Primary Industries.

A large number of field trials were carried out to verify the effectiveness of Monto Vetiver in soil erosion and sediment control in Queensland. The followings are results to date of some case studies:

Steep slope stabilization: Embankment of both cut and fill slopes can be effectively stabilized by establishing Vetiver on contour lines. The deep root system stabilizes the slope while the hedges reduce runoff, increase infiltration and trap sediment providing a very favourable environment for the colonization by local volunteer species. This is well illustrated in the following two examples.

A very steep (1:1) and highly erodible sodic soil on a railway embankment near Cairns collapsed and needed to be rebuilt after almost every wet season. Obviously, the solution to this problem is a very costly engineering structure. As a trial, six rows of Vetiver were established on mini benches (0.25m wide) on the slope at 1 m VI (Vertical Interval). A total of approximately 250 m embankment was stabilized with Vetiver in June 1992. The Vetiver established and grew well despite the dry season and by December 1992, the slope was reasonably stabilized by the young Vetiver plants and local species began to establish between the Vetiver rows. In March 1993, nine months later, the slope was completely covered with local vegetation between the Vetiver hedges. Fifteen months later the embankment was completely stabilized with a mixture of Vetiver and mature local grass species. This embankment has withstood up to the last three wet seasons.

On another site, an old quarry at Henlies Hill in Cairns, where the old rubble surface has remained bare of vegetation since the quarry operation stopped five years earlier. Four rows of Vetiver, established on an 80% slope at 1m VI. Despite the extremely poor and hostile conditions of the coarse gravely ground, Vetiver established well (with NPK fertilizer) and started trapping debris from upslope. The stiff stems of Vetiver provided a very effective barrier trapping debris and rocks up to 70 rnm in diameter. Twelve months later the old gravely slope was 75% covered with local vegetation between the rows of Vetiver hedges which had grown to 1.2 m tall. Eighteen months later the slope was completely stabilized and revegetated with Vetiver and other local species including a pasture legume (Stylosanthes).

Filter strips : When established across drainage lines and water courses, Vetiver hedges filter and trap both coarse and fine sediment resulting in cleaner runoff water. At Excel Quarry north of Brisbane, Vetiver was used to stabilize steep slopes of overburden and waterways. When planted across a long (500 m) and steep (20%) waterway, Vetiver hedges stopped the erosion on the waterway floor and trapped both coarse and fine sediment in runoff water from this working quarry. On another waterway leading to a dam, Vetiver hedges trapped most fine sediment resulting in less polluted water in the dam. Following the success of these trials, Vetiver is now being used as a standard method of trapping sediment and land stabilization at the quarry.

Gully stabilization: Vetiver hedges are very effective in stabilizing gully erosion. When planted on contour line above the gully head, Vetiver hedges will spread and slow down runoff water and stop the advancement of gully heads. This is well illustrated at a number of gullies in both cropping and grazing lands. Following the control of active erosion at the gully heads, gully floors are normally revegetated naturally with native species. On large and long gullies where active erosion occurs both on gully floors and walls, Vetiver hedges established on the gully floor will reduce flow velocity, trap sediment and reduce further erosion on the floor. At Ashall Creek, a very large gully system in the black earth on the Darling Downs, more than 0.3m of sediment was trapped by a series of 17 hedges over an area more than 400 m long and 50m wide during the 1994 summer.

Wave erosion control: Being able to establish and thrive under waterlogged conditions, Vetiver has proved to be very effective in reducing erosion caused by wave action on big farm dam walls. The erosion caused by wave action on the inside wall of a very big farm dam near Cloncurry was effectively controlled by establishing a Vetiver hedge along the high water mark.

Rehabilitation of mining waste and contaminated land: With its very wide range of tolerance to adverse soil conditions such as pH, soil salinity and mineral including heavy metal toxicities, Vetiver is highly suitable for the rehabilitation of mining waste and contaminated lands. Early results have shown that Vetiver is the most promising species grown on coal mine tailing in Central Queensland.

Photo 5. *Darling Downs, Queensland, Australia. Under dry (or drought) conditions, water competition occurred affecting establishment and yield of the first row (0.85 m from Vetiver hedge) but not the second.*

Photo Credit Paul Truong

India. Vetiver Has Found A Permanent Place In Land Management Practices.

Khus (Vetiveria zizanioides) in Watershed Development in Karnataka (India) by Prof. K.N. Ranganatha Sastry, Head of Department of Agricultural Economics, University of Agriculture, Bangalore, Karnataka.

Though Khus (vetiver grass) is a native grass in Karnataka the credit of introducing this in rainfed areas under Watershed Development Program for Rainfed Areas (WDPRA) in Karnataka goes to the World Bank in general, Mr. John Greenfield and Mr. Richard Grimshaw in particular. During 1985-86 a bag of khus slips was air lifted from Jhansi and planted in the prepared raised beds

in World Bank aided Kabbalanala Watershed. It is only after 4-5 years that the author and Dr. S. Subramanya were able to spot 3-4 locations in the southern part of Karnataka, mostly with red, red-laterite soils, where Khus was grown naturally as an indigenous grass. Most often used in small stretches or points wherever erosion was maximum. In Gundalpet area of Mysore District, khus had been grown on bunds for over 200 years (R. Grimshaw 1993).

This small note cannot justify the full extent of the features of the versatile Khus grass. In this note a features are highlighted through photographs rather than lengthy descriptions:

Photo 7. *Karnataka, India. Preparation of vetiver slips by farmer prior to field planting. These are good quality plants and should establish well.* **Photo Credit. K.N. Ranganatha Sastry**

Soil Conservation: Photograph 6 indicates the efficiency of khus in conserving soil in-situ, which an earthen bund cannot do satisfactorily over time. The strip in the upper reaches where the damage has been more with lot of rills is gradually getting protected with khus while the second strip is already protected satisfactorily as perceived by the absence of rills and uneven surface. The greenery is also uniform. In the third strip the green cover is more perfect. At the periphery one notices a small patch of exposed surface which was the mouth of the gully. Khus was able to protect the land which was earlier covered by rills and uneven surface leading to a gully. This was the state after two years. However, the entire plot was protected after 4-5 years.

Skill level: Since all the farmers are familiar in handling planting materials, they do not need any training in handling khus grass. All that they need is the information regarding its habits, planting methods, maintenance and so forth. Just like an Indian woman preparing the new food menu with mere explanation without requiring demonstration, even average farmers can pick up the technology of planting, maintaining and expanding Khus hedges. There were instances where even average farmers altered the planting distance and intensity to suit particular spots in the field and along the bunds. Photograph 7 shows the preparation of slips by a farmer for establishing hedgerows on his field.

Photo 6. *Karnataka, India. Erosion control on fallow land.*
Photo Credit K.N. Ranganatha Sastry

Fodder: The top portion of khus, after preparing slips, can be used as fodder supplement. Photograph 8 shows a heap left over after planting slip preparation. Since the women and children in rural areas participate in farming activities they are fully aware of khus technology. It is becoming a most familiar grass like an other crops. In the process they are acquiring knowledge about its contributions to soil and moisture conservation. They expressed the view that if Stylozanthus hamata is mixed with

Photo 8. *Karnataka, India. After the vetiver plants have been topped in the process of preparing planting slips, the residual leaf is used for fodder. Here farmers' wives get ready to head load the fodder to their farms.* **Photo Credit K.N. Ranganatha Sastry**

khus, the animals could get almost a balanced diet since the former is a leguminous plant. It is easily possible to get both if khus and hamata are grown as hedges and inter hedge spaces in public, non-arable, lands where forest is developed or on private marginal lands where forest or horticulture is practiced. In some of the cropped fields, where existing bunds were stabilized with khus hedges farmers had sown hamata on bunds. In a single harvest they were able to get both succulent cuttings of khus and hamata.

Fodder Bank: During shortage of fodder in 1986 -87, the farmers in Asundinala (Dharwad District) Watershed were asked to take khus by head loads from a forest nursery. All the poor farmers, who were having short supply of their traditional sorghum fodder were able to survive this crucial period. Photograph 9 shows the farmers, men, women, and children - carrying head loads of khus. In a fodder farm khus constitutes a main component along with Scabra, Hamata and other fodder species. Because fodder farms have the additional role of conserving soil and moisture in the they are usually established on problematic marginal non-arable lands.

Animal Food: Photograph 10 proves that bullocks (the most important draught power in Indian agriculture) will eat the succulent top portion of khus grass. If, as already mentioned, mixed with Hamata or Scabra it could form a regular fodder like an conventional grass. Since the live hedge rows should be trimmed periodically, the harvested top portions become an important by-product and has immediate use on the farm as an animal feed.

Gully Stabilization: Photograph 11 taken in Hirehalla (Raichur District) Watershed amply proves the necessity of bio-intervention. Most of the times the gully checks constructed with stones fail to provide sustained relief in checking gullies. The photograph reveals a few salient features of khus in the management of gullies. Two gullies joined and formed a bigger gully. Across both these gullies, at their mouth stone gully checks were constructed. One of them was also supplemented with khus on a small (not matching the size of the gully) scale. During high intensive rains, the check which was not supplemented with Khus was totally washed out, almost leaving the gully in a state as it was prior to treat-

Photo 9. *Karnataka, India. Farmers' wives and children headloading vetiver leaves to the farmstead for livestock feed.*
Photo Credit K.N. Ranganatha Sastry

Photo 10. *Karnataka, India. Brahmin cattle eating vetiver leaves. If cut regularly vetiver leaves are good as a maintenance ration, better still if mixed with a legume.* **Photo Credit K.N. Ranganatha Sastry**

ment. The second gully check also was destabilized but the degree of damage was relatively less. During a site inspection and discussion, project personnel not only accepted the concept of vegetative stabilization but also considered that the second gully check would have remained intact if more lines of khus had been planted across the gully. It is a known fact that a gully check, on an average, costs Rs. l500 (US $ 50). If a gully check cannot withstand even one monsoon season, the investments will not be justified. Apart from the cost, the farmers will loose confidence in any of the technologies adopted or disseminated by the government agencies. This may result in an increasing cost of dissemination, both for new and existing technologies, and may increase in the delay in acceptance if the confidence of the farming community is shaken.

Photo 11. *Karnataka, India. Gully stabilization using vetiver grass to provide added support to stone check structure.*
Photo Credit K.N. Ranganatha Sastry

Summary and Conclusions: This note is prepared to convey a few features of khus (Vetiveria zizanioides) grass, as experienced in the fields of Karnataka. The photographs were taken in the project watersheds. A few features: (a) effective soil conservation, (b) easiness in dissemination of skills, (c) a good fodder supplement, (d) a fodder that withstands drought, (f) acceptance of khus by animals and (g) a good supplement / replacement of earth, masonry structures have been highlighted. These features implicitly indicate positive physical, and financial benefits. Estimation of exact economic benefits is not this note this note. It is deferred for future papers.

Introduction of Vetiveria zizanioides in Phulbani District.

by H.S. Kumar, Project Manager Integrated Watershed Development (Plains) Project - Phulbani District, India.

At the outset, I feel that with all humbleness, I should admit on behalf of all members of my I.W.D.P. family that in March, 1992, when we started this World Bank aided project, the two words; "V-ditch" technology & "Vetiver" application were strange to us. Moreover, we had no idea how and from where to get such huge quantity of vetiver. In case of some of my project members, they did not know what vetiver was and how it looks like, let alone its procurement, propagation and contour planting. It was with lot of apprehension & fear of criticism from one and all, as well as the World Bank's first visit which was set for some time during September 1992, we started searching for vetiver. In the process of searching, many types of grasses were brought which people said was vetiver.

Photo 12. *Phulbani District, Orissa, India. A happy Mr. Kumar inspecting a "new species" of vetiver that can be grown in air on a tree. He and his colleagues are standing in one of the many vetiver nurseries developed under the project.* **Photo Credit H.S. Kumar**

But aroma of the root was not there. The search came to an end by locating Vetiver zizanioides in the Coastal areas of the State. Thus began our journey into the use and development of our own innovations into the various practices for using this wonder grass which was easy to use, for insitu soil & moisture conservation, for creating a thin Green Line for the future.

Phulbani District in Orissa is a varied land of forests, mountains, plateaus and sloping table lands, having an area of 4282 sq. miles and lies at the latitude of 19.36˚ N to 20.53˚ N & longitude of 83.33˚ E to 84.00˚ E, situated at an elevation of 650-750 meters. This District is a source of origin of several rivers of Orissa namely the Loharakhandi & the Badanadi which feed the Pushikulya in Ganjan District. The river Roul, the Jhirpani, the Khadaga & the Kalapani, eventually fall into the river Tel and this along with Paburia river & Bagha river fall into the basin of River Mahanadi. The district which originates so many important rivers and feed two of the main river systems of Orissa i.e. Pushikulya & Mahanadi is rightly selected for watershed management under Integrated Watershed Development (Plains) Project, with World Bank assistance.

The first 3 years of the Project were the pilot phase and the succeeding 4 years, up to 1997, the expansion phase. The total gross area envisaged to be treated, is 57,000 ha. covering arable & non-arable lands. To treat such a huge area with vetiver under different models, starting from ridge to toe basis, where soil conservation measures are taken up with brush wood check dams, small loose rock check dams, protected on either side by multiple rows of vetiver. Rills prevented from expansion by vetiver plugging. Forest areas with continuous "V" ditches along the contour reinforced with vetiver. Pasture grounds adopt the same "V"-ditch & Vetiver techniques for insitu soil & moisture conservation. Under arable land treatment vetiver is used in field planting along the contour in the property bunds.

For treatment of all these models, a lot of vetiver was required. To meet such huge annual requirement, it would not be possible to import annually 60 - 100 truck loads, as it (Vetiver) gets dried in the process of transit & survival comes down, also the transportation cost is very heavy. In the first year, vetiver was imported since it was not available locally and the Project identified potential locations in the Coastal districts, from where every alternate day, 2 truck loads of vetiver rolled into the Project area.

To cut down the expenses and to have a permanent supply of vetiver, the urgent necessity of raising our own mother nurseries of vetiver, was very essential. This district being a drought prone area, selection of sites posed a major problem. For the future requirement, it was not possible to have small nurseries. Sites having an area of 1.00 ha. or above, were only selected, having adequate water facility either in shape of perennial sources or canal facilities. By May 1992, selection of such sites were completed at 3 locations and the smaller existing nursery with an area of 0.5 ha. was also revived. The usual nursery techniques were followed during July '92: (i) Selection of sites having at least 1 Ha. area; (ii) ploughing & leveling; (iii) live fencing of the site; (iv) laying out of beds with inspection paths; (v) planting of vetiver slips @ one slip per every 40 cm; (vi) use of chemical fertilizers; (vii) as per vetiver guide lines, we used DAP as a basal dose @ 100 Kg. to 250 Kg. per Ha. Applied in split doses in 2-3 applications; (viii) nitrogen @ 100 to 250 Kg./Ha. after tillering started as top dressing, also in split doses & foliar spraying; (ix) in the initial stages the nurseries had the advantage of natural monsoons. Subsequently pump irrigation or flow irrigation from canal was carried out; (x) for pest control, BHC 10% @ 2.00 Qtls./ha. was used both as precautionary dose & when required; and (xi) other operations such as weeding, topping & fertilizer application & soil working were carried out at regular intervals.

I still remember, the first visit of the World Bank Mission when Mr. Jim Alexander & Mr. M.C.Lodha visited the first mother nursery at Nabaguba and inspected the layout. We had the utmost apprehension. At that time, the planting was hardly 35 days old. To add to our apprehension, Jim at random started trying to pull out the vetiver to see whether it was properly planted and root established. We had no idea about the root

system. Fortunately, not a single plant could be uprooted. When we heard the word 'GOOD' both from Jim & Lodha, all apprehension melted away!!

In course of their field visits, certain observations and suggestion were made relating to both arable & non-arable land, and the defects were also pointed out. Thus, we started improving on our own techniques, rectifying our earlier errors, creating our own designs to tackle the different types of terrain within the Project area irrespective of the site condition.

The low number of tillering in the nursery started worrying us, as the cost would increase. To find out the reasons for low tillering, soil testing was carried out. The observation from the three nurseries are as follows.

Nutrient content of soil ppm	Nabaguba	Kanbagedi	Dakapalla
Nitrogen	1.46	1.81	2.02
Phosphate	2.00	1.75	1.54
Potash 2.60	2.18	1.82	1.82
ppm	<6.5	<6.5	<6.5

From the above table it was observed that tillering was less probably for the following reasons: in acidic soil, the available phosphatic content of the soil is less due to phosphatic fixation by minerals; and waste land sites which were selected for nurseries, have been badly eroded due to over exposure for want to top cover & was devoid of any humus and biomass as a result of repeated erosion, thus have very low organic matter.

At the time of laying out of the beds, DAP & Urea were applied as per the prescribed doses. This was in keeping with the guide lines as circulated from time to time in the World Bank vetiver newsletter. Hence, it was high time that to cut down the overhead cost & improving the soil texture by addition of organic manure, in the form of farmyard manure was added to improve the soil texture which when added with judicious mixture of fertilizer already applied, was expected to increase the tillering.

This integrated nutrient management proved superior *(Ed ... we found similar results on the red acidic soils of Fujian Province in China back in 1989)* to use inorganic fertilizer alone & enhanced tillering to the tune of 110 to 120 slips per clump, bringing about 75-80% improvement. Thus, organic & inorganic sources influences physio-chemical & micro-biological properties of soil favorably to supply the additional major plant nutrients from inorganic sources & micro nutrients from organic sources. Farm yard manure improved aeration in the rhizosphere & secretion of growth promoting substances by the beneficial micro organisms. The result was better root proliferation, vigorous vegetative growth & doubling in rate of tillering. These above observation drastically made us change the nursery pattern, where organic & inorganic fertilizers were used in appropriate proportions as per the local site conditions.

The result of soil analysis samples from nursery areas and adjoining fallow sites confirms the above conclusion. Inside nursery, soil pH increased marginally from 5.7 to 5.9 and from 5.8 to 6.0 due to prevention of soil erosion and better retention of bases in the profile. Organic carbon content has increased significantly within the nursery from 0.22% to 0.28%, the reason could be attributed to addition of farmyard manure and leaf toppings of vetiver added to the soil. Increase in organic matter, status of the soil consequently increased soil moisture content from 12% to 18%. Soil potash status has declined from 350 to 400 kg/ha to 316 kg/ha. This is due to crop uptake and non-supply of potash fertilizers. A marginal decline in phosphorus status could be attributed to higher crop removal. By random sampling during April, l993, 9 months after raising of the nursery, initially raised by planting one slip at 40 cm square & the count of maximum tillers per clump was 293 slips at Nabaguba and 327 at Kanbagadi. Before planting in June, a random counting was again conducted of the vetiver clumps & the average stood at 120-145 slips/clumps in all the location. Some observations were made as under:

- topping the vetiver slips merci-

Photo 13. *Phulbani District, Orissa, India. This area was a heavily eroded and gullied area devoid of all top soil. After two years the central gully is stable and the surrounding area has been rehabilitated using vetiver and other grasses and shrubs.* **Photo Credit H.S. Kumar**

Photo 14 *Phulbani District, Orissa, India. This scene is typical of the rehabilitation of non arble lands in the district. Vetiver hedgerows are the mainline of defence, once established other shrubs, trees and grasses are planted.*

Photo Credit H.S. Kumar

lessly up to 20 cm. height with soil working & weeding with usual root zone treatment encouraged tillering by 15-20 % after each topping;

- watering in the nursery by lift irrigation did not produce profuse tillering. The method was costly & time consuming, but could not be avoided. At Nabaguba, the nursery was irrigated by flow irrigation from the canal. This gave at least 20% more tillering than the lift method;

- for gap planting of failed clumps in the nursery or in the different field models, it was most successful when slips ware removed or adjoining clumps planted immediately in the gaps. The reason was quite obvious that the gaps were filled up by slips from the same age group & moisture loss was negligible; and

- irrespective of the irrigation systems adopted, to arrive at the break even stage by optimum tillering visa-via the cost per slip, it was observed that when the nursery receives natural rain irrigation with the onset of monsoon, for a period of 7-10 days, profuse tillering took place & thus reduced the cost of the nursery & increased the survival percentage in the field planting.

The Project further improved its techniques & started raising vetiver in polypots during 1993. Within the short span of March to June of that year, the polypots developed 15 - 25 tillers on average. The maximum count exceeded 31 slips in some polypots. To reduce the cost of polypot vetiver during l995, the project introduced smaller size polypots of 8" x 4" and it is expected that at the time of planting, minimum 15-18 slips would be present per polypot. At Lambagudari, the polypot vetiver nursery had 25 to 41 tillers per pot in July 10, 1995. Raising of polypot vetiver was new to the Project & some observations are as under:

- proper proportion of FYM with fertile & sandy soil in the proportion of 1:2, with 2 gm. of DAP is very essential for good tillering; and

- at best, the polypot can be topped only twice before transporting to the field. The height of the vetiver in the polypot in the nursery is on an average one meter, at the time of planting.

Under the planting technique, the Project has tried both planting the polypot with full length of the vetiver and planting the polypot by topping vetiver to a height of 20 - cm. In both the cases, there was no difficulty in tillering, because the polypot was planted with the exposed node on the surface of the polypot inside the pot & immediately sprouting started.

In case of the first planting method, drying up the of the slips in the polypot did not take place and thus the effectiveness of the staggered hedge planting for silt load arresting was remarkable. In the second case, silt load arresting occurred from the first day of planting, but by the time of tillering, the topped tillers had a dry appearance attracting termite attack till new tillering took place.

At the time of planting of slip & polypot respectively, a basal dose of DAP @ 5.00 gm. per hole, or 10 gm. per vetiver polypot pot, followed by regular topping after establishment & repeated at least 3 times up to the end of the monsoon, has created such density, that it was difficult to identify the slip from the polypot vetiver planting material.

Using polypot vetiver planting, soil loss & expansion of the eroded areas have been stopped over extreme slopes.

Under non-arable land treatment, vetiver is used widely under Silvipasture, Forestry & Drainage Line treatments. In all cases, this Project has successfully implemented vetiver planting taking into consideration the slope of the land. For less than 5% slope, slips have been planted @ 2-3 slips at every 10 cm in a furrow or V-ditch of one sq.ft.; the latter improves retention of moisture and thus reduces water stress at planting. In all cases, a judicious mixture of agave, hill broom, bamboo & forest species are planted to creating a green crown cover & to control the splash erosion.

On slopes of more than 10%, successful vetiver planting is executed by using vetiver polypots, planted in a staggered manner at optimum spacing of 3 polypots per meter. Mixture of bam-

boo, hill broom & tree species ware encouraged. With hill broom it was noticed at the time of inflorescence the local people cut the stems low down on the bush, for commercial purposes, and in 50% cases, due to extreme ground frost, as the temperature recorded during peak winter was 0˚ C followed by extreme summer temperatures of 45˚ C, heavy hill broom casualties are noticeable. On such slopes, it is now programmed to introduce by notching & sowing of various grass seeds and slips, as grasses would give a good ground surface cover and add to the biomass.

Under forestry models, gentle to steep slopes are present. On steep slopes of more than 10%, vetiver is planted at erosion prone locations, with hedge intervals of 4 to 8 m. between lines. The first "V" ditch row are planted with vetiver polypots and the second row planted with slips. In some cases, over extreme slopes, polypots are planted at the standard 3 per m., and in the gap in between each polypot, slips are planted at 10 cm. apart; the result is extremely encouraging.

For engineering structures, with low height loose rock check dams or brushwood check dams, vetiver filter strips with vegetative barriers such as bamboo & vitex, have bean planted on either side of the structure & it has been observed that, silt load has been arrested at stages upstream and after the water has passed over the structure, soil erosion by scouring on the down stream side has been prevented, by vetiver filter strips & vegetative aprons. Side slopes have also been prevented from erosion by multiple rows of vetiver mixed with vitax, bamboo, agave etc.

In Diversion Channels on the foot hills, vetiver slips have been planted inside the channel. Immediately after establishment, moisture retention is quite feasible, retaining moisture for at least 7-10 days more, excess water was allowed to flow through well protected aprons with filter strips to a stabilized natural drainage line. Thus ground water table is gradually restored.

Similar is the case studies relating to Forestry, Silvipastural & Horticulture, the V-ditch rows with vetiver, retain moisture for longer time. This has helped the plants and grasses to tide over the moisture stress condition during the short period when rain stops, and has resulted in good growth.

Table: Water Table Well Recordings Of I.W.D.P. Over Different Periods in feet.

Month	Nabaguba Water Table					Dutimendi Water Table					Nedisahi Water Table				
	DW	92	93	94	95	DW	92	93	94	95	DW	92	93	94	95
May	33.5	7	8'	9.5	18	30.5	Dry	1	2	16	31	1	2	2.5	17
June	33.5	11	12	13.5		30.5	12	13	13.5	13.5	31	13	14.5	15.5	15.5
Dec	33.5	15.5	16.5	18	N.A	30.5	10	11	12.5	NA	31	6	7	7.5	N.A

	Karuna Water Table					Charipada Water Table				
	DW	92	93	94	95	DW	92	93	94	95
May	20.5	1	2	2.5	2.5	20.5	Dry	1	2	5
June	20.5	3	4	5	5.5	20.5	2.5	3.5	5	5.5
Dec	20.5	4	4.5	5	5.5	20.5	10	11.5	12.5	N.A

DW = Depth of well when dry

Water table measurements = depth of water in well

While using vetiver slips under arable land treatment, care had to be taken in selecting a cluster of beneficiaries who had proposed to take-up farming during the monsoon. At such sites vetiver is planted in 1 ft^2 "V" ditches. Only in such cases where grazing was prevented, during the time that the agriculture crop was raised was the vetiver sustained ; in other cases, where planting was done on fallow arable lands, vetiver was unable to properly establish due to the immediate grazing of the succulent tillers by cattle who uprooted newly planted tillers within 3-7 days of planting, and before root establishment took place. This Project has adopted selection of beneficiaries, taking into consideration the farming practices of the locality,

where they take-up rotational cultivation, thus arable land treatment with vetiver has become successful.

The visit by Mr. Richard Grimshaw on March 23rd & 24th 1994, came as a real booster. After the extreme winter with the mercury touching 6˚ C with severe ground frost, with no summer showers, the vetiver clumps were in a very poor condition. The Project was not aware about the tolerance limits of vetiver & had pruned the vetiver before onset of winter. Practically, there was nothing to show except the existence of the pruned clumps. Lot of first hand and useful instructions were given during his field visits. The application of vetiver in the field and the model patterns, were well appreciated by him. After his detailed inspection of various nurseries & work sites of 1992 & 1993, this Project found place in the Search & Find Mission Report of the World Bank, which gave us the impetus to create our own innovated patterns & tackle the most impossible eroded site to the smallest rill formations with success.

Within the short tenure of the Project, the Project's M & E cell, recorded the water table of the open village wells, the rise of the water table over the last 3 years, during peak summer months and in winter is an indicator of improvement in the ground water table, mainly due to the V-ditch & vetiver technology.

Surrounded by high hills & deep valleys, with sloping table lands, the hills being devoid of the rich Shorearobusta(Sal) & other valuable compatible species, reduced to rooted wastes, due to over exploitation of the forest, age old and traditional shifting cultivation, great demand for forest material & such reasons, soil loss from the hill slopes is very heavy. Similar is the case in the foot hills, where the vegetation has disappeared & hamlets have encroached into forest lands. Over grazing in pasture lands by rapid increase in cattle population, irregular cropping pattern and reasons beyond human control, have resulted in fast degradation of the ecology and the environment. A single rain drop creates severe splash erosion and it could be wall imagined, as the district experiences the rainfall between 1200 - 2000 mm. annually, what would be the quantum of soil loss! Moreover with a number of rivers originating from the district, feeding two major river basins of the State, as to the quantum of siltation down stream when calculated would leave one awestruck. This being a Tribal district, sparsely populated by the local inhabitants, with low per capita income, the Project has come as a boon to the locality. With all round development of the degraded Forests and eroded sites by the local people, by the Project, continuous labor generation is ensured. Transfer of technology for the cost effective, easily replicable and sustainable models, have brought about all round development of the Community and the Environment within the Project area.

Thailand - A Visitor's View

Truong visits Thailand

P N Truong Principal Soil Conservationist (Natural Resource Management)

.... The few things that really stand out are:

Reclamation of degraded land. This works really well; all the sites I visited were grassed up within a year and tree crops (teak and neem) are much improved. The Thai attributed this solely to the water conservation aspect of the hedges but I suspect that keeping cattle out of their trial sites had a big effect on the grass cover. This happens here in Queensland all the time - we call it the "barbed-wire treatment!

Water Conservation around fruit trees. Most of the Thai works concentrate on this aspect and some with spectacular results that I have trouble accepting it purely on the water conservation basis. You know what I mean with the attached photos. I suggest that they have a closer look at it, the only think I can think which can give such spectacular results is some form of symbiosis such as Micorrhyzal effect.

Alley cropping. As expected, the effect of alley cropping on soil erosion in their research plots in the first two years was very good, as good as Vetiver with the added bonus of leguminous plants (Leucaena and pigeon peas). However it needs more works as pigeon peas have to be cut three times a year and put down as mulch. But the big difference is after two years, the pigeon peas are too tall with thin stems which give no protection at the ground level. This is in sharp contrast to VH as we know, resulting in very marked erosion, unless you can replant the pigeon peas again. So the Thai decide to replant the alley with Vetiver instead of pigeon peas, Vetiver was planted among old Leucaena bushes which makes a very good combination and works very well. Most of the old alley crops at the Thai-Canadian project near Chiang Rai have now replaced pigeon peas with Vetiver

Waterways stabilization: Most of the sites visited experienced some forms of erosion on their waterways when VH was planted across the flow. This is due mostly to the overall effect caused by a neatly trimmed single row. I suggest they plant more than one row, 0.5m intervals of 3 rows and do not trim their hedges as I noticed in our hydraulic tests in flume, water glides over the bent tops instead of tumbling over a rigidly trimmed hedge. They are experimenting with inverted 'V" shape hedges. This is quite a problem for them and for us here too, so I have asked our engineer friend to look into different shapes and size of the barrier across the flow.

Research Abstracts And Summaries

Aquacultural Sludge Stabilization Within Created Wetlands Bulletin #8 (last revised June 20, 1995). The Freshwater Institute, PO Box 1746, Shepherdstown, WV 25443 (304) 876-2815. A cooperative project between

Photo 15. *Very good grass cover and Neem tree on the rehabilitation of degraded pineapple land near Hua Hin.* **Photo Credit Paul Truong**

the Freshwater Institute and the USDA IARS Appalachian Fruit Research Station. Funded by the USDA/ARS under a grant titled "Aquaculture Linked to Plant Culture: Products and Processes "(#0500-00022-003-00D) and a grant titled "Water Quality Control in Intensive Recycle/Reuse Aquaculture Production Systems" (#59-1931-3-012). Principle investigators are Dr. Steven Summerfelt (Fl) and Dr. Paul Adler (USDA/ARS).

Disposal of solids produced from an aquaculture operation is a serious is-

Photo 16. *Thailand. Water conservation insitu. Left - Lychee trees improved fruit setting compared with right the same age tree not surrounded by vetiver hedge. Note the size and poor conditions as compared to the tree surrounded with vetiver.* **Photo credit Paul Truong**

moval rates and efficiencies as well as levels of nutrients leaching from both wetland types. Preliminary results indicate that filtration and anaerobic digestion occurring within the vertical flow wetlands removes 90-98 percent of the total solids, a large fraction of the dissolved COD, and more than half of the percentage of volatile solids. The horizontal beds removed only 70% of the total solids and produced dissolved COD. The horizontal flow wetlands did not perform as well as the vertical flow wetlands, probably because (1) the hedges had not fully developed a stalk and root mass thick enough to trap solids and (2) the length (aspect ratio) and number of hedges were probably inadequate to provide the physical means for removing greater than 90% of the solids. Nutrient leaching data is not yet available.

Vertical flow wetlands have been used for more than 20 years to treat sludges at municipal wastewater facilities. When used for municipal treatment, vertical flow wetlands are typically planted with reeds or phragmites and are loaded with solids approximately once every 14 days, with 7 - 10 cm of 2% solids applied each load (about 30 kg/m2/yr). In this research, solids are loaded onto both horizontal and vertical wetland types at a rate of 30 kg/m^2/yr, six times a day, every day, year round. Semi-continuous application of sludge means that only a small volume of sludge, 0.5-1.0 % solids in this research, is distributed at any given application. Semi-continuous application also maintains saturated conditions that support anaerobic microbes in both the horizontal flow wetland and at the surface and sand layer of the vertical flow wetlands. Some aerobic treatment is provided in both wetland types through root transport of oxygen and by aeration within the gravel layers of the vertical flow wetlands, which are not saturated with water. A more aerobic environment helps to minimize odors, breaks down organic matter more rapidly, and makes phosphorus less susceptible to leaching than under anaerobic conditions. However, an anaerobic environment stabilizes sludge to the minimum solids mass.

Vertical flow wetlands are generally more expensive to construct than horizontal flow wetlands because vertical flow wetlands require more and much more complex distribution and drain piping as well as large quantities of sand and gravel. Horizontal flow wetlands are vertical flow wetlands because they can use the clay, gravel, or soil available on site.

Hydraulic Characteristics of Vetiver Hedges: An Engineering Design Approach to Flood Mitigation on a Cropped Flood Plain - P.A. Dalton, R.J. Smith and P.N. Truong, Faculty of Engineering and Surveying, University of Southern Queensland, Toowoomba, Qld. 4350, Australia. Resource Management Institute, Queensland, Department of Primary Industries, Indooroopilly, Qld. 4068, Australia.

Abstract. In this paper trials aimed at a quantitative description of the hydraulic characteristics of vetiver grass hedges are described. Three hedges were planted across a large outdoor flume, perpendicular to the flow. Trials were conducted at various discharges and depths and the discharge and depths upstream and downstream of each hedge were recorded. From this data an empirical hydraulic relationship was developed between the depths and the discharge. relationship was used to calculate the maximum vetiver grass hedge spacing required to control soil erosion on a cropped flood plain of low slope subject to deep erosive overland flows Finally an appropriate hedge spacing was calculated for a field site on the Darling Downs of Queensland Australia Hedges were planted at the appropriate spacing and flow retardance and sediment trapping were monitored for the validation of this theory.

Conclusions The flow of water through a hedge can be described by a simple equation relating discharge to the depths upstream and downstream of the hedge, with upwards of 90% of the variation in discharge described by the equation. Secondly it appears hydraulically feasible to use vetiver hedges to control flood flow and erosion on a cropped flood plain. It also appears that vetiver grass hedge spacings are practical up to land slopes of 2%. At this land slope and beyond the design for vetiver hedge spacing would require a different model of flow. Although flow discharge depth equation has only been applied to design spacings on a flood plain it might be assumed that the hydraulic equation could be applied to vetiver hedge spacing design for soil conservation on various topographical situations provided.

Vetiver For Sodic Land Reclamation H.M.Behl & A.K Singh Tree Biology, National Botanical Research Institute, Lucknow 226 001, India.

National Botanical Research Institute (then NBG), Lucknow in Uttar Pradesh was a pioneer for using vetiver (in 1956) for amelioration of sodic sites. However, it is only recently, after 40 years, that vetiver has again been opted for large scale trials under a World Bank program in the state (Uttar Pradesh). High concentration of salts in the root zone of soil limit the productivity of 950 million hectares of otherwise productive land around the world. In India alone, there are 8.1 million hectares of sodic land, where productivity is limited. We have been able to grow Vetiver successfully in the soils with high levels of echangeable sodium in the root zone with high pH (9 to 10.6) throughout the profile, poor water intake, occasional anaerobic stress due to water logging, poor availability of phosphorus that limits the growth, and low fertility.

Agrotechniques were developed for growing vetiver as hedgegrow on flat beds in barren uncovered lands. The agrotechniques included developing quality planting material selected for tolerance to high pH, optimum root formation, mycorrhizal association and vigorous vegetative growth. The nursery was raised in a polyhouse with mist irrigation. Application of endomycorrhizae cultures (Glomus fascicutlatum) facilitate root growth and P uptake. Such selected and tailored slips are being used for hedges under sodic land afforestation and development programing. Capacity to provide planting matinal in commercial quantities has been developed.

Farmer are yet slow to accept the technology, however, a marketing strategy with appropriate training is being planned. Initial training is provided,by "motivators" while technical tips are provided by experts. Key personal are being trained for faster dissemination to end users. Vetiver along with other aromatic grasses such as lemon grass and palma rosa are gradually gaining cognizance and acceptability.

Vetiver's Resistence to Damage by Native Pig in Papua New Guinea Allai R. Aina (Forester), PNG Forest Authority, P.O. Box 668, Kundiawa, Simbu Province, Papua New Guinea.

Papua New Guinea is a small country in the Pacific with more than 200 different languages and varied beliefs, even more complex are the varied traditional practices of maintaining soil fertility and conserving soil and moisture. The taming of the New Guinea native pig is a custom to most of the Highlands region of PNG, and in equally to be able to tame the native pig is considered to be the a very valuable asset. The number of pigs one tames determines the role that he/she plays in a defined community. Vetiver was introduced to the Highlands region, particularly in the Simbu Province, by Mr Allal Aina in 1989. Simbu now can boast in having the largest Vetiver nursery in the country (PNG). Over the years I have put some native pigs with vetiver plantings in various locations within the district (GUMINE) and have found out the following results:

- pigs tend to dig as close as possible around the Vetiver base but have not removed any clumps;
- pigs tend to dig down as deep as 30 cm. but thus far they have not fully exposed the roots or have completely dug out the plant (Vetiver);
- where pigs were left to plough

the whole area, and after 2 days of rain there was no sign of soil being washed down. There is a strong evidence that in PNG soil is trapped behind the dynamic plant (Vetiver);

- pigs were fed with vetiver grass together with sorgham or elephant grass. It was observed that pigs only ate the elephant grass and inever bothered to eat the vetiver grass.

Having witnessed the research I have the following comments:

- vetiver is truely a deep rooted plant that stabilizes the soil;it is resistent to ploughing by native pig;

- Soil trapping is a clear indication when the area was ploughed prior to heavy rainfall; and

- for now pigs don't eat the vetiver grass.

It is truely a dynamic plant and I will report any strange things when I come across one.

Salient Research Results on Vegetative Technology. Regional Research Station Kandi Area - Hoshiarpur, Punjab, India. Comparison with vetiver and other grasses. vetiver can be established as thick hedges in the area but are susceptable to termites.

Integrated watershed Development (Plains Project) Orissa State. Vetiver is a major component of this project along with the technology of "continuous contour trenches" Booklet describing project available from Watershed Planning & Coordination Organization, Directorate of Soil Conservation, Government of Orissa, Bhubaneshwar, 751 001, India.

Evaluation and Potential Uses of Vetiver Grass for Erosion Control and Soil Improvement, and Development of Adaptive Implementation Plan for Plantation and Soil Conservation Project Vinh Phu, Vietnam. By P.K.Yoon. Published by Vietnam Sweden Forestry Cooperative Programme. January 1994. Vetiver grass exists in Vietnam and has great potential in that country. This report analyses what is there, and establishes how to set up an effective and quality program. Report is very nicely illustrated with color photographs.

Vetiver As a Source of Soil and Moisture Conservation. Tamil Nadu Agricultural University. Experiments conducted at the Regional Research Station at Aruppukottai and at Kovilpatti in Tamil Nadu clearly revealed superiority of vetiver over other hedges in conserving soil moisture. A similar consistent influence of vetiver was observed from an Agricultural Engineering experiment over three years.

Continuing Studies of Over wintering Success Rates of Vetiver by the US Army Construction arid Engineering Research Laboratories at USACERL, Champaign, Illinois. From: Dr. Mohammed Sharif at 1-800-872-2375 ext.5519, Dick Gebhardt ext. 5475, Gwyn L. Howard ext. 5467 or Heidi R. Howard ext. 5205. US Army Construction arid Engineering Research Laboratories, Champaign, Illinois:

As mentioned in the January edition of the Vetiver Newsletter, the US Army Construction and Engineering Research Laboratories in Champaign, Illinois has been conducting an ongoing investigation into the uses of vetiver in controlling soil erosion Vetiver has been studied in plots located on USACERL grounds in Champaign and at several Army installations including Ft Bragg and Pt. Campbell.

During February of 1995 at the Ft. Bragg installation, experiments were conducted to determine vetiver's resistance to fire burning. It was found that burning enhanced plant vigor and fecundity of new shoots. Those subjected to fire burning were also observed to sprout more vigorously and earlier than those plants left untouched. However burning may not always be used when vetiver is employed as a filter strip for sedimentation trapping of soil runoff; this could defeat the purpose of the terrace-building effect of the grass strips

Winter climatic conditions at the Ft. Bragg area (Fayetteville NC), which is located on the northern border of the USDA Hardiness Zone of 8a, are suitable for an average to above average success rate of vetiver re growth. During the 1994-95 winter at Ft. Bragg, daily minimum temperatures were recorded and averaged to produce the following data:

Month	Averaged minimum Daily Temperature
September	62.50˚F
October	51.52˚F
November	45.60˚F
December	39.45˚F
January	35.03˚F
February	34.14˚F
March	42.68˚F
April	53.43˚F

Let it be noted that during d the month of January temperatures dropped below 20˚ F on 2 days and during February 3 days. After wintering, 90% of the vetiver plants survived to become healthy and vigorous plants for the Spring. All of these will remain in place for the determination of survival rates through the 1995-96 winter at Ft Bragg.

At the Ft. Campbell site, daily temperatures were also recorded. Ft. Campbell is located near Clarksville, Kentucky which is within the USDA Hardiness Zone 6b. It was noted, that on the average, the 4 local plots had above a 50% survival rate. interestingly enough, 2 of the sites which had not grown very well throughout the first growing season were flourishing during the second growing season. The remaining 2 sites which had performed superbly during the initial growing season were not performing as well for the second growing season. The reasons for the unusual growth patterns will be investigated further over the next year or more

Currently, we have 40% survival rate in the vetiver plot located at USACERL Champaign, Illinois, which is located in the USDA Hardiness Zone 5b; a total of

20 plants were left in the soil to over winter. The only precaution taken for exposure to winter extremes was coverage of the plants with a clear plastic tarp, of approximately 1 mm in thickness, which was secured with concrete blocks along the edges. Out of the 20 plants, two plants are sprouting vigorously, 6 are sprouting, but not with the same degree of vigor witnessed in the former, and the remaining 12 succumbed to the climate. Winter temperatures were very mild with lows reaching down to an average of l9.6˚ F for the month of January and 19.5˚F during February. The lowest temperature recorded during the season was -4˚F on January 5, 1995. Temperatures bounced back up to 17.0˚ F the following day. Consequently, results for our area may be skewed due to the unseasonably warm temperatures experienced during the 1994-5 winter.

Future endeavors will include analyzing the effects of an array of herbicides as a means to control and destroy vetiver.. The collection of climatic data will continue to be amassed for determination of the success rates for vetiver nationwide with regard to hardiness zones. Plots have recently been established at the following installations and experimental stations: Anniston Army Depot, Alabama; Ft. Chaffee and Pine Bluff Arsenal, Arkansas; USACERL, Champaign, Illinois; Ft. Leonardwood, Missouri; Ft. McAlester and Ft. Sill, Oklahoma, AP Hill, Virginia; arid Texas Tech University.

Vetiver Oil Extraction

Oil of Vetiver ***Paper written in 1949. Author unknown***

Essence de Vetiver Aceite Esencial Vetiver Vetiverröl Oleum Andropogoflis Muricati

Introduction. - The vetiver grass *Vetiveria zizanioides* Stapf *(Andropogon muricatus* Retz., *Anatherum zizanioides* [L] Hitchc. and Chase) occurs wild, semiwild and cultivated in many tropical and subtropical countries. The underground part of the plant consists of numerous fine rootlets, light yellow or gray to reddish in color, which contain a viscous essential oil of pleasant, persistent odor. The commercial oil of vetiver is obtained by distillation of the root. The root itself possesses a most agreeable aroma, for which reason the dried root is employed to scent linens, clothes, etc., either by itself or in the form of sachets. In the Orient the root has been used extensively since antiquity; it was described in the ancient Veda of the Hindus. From time immemorial the root has also been employed to make baskets, and to weave mats, which, sprinkled with water and hung like curtains in the house, cool the air and emanate a pleasant odor. In Java the root is often used to support the walls of fish ponds and to protect them against collapse. In Haiti the natives employ the overground part of the plant, the dried grass, for the thatching of their huts.

In Java the vetiver root is called “Akar wangi,” in India “Cus-Cus” or “Khas-Khas,” meaning “aromatic root.” In its wild state the plant flourishes on the slopes of the Himalaya Mountains, in many parts of India, Ceylon, and Malaya. Vetiver is cultivated extensively in Java, on Réunion Island, in the Seychelles Islands, and in some parts of the Western Hemisphere - Louisiana (U.S.A.), and in Sao Paulo (Brazil), for example. Cultivation experiments (for the distillation of its oil) have been conducted in Honduras, Guatemala, and Mexico. In Haiti (West Indies) the plant escaped cultivation long ago, and now grows semiwild and scattered over wide areas.

The commercial vetiver oil is distilled from root material grown chiefly on plantations, the principal producing regions being Java, Reunion Island, and Haiti. The trade distinguishes the following types of vetiver oil:

Oils produced by modern methods in European and North American essential oil distilleries, from dried root material imported from Java. This type of oil is of excellent quality. Prior to World War II about 60 metric tons of vetiver root were exported annually from Java. Assuming that all of the exported root was used for distillation purposes, this quantity corresponds to an approximate annual production of 1,000 kg. of European or American distilled vetiver oil.

Oils distilled in Java from domestic root material. Owing to the strict analytical control exercised by the government of Indonesia (formerly the Netherlands East Indies) over all outgoing shipments, this type of oil is also of good quality. Prior to World War II, annual production amounted to about 20 metric tons of oil.

Oils distilled on Réunion Island from roots grown locally by small-scale planters, in large part sharecroppers. The oil is usually of excellent quality. Annual export figures have varied considerably (from 5 to 15 metric tons), depending upon competition from the Java type of vetiver oil.

Oils distilled chiefly in Haiti (West Indian islands) and to a small extent in Mexico, Central America (Guatemala and Honduras), and South America (State of Sao Paulo in Brazil). As we shall see below, this type of oil differs somewhat from the other types of vetiver oil; its quality depends upon the age of the root material and the method of distillation. Haiti has been producing the oil, but in limited quantities only. Production, however, could be increased substantially, should demand and market prices warrant it.

Hearsay reports from the interior of Java indicate that the principal (and quite modern) vetiver distillery was destroyed during the occupation by Japanese forces and many of the vetiver plantings have been discontinued in favor of other, more vital, crops. It will be quite some time before normal conditions are restored in Java. Shipments of Java vetiver oils reaching Europe and the United States at present, represent, in the main, old stocks accumulated here and there during the Japanese occupation. The following monograph on Java vetiver is, therefore, based chiefly upon conditions prevailing in Java prior to the outbreak of World War II, when the author had occasion to visit the island and

survey the vetiver producing regions. Undoubtedly the Java oil will again be offered in large quantities, when conditions on the island become normal.

As far as the American vetiver oil industry is concerned, it came into existence during the years of World War II, when the Java and Réunion oils were no longer available, and when very high prices encouraged the production of vetiver oil in certain parts of the Western Hemisphere. However, some of the new plantations were started without previous experience and in soils not for vetiver. The result was a very low yield of oil, and therefore an excessively high price. Potential production in the Western Hemisphere is large, but future developments will depend entirely upon the availability of the Java and Réunion oils (which are the most important types), and the price the oil brings on the world market. It should also be remembered that the use and consumption of vetiver oil are rather limited, and any over production will only cause ruinous competition. Moreover, vetiver root is difficult to distill, giving a great deal of trouble in the separation of the oil from the water, and the yield of oil in general is low. Therefore, any prospective grower of vetiver should first ascertain, by systematic distillation experiments, whether his root material will yield sufficient oil to make commercial exploitation worthwhile. The vetiver root grown in Louisiana (U.S.A.), for example, does not contain sufficient oil to permit distillation on a competitive basis. The Louisiana root is therefore sold as dried root, in small bundles for the scenting of linen in drawers and closets.

An English controlled company in the interior of the State of Sao Paulo (Brazil), during World War II, began extensive cultivation of the root on its vast properties (mostly coffee plantations), but it is doubtful if this potentially large vetiver industry can survive, once competition from Java is felt again.

Oil out of Java

Development. - Before World War I, Java exported large quantities of dried vetiver root to Europe, chiefly to Germany, France, and England, where the root was used either for the distillation of its oil, or in the form of sachets, for the scenting of closets, drawers, and chests. The year of 1917, however, brought about such a shortage in shipping space that much root material accumulated in the ports of Java. Since the warehouses were filled to capacity, this material could not even be properly stored. It was principally as a result of this situation that Hischmann conceived the idea of distilling the root material on the spot and of exporting the less bulky oil. Preliminary distillation experiments convinced Hischmann that the root should be distilled with direct steam, and a substantial quantity of the accumulated stocks were then processed in a distillery near Bandong. Owing to the fact that the root had already been stored and aged for almost two years, an oil of high specific gravity and very good quality was obtained. It found ready acceptance in Europe and America, and thus Java's vetiver oil industry came into being. Despite occasional setbacks the industry grew, and in 1935 Java surpassed Réunion Island in quantity of vetiver oil exported.

Producing Regions. - Java's main vetiver producing regions are near Garoet (western Java) and Wonosobo (central Java). Practically all of the root originates from scattered patch plantings and from small holdings, ranging from one-quarter of an acre to twenty acres in rare cases. The production of the root has always been in the hands of natives, few white planters growing vetiver on their estates.

Soil Conditions.- The most suitable soil for the successful growing of vetiver consists of loose sandy ground, or, even better, young volcanic ashes on the slopes of hills. The root can easily be pulled from such soils without parts of the thin rootlets adhering to the ground and being lost. Compact, heavy, loamy soil should be avoided, not only because the root cannot be pulled out readily, but also because root grown in such soil gives a lower yield of oil. Harvesting from heavy soils is a problem. If the root is planted in proper soil, the altitude does not matter. Young volcanic soils, however, do not occur in the plains of Java; but only on the slopes of volcanoes, usually at about 5,000 ft. above sea level. Good export root is often characterized by the presence of small, black cinders.

Planting.-"Akar wangi", the vetiver plant of Java, is a nonflowering variety of Andropogon muricatus Retz.

According to experiments carried out in Buitenzorg, vetiver should not he planted in shaded places, as shade will exert an unfavorable influence upon the development of the root system. Regular cutting of the grass seems to benefit the root.

As on Réunion Island (cf. the monograph on "Vetiver Oil Réunion"), vetiver is planted by root division. The planting takes place in the rainy season. Distance between the plants should be 2 to 3 ft., but, due to local conditions, is frequently irregular. The ground used in Java for the planting of vetiver seldom lends itself to the raising of other crops. It is not always possible to replant vetiver on the same field.

One hectare yields about 1,000 kg. of air-dried root, the quantity, of course, depending upon the soil and the general condition of the planting. Occasionally root fungus (the nature of which has not yet been established) damages the plants and lowers root yield.

Harvest - The harvesting period depends upon the weather. If the same field is to be replanted with vetiver roots can be extracted from the ground only during the rainy season, because the root stocks have to be divided and replanted immediately. However, if the field is to be used for some other crop, harvesting of the root will be more convenient during the dry season, not only because the earth can be shaken off the extracted root more easily, but also because the root will dry more quickly. Distillers prefer to purchase dry root material, to avoid any argument with the supplier over weight and water content. The collected root is first washed in a

river or fountain, and then dried in the sun, or preferably in the shade.

If intended for local distillation, the dried root is packed loosely, if intended for export, it is pressed into bales of 100 kg. and wrapped in jute bags.

The native growers sell their crop to middlemen, usually Chinese, from whom they have received advance payments. The middlemen, in turn, sell to the local distillers or to exporters in Batavia (Jakarta) and Surabaya.

Quality of the Root - If a fully developed root system and a high quality of oil are desired, the root should not be extracted from the ground earlier twenty-four months after planting. Young roots are tender, thin, almost hair-like; on pulling they break easily and stay in the ground. Furthermore, on distillation they yield an essential oil with a low specific gravity and low optical rotation. The odor of these "light" oils is "green," "earthy." Older, more developed, somewhat thicker root, on the other hand, yields an oil of better quality; its specific gravity and optical rotation are higher, the odor fuller, richer, more lasting. Oils derived from older root are usually of darker color than the oils distilled from younger root.

However, for obvious reasons, it is difficult to induce the natives to wait twenty-four months before harvesting the root. Always in need of cash, they are inclined to collect the root as early as eight months after planting; at any rate they expect at least a yearly crop from their vetiver fields.

Any experienced distiller will carefully examine a lot of root material before paying for it. Some "smart" natives or middlemen occasionally admix root that has previously served for mats or other purposes or has already been exhausted by steam distillation. A good quality of root, giving a high yield of oil, can usually be recognized by its slightly reddish-brown color. Very light, almost whitish root as a rule contains very little essential oil.

Distillation - Prior to World War II, there were in Java several vetiver oil distillers, a few of them Europeans, the others Chinese and Malayan. Two of the distilleries were of large size and equipped with efficient, specially designed stills and oil separators. The vetiver distilleries owned by the natives were not quite so advanced. A few producers used their citronella stills for distillation of vetiver, which explains why some lots of vetiver oil received abroad were contaminated by a slight by-odor of citronella.

Because of the high boiling points of its chief volatile constituents, and their high viscosity, the distillation of vetiver root is beset with considerable difficulties, particularly in regard to the separation of the oil from the distillation water.

Prior to distillation, the dried root material should be reduced to small pieces in a solidly constructed ensilage cutter. To prevent formation of dust, annoying to the workers, the root is first wetted by sprinkling with water.

Distillation is carried out with live steam of 4 to 5 atmospheres pressure (measured in the separate steam boiler). The stills should be well insulated, to prevent internal condensation and excessive wetting of the plant charge during the long hours of distillation. Depending upon the pressure and amount of steam injected, distillation of one charge requires 12 to 36 hr.

The oil distills over first as a fraction lighter-than-water, and toward the end of distillation as a fraction heavier than water. For a time the distillate may run in the form of a whitish milk like emulsion which has to be separated (1) by regulating (modifying) the temperature of water in the condenser, and (2) by using proper oil separators. Some distillers in Java employ a series of large tanks as oil separators. At the bottom of each tank is a narrow, tube like pocket in which the fraction heavier than water collects and from which it can be drawn off. The combined fractions of the oil are finally filtered warm in steam-jacketed filters; some producers use small centrifuges for the purpose.

Yield of Oil - Dried Java vetiver root of good quality, yields from 1.5 to 2 per cent, in rare cases as much as 3 percent, essential oil. Fresh (undried) root, of course gives a much smaller yield.

Quality of the Oil - The quality of vetiver oil depends not only upon the age of the root (see above), but also upon the length of distillation. The most valuable constituents of the oil, and most important in regard to odor, are high boiling and can be recovered only by prolonged distillation, which, obviously, means more steam consumption and a higher cost. By the use of slightly superheated steam toward the end of distillation, the hours of distillation may be shortened.

In order to produce vetiver oils of good quality the leading distilleries in Java, prior to World War II, stored, their root material for about six months before they processed it, and extended distillation to almost 36 hr. Such oils are quite dark in color, rather viscous and possess al high specific gravity and optical rotation. The odor of these "heavy" oils is full, rich, and very lasting, quite superior to that of "light" oils obtained either from young roots or by short distillation.

On aging, the odor of vetiver, in general, improves, freshly distilled oils exhibiting a somewhat "green" odor.

The oil is usually shipped in galvanized iron drums of 25, 50, or 100 kg. capacity. In normal times every shipment of Java vetiver oil must first be examined in the government laboratories of Buitenzorg before a certificate of purity is granted to the exporter.

Oil Of Vetiver Réunion

For years the oil of vetiver produced on the island of Réunion (located in the Indian Ocean, 400 miles east of Madagascar) has been noted for its good quality, a result of the care applied to the root material prior to distillation. The odor as well as the physicochemical properties of a vetiver oil depend greatly upon the age of the root, i.e., the time which elapses between planting and harvesting.

Producing Regions - The growing and producing regions on Réunion are located in the southern, eastern, and extreme southeastern parts of the island, the most important centers being La Petite Ile (in the southeast), Montvert (in the south), and Les Lianes (in the east).

These are mountainous sections of Réunion and abound with water, drawn from nearby springs or rivulets. This fact is important, as the distillation of vetiver root requires a great amount of water. Stills on Réunion are supplied with water by a system of simple bamboo tubes.

The plantings are located on the slopes of hills and mountains, above sea level, but well below altitudes at which geranium is grown.

Economic Setup.-The bulk of the oil is produced by settlers of French descent, who own large or medium sized tracts of land. With the help of employed labor they grow the crop and distill the root material in their own still. Often, however, the root is grown by sharecroppers and delivered to the landlord for distillation.

The annual production of vetiver is influenced by several economic factors: (1) the price of the oil on the world market which depends upon competition (chiefly from the Java oil); (2) the cost of labor, which is governed entirely by the social laws of France; (3) the price of sugar.

Since cane sugar and vetiver are grown on the same type of soil on Réunion Island, and at about the same altitudes, the two crops compete with one another, and obviously the planters are inclined to give preference to the more remunerative crop. Most of the sugar produced on Réunion, however, goes to France, where, after the leveling of a very high import duty, it has to compete with beet sugar, which crop fluctuates widely in France.

Planting, Cultivating, and Harvesting. Most vetiver plantings on Réunion Island are small, patch like, and widely scattered. The best soil consists of loose volcanic ashes, since the roots can be pulled easily from such soil, and without any portion of the fine roots remaining underground. Vetiver root grown on such soil can be cleaned quickly by simply shaking any adhering soil particles off the extracted root.

Whenever a new planting is started, fertilizer is applied in the form of ashes of residual vetiver root which has been distilled and used as fuel.

A new field is started on the same ground, immediately after, in fact simultaneously with the extraction of the old roots. Harvesting and planting take place from June to November. The leaves and stalks of the old plants are cut with machetes and the entire root system is pulled out of the ground by hand. The lower, fibrous parts of the root are cut off, and the remaining center parts of the root stocks (stools) are divided for replanting. The root segments are then planted out, 1 ft. apart, in rows also 1 ft. apart. The plants should be so close together that the roots, after growing, touch one another underground. This will facilitate extraction of the ensuing root crop.

Quality and Age of the Root The quality and the age (i.e. the length of time between planting and harvesting) of the root are of fundamental importance, and greatly influence the yield, physico-chemical properties, and odor of the oil.

In poor soils the root will develop very little oil; hence the necessity of frequent manuring and fertilizing. After one year in the ground the root contains sufficient essential oil, but the oil will be of substandard quality. After two years in the ground, the root yields a little less essential oil, but the oil will be of excellent quality. Three-year-old root yields so little oil that distillation becomes uneconomical. It is questionable whether the content of oil actually decreases as the root stays in the ground. More likely the oil contained in old root is composed chiefly of high boiling constituents (sesquiterpene alcohols) which do not readily distill over, particularly in the low-pressure type of stills (water *and* steam distillation) used on Réunion Island.

Obviously, then, the best distillation material is two-year old root, and the distiller producers insist upon such root when purchasing from sharecroppers. The latter, however, are usually in need of cash, and like to reap a yearly crop from their fields. Producers, who have to depend for part of their root requirements upon other growers or sharecroppers, are, therefore, very careful in their selection of material, preferring to buy it from their neighbors, with whose fields they are well acquainted. Good root can be distinguished by very fine black rings, whereas superannuated root (yielding very little oil) possesses a dead, gray-brown color.

Distillation. - The root material grown on Réunion is not exported, but processed locally, in a number of rather primitive stills sheltered under simple roofs, or in wooden shacks, and distributed over the producing regions. The stills operate on the principle of water and steam distillation. Frequently, however, the water rises above the false bottom (usually made of wood) and immerses part of the charge, causing excessive wetting, which means that longer distillation is required.

Many stills are of relatively large capacity, one charge consisting of 300 to 400 kg. of root material, after it has been dried in the sun for one or two days. The water below the false bottom is brought to the boiling point with a fire kindled with wood or exhausted vetiver root. Distillation of one charge requires 36, or sometimes even 48 hr. Whenever the cost of wood is high, and the price of vetiver oil relatively low, some producers are tempted to shorten the distillation, to the detriment of the quality of the oil (cf. the section on “Distillation” in the monograph on “Oil of Vetiver Java”). Since the larger landowners and producers cannot personally supervise distillation for 36 to 48 hr., the Florentine flasks and oil receivers are sometimes enclosed in a special compartment of which the owner alone has the key. This protects against theft of oil by the laborers who, during

the night, must watch distillation, regulate the temperature of the condensers, and keep the fire burning.

In view of the difficulties connected with the distillation of vetiver, the visitor to Réunion is inclined to wonder how the distillers can produce such a good grade of oil with their primitive equipment. It is simply a matter of "know-how" acquired through many years of experience. No facilities for the automatic reflux of the distillation waters (cohobation) existing, the distillation waters are collected in barrels and used again (instead of fresh water) for the next charge. To prevent the flow of the distillate in the form of troublesome emulsions, the water inlet to the condenser is regulated so that the distillate (condensate) runs quite warm. Moreover, fuel will be saved if the warm distillation water is used again for a new batch of root in another still.

While practically all oil of vetiver in Réunion is produced in primitive direct-fire stills, there are on the island two steam distilleries, one in St. Paul, Piton, and the other one in nearby St. Paul, Grand Pourpier, which in years past produced limited quantities of vetiver oil by steam distillation. These oils, therefore, resembled the higher type of vetiver oil distilled in Europe and America from imported root material.

The process applied in the two plants in St. Paul is, in reality, a combined form of direct steam, and water and steam distillation. The root material is charged above a false bottom, and direct steam is injected through a steam coil. The distillation water is returned warm into the still, i.e., cohobated. When the water in the still reaches a certain level above the false bottom, the direct steam is turned off, and distillation is continued by indirect steam (steam jacket). Here, too, the distillation water is automatically cohobated. The proper quantity of water in the still and a warm flow of the distillate are of great importance for successful distillation. Distillation of one batch requires 24 hr., 15 of which are for actual distillation. Due to relatively high cost of labor and fuel, the two distilleries in St. Paul in 1935 discontinued production of vetiver oil, other products, such as cane sugar and rum, being more remunerative.

The small lots of oil produced in the various distillation posts are purchased by field brokers and sold to exporters in St. Denis, who first have to filter the oil, and free it of small quantities of water. Combined lots are analyzed in the official control laboratory in St. Denis and then shipped abroad.

Yield of Oil As was pointed out in the section on "Quantity and Age of the Root," the yield of oil depends upon the age of the root material. Two year-old root of best quality, distilled for 36 hr. in the primitive type of still used in Réunion, yields from 0.8 to 1 per cent of oil. The same root material, if processed in modern steam stills, may yield 1.5 to 2 per cent. In general, the yield of vetiver root oil in Réunion ranges from 0.6 to 1.2 percent.

Physicochemical Properties - Oils distilled from young (about one year old) roots exhibit a low specific gravity, a low optical rotation ($_{\infty}D$ + 13° to +17°), and a poor solubility, a result, probably, of the predominance of terpenes and sesquiterpenes, rather than of sesquiterpene alcohols (cf. "Chemical Composition of Vetiver Oil"). The odor of the oils distilled from young roots is "green", "earthy," and slightly harsh. Prior to World War II the government of the island, in collaboration with the Chamber of Commerce in St. Denis, enacted a ruling by which such oils, when exported, must be marked "substandard in regard to specific gravity" or "substandard in regard to optical rotation."

Adulteration. Vetiver oils imported from Réunion are usually pure, because the producers and exporters in Réunion are not familiar with the methods of "skillful" adulteration. Moreover, Réunion is a small island, and imports of any products which could be used for the purpose of essential oil adulteration would at once arouse the suspicion of the custom authorities. Dishonest field brokers and Chinese middlemen occasionally resort to alcohol, kerosene, or fatty oils as adulterants, but such additions are readily detected in the official control laboratory in St. Denis, which examines every outgoing shipment.

Total Production -prior to World War II, annual production of vetiver oil in Réunion varied from 5 to 12 metric tons, depending on the competition and the price of the Java oil. During World War II competition with Java was eliminated, and prices of the Reunion oil rose sharply. In December 1945, prices were as high as $75.00 per kg. of oil. In the same year Réunion produced about 15 tons of oil. The future development of the industry will depend upon the reappearance of the Java oil on the world market.

Chemical Composition of Vetiver Oil

The first investigations of the chemical composition of this important oil date back to the beginning of the twentieth century, when Theulier fractionated vetiver oils distilled in Grasse (A. M.), France, and on the Island of Réunion and studied the physicochemical properties of the fractions b_{25}) thus obtained. Other investigations were carried out by Franz Fritzche & Co.Genvresse and Langlois and Semmler, Risse and Schröter· However, in the light of the latest findings mentioned below, the conclusions reached by these authors cannot be fully accepted. Research on the chemical composition of this oil has been beset with considerable difficulties; and it is only lately that we have obtained a better, although still incomplete, insight into this complicated subject. Up to the present the following constituents have been identified in vetiver oil:

Alpha and beta Vetivone (Vetiverone). According to Pfau and Plattner, Java and Réunion vetiver oils contain from 7.8 to 35.1 percent (in most cases, from 15 to 27 percent) of ketones, determined by the hydroxylamine method. By oximation, Sabetay and Trahaud estimated a ketone content ranging from 12 to 13 percent. The odor of vetiver oil is due chiefly to the ketonic sesquiterpenes $C_{15}H_{22}O$ (bicyclic and alpha ethylenic), of which only alpha vetivone and

beta vetivone have so far been isolated. For details pertaining to these apparently stereoisomeric substances.

Vetivenols, (Vetiverols). The alcohols occurring in vetiver oil were investigated first by Franz Fritzsche & Co, later by Genvresse and Langlois but in both in instances with inconclusive results. According to our present knowledge, at least 60 per cent of the sesquiterpene alcohols occurring in Java vetiver oil seem to consist of a mixture of prirnary alcohols $C_{15}H_{22}O$, in which a tricyclic alcohol largely predominates, whereas the bicyclic alcohols amount to only about 10% of the mixture of primary sesquiterpene alcohols. The tertiary (bicyclic) sesquiterpene alcohols present in Java Vetiver oil also seem to be a mixture. They amount to about one third of the total Sesquiterpene alcohol fraction of the oil.

Réunion vetiver oil contains a similar mixture of sesquiterpene alcohols $C_{15}H_{22}O$, which consists of a primary bicyclic alcohol and a tertiary tricyclic alcohol. Depending upon their origin and quality, vetiver oils contain from 45 to 65 per cent of free sesquiterpene alcohols (observations in the laboratories of Fritzsche Brothers, Inc., New York).

Vetivenyl Vetivenate. In the fraction $b_{0.3}$ 170˚ - 250˚ of vetiver oil, Ruzicka, Capato and Huyser observed an ester which, on saponification with a 10 per cent alcoholic potassium hydroxide solution, yielded the tricyclic vetivenic acid, $C_{15}H_{22}O$, a viscous oil $d^{20}/_4$ 1.0748, $n^{20}/_D$ 1.5203. Treating the neutral saponificetion products with phthalic anhydride, these authors obtained a primary tricyclic sesquiterpene alcohol $C_{15}H_{22}O$, b_{12} 160˚-162˚, $d^{15}/_4$ 1.0186 $n^{15}/_D$ 1.5251.

Vetivenic acid had previously been observed in Vetiver oil by Semmler, Rinse and Schroter and before them by Genvresse' and Langlois and by Bacon. The proper empirical molecular formula, $C_{15}H_{22}O$ was established by Sesmmler and collaborators. Genvresse and Langlois expressed the opinion that the characteristic odor of vetiver oil is due to the ester which vetivenic acid forms with vetivenol. The ester readily hydrolyzes, even under the influence of water.

Palmitic Acid. In a vetiver oil which for a period of time had been stored in a tin-lined vessel, Schimmel & Co. observed the crystalline zinc salt of palmitic acid, which permits the conclusion that this acid is a constituent of vetiver oil.

Benzoic Acid. Bacon reported the presence, in a sample of vetiver oil, of considerable quantities of benzoic acid.

Oil of Vetiver Haiti

Chief producer of vetiver oil in the West Indies is the small Republic of Haiti, part of the historical island of Hispaniola where Columbus established his first settlement in the New World. Nothing is known about the introduction of vetiver to Haiti, but the root has been grown there for a long time. The plant has escaped cultivation and now grows wild and semi-wild over wide areas of the island *(Ed, ...I wonder if the cultivars originated from North India. It would be interesting to do some DNA testing on this material)*. It was formerly planted along roadsides and on the edges of fields. For generations the dried leaves (grassy part) have been used by the natives for the thatching of their huts, little attention being paid to the roots, except that occasionally they have been sold in the towns for the scenting of linen or as insect repellents. Most of the root material was allowed to remain in the ground, with the result that much of that collected today for oil distillation originates from very old plants. (As was explained in the monographs on "Oil of Vetiver Java" and "Oil of Vetiver Réunion, "the age of the root material exerts a considerable influence upon the quality of the oil.) Recently the importance of vetiver for soil conservation has been recognized in Haiti, and today vetiver is planted extensively as a protection against soil erosion. It is estimated that about 4,000 acres are now under cultivation on the island. These, about 600 acres have been planted on large fields for the special purpose of oil production, particularly on the small island of Ile à Vaches and in the Plaine des Cayes. Small peasant plantings are located in Kenscoff, Dondon, Plaisance, Limbé, La Vallee de Jacmel, Bainet, Dame-Marie, and Chambellan. At St. Michel de l'Attalaye small planting experiments are being conducted in heavy black soil.

Vetiver is planted by division of the root stocks (stools), from which three to six new plants can be obtained, depending upon the age of the old stock. The plants are set out 2 to 3 ft. apart. The most favorable time for planting is in the spring, i.e., in the rainy season. The root material is extracted from the ground, usually in the rainy season, at which time the earth is softer than in the dry season. Harvesting of the roots is a tedious task, particularly in heavy clay. The roots are dried in the shade sun-drying causing some loss of oil. Only the slender and fibrous parts of the root system are distilled. They are not triturated prior to distillation.

Distillation is carried out chiefly in two well equipped distilleries, one located in Maniche, the other in Ducis (Aux Cayes, in the southern part of Haiti). Care must be exercised not to pack the charge in the stills too tightly. Distillation of one charge lasts from 36 to 72 hr. The older the root material, the longer it has to be distilled. Young roots are exhausted after 12 to 16 hr., but they yield an oil of low specific gravity and "green" or 'earthy" odor. The heavy fractions of the oil are collected in large separating vats, arranged in sequence, to allow emulsified oil to separate at the bottom. After completion of the distillation, the lighter-than-water and heavier-than-water fractions are mixed and run through a centrifuge, to remove traces of water. After having been freed of water, the oil is once more centrifuged; traces of sediments are retained in the clarifying bowl. The final limpid oil exhibits a color ranging from light amber to almost black. The color depends upon the material of which the stills are constructed, and, according to Dejoie upon the iron content

of the soil in which the plants have been grown. As was pointed out in the monographs on Java and Réunion Vetiver Oils, only roots of a certain age develop the full fragrance of a high-grade vetiver oil, but such roots give a low yield of oil. Plants less than two years old should never be distilled.

As regards the yield of oil, experiments conducted by Dejoie in Aux Cayes indicate that fertility of the soil is the principal factor in successful vetiver oil production. The richer the soil, the higher will be the yield of oil per ton of root material. Vetiver grown in sandy seashore land does not yield more than 0.5 per cent of oil, not withstanding the size of the leafy over-ground part of the plant. (There is no relation between the size of the leaves and the content of oil in the roots.) In general, the yield of oil varies from 1 to 1.5 per cent. In roots from very rich soil it may occasionally reach 2 per cent; but in Haiti such fertile soils are usually planted with sugar cane or other staple food crops. Only the poorest (and particularly the eroded) sections are planted with vetiver. In consequence, root material collected from mountainous sections usually yields less oil than root from the plains. However, the quality of the former is often better, the oil possessing a higher specific gravity and a fuller, more lasting odor.

The vetiver oil produced in Haiti differs from those produced in Java and Réunion in regard to odor, physicochemical properties, and chemical composition. The Haitian oil is of very good quality; it has a high content of vetiverol, the principal constituent of all vetiver oils. For this reason the oil seems to be particularly useful as a starting material for the isolation of vetiverol and its conversion to vetiveryl acetate. The odor of the Haitian oil is rich, full, and lasting; its color usually dark. The properties characteristic of the Haitian oil are probably attributable to the unusual length of time the root has been permitted to remain in the ground (see above). The odor of the Haitian oil being somewhat different from that of the other types, the Haitian product cannot always replace the Java and Réunion oils in established perfume formulas. Preliminary experiments ought to be made whenever such a change is contemplated. In the author's opinion the Haiti oil should be marketed as a separate and distinct type of vetiver oil, the label indicating its origin.

Oil Of Vetiver Brazil

The development of the Brazilian vetiver oil industry resembles that of Brazilian lemon grass oil (cf. the monograph on "Oil of Lemongrass Brazilian"). The oil is produced on the same large estate in the State of Sao Paulo, and by similar modern methods. In the course of World War II the plantings were increased to several hundred acres, and the oil found a ready market in Brazil, Argentina, and other South American countries. The future development of the Brazilian vetiver oil industry will depend upon the demand for the oil as well as upon its price on the world market. The latter, of course, is influenced chiefly by the quantity of Java oil available, and to a lesser degree of the Réunion oil.

In the Araraquara region of Sao Paulo, soil and climatic conditions favor the growth of vetiver. Plants grown in light sandy soil yield a much larger proportion of fine roots than those grown in heavy "terra rocha" (red laterite). In the latter case a good part of the fibrous root will remain in the ground when the stocks are pulled out. Moreover, more water is required for the washing of the harvested root material when the root originates from a heavy soil. Only roots at least sixteen months old are dug up, which precaution, combined with the use of modern distilling equipment, assures the production of a high-grade oil.

Vetiver may be planted at any time of the year provided there is rain, but the most favorable months are November to February, when rainfall is assured. Furthermore, if set out during these months the plants will usually flower in the same season. Since the fine, hairy, oil-bearing rootlets develope only after the flowering period, some time will be saved by planting early in the rainy season; otherwise the plants tend to lie dormant or, at best, to produce only coarse roots which yield an inferior oil. Planting is done by subdivision of the root stocks. Most of the fine, hairy root system is separated and set aside for distillation, but some of the fine roots must be left on the stock for replanting. Planting stock may be stored in the shade until the root divisions can be set out in the fields, but exposure to the sunlight for a few days will do no harm as the plants are actually quite hardy. Since the grass tops have to be cut off, prior to planting, in any case, they can be used as cover and shade for the piles of root awaiting planting. The methods of planting resemble those employed with lemongrass. The grassy tops are cut off to within 6 or 9 in. of the root, the clumps are then split with a machete into divisions of 3 to 4 shoots each, after which the latter are set into holes previously dug with a crowbar or other implements. The distance between the plants is 0.5 m., that between the rows 1 m. The root divisions are firmed into the earth with a pole, or by treading with the feet.

Scarcity of agricultural labor in Brazil has made it necessary to mechanize the production of vetiver as much as possible. The primitive methods used in some parts of the world would not allow for a large acreage to be harvested within a few months. In Brazil vetiver producers follow this procedure: when about sixteen months old and 2 to 3 m. high, the grass is cut roughly with scythes, left in the field to dry for a few days, and then burned off. By this method, both the cut grass and that left protruding from the ground are disposed of. The ash serves as fertilizer. In dry weather the burning takes place so quickly that the flames have no time to heat up more than, say, 1 cm. of the surface earth, with the result that the roots are not damaged by heat. After the fire has died out, the hard cores protruding from the ground are chopped off level with the ground by means of mattocks, and cleaned away. The plantation, now clear of surface vegetation and trash, is plowed with a disc plow, tractor-drawn. The earth is turned over to a depth of about 35 cm.; it contains all the root material, with the exception of a few coarse taproots. Deeper plowing would not compensate

for the very small extra yield obtainable at, say, 40 cm. depth.

Once the plowing is finished, the loosened earth and freed root material are treated in batteries of shaking machines provided with screens. Mixed soil and earth are shoveled on top of the screens. The roots stay on the shaker screens, while the soil falls through the meshes and piles up beneath the machine. At intervals the root material is cleaned off the screens and collected in heaps. Being of light weight, the shaker machines are moved along the rows to continue operation. Four men accompany each machine, and about one dozen machines operate in a row. At the end of the day the collected roots are carted away, while the piles of sifted earth are leveled by tractors. All the work is done on a contract basis, and paid for per weight of dry, uncleaned root, as it comes from the field. Thus each day's harvest is weighed before further treatment.

On poor, highly acid soil the yield of root per alqueira paulista (1 alqueira paulista equals roughly 2.5 hectares or 6 acres) averages 700 kg., whereas on well-fertilized and irrigated soil it may be as high as 1,300 kg. The uncleaned root material is hauled from the fields to large concrete washing tanks, cleaned of adhering earth by washing, and spread on extensive "terreiros" or drying grounds made of bricks (such as are used for washing and drying of coffee). Here the root is turned over at regular intervals until dry, and any foreign matter is removed. The cleaned and dried roots are finally sacked for transportation to the distillery or storage shed, where they are allowed to mature (age).

Before distillation, the root is again weighed and passed through a motorized driven cutter which reduces the length of fiber to about 1 in. The stills, which hold about 600 kg. of dried root, are loaded, and the charge is tramped down evenly, during which time a stream of water plays on the material. After the charge has been soaked for a period, distillation is started, first with direct steam and later with indirect steam (by means of pressure steam coils), the pressure being varied and regulated as dictated by the progress of distillation. All the condensed water is cohobated and the oil collected in separating tanks. Distillation of one charge (600 kg. of dried root) requires about 36 hr. The lighter-than-water and heavier-than-water oil fractions are mixed and transferred, together with some water in emulsion form, to the separating room, where the oil is freed of water by centrifuging. The clear oil is then placed into cans of 5 0r 18 kg capacity, and whenever possible, left to age and mature.

It should be noted that aging for a period of six months improves the odor of the oil substantially; the harsh, "green" and earthy odor characteristics of the freshly distilled oil will disappear and develop into a fuller, heavier, and sweeter odor.

Young plants do not possess the same proportion of fine, hairy roots as do plants which have been in the ground more than sixteen months; on distillation roots from young plants give a low yield of oil. The color of such an oil is gene, the odor harsh, the specific gravity subnormal (low).

Oil of Vetiver India

In the Central Indian State of Uttar Pradesh (perhaps the most important area for vetiver production in the whole of India) no attempt is made to cultivate the roots. Roots growing wild in the extensive forest areas of the state are dug out and distilled insitu. Although these roots are said to yield only 0.2 to 0.3 percent oil, the industry has been able to operate profitably because there are few cultivation expenses beyond payment of a royalty to the state. *(Ed. ..... this vetiver is nowadays described as the north Indian cultivar - a seedy type, and different to that of south India)* The production of vetiver oil in India increased during World War II, due to the steep rise in price a result of the complete stoppage of imports from Java. This condition stimulated several private and state efforts toward a scientific study of the cultivation and distillation of this valuable and neglected crop. The most important work along these lines is that sanctioned by the Government of Madras, and carried out by the Kerala Soap Institute, Calicut.

According to Murti and Moosad, the white sandy soil on the west coast of southern India were first considered to be the best suited to the cultivation of this crop. Cultivation and distillation experiments carried out by Murti and Moosad, however, proved that pure (white) sandy soils not suited to the growing of vetiver. The root on distillation (for 16 hr.) yielded only 0.18 to 2.22 percent oil. Root grown in red laterite loam, on the other hand, yielded from 0.76 to 0.94 percent oil. Root grown on red laterite with very little sand yielded 1.02 percent oil. In all experiments root of 18 months was used. In two years of experimentation the roots produced in loamy soils were found to be thick and wiry, with only a small proportion of hairy rootlets, whereas the roots grown in sandy soil were thin and hairy.

So far as the maturity of the roots at harvest time is concerned, Murti and Moosad found by systematic experiments that the oil content increases progressively up to twenty-one months (yield 0.87 percent); at ten months it is 0.10 percent, at fifteen months 0.56 percent, at seventeen months 0.79 percent. It is definitely uneconomical to harvest before a minimum maturity of fifteen months, while a period of twenty-one or twenty-four months will also be uneconomical. A period of maturity of fifteen to eighteen months for the roots in the soil may be considered the optimum. In these experiments Murti and Moosad harvested the root during the dry period.

The same authors also found that at twenty-four and twenty-five months maturity the roots yield only 0.25 and 0.20 percent of oil, respectively. However, in these two cases the root was dug up during the rainy season. It may well be that the drop in oil content of the root, twenty-four and twenty five months old, was due to washing out of a part of the oil from the underground roots during heavy rains.

Data on manuring showed that fertilizing with ammonium sulfate, brine manure, and groundnut cake increases the oil content of the roots to some extent, but the increase is far less than that of roots cultivated in a good .....

[Article incomplete]

Large Scale Mechanized Runoff Water Harvesting: Prospects For Future R&D Activities.

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Brief presentation of the technique. Throughout the last decade, development of micro-catchment systems for runoff water harvesting purposes (runoff farming) was increasingly considered amongst the most suitable strategies for improving soil productivity in semi-arid and arid areas, where rangeland, fodder, trees, or crop production schemes are hampered by harsh soil and hydric conditions; on the other hand, implementation of efficient water harvesting systems represents sometimes a costly exercise, and can be of difficult optimization: thus, it is widely accepted that micro-catchment schemes and other water harvesting methods have to conform with a set of primary criteria, amongst which the essential are those related to land configuration and slope, soil characteristics and quality, economics of operation (1.).

Photo 18. *Reversable Dolphin plough. Close up view. Note seed drill at rear.* **Photo credit. Domenico Bruzzone**

Photo 17. *Reversable Dolphin ploughin operation in Niger on black, flat and very dry soil conditions - "V" ditching.* **Photo credit. Domenico Bruzzone**

New perspectives for optimized and economical runoff water harvesting practices were opened - after preliminary field trials (2., 3., 4.) by the application of specialized mechanization schemes to small-scale hand dug systems for semi-circular bunds making (the so-called demi-lunettes or croissant fertiles in most Sahelian Countries), which led to the design of a powerful system for large-scale applications of semi-circular bunds or discontinuous furrows making.

The ploughs prepare soil by a regular and sequential digging operation, either by excavating crescent-shaped micro-basins (i.e. the 'dolphin' -t ype ridger), or by digging discontinuous furrows (the 'train' type ridger) for runoff water harvesting. The "Dolphin" hydraulic, single-furrow plough for programmable, discontinuous ploughing, has been tested in afforestation schemes, reclamation trials of marginal lands and in trials for im-

proving pastures and rangelands; one plough device, combined with a 160 HP tractor, can treat up to 10-15 hectares per day after the digging operation of ca. 10-15 micro-pits per minute or, 4500-7000 micro-pits per day; the size of microbasins being of 5x0.5x0.45m (plus approx.20 cm of subsoiling). The potential of the technique, as compared with the traditional, small-scale hand dug is therefore impressive.

The technique allows the direct seeding operation of trees and shrubs, with improved rooting rates, that might disclose unprecedented prospects for reforestation and desert reclamation action programmes in arid and semi-arid areas, thus escaping the problems associated with seedlings transplantation processes: transplanting stress, curbed development of the rooting systems, and the associated reduction of plant resistance to drought.

The reversible, single-furrow plough for double-layer ploughing, with sub-soiler, was designed to prepare soil with furrows, excavated at intervals (discontinuous furrows): the plough is equipped with a device that aggregates and lays down into the furrow the fertile top soil layer separated during the ploughing process; the plough has been tested for improving lands within agro-sylvo-pastoral schemes and for afforestation trials on plain, hard soils of colluvial origin, or slightly sloping soils, on contour lines. The plough allows large-scale optimum tillage of soil surfaces under conditions of poor rainfall and soil fertility, after recovery and concentration of the top-soil layer, gathered in the furrows and by promoting the sinking process of runoff water within the furrows, at a rate directly related with the extent of the uncultivated soil strip.

A ripper is also designed for the improvement of natural pasture lands and an injection seeding device is allowing to carry out direct seeding of shrubs and trees seeds, thus promoting pre-germination and early development of tap roots.

Due to the potential and considerable technical interest displayed after the first trials, a similar project device, clearly inspired to the dolphin-type plough concept was designed and constructed in the frame of a separate research project (5.).

The direct seeding operation is conceived as a key developmental issue in the greening process of the mechanized micro-catchment system, for it can allow skirting the nursery and transplanting operation, with important effect on plant biology (tolerance quality) and on the economy of the process.

The technique was tested in the frame of major integrated rural development schemes and related operations, after the first trials carried out in the Department of Zinder (Niger), at the Projet Intégré de Réhabilitation du Damergou (PIRD), financed by the former Italian Authority for Development Co-operation, Fondo Aiuti Italiani - FAI, 1986-1988.

Conclusions.

The building of micro-catchment systems by the special ploughs technique allows mechanical treatment of vast land surfaces so as to convey, gather and concentrate the runoff water within the room of the excavated pits or furrows, where sowing or transplanting of vegetation can be carried out adopting annual or perennial plant species; it is reported (6.) that the performance of this technique, coupled with adequate standards of field operation management and control, resulted, under favorable conditions, in impressive biomass production; in the same account, information is provided on the costs involved with the adoption of this technique.

Very schematically, it can be stated that the technique appears to offer the prospects for developing micro-catchment systems for large-scale runoff water harvesting, with low-cost equipment, economic operation, minor manpower requirement and, with a direct-seeding system, avoidance of the costly nursery and transplanting operations.

While ploughing trials appeared impressive in most cases, and extremely encouraging in some other circumstances, as it has been documented, and the technical package has displayed its potential for practical application, the output results of trials were not duly appraised by the classical probability analysis methods and experimental design, assessment with data from control areas, and after application of standard schemes for the monitoring of figures. Therefore, a considerable share of the available technical information, is only descriptive or anecdotal, with monitoring data limited to some basic assessments on vegetation patterns resulting from plough testing.

A detailed analysis of the Dolphin and train plough application has been conducted in the frame of a GTZ financed project in Niger - the Projet de Développement Rural Tahoua (PDRT) where some economic considerations on the technique have been taken into account.

Technical specifications of ploughs

Technical specifications of the dolphin hydraulic single-furrow plough for discontinuous ploughing (Mod 40 MI/CM): micro-pits size: length: 3-5 m; width: 40-60 cm; depth: 40-50 cm; programmable distance of pits along the row: l-2 m; subsoiling beyond furrow bottom: 15-25 cm; working speed: 50-70m1/min (tractor power: 160-180 HP).

Technical specifications of the train reversible single-furrow plough for double-layer ploughing, with subsoiler (Mod Por 130-119 Mz/RCM): furrow size: depth: 40-50 cm; width: 45-50 cm; surface fertile layer tillage: depth: 5-10 cm; width: 45-50 cm; sub-soiling beyond furrow bottom: 15-20 cm; deployment of fertile topsoil at programmable intervals, from2.5 to 5 m; tractor power: 160 -180 HP.

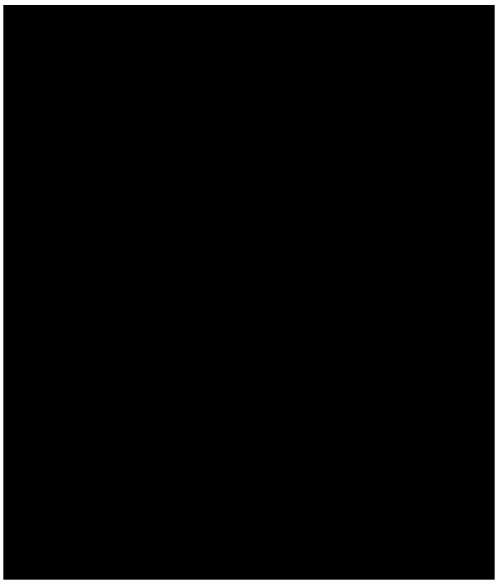

Photo 19. *The All American Disc for reclaiming road shoulders shown here attached to a farm tractor.*

Photo Credit. Bill Doyle

Shoulder Reclaimer Saves Time, Money.

by *Thomas 0. Zimmerman Highway maintenance supervisor Wisdom District, Minnesota*

Each spring many gravel road shoulders must be reconstructed ridges and ruts removed, inslopes reshaped, among other things to reverse the effects of the previous winter. Standard repair methods require a virtual parade of graders, rollers, mixers, and other equipment (and sometimes thousands of yards of new aggregate), all at considerable expense. To help streamline this process and reduce costs, Minnesota Department of Transportation (Mn/DOT) is testing a new wing-mounted disc designed to eliminate the outside ridge that develops from routine blading and "reclaim" gravel from that portion of the roadway. In one particular operation, the shoulder reclaimer saved Mn/DOT over $2,400 per mile compared with the previous method, while accomplishing the same result. The cost of the disc-approximately $5,000 was recovered in just a little over two miles of shoulder reconstruction.

The Windom District purchased the new disc in spring 1992 using funds from Mn/DOT's Maintenance Operations and Research Division experimental equipment initiative. The disc consists of 12 disc plates mounted on a very heavy duty frame (see photo). Although it requires no modifications for mounting, the Windom district did modify the unit by adding chain links between the discs, to prevent dirt and mud build-up.

Better Results, Less Equipment

The first usage of the disc was on Minnesota TH60 just west of the Brewster city limits, in spring 1992. The previous year (1991) Mn/DOT had narrowed the inslope of the shoulders and reclaimed gravel that had been thrown into the ditch by snowplows. The operation consisted of two and sometimes three motor graders, two rubber tire rollers, three loader tractors, a Ceman mixer, a water truck, and one person for traffic control. Between a quarter and a half mile were reclaimed per day. The motor graders first windrowed the gravel along the edge of the roadway, then proceeded to move the dirt from the ditch bottom up the slope to the edge of the shoulder. When the blades created a windrow, the mixer would go across it to break up the clumps of dirt and sod. This was necessary to properly shape and compact the new inslope. The cost of this operation was $2291.92 per mile on one side only. In 1992 Windom again repaired the shoulders on TH60, this time with the new disc mounted on a motor grader In contrast to the old method, only two motor graders, one roller, and one person for traffic control were needed. With the disc, the roller operator did not have to wait for the mixer to cross The windrows, which enabled the roller to operate more frequently. This in turn meant one roller was eliminated from the operation. After some experience with the disc, workers were able to reclaim one mile of shoulder per day in one direction, with more time and practice this rate could possibly increase by about another mile on both sides per day. We were unable to confirm this in 1993 because the extreme moisture prevented us from performing this type of operation, but we will resume testing this spring, weather permitting. The cost of the operation with this equipment was $963.60 per mile.

The Windom District used the disc chiefly on narrow gravel shoulders. A typical operation had previously taken three days for 48 lane miles of shoulders, resulting in a shoulder full of clumps and grass. With the disc the same road is reclaimed in one day with much better results a shoulder with no trough, and the grass and sod chopped up-leaving an attractive shoulder. The disc has worked well for other uses, such as eliminating ridges on wide shoulders, minor narrowing of wide shoulders, re-establishing water flow in the bottom of ditches, and removing ruts left by trucks along interstate ramps.

Conclusion

The Windom District has been able to maintain more shoulders with the new disc simply because of the resulting time savings. In the past some shoulders had been difficult due to excessive sod build up, last year we were able to disc them two to three times because we were able to cover more ground more frequently.

Other districts have also tested the disc, with very positive reports to date. If you would like further information or wish to borrow a video tape of the disk please contact Doyle Incorporated Equipmen, PO Box 89947, Sioux Falls, South Dakota 57105, USA. at (612) 890-3326, or (800) 658-5491. *(Ed. .... Note, Bill Doyle manufactures the equipment to fit on the three point hitch of a farm tractor. It could therefore be easily used in most parts of the developing world with good effect)*

Spanish Readers Column

The following paper was presented in English at the International Soils Congress in Mexico in July 1994. Kevin O'Sullivan had it translated into Spanish for his associates in southern Mexico. I have copied it to the newsletter so that those growing number of vetiver uses in Spanish speaking countries can take advantage of its content.

Articulo presentado en el Congreso Internacional sobre Suelos que se llevó a cabo en Acapulco, México, en julio de 1994.

El papel del Pasto Vetiver en el sostenimiento de la productividad agrícola

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Sumario

El artículo resume los resultados experimentales y observaciones de campo del uso del pasto vetiver, Vetiveria zizanioides, y señala su uso como un importante y efectivo seto vegetativo que, cuando crece en el contorno, reduce significativamente el flujo de sedimento de sitios en erosión y reduce el desagúe, ambos simultaneamente y a bajo costo, comparado con las practicas de ingeniería tradicionales. El pasto vetiver posee características únicas. El articulo también muestra evidencias de que el pasto vetiver crece en un amplio rango de condiciones locales; no compite con cultivos contiguos; no es una mala hierba; resiste las plagas y enfermedades; es utilizado como forraje para el ganado; es usado para estabilizar terraplenes, lineas de drenaje, caminos, etc.; resiste al fuego y se sabe que es repelente de roedores; y requiere de un mínimo de mantenimiento. El principal obstculo para extender su utilización y aplicación se debe a un pobre sistema de transferencia de tecnología y a la falta de entrenamiento de granjeros y técnicos.

Introducción

El presente artículo resume los descubrimientos experimentales y las observaciones del escritor en el resurgimiento del uso del pasto vetiver como una tecnología importante en el sostenimiento de la productividad agrícola en tierras tropicales y semitropicales. Como resultado de una precoz iniciativa del Banco Mundial [1], el pasto vetiver fue introducido a los proyectos de desarrollo en la India como un sistema vegetativo de bajo costo para la conservación del agua y el suelo.
Su utilidad y potencial fue ampliado aún mas en posteriores artículos [2, 3, 4, 5 y 6]. Este artículo se dedica a resumir los hallazgos de un creciente número de científicos independientes y usuarios del pasto vetiver quienes, en años recientes, han demostrado la singularidad del pasto y su utilidad como una tecnología formidable para incrementar la humedad de la tierra y en la conservación del suelo.

El mantenimiento de la fertilidad del suelo y la disponibilidad de humedad en la tierra son los dos mas importantes elementos críticos para la producción agrícola sostenible. La prioridad dada a estas dos actividades durante los últimos cuatro mil años ha permitido a China sobrevivir y alimentar a su enorme población [7], en el pasado lo mismo que en la actualidad, mientras otras sociedades se han desmoronado por no haber mantenido estas actividades clave. En un tiempo en que se presta una gran atención a la tecnología simple de bajo costo para la agricultura sostenible, el pasto vetiver ofrece una tecnología muy buena, amplia y fácilmente aplicable que es practica, probada, efectiva y beneficiosa.

La Tecnología del Pasto Vetiver (VCT), en su forma mas común, es simplemente el establecimiento de una barrera viva, estrecha (de menos de un metro de ancho) y firme de pasto, en forma de seto vivo, a lo largo de la pendiente de un terreno. Cuando se aplica correctamente, esta tecnología es efectiva en pendientes de menos de 1% y hasta de 100% de inclinación. Un seto de pasto vetiver bien establecido retardará el agua rodada, esparciéndolo uniformemente, y atrapará los sedimentos del agua rodada para crear terrazas naturales. Todo esto es posible sin el uso de complejos detalles y diseño hidrológicos y sin necesidad de caros consultores y topógrafos. Es una tecnología realmente de los campesinos, creada por los campesinos; una tecnología que pasó desapercibida por la mayoría de los desarrolladores y científicos. Su singularidad radica en las características de la planta.

Material y métodos

La hipótesis que sustenta el uso de VCT fue establecida en un pequeño manual para campesinos, ahora en su tercera edición, "Vetiver Crass (Vetiveria zizanioides). A Method of Soil and Moisture Conservation" [8 y 9]. Las afirmaciones que fueron hechas a la VCT en esa primera edición, lo mismo que en las subsecuentes [10], fueron en ocasiones refutadas por los investigadores, y como resultado, han sido y continúan siendo intensamente investigadas por numerosos científicos y campesinos. Este artículo tiene su origen en estos trabajos, y es respaldado por las propias observaciones del autor en países de Asia, Africa, Centroamérica y el Caribe. Describe los resultados de las pruebas y experimentos, y cita a los autores. En ocasiones el artículo reporta observaciones que no están respaldadas por una investigación, pero son conclusivas por su sola existencia bajo las condiciones descritas.

Resultados y discusión

Denuncia núm. 1. Un seto de pasto vetiver es una medida efectiva par la conservación del suelo y la humedad.

En investigaciones en ICRISAT, India [11], se comparó la VCT con barreras de piedra, té limón y la tierra descubierta (como control) bajo condiciones de lluvia naturales (precipitación total de 689 mm) y artificiales. En todos los casos la VCT fue la tecnología más efectiva para reducir la pérdida de tierra y agua. La VCT redujo 57% las corrientes de agua rodada y más del 80% la pérdida de suelo. Los resultados mostraron claramente a partir de la hidrografía experimental el mayor retardo en la liberación del agua rodada de las parcelas de vetiver, una interesante característica que podría ser aplicada como medida superior de control de crecientes. El mismo equipo de investigadores [12] confirmó que al siguiente año el vetiver tuvo un desempeño aún mejor. El vetiver muestra una distinta mejoría en su eficiencia cuando los setos envejecen y son más densos. En CIAT, Colombia [13], el vetiver fue comparado con otros sistemas vegetativos que fueron crecidos junto con yuca. A los 11 meses (con una precipitación de 1240 mm) los setos de vetiver redujeron la pérdida de suelo de 142 toneladas por hectárea en una tierra descanpada en descanso, a 1.3 toneladas por hectárea para la yuca cultivada entre setos de vetiver. El agua rodada se redujo de 11.6% a 3.6%. Otros investigadores han reportado resultados similares. La evidencia [14] muestra una fuerte correlación positiva entre la pérdida de suelo y la reducción de agua rodada cuando la VGT se aplica al Vertisol negro en India occidental, y la VCT es significativamente superior a otros tipos de setos. En Louisiana [15], las demostraciones muestran de manera conclusiva el impacto de los setos de vetiver en la retención de sedimentos. En Malasia [16], experimentos a gran escala han demostrado que hay depósitos de sedimento sustanciales detrás de los setos de vetiver, en un caso de cerca de un metro en un año.

Los campesinos han reportado en prácticamente todos los casos el uso favorable de la VGT. Un campesino [17] ha usado el vetiver en la granja familiar de caña de azúcar en Natal, Sudáfrica, por más de 70 años como una herramienta para estabilizar los costados de los caminos. Desde 1989 ha protegido 186 hectáreas de su granja con setos de vetiver. Las pérdidas por erosión se han reducido sustancialmente y el agua rodada disminuyó al grado que en una tremenda sequía en 1992, ninguno de sus jóvenes árboles de litchi se perdió. Los usuarios de vetiver en Centroamérica, entre ellos los de Honduras [18], confirman que los setos de vetiver son el método efectivo más costeable para la conservación del suelo, como lo han hecho usuarios [19] de Etiopía y otros paises africanos. La retroalimentación de 17 granjeros en Layete, Filipinas [20], indica claramente el impacto de la VGT y su superioridad sobre otros sistemas. Debe resaltarse que el pasto vetiver puede regenerarse a partir de nudos en el tallo. Esto significa que mientras el sedimento se forma detrás y en el interior del seto de vetiver para formar una terraza, el pasto crecerá junto con la terraza - en Fidji, bajo ciertas condiciones, se han formado terrazas naturales de 3 metros de altura.

No hay evidencia que permita demostrar que los setos de pasto vetiver son inferiores a otros tipos de seto. Por el contrario, la evidencia sugiere que los setos de vetiver constituyen la barrera vegetativa más efectiva.

Afirmación núm. 2. El pasto vetiver puede crecer en una gran variedad de condiciones locales.

Investigaciones con vetiver bao condiciones salinas y sódicas en Australia, han demostratado que el pasto muestra tolerancia a elevados índices de salinidad, de hasta ECse de 15 mScm-l sin una reducción apreciable en el rendimiento de materia seca. Se han realizado investigaciones sobre la tolerancia del vetiver a un espectro de pH del suelo [22], y en ellas se ha demostrado la tolerancia del vetiver a niveles de pH tan bajos como 3.8, con niveles de toxicidad por aluminio en el suelo de 68% -según indicaciones, el vetiver puede ser una de las especies de cultivo más tolerantes (¿junto con la pastura?) a la toxicidad por aluminio. También se demostró que el vetiver podía establecerse en suelos con pH de 9.9, y que sobrevivía bien cuando se suministraban niveles apropiados de fósforo y nitrógeno. Se ha demostrado que el pasto vetiver puede crecer bajo una gran variedad de tipos, profundidades y estructuras de suelo. Se comparó el crecimiento del vetiver en cinco diferentes tipos de suelo en Malasia [23]; y aunque el crecimiento del vetiver difería de un tipo de suelo a otro, en todos los casos creció razonablemente bien. También se demostró que el vetiver puede establecerse en terrenos donde funcionaban minas de estaño, lo que lleva a la rehabilitación de esa tierra degradada. En India, el vetiver crece vigorosamente en los Vertisoles negros lo mismo que lo hace en los Alfisoles.
El vetiver crece bien en tierras altas lo mismo que en condiciones pantanosas, lo que demuestra sus características xerófitas e hidrófitas [23]. El límite de tolerancia del vetiver al frío se encuentra alrededor de los 9.5C bajo cero [24], aunque algunas plantas han logrado sobrevivir cortos períodos a l5C bajo cero [25].

La mayor limitante para el crecimiento del vetiver es la lluvia. Crece en áreas con escasa precipitación, de 300 a 400 mm, pero requiere de mayor atención. Bajo estas condiciones es más difícil que se establezca el vetiver, y debido a los extremos estacionales, causados por el sobrepastoreo, las sequías periódicas, etc., el vetiver sufre al igual que otras plantas. Como una regla empírica, el vetiver crece bajo más condiciones locales a lo largo de tierras tropicales y semitropicales. Lo hace mejor en suelos bien drenados. No crece en áreas con heladas invernales, y donde existan condiciones de escarcha permanente. Excepto por efecto de la temperatura, el vetiver puede crecer en la mayoría de las altitudes. En Honduras [18] el

vetiver crece muy bien a dos mil 800 metros. Se han establecido setos de vetiver en el occidente de Etiopía a dos mil metros [26]. El vetiver ha sobrevivido en la nieve a tres mil metros en Lesotho [27]. El vetiver tiene un gran potencial para crecer en áreas salinas [28] en Australia, y fue utilizado con éxito en la rehabilitación de tierras sódicas abandonadas en Ussar, al noroeste de la India [6].

Toda la evidencia apunta a la tolerancia del vetiver a una amplia gama de condiciones locales, incluyendo aquellas que pueden ser consideradas extremadamente hostiles para el crecimiento de la planta. El vetiver será aún mas adaptable a diferenes sitios cuando sean identificadas condiciones más específicas a las condiciones locales.

Afirmación núm. 3. El pasto vetiver no compite con los cultivos adyacentes.

La mayoría de la evidencia indica que el vetiver no reduce de manera significativa el rendimiento de los cultivos adyacentes. Experimentos en Colombia [13] señalan que no hay pérdida de rendimiento de yuca cuando se cultiva junto con setos de vetiver, mientras que hay una reducción del 33% con setos de pasto elefante (Pannisetum purpureum). Se han demostrado resultados experimentales semejantes en Maharashtra, India [30] y Malasia [16], que han sido confirmados por campesinos desde el sur de India hasta Fidji. Los productores de azúcar de Natal, Sudáfrica [17] y Fidji [8] reportan ganancias en la producción.

Investigaciones llevadas a cabo entre 1989 y 1991 en Akola, Maharashtra, India, en Lithic Ustorthent suelos con una precipitación promedio de 840 mm [31], muestran que los cultivos crecidos en asociación con los setos de vetiver alcanzaban niveles superiores de producción. La producción total promedio fue 17.1% y 32.3% superior en los cultivos crecidos en parcelas protegidas con vetiver, en comparación con los cultivos crecidos en terrenos con bordos y con los cultivos en pendiente, respectivamente. La mayor ganancia monetaria se registró en cultivos asociados al vetiver -6,833 rupias-, comparada con 5,969 y 5,065 rupias para graded bunds y cultivo en pendiente. La eficiencia en el uso de la humedad fue mas alta en las parcelas de vetiver, lo mismo que el nivel de nutrientes residuales. Los investigadores también compararon la eficiencia del pasto vetiver con otras barreras vegetativas. En total se hicieron cuatro comparaciones - Vetiveria zizanioides (pasto vetiver), Leucaena leucocephala (subabul), Cymbopogon flexuosus (té limón) y Chrysopogon martini (Tikhada). Los rendimientos de semilla de algodón fueron 25.5% superiores con vetiver que con el control sin tratamiento, en comparación con 24%, 15% y 11% de la Leucaena, el té limón y el Chrysopogon, respectivamente. En todos los casos, los mayores porcentajes de humedad promedio, perfil y disponibilidad del almacenamiento de la humedad, se registraron con el vetiver. Los campesinos en Filipinas señalan que el maíz y el arroz plantados cerca del seto de Mura (vetiver) se comportaron mejor [20]. Un experimento de un año en suelo rojo en ICRISAT, Hyderabad, India [12], apunta evidencia contraria que señala que el maíz, cuando se cultiva en asociación con setos de vetiver, tiene un rendimiento en grano reducido, aunque la biomasa total no se afecta. Observaciones posteriores en esas mismas parcelas podrán resolver esas contradicciones, y también podría ser más apropiado usar cultivos, como sorgo y mijo, mas comunes en el área que el maíz.

Aunque en algunos casos hay evidencia de competencia con el surco de cultivo inmediatamente adyacente a la barrera de vetiver, la mayoría de los resultados experimentales, junto con un número abrumador de reportes de campesinos señalan que no hay cambios negativos de rendimiento, y que por el contrario, la mayoría de los cultivos muestran respuestas positivas a las barreras de vetiver. Debe notarse que los setos de vetiver usan menos tierra que otros sistemas de barreras, por lo que (si todas las demás condiciones permanecen sin cambio) el rendimiento global por unidad de área debe esperarse que sea mayor.

Afirmación núm. 4. El pasto vetiver no es una mala hierba, no es invasor.

No hay pruebas de que el vetiver sea invasor en tierras altas de temporal [6]. Hay alguna evidencia de dispersión natural bajo
condiciones pantanosas [32 y 33]. En ningún lugar se le ha visto como una mala hierba amenazadora (nótese que este no es el caso de otras especies de setos, como Leuciana sp., que puede convertirse en una maleza mayor si no es manejada apropiadamente). Sus raíces no son estoloníferas, algunos de los tipos originadas en el sur de la India rara vez florean, y si lo hacen las semillas son en su mayoría estériles. Un vetiver, probablemente originario de Guatemala, cultivado ahora en Louisiana, ha estado sin floración en un mismo lugar por 25 años [34]. El vetiver se propaga vegetativamente. En Zambia, los setos de vetiver de Msamfu Research Station han permanecido intactos por mas de 60 años [8].

Uno de los principales objetivos de la revisión del National Research Council [6] del vetiver, era verificar donde podía el vetiver ser una amenaza como una mala hierba potencial. La revisión encontró que en la mayoría de los casos el vetiver no era invasor, pero recomendaba vehementemente que sólo se usaran los tipos sin semilla. La evidencia sugiere que los tipos introducidas de India a las estaciones ARS en Mississippi resultaron muy fértiles y germinaron vigorosamente. No parece ser el caso de las accessions de Le Blanc, cerca de Baton Rouge, Louisiana, ni de Boucard [35], en Leakey, Texas. Se necesita más investigación sobre los hábitos de floración del vetiver en relación al cultivo, el clima, la lluvia y la duración del día. Un diagnóstico molecular [36] vinculado con análisis biométricos rigurosos fue utilizado para identificar las relaciones entre los diferentes linajes de vetiver. Se extrajo

DNA de tejido folicular joven. Se encontró que la Coucard accession, y la que se conoce como Hauffman accession (que se cree es originaria de Guatemala) tenían esencialmente el mismo genotipo, y que eran muy diferentes de los tres tipos recibidos de la India. Se cree que mas de 20 tipos de pasto vetiver han sido introducidos a Estados Unidos. Los diagnósticos moleculares ofrecen una herramienta para identificar las diferentes tipos y para correlacionar características biológicas positivas relevantes de estos. Esto deberá llevar a un uso mas científico y controlado del vetiver, con resultados potencialmente mejores.

En Tailandia [37], mas de 30 diferentes tipos de Vetiver han sido identificados. Estos a menudo difieren marcadamente en carácter, e incluyen seis tipos de especies de vetiver identificadas como Vetiveria nemoralis. Estos incluyen algunos que tienen floración, pero que producen semillas estériles, y otras cuyas semillas germinan más libremente.

Una conclusión mas general es que en la mayoría de los lugares rara vez se ha reportado al vetiver como invasor, y si se encuentran plantas de semillas germinadas, pueden ser fácilmente removidas mediante la labranza (esta es probablemente una razón por la cual los campesinos nunca lo han visto como un problema). Hay claras diferencias entre tipos, que deben ser mejor identificadas, para que en el largo plazo puedan ser caracterizados los mas apropiados, de acuerdo a las necesidades locales.

Afirmación núm. 5. El pasto vetiver es extremadamente resistente a las plagas y enfermedades.

El vetiver es extremadamente resistente a las plagas de insectos y las enfermedades [23 y 24]. Hay evidencias de la India [38] que muestran que cuando una planta muerta de vetiver es atacada por las termitas, puede dar lugar a una reacción alelopática que evita el resurgimiento del vetiver a partir del centro de la planta, y bajo condiciones de sequía severa, los retoños de la periferia de la planta son rozados y la planta muere. De manera alternativa, y mas probablemente, el retoño es demasiado correoso para que la termita cast pueda penetrarlo. La quema puede erradicar este problema. Reportes de Brasil [39] sugieren que el vetiver es resistente a Meloidogyne javanica y M. incógnita raza 1 (nematodos de los nodos de la raíz), ambos nematodos de la raíz del tabaco. Existen reportes de China en el sentido de que el vetiver ha sido afectado por el barrenador del tallo del arroz [24], y aunque no ha afectado el crecimiento del vetiver, el último puede actuar como planta hospedera. Sin embargo, en Fujian (en el sureste de China), donde el vetiver ha sido cultivado en asociación con el arroz por muchos años, éste no parece ser un problema. En la mayoría de los casos las plagas y enfermedades del vetiver pueden ser meor controladas mediante la quema, y como se notará mas adelante en este artículo, la quema puede tener un lugar importante en el manejo general de los setos de vetiver.

La evidencia actual indica que sobretodo, el vetiver es resistente a las plagas y enfermedades, y no es vista como una planta hospedera importante.

Afirmación núm. 6. El pasto vetiver no es alimento del ganado.

Donde hay pastos más apetitosos, el pasto vetiver es normalmente ignorado por el ganado, esta es una característica importante si los setos de pasto deben permanecer intactos por muchos años. Se ha llevado a cabo muy poca investigación sobre el manejo y el valor alimenticio del vetiver como forraje. En numerosas ocasiones se ha observado, bajo condiciones agrícolas, que si el seto es manejado correctamente, es posible cosechar regularmente las hojas jóvenes, que proveen una racion de alimento. En Malasia las ovejas no comerán el vetiver en el campo si hay abundancia de especies mas apetitosas, pero las puntas recortadas fueron ávidamente consumidas cuando se ofrecieron a ovejas en cautiverio. En China y Malasia el vetiver ha sido utilizado con éxito como alimento para la cara rass. Al este de Indonesia, bajo condiciones sumamente secas, el vetiver fue comido por vacas y caballos. Con un buen manejo, las hojas jóvenes de vetiver tienen un valor nutritivo similar al pasto naperiano, con niveles de proteína cruda de alrededor del 7.0%. Bajo condiciones adecuadas, grandes volúmenes de hoja verde se encuentran disponibles. En Texas [35], en condiciones de riego, se ha alcanzado una producción de materia seca de mas de 100 toneladas por ha. al año, equivalente a alrededor de 350 toneladas de hoja fresca. Reportes de China [40] indican una producción de mulch de vetiver de 11.4, 14.7 y 17.8 toneladas de peso verde por 100 metros cuadrados de seto por tres años consecutivos. Nótese que en este caso, 100 metros cuadrados equivaldría a 230 metros lineales de seto. Hay poca duda en que, mejorando un poco su manejo, el vetiver sería un forraje adecuado para la sequía, particularmente si se le combina con otro forraje de alto contenido de proteína. Los campesinos de Gundalpet, India, han utilizado el vetiver por siglos como división entre parcelas, y como forraje en donde se corta una vez cada tres semanas, durante la temporada de crecimiento. Hay reportes de muchos otros países sobre su uso como forraje, incluyendo China, Guatemala, Honduras, Nigeria y Mali. Se sabe que algunos tipos son mas apetitosos -i.e. las así llamadas "farmer" cultivar de Karnataka, que han sido seleccionadas por los campesinos por décadas como un cultivar mas suave y apetitoso.

En áreas donde hay especies de pastos mas apetitosas como forraje, o donde no hay ganado, y quienes necesiten de un pasto inerte que pueda crecer con un manejo mínimo deberían fijarse en el vetiver. Hay excelentes ejemplos de esta aplicación en Costa Rica [41] para la protección de huertos de mango en pendientes pronunciadas.

Dónde el vetiver pueda ser usado como forraje, será determinado por los objetivos del usuario y del manejo que se le de. Algo que se necesita es la identificación y selección de los tipos

mas apetitosos y manejables como un propósito dual de conservación y de planta forrajera.

Afirmación núm. 7. El pasto vetiver puede ser usado para fortalecer estructuralmente terraplenes, líneas de drenaje, caminos, canales controladores, etc.

Hay evidencias en todo el mundo que respaldan el uso del vetiver para la estabilización de terraplenes [9, 10, 17, 27, 42]. Ha sido utilizado con éxito en Malasia, India, Sudáfrica, Indias Occidentales y Brasil en la estabilización de los márgenes de carreteras. El vetiver ha sido utilizado junto con aplicaciones geotécnicas para la estabilización de terraplenes en Nepal. Ha sido probado con éxito [27] en la estabilización de desechos de minas de oro en Sudáfrica. También ha sido utilizado para estabilizar represas de inundación, de ríos y canales en Bangladesh. Por su gran fuerza y capacidad para absorber sacudidas, el vetiver tiene potencial en la estabilización de las riberas de canales contra la fuerza y el choque de los barcos -de ahí que la Comisión del Canal de Panamá muestre interés en la aplicación del vetiver en el Canal.

La Vetiver Network ha recibido reportes positivos del uso del vetiver para reducir la erosión en vertederos de pequeñas presas en Zimbawe [39], arroyos en Fidji [8] y canales de drenaje en Guatemala, Sudáfrica, Malasia y Nepal [16, 17, 41, 42]. Se han recibido reportes mas recientes de que el vetiver está siendo usado para la protección de terrenos de construcción localizados en áreas con pendientes [27].

El VGT puede ser usado de manera efectiva en la estabilización de canales de irrigación [43]. En experimentos en los que se utilizaron canales de irrigación con pendientes verticales, se comparó el vetiver con pendientes no canalizadas, con el vetiver en pendientes canalizadas con polietileno. Las pendientes donde se plantó vetiver con los canales entubados con polietileno permanecieron verticales, y prácticamente igual en las pendientes no canalizadas. Los resultados muestran la gran habilidad del vetiver para amarrar el suelo (una arcilla arenosa), y el potencial para el diseño de canales propensos a deslaves, con el consecuente ahorro en área de terreno.

El VGT ha sido usado en muchos paises como una herramienta efectiva para el control de escorrentias. Debido a su fortaleza, el vetiver puede resistir corrientes de agua de gran velocidad en los arroyos, y puede crecer y acumular profundos depósitos de sedimento que se forman tras los setos de vetiver establecidos en los arroyos. Como resultado, se forman escalones naturales en los arroyos. Donde se usan gaviones para la estabilización de arroyos y canales de agua, el vetiver, si se planta en asociación con las estructuras, ayudará a estabilizarías. En lugares donde se pueden esperar altas velocidades del agua, el vetiver puede ser plantado mejor embolsado para asegurar su rápido establecimiento, y puede necesitar durante el primer año protección mediante bolsas de arena, así como la fijación con estacas de bambú.

Es probable que el vetiver sea mas ampliamente usado para la estabilización de terraplenes cuando los ingenieros se den cuenta de su potencial. Ya que es muy importante para el control de escurrimientos en áreas no cultivabables.

Afirmación núm. 8. El pasto vetiver resiste el fuego y ahuyenta roedores y otros animales.

El vetiver es bien conocido por su resistencia al fuego. Esta resistencia ha dado como resultado su sobrevivencia en campos cañeros que son quemados antes de la cosecha. En Sudáfrica el vetiver es usado para proteger las barreras contra incendio de la erosión [27], y este método es aceptado por las compañías aseguradoras forestales. El vetiver joven calcinado (calcinado como resultado del corte y secado de una masa) en las condiciones prevalecientes en Malasia, se recupera totalmente en cuatro semanas [16]. Pastores históricamente nómadas con grandes rebaños en planicies rozadas del Río Níger en Mali, Africa Occidental, queman el vetiver para obtener un crecimiento rápido del pasto. La resistencia y rápida recuperación del vetiver del fuego se debe principalmente a su corona protegida y a su profundo sistema de raíces y el depósito de nutrientes asociado, lo que permite el rápido restablecimiento. Estas mismas características permiten que el fuego sea utilizado como un sistema de mantenimiento del vetiver en áreas secas donde grandes cantidades de hojas se acumulan en los setos de vetiver, quemándose los claros, y reduciendo la incidencia de la infestación por termitas.

Hay conflicto en cuanto a la efectividad del vetiver para alejar roedores y otros animales. Los campesinos reportan continuamente que, aparentemente, las ratas son repelidas por el vetiver y no se amadrigan en el sistema radicular. En efecto, en los sistemas de irrigación de Nepal muchos campesinos han plantado vetiver en terrenos entre sus límites, con el propósito de reducir la infestación por ratas [42]. Recientemente, un silvicultor de Papúa Nueva Guinea reportó [44] que en tres años, el cerdo de monte no ha desarraigado los setos del pasto.

Afirmación núm. 9. El pasto vetiver no requiere mantenimiento o manejo.

Inicialmente, en la diseminación de la VGT, la afirmación de un mínimo o ningún manejo se basaba en su uso en áreas de elevada precipitación pluvial, como Fidji y las Indias Occidentales. En estas áreas, la experiencia mostraba que en tierras cultivadas el vetiver se conservaba en buenas condiciones por sí mismo, siendo su único mantenimiento un corte anual. Después de introducirlo a condiciones climáticas menos favorables, como las áreas semiáridas del centro de la India (con precipitaciones de 500 a 600 mm anuales), se ha observado que al seleccionar material de buena calidad

para el transplante, su plantación se debe hacer en el tiempo correcto (bajo condiciones climáticas como esas, donde el tiempo de plantación es extremadamente corto), rellenar los claros durante el primer año al menos, plantar utilizando bolsas de plástico (como contenedoras de la planta) bajo condiciones extremadamente difíciles, el uso del fuego como una herramienta para erradicar el exceso de plantas muertas, etc., y el uso de diferentes técnicas de plantación para conjugar diferentes condiciones locales. Son todos aspectos importantes de manejo que requieren un buen criterio práctico. Se ha demostrado experimentalmente [15, 16, 23 y 30] que el manejo juega un papel importante en el nivel de éxito de los setos de vetiver como sistemas para el control de la erosión. Hay evidencia conclusiva de que "plantar el pasto y olvidarse de él" a menudo no lleva al éxito, es por ello que la mayoría de las tecnologías fracasan cuando se sigue este camino.

Estudios en Andhra Pradesh [45] y Filipinas [20] muestran que cuando los campesinos han entendido la tecnología y la aplican y manejan adecuadamente, el sistema es efectivo. Cuando el gobierno hace el trabajo en lugar del campesino, hemos encontrado que el campesino se compromete menos con la VGT; no se lleva a cabo el mantenimiento y el sistema de setos se degenera. Por otro lado, la VGT aplicada en un huerto de cítricos en Costa Rica [41] (libre de ganado) no mostró signos de deterioro después de cinco años de no haber recibido mantenimiento. Otro estudio [46] muestra que en granjas muy pequeñas (de menos de media hectárea), los granjeros están renuentes a poner cualquier barrera en su tierra, ya que les quitan áreas potenciales para el cultivo de alimentos. En estos casos debemos conocer mejor las prácticas campesinas y alentar a los campesinos a usar la VGT como demarcación de límites, tal como ha sido practicado por siglos por campesinos en Gundalpet, al sur de India, y por miles de campesinos en las afueras de la ciudad de Kano, al norte de Nigeria.

Afirmación núm. 10. El pasto vetiver es un sistema de bajo costo para la conservación del suelo y la humedad.

En un análisis económico [3, 47] se comparó el establecimiento de setos de pasto vetiver por menos de $30 US dlls. por hectárea, con más de $500 US dlls. por hectárea de los sistemas de ingeniería convencionales. Los índices económicos de recuperación en el segundo caso se ubican alrededor del 20%, comparado con más de 90% para el vetiver. El costo del establecimiento de setos de vetiver varía de un sitio a otro. En terrenos con poca pendiente los setos pueden ubicarse a 50 m uno de otro, por lo que sólo se requieren 100 m de seto por hectárea de terreno protegido. En terrenos empinados con 60% de inclinación, la distancia entre los setos puede ser de cuatro metros o menos, necesitándose dos mil 500 metros de seto por hectárea. El costo de la planta varía dependiendo de la forma en que se produce. Costará mas si se propaga a mano en un vivero comercial, y menos por métodos mecanizados, como hacen los hermanos Boucard en Texas, y aún menos si los setos existentes en granjas se dividen para trasplantarse como nuevos setos. En la India, un campesino puede excavar y plantar 200 metros diarios -con un costo de $3 US dlls. al día. Los viveros "comerciales" de vetiver en la India cobraban en 1987 alrededor de 0.01 rupias por esqueje plantado. Con tres esquejes por excavación, las plántulas costarían alrededor de 300 rupias ($10 US dlls. por kilómetro de seto plantado). En 1993, en Tailandia se pagaba productores de esquejes a raíz desnuda y de buena calidad $2,600 US dlls. por hectárea, lo que, con un millón 25 mil esquejes por hectárea equivale a 0.2 centavos de dólar por esqueje, y $60 US dlls. por kilómetro. En Tailandia se producen bolsas con vetiver, que se plantan por 62 centavos de dólar el metro. El costo mecanizado de la plantación de vetiver, incluyendo el costo de la plántula, se estima en alrededor de $175 US dlls. por milla. En Estados Unidos, proteger una hectárea de terreno con una pendiente de 4% costaría, utilizando seis líneas de seto vivo, alrededor de $90 US dlls.

Es más difícil determinar los beneficios que representa el uso de setos de pasto vetiver. En la mayoría de los casos, la pérdida de suelo disminuye rápida y permanentemente, y se reduce la pérdida por erosión de 143 a 1.3 toneladas por hectárea al año [3]. Se han demostrado ganancias a corto plazo en la India [31], dando como resultado relaciones costo-beneficio de más de 2:1.

Algunos campesinos en la India han reportado que no sufren pérdidas de cultivos en años de sequía cuando usan el vetiver, mientras sus vecinos han perdido sus cultivos desprotegidos. Otros beneficios que deberían ser cuantificados incluyen el valor del vetiver como paja (en China, cuesta 2 centavos de dólar el kilogramo), como combustible (el vetiver tiene un valor energético de alrededor del 55% de el del carbón) y como forraje. Los beneficios indirectos incluyen el valor y los nutrientes del suelo que de otra forma se perderían, el valor del incremento de la recarga de agua en la tierra, su valor en la protección contra las fuertes inundaciones y la reducción del costo de mantenimiento de terraplenes. Si se asume que los beneficios de los sistemas de ingeniería y del pasto vetiver son los mismos (que no lo son - los beneficios del vetiver son superiores), el bajo costo del vetiver comparado con aquéllos (alrededor de una quinta parte) debería ubicar a la VGT como una prioridad tecnológica. Los costos detallados del desarrollo de setos de vetiver [3] muestran su superioridad sobre otros sistemas, incluyendo estructuras de ingeniería, en términos de la relación costo-beneficio.

Conclusiones

Lo anterior establece una fuerte evidencia de que el vetiver reúne los requisitos de una tecnología vegetativa de largo plazo y bajo costo para la conservación del suelo y la humedad, como se establece en la primera

edición del manual “Vetiver Grass (Vetiveria zizanioides) A Method of Vegetative Soil and Moisture Conservation1'” [9]. La prueba no descansa tan sólo en los resultados experimentales mencionados anteriormente, sino en un número cada vez mayor de usuarios alrededor del mundo, quienes parecen estar votando a favor de la inclusión de la VGT como parte de sus prácticas campesinas. En ningún lugar se demuestra esto en una forma tan vívida como durante la introducción masiva de VGT en Tailandia en los últimos dos años [37, 48]. La educación de los campesinos para la conservación del suelo es un proceso lento que no debe ser acelerado. El pasto vetiver es otra de las herramientas que pueden ser usadas, junto con otros métodos (labranza en contorno, cero labranza, cultivos apropiados para la fijación de nitrógeno, etc.), para reducir la erosión del suelo. El vetiver tiene méritos especiales por sus características que lo hacen durable, relativamente inerte y un pasto altamente efectivo que cuando crece como seto vivo, detiene el flujo de sedimentos y reduce la pérdida de agua de la lluvia.

The Last Word From The Editor

On reading through the text and other documents not presented in this newsletter I believe that I should draw your attention to the difference between the north India vetiver (possibly Vetiveria lawsoni) and that of south India (Vetiveria zianioides). It seems increasingly clear that the north Indian vetiver is less robust, is "weedy" to a certain extent, produces less oil, and produces smaller, shallower, and has a less dense root system. I suspect that sometimes users in north India, Nepal and Pakistan are disappointed with their results with vetiver because they are using the "north Indian type". Elsewhere in the world the vetiver that seems most common is that from south India that produces a heavier oil from a more robust and stronger plant. The south Indian vetivers rarely flower, and do not display weediness. Those of you using north Indian vetivers are advised to try out the south Indian vetivers. I urge you to participate in Mr. Adams' DNA testing program for vetiver, just to see the relationships between the vetivers and thus further expand our knowledge about this remarkable plant.

Table of Contents

Editor’s Page 1
Letters to the Network.....2
NewspaperReports 8
Vetiver Developments in Mexico.. 9
What two men with a mission can accomplish.....9
Accelerating Vetiver Developments In Africa.....12
A Practical Look At Vetiver And Its Uses As Applied In The Republic Of South Africa.....12
Vetiver Grass As A Tool For Consideration In The Forestry Erosion Management Program.....13
Prospects And Problems Associated With The Use Of Vetiver Grass As A Biological Mean Of Soil And Water Conservation In Lesotho Lowlands And Foothills.....13
Australian Pilot Programs Steam Ahead 15
Effectiveness Of The Vetiver Hedges In Soil Erosion And Sediment Control In Queensland.....15
India. Vetiver Has Found A Permanent Place In Land Management Practices.....16
Khus (Vetiveria zizanioides) in Watershed Development in Karnataka.....16
Introduction of Vetiveria zizanioides in Phulbani District.....19
Thailand - A Visitor's View.....24
Research Abstracts and Summaries.....24
Vetiver Oil Extraction.....28
Shoulder Reclaimer Saves Time, Money.....38
Spanish Readers Column.....39
El papel del Pasto Vetiver en el sostenimiento de la productividad agrícola.....39
The Last Word From The Editor.....45

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