VETIVER NEWSLETTER

NEWSLETTER OF THE VETIVER NETWORK
NUMBER 15 APRIL 1996

News Line

The First International Vetiver Conference, "Vetiver - A Miracle Grass"

The Conference, hosted by the Government of Thailand, The Chaipattana Foundation, Ma Fah Luang Foundation, Office of the Royal Development Projects Board, and the Land Development Board was held at Chiang Rai from February 5 - 8 1996. It was attended by about 300 persons, 100 of which came from 40 countries. We learned much from each others experiences, (detailed in this newsletter) some was confirmation and reinforcement of what we knew already, and some was new. In total we received confirmation that Vetiver grass is indeed a "miracle" grass — a miracle grass, not that it is the only grass (there are other grasses that can be used effectively under conditions not suitable for vetiver) for forming stiff grass barriers for soil and water conservation, but rather what is emerging is its potential range of uses for biological engineering and economic uses over a very wide area of eco-adaptability. This is likely to expand as new cultivars are identified, and vetiver grass breeders start selecting and improving the grass not only for its aromatic oil (as in the past), but also for its other traits. Lest we forget, let me list 31 uses of vetiver:

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Vetiveria zizanioides. Water color by Anita Cooper

- Mushroom substrate*

* proven; + under investigation, early results promising

It is little wonder that the farmers of northern Nigeria, for generations, have called the grass "Wonderful Grass".

From our work with vetiver we find some interesting pointers that government technical transfer systems are not working too well. Too often the initiative of introducing new technology is not being properly administered, and seems often to be done better by NGOs. Even the latter need help. Extension and conservation staff are not properly trained, dissemination aids (books, slides, videos) are not available; and linked

to this, farmers are not properly trained in use of technology nor are they involved enough with the planning and evaluation of research and technology dissemination. This not only applies to vetiver, but to many other technologies as well, particularly those relating to long term natural resources sustainability. It is also evident that the success of land use policy will depend directly to a land users willingness to look after the long term needs of the land. There is a lot to do.

Funding Support For The Vetiver Network

The Vetiver Network needs **your** financial support to keep the Network alive and strong. As you can see from the above list of potential uses there are many areas that need information and support. There is a limit to what the Network can do, but in the area of information collection and dissemination of information about vetiver we can do a lot.

Currently, The Network has prepared a funding proposal, "The Vetiver Network Support Project", which is being sent to potential donors around the world. The project consists of a request for funds for a three year period:

- Establishment of at least five regional/ national networks.
- Start up support to NGOs to develop vetiver programs.
- Awards for good research.
- Development of new technical videos.
- Revising and publishing "Vetiver Grass - A Hedge Against Erosion"
- Printing and mailing of Vetiver Newsletters
- Administrative cost support for The Network.

The total cost is estimated at US $500,000. We hope to obtain most of the funds from major donors, but we need support from those users that can afford it, so if you think that the Network serves a useful purpose please help. If anyone needs a copy of the funding proposal please let us know, and The Network will send you a copy.

The Vetiver Network has now been established as a non profit charitable organization, with a board of 8 directors, and has US Internal Revenue Service approval as a tax exempt organization under Code 501 (c) (3). Thus for US citizens your contribution is tax deductible.

A Call For Help from The Land of the People of Kom
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Cameroon, West Africa

For three years now the Network has been in regular correspondence with Mr. Ngwainmbi Simon who works at the Medical Centers of West Africa, Maroua, BP 382, Cameroon. He, with virtually no help, has started vetiver programs with farmers. The man is tested, he is committed to working with vetiver to help his people reduce erosion. If any of you, particularly those that have operations in Cameroon, who read this newsletter feel that you would like to support Ngwainmbi Simon please get in touch with him at the above address. I want to share part of his most recent letter to me:

".....I learned a lot from your newsletters; I wish people could aid the project that I want to start. In Bamenda it is all hills and it is not easy for farmers. Rain water has washed away all the top soil. The hills (land) from which farmers used to have 10 bags (400 kg) of maize can now can only produce half to one bag (20 - 40 kg). This has resulted in some poor families having to go 30 km in search of farms. The new farms have again started producing less and less. This area is in trouble. Women will go out of their homes to stay out on their farms for one week, only to come home once a week to rest with the family. This happens every year from March to June. Again from October to December during the harvest time. These same women have to carry the maize 30 - 40 km to their homes — what a problem!

I am sure that I have the answers to this area, and that is Vetiver. I did try a section on the hill near the compound and it is doing very well now. Again I have traveled to get Vetiver from this part of Cameroon (Maroua). It is more than 1,500 km from Bamenda, it takes two days and two nights to get from Maroua to Bamenda. My problem now is where to get a four wheel truck to carry these seedlings to Bamenda. If we can start this project and I use the seedlings to carry out small experimental plots for 4 - 5 years, I am sure, God willing, the land of the people of "Kom" will be useful again. Are there people who are willing to aid us? is it possible for the World Bank to give us a loan or give a grant for such a project. I would be very happy to have an assistant from overseas who is willing to come to aid me in this development project. If at the conference in Thailand (4 -8 Feb. 1996) you could announce that (FARDP) Family Association Rural Development Project needs funds, transport, and volunteers who can come to aid in the soil conservation work in Bamenda (Kom) North West Province of Cameroon I shall be very happy....."

We received this letter after the Thailand conference. If you can, and are interested, please help.

Regional Networks

Regional Networks are being established for Latin America and Europe:

The first formal network is now under establishment in Costa Rica and will serve Spanish speakers in Central and South America. It will be known as "The Latin America Vetiver Network". Detailed information is available in English and Spanish. The Network will be managed and coordinated by Jim Smyle and his wife Joan Miller. Jim was very instrumental in the production of vetiver newsletters when he worked in Washington. He is also a director of the Vetiver Network.

Another formal network is under establishment in Europe. It will be known as "European Vetiver Network" (EVN). In cooperation with the Servizi Informatici Area di Milano of the Italian National Research Council, EVN provides the mirroring of the Vetiver Network WWW pages at the URL: **www.siam.mi.cnr.it/Vetiver**. European users are invited to connect directly to the mirror. For further information please contact the EVN coordinators Marco Troglia (E.mail: **tecnagrind@popmail.iol.it**) and Fulvio Naldi E.mail: **naldi@siam.mi.cnr.it.**

Marco Troglia is managing a demonstration project in Murcia (Spain) using the Vetiver grass for soil erosion control; the project started in 1993, thanks to the finan-

cial contribution of the European Union, General Direction VI-Agriculture. Fulvio Naldi is chief technologist at the Italian National Research Council and works in the field of networking and documentation.

Anyone interested in establishing a formal regional Vetiver Network please contact The Vetiver Network.

Red Del Vetiver Latinoamericana

(*Pidiendo perdón de todos aquellos quienes escriben español gramático)*

Receintemente hemos inaugarado la Red Latinoamericana De Vetiver, con el sede ubicado en San José, Costa Rica. La red será manejada por Jim Smyle y Joan Miller; Joan funcionará como coordinadora. El objectivo principal de la red es servir y informar a todos usuarios quienes hablan español. Nuestra herramienta principal realizar este objetivo será un boletín escrito en español. El boletín permitirá a usuarios e investigadores de tecnología vetiver compartir sus conocimientos y experiencias con los demas en America Latina y para ampliar el uso adecuado de vetiver para la conservación de suelos, aguas y infraestructura rural.

Por difundir información y ejemplos (exitos y fracasos) de la tecnología vetiver en latinoamericano, tanto como el resto del mundo, esperamos educar a usuarios y usuarios potenticiales de vetiver sobre el mundo de posibilidades que existen para su aplicación. Además esperamos a que la red servirá aumentar participación y número de miembros en la red del vetiver mundial. El Vetiver Boletín; será gratis a todos aquellos quienes quieren recibirlo. Tambien, la red servirá como un centro para todos que necesitan información individual sobre el uso y aplicación de la tecnología de vetiver. Y caso-por-caso, proveeremos asimismo información sobre otras tecnologías y sistemas innovadores para el manejo de recursos naturales bajo uso o apropriado para uso en America Latina.

La Red Del Vetiver Latinoamericana esta planificando publicar su primer boletín por los principios de 1996. Si se quiere recibir una copia o comunicar con la red, nuestra dirección es:

Joan Miller
Coordinadora de la Red del Vetiver
Apdo. 173-2020
Centro Postal Zapote
San José, Costa Rica
Tel: 506 255 4011
E.mail: hamilton@sol.racsa.co.cr

En anticipación de nuestro primer boletín, querríamos solicitar apoyo en lo siguiente:

- Necesitamos articulos escritos por usuarios de vetiver en America Latina. Publicarámos cualquier información que sea util. Y cuando sea posible, favor de incluir fotos. Les volveremos a todas fotografías si así pide.

- Necesitamos desarrollar un base de datos de usuarios quienes pueden proveer plantulas de vetiver a usuarios nuevos; sea en cantidades grandes o pequeñas. Favor de ayudarnos con éste por informarnos en caso que tiene acceso a vetiver.

- Y quizas ustedes han dado cuenta que nuestras habilidades de escribir en español son algo debiles. Por consiguiente, si querría ofrecer su tiempo ayudar redacta nuestro material, favor de contactarnos.

The Vetiver Network Homepage on the Internet

The Homepage is up and running. It publishes most of the information that we receive from you from time to time. You can find it at **http://www.vetiver.com**

Change of Address

Because of the large number of people living in Northern Virginia the Post Office will on July 1 1996 change the Zip code of The Vetiver Network from 22075 to 20176.

Mailing address:

The Vetiver Network,
15 Wirt Street NW,
Leesburg,
Virginia 20176 USA

Letters to the Editor

.....Many thanks for your mail. I am primarily involved in research group of soil amoebae called cellular slime molds. They are social also! Regarding Vetiver — I plan to use the extracts of vetiver & look for their anti-fungal activity (primarily on plant pathogenic fungi). In my own home — we use Vetiver extensively for two purposes: to add the gentle aroma of Vetiver in drinking water, we put dried roots in the water; and we also use it along with *Shikakai*, the natural shampoo. A soap is also available with Vetiver aroma, called *Moti*.

With regard to technology adoption — Whenever I chance upon farmers I urge them to cultivate Vetiver as hedges. They are bit reluctant at first, because it doesn't give any commercial value as other crops. But if I explain with photographs, they are taking initiatives.

Now the source — Many of the farmers feel that it is not available freely — which is true. The agriculture department here doesn't give much importance to Vetiver. Moreover the farmer has a concern that there will be lot of snakes. So some of the farmers try to remove Vetiver rather than cultivate them. Another interesting aspect which I plan to embark on is — whether Vetiver competes for resources with other plants - especially with weeds (*Parthenium* etc.).
R.Baskar, Karnataka, India
E.mail:
jatinder@vigyan.iisc.emet.in

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I read the Vetiver Newsletter in our library. I am assigned as program field coordinator of our institute. Our farmers have been planting vetiver grass (locally named *Mura*) since 1991 when our soil and water conservation project started.

I am interested to have my own copy of the Vetiver book and the Technical Publication "Vetiver Grass for Soil and Water Conservation, Land Rehabilitation and Embankment Stabilization". Also, I am applying to be a member of the Network. We are now on the process of getting farmers' testimonies of the benefits of using vetiver in controlling soil erosion. We have trained about 200 farmers in SWC with *Mura* as the foun-

dation hedgerow. I have a plan to produce a simple brochure in Cebuano dialect about Vetiver and some of the testimonies of our farmers. Can you give me advice for possible source of funds. I need about US $1,000 for the project. Thank you very much and more power.

Edwin A. Balbarino, Farmi-Visca, Baybay, Leyte 6521-A, Philippines
Email: v+visca@ sat.vitanet.org

If anybody with an interest in the Philippines would like to help Edwin publish a book on vetiver in the local dialect please get in touch with him. I can vouch for Farmi-Visca, your money won't be wasted, and we will get some interesting results for all to share. Ed.

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Yesterday we returned from a four day trip, locating vetiver for the Panama project. We found some very interesting stuff (as well as the planting material). The best of it is at a coffee finca (farm) (Rio Negro) that is owned by a Swiss company and operated by Costa Ricans. Since they purchased the finca and its 200 ha of coffee five years ago, they have rehabilitated 60 ha and protected them with vetiver hedges associated with drainage canals (they are in a 3,800 mm rainfall zone). The story of how they got on to the vetiver is interesting. The finca was started in the early 1950's by a Chinese (Taiwanese?) family named "Wachong". They planted all the roadsides with vetiver to stabilize them (we have pictures of the 30 plus year old roadsides), but nothing in the coffee. They even planted the coffee up & down slope! When the Swiss bought it, the consultants they hired to do the initial planning recommended getting rid of the vetiver on the roadsides as "it served no purpose and took up space". However, the fellow charged with managing the fields had, in about 1988 or 1989, received one of the green books on vetiver while working with the government's Agricultural Development Institute; he also said that he had heard about vetiver in some soil conservation courses. So he decided to use the roadside plantings to begin establishing hedges in the plantations. Five years later it looks good, the rehabilitated coffee is on the contour, the hedges are well-planted, dense and thriving, and well-maintained. It never ceases to amaze me how well the word on vetiver has spread.

Jim Smyle E.mail:
hamilton@sol.racsa.co.cr

Photo 1: *Vetiver hedges used on coffee just farm in Panama, adjacent to the area Jim Smyle writes about in Costa Rica. In this instance the hedge is two years old and is protecting the interface of a field and road.*

Photo credit: Dick Grimshaw

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I am delighted to hear that vetiver will soon be on the internet. I came across a terrific site, The International Arid Lands Consortium — I don't know if you are familiar with them. They are a jumping off point for all sites to do with arid lands and land resources. Fantastic! They are actively seeking sites to connect with them so it would be a great place to register the vetiver site. The address is: **http://ag.arizona.edu/OALS/IALC/Home.html** (*I have checked this site, it's good, and I have registered our home page with them...Ed)*

I will certainly send you an update of our activities with seabuckthorn. It is an extremely exciting plant and there is as much activity around it as with vetiver. Colin will be attending a conference in Beijing in December on seabuckthorn. The Chinese have over 100,000 hectares of badly eroded lands planted to seabuckthorn now, and are producing over 200 products from the berries. However, seabuckthorn is much more intrusive than vetiver as it sends up shoots from the roots after about four years. For the Chinese this is great as they can cover huge tracts of land this way. Especially steep mountain slopes. We have a video made for ICIMOD in Nepal. If you would like a copy please let me know and I will send one to you.

Susan McLoughlin. E.mail:
sam@wimsey.com

(I have worked with seabuckthorn in China. It is very good for wasteland rehabilitation, and is particularly useful in climates that are too cold and too dry for vetiver. If you want more information contact...Ed)

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A consistent problem for us V.Es. (Vetiver-Enthusiasts) is the poor performance of most varieties of Vetiver under shade. Even under the partial shade of coconuts and rubber, Vetiver planted with great care gradually dies out; and this is a severe constraint as it is often that these plantation crops are grown on slopes which need protection of the soil below them.

Another instance of Vetiver dying out under shade occurs when it is planted to protect road banks, and then shade trees develop overhead.

I feel sure that amongst the many varieties of Vetiver, there must be some which have adapted to growth under shade, and I wonder whether there is any source of research information to which we may go for guidance towards such shade-tolerant varieties. Have these various varieties of Vetiver been classified (perhaps numbered) according to their particular characteristics and adaptabilites? If not.... here is a **VERY** urgent area for research.

You may recall that interest in *Leucaena* was for many years mainly emotional.... enthusiasm without much REAL research backing. Then a pest appeared (Psyllid) which wiped out much of the *Leucaena* in the world. It was then found that certain *Leucaena* trees were resistant and from this arose very extensive research into the characteristics of the various varieties of *Leucaena*, and interest in *Leucaena* revived.

I shall appreciate your own views on this proposal.... or must we wait for a pest?

Ray Wijewardene DSc.

Tel: Colombo (94-1) 421881

Has any reader got any ideas for Ray regarding shade tolerance. I know that in Karnataka, India, some cultivars are know for being "forest types". In Panama and Guatemala vetiver hedges grow well under light coffee plantation shade. If anyone can help Ray, please get in touch with him. Bob Adams will be undertaking DNA classification of vetiver, this should be a start, but much more needs to be done. Mark Dafforn is trying to coordinate some of this work for the Network. If anyone wants to help Mark please get in touch with him at: mdafforn@nas.edu ...*Ed*

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I am pleased to say that at long last Vetiver is gaining the approval of more and more people around us here in Zimbabwe.

As a consequence of the two workshops I held on the farm with section managers of the large Hippo Valley Sugar Estates (Triangle) management has embarked on a major exercise in accordance with the Anglo American Corporation Zimbabwe Environmental Management Code of Practice. They have planted out Vetiver grass along 191 km of rivers and drains with a further 122 km identified for future planting.

Furthermore they have embarked on what is known as the "Magudu Vetiver Outreach Project" involving the local Chief, the District Administrator, and Agritex (Government extension and research service) officials. In February 1,400 meters of vetiver was planted, and watered by local people carrying 20 litre tins of water from the nearby dam. The grass in fact started catching the top soil when heavy rains fell shortly afterwards. Once again the primary objective of this exercise is to teach the communal farmers to conserve soil, and to see the many other advantages of vetiver i.e. thatching, mulch etc.

On the 28th October a Zimbabwe Sugar Symposium was held at Triangle, and I was invited to give a presentation on vetiver. I gave a short talk accompanied by a slide show on the grass itself, its uses on sugarcane farms, dam walls, and drains. It was well received by most of the 193 delegates some of which came from Malawi and Swaziland. There were also representatives from a major local chemical company who sought me afterwards for additional information.

I must say that all this is most encouraging and with the rainy season about to start we hope there will be more vetiver planted and more soil saved! Water situation, at present in the country generally, and more particularly in the Lowveld is critical.....I often receive letters from Agritex personnel requesting information to help them study the value of vetiver. In fact I am running out of the little green booklets fast ..... **Jano Labat,** Chiware Holdings Pvt Ltd. P.O. Box 14, Chiredzi, Zimbabwe.

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I just got the vetivers from Panama and Costa Rica! I'll stick them in the freezer. They look fine for DNA extraction. It will be about April before I have a student to start. Hopefully I will have lots of samples by then.

I have Vetiver newsletter #14 and note that on p. 28 (Vetiver Oil Extraction) is by an unknown author. The article was copied from "The Essential Oils, Vol IV" by Ernest Guenther, pp. 156-180. Robert E. Kneger Publ. Co. NY (1977 reprint from 1950 original edition book by Litton Educational Pub., Inc.). The technical specifications on oil density, etc. were omitted, but otherwise the article is a word for word copy of the original. Your article ends on page 179 (of the book). The last page of the treatment of Vetiver by Guenther is p. 180 and contains two paragraphs on "Use of Vetiver Oil". You should probably note this source in another newsletter (else you might be sued for copyright infringement). There were several very useful bits of info. in newsletter #14.

Bob Adams
E.mail: rpadams@aol.com

Thanks Bob, readers please note the source of the article that he refers to. Bob needs all of you who can and are interested to send in a few small leaf pieces (10-15 cm long) of your locally grown vetiver for his DNA vetiver classification work. This work should result in a clearer picture of which vetivers are related, seediness of vetiver, and any other traits, such as shade tolerance, winter hardiness etc. He will share his results with you all through the Network. All you have to do is to dry the piece of leaf in the shade or deep freeze it for a couple of days, so as to kill the leaf quickly (without rotting). Put it in an envelope together with information of where it comes from, and any unusual characteristics, such as shade tolerance and send it to him at: **Dr. R.P. Adams, Plant Biotechnology Center, Baylor University, Box 669, Gruver, Texas 79040 USA.** *With regard to US customs, you should put a label on the envelope with the words "Dried Botanical Specimen (Genus Vetiveria) for destructive testing. Phytosanitary Permit/ Quarantine* ***Not*** *required. Please expedite"..ED*

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For about three years now I have been interested in Vetiver as a means of protection against erosion in a mountainous region of Colombia, S.A. I first obtained material from CIAT (Cali, Colombia) and planted the slips on rich fertile soil. The percentage of survival was fairly high, considering that the farm where planting was carried out, is located on a plateau (Sabana de Bogota) 2,630 meters above sea level, with a mean annual temperature of 15˚C in the Andes mountain range of Colombia.

Development of the plants was relatively slow, due to climatic conditions - I presume - but after 1 year the leaves had a length of about 3 feet, and clusters were increasing in size at an appreciable rate. The leaves, by the way, turned a reddish color from the middle up to the tips. Is this caused by ambient temperature? (*probably cold winter temperatures ....Ed*)

After two years I started using this material to plant it in a region of different soil and climatic conditions (clay soils, altitude of 1,000 meters above sea level, temperature of 26˚ C). Two and three slips per site were planted under different local conditions, (some were planted under shady conditions in a coffee plantation while others were planted on the bank of a water reservoir). Slip survival was somewhere around 70% but after about 5 months, growth is rather slow *(may be a shade problem....Ed)*; the plants do not show a vigorous development, as you would expect under the new climatic conditions (rains started after planting); they are thin single or double leaf shoots with no tillering showing. It is important to mention that at planting the slips were put into a mixture of black soil, water and 15:15:15 fertilizer. Some of the plants located on the banks of the water reservoir have flowered; this never happened at the higher altitude farm where these plants came from. The flowered plants do show a

somewhat better growth than the others, but they still seem weaker than the mother plants. I will be testing the seeds for fertility. My next step is to plant some of the materials in polybags to be transplanted at a later date in the field.

Hernando Gutierrez De La Roche - Ph.D. Carrera 20 # 86a - 16 Apt. 301 Santafe De Bogota, Colombia S.A.

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I am regularly receiving your Vetiver Newsletter and find it a very useful publication. The place where I am located is situated between 20˚ 15' and 21˚ 23' N latitude while 70˚ 33' and 74˚ 23' E longitude with the elevation ranging from sea level to 800 m. This region is characterized by heavy rainfall (1,500 to 2,500 mm), moderately cool winters and hot summers. A huge area in this region has been subjected to soil erosion due to deforestation, faulty tillage practices, heavy rainfall and unavailability of appropriate soil conservation technology. When I got your first newsletter, that was about 2 years ago, I contacted Gujarat Land Development Corporation, which is handling the watershed management projects and obtained 5 seedlings of vetiver from them. I multiplied them to initiate the following two experiments:

- spacing requirement of vetiver for obtaining maximum number of tillers; and
- optimization of contour width using vetiver on lands having 5% slope.

The first experiment is in second year while the second experiment has completed just one season. I am also thinking of initiating another experiment. The details of which would be communicated to you in my next letter.

Meanwhile we have taken up a multiplication program to distribute the seedlings to the farmers, as many of the farmers of this area have shown interest. Few of them have already got 10 to 15 seedlings each from our farm for further multiplication. I am intending to involve some non-government organizations for further multiplication programs to meet the farmers' need of their area. I will use this opportunity to explore if you know of any agency which is financing research projects on vetiver.

R.P.S Ahlawat University Office: Sardarkrushinagar.385506 Banaskantha District, Maharashtra, India,

Photo 2: *China. Guangdong Province. A slipping highway cut just planted to vetiver.*

Photo credit: Xia Hanping

(Mr. Ahlawat has subsequently written to say that his research has been funded, he is also interested in testing out vetiver for flood plain conservation...Ed)

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I was very glad that one of our staff members, Mr. Habtamu Wubshet, was invited to attend the International Conference on Vetiver grass : "Vetiver: The Miracle Grass" held in Thailand from February 5 - 8 1996. He is one of the promoters of vetiver grass among the peasant farmers as a major means of biological soil conservation. His immediate boss is of course Mr. Alemu Mekonnen, Head of our Agro-Ecology Development Department. Mr. Habtamu, although very busy this time of the year in preparing terraces, etc. is preparing to brief us about the conference. In the mean time our GM after seeing the Thai experiences has instructed me and the Women's Department + Mr. Alemu to see if vetiver leaves and roots can be used for small handicrafts like baskets, hats, etc. It would be helpful if we got the experiences of other countries through Vetiver Network or you personally. (*if anyone can pass some ideas to MfM please write direct... Ed)*.

Well coming to myself, I was employed by Menschen fur Menschen Foundation as a Deputy GM of Illubabor Projects as of July 1995. This means that I am closely working with the two vetiver promoters, Alemu and Habtamu. I have personally witnessed that vetiver is really a "miracle grass" against soil erosion. The methods that we use to promote vetiver among the farmers is simple extension approach.

Alemu, Habtamu and myself are of opinion that from the experiences of MfM, it would be possible to aggressively promote vetiver throughout Illubabor Administrative Zone, where our project is operating. However, as a small NGO, MfM is limited to its own concentration areas (project areas) and can't support the extension services of Illubabor Agricultural Development Department, the service responsible for extension services in the Zone. Is it possible for the latter to get financial, material and technical support if they prepared a project promoting vetiver for the control of soil erosion? As far sharing experiences is concerned, MfM is willing in all respects. *(another challenge, any aid agency interested in working in Illubabor, Ethiopia??....MfM has done a top class job on their project ..... Ed)*

Debela Dinka, MfM, P.O. Box 120372, Addis Ababa, Ethiopia

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Thank you for your letter of May 5. We have

Photo 3: *China. Guangdong Province. A slipping highway cut fully stabilized 6 months after planting vetiver grass*

Photo credit: Xia Hanping

made new progress in our vetiver projects this year. Do you still remember what I said - the local road and railway departments are not willing to accept the practice of planting vetiver along the both sides of highways and railways - in my letter of March 5th to you? However we never lose heart. Later, my colleagues and I took a lot of material on vetiver, especially those you sent to me, to the Guangdong Provincial Highway Administrative Bureau (GPHAB) again and again, and related and showed the excellent effects of vetiver on controlling erosion and landslide, to the leaders and staff members of GPHAB. Constant effort yields sure success. At last, we convinced them, and started to collaborate with the Bureau. The two photos are just from one of 4 sites GPHAB offered us for carrying out the trials. Photo 2 is the background, and the part exterior after vetiver being just planted (May 4 - 5th). Note the severe landslip, almost total exposition, and piling silt on the road. We made the second observation to the experimental sites on September 19. It is very clear from the photo 3 that vetiver has formed dense lines and almost completely controlled the erosion in only four and a half months! Note among the lines there have been overgrown with some "weeds", one of which is mostly *Isachne indicum.* It indicates that "weeds" can grow once a sliding slope is held up. Obviously, these "weeds" are very helpful to control erosion. Currently, both sides express satisfaction with the experimental result, and are willing to continue cooperating in next years. Because of a great scarcity of funds, however, we feel quite difficult in enlarging the trial's scale. We are looking for resource of funds. Of course, we wish you and Vetiver Network could aid our this project financially. Thank you very much!
Xia Hanping South China Institute of Botany, Academia Sinica, Guanzhou, China

(another very good research group doing practical research and testing of vetiver. Any funding support to this group will give excellent returns and will have a wide range of applications. Ed)

Thailand First International Vetiver Conference "Vetiver: A Miracle Grass"

Draft Conference Resolution

This draft was prepared by the Vetiver Network and left with the organizers of the Conference. It reflects the general views of those who attended. The recommendation for the Second International Conference to be held in South Africa in the year 2000 was a recommendation of a special conference committee (the one and only committee established under the Chairmanship of Mr. Narong of FAO)

Preamble.

1. The conference recognizes the extraordinary leadership of His Majesty The King of Thailand in His Vetiver Grass Initiative and to the agencies that responded to His Initiative on June 21 1991 . This initiative comprising research, field testing and demonstration impacted on a wide range of applications covering soil and water conservation, road and pond stabilization, pollution control, and handicrafts in the Kingdom of Thailand.

2. The initiative that was primarily a Research and Development Program carried out by Chaipattana Foundation, Ma Fah Luang Foundation, Office of the Royal Development Projects Board, and the Land Development Board in conjunction with other various government departments has over a period of five years developed and identified techniques in the application of the vetiver grass hedge technology (VGHT) and has confirmed that VGHT involving the unique grass - *Vetiveria zizanioides* - has a very wide application throughout the tropics, and semi tropics for low cost soil and moisture conservation, and for other biological engineering purposes including land rehabilitation and stabilization, flood control, and for remediation of a range of pollution related problems.

3. The conference recognizes the efforts and contributions made by individual user, scientists, and government and non government agencies in over 100 countries in their contribution to the development and extension of new knowledge and information relating to VGHT.

Technical application

4. In summary VGHT has some very clear uses and advantages for the stabilization of the world's land and water resources that are located primarily between latitudes 30 degrees north and south of the equator. The technology is user friendly, low cost, and has wide adaptability over a range of ecological conditions. The conference confirms that nowhere is the grass seen as an

invasive weed, even in its natural habitat (wet lands).

5. VGHT when applied correctly has proven to:

- reduce the movement and loss of soil from lands protected with vetiver grass hedgerows;
- significantly reduce rainfall runoff losses, with the consequent positive impact on improved soil moisture content and ground water recharge;
- recycle plant nutrients;
- under conditions of water stress has generally resulted in significant crop yield increases;
- provide for a low cost and effective means for stabilizing earth fill and cuts in relation to roads, drainage and irrigation works;
- stabilize and rehabilitate mining sites;
- stabilize river and pond banks;
- tolerate heavy metals and other toxic minerals and chemicals at higher levels than most other plants, and thus has potential in the prevention and clean up of polluted sites that might include municipal waste dumps, mine dumps etc.; and
- have important byproducts including: thatch, fodder, mulch, aromatic oil production, medicinal products, fuel, and as a material for handicrafts.

6. The above uses and applications have been confirmed by research and practice in Thailand and in other countries in Asia, Africa, and Latin America over the past 10 years.

Future Directions and Applications

7. The Conference endorses the use of vetiver grass for such purposes as outlined above, and recommends that individuals, private agencies, governments and international agencies extend the use of vetiver grass on a wider basis and accelerated time frame. The conference noted the integrated and well coordinated efforts of Thai agencies in the development of a strategic approach to resource conservation using VGHT. Other Asian, African and Latin American countries could well use this approach for the introduction of this low cost technology, as an important environmental measure for the stabilization of agricultural lands that would result, in conjunction with other management practices, in improved incomes of the rural poor, and in reducing the pressure on adjacent forest lands where relevant. VGHT should be used more often in watershed conservation for improving ground water recharge and the resultant positive impact on rural water supplies. It was noted that VGHT has potential as a measure to reduce sediment flows that would normally be detrimental to the life of reservoirs and to the good health of coastal reefs and fisheries.

8. The conference recommends that efforts are intensified to use VGHT for stabilization of engineered works, phyto-remedial uses, and for biomass production.

9. The conference urges that funding for research and technology transfer be improved. In particular, research and testing efforts should be intensified in:

- the identification of the different vetiver species and cultivars in the world, their relations to one another, and their different physiology and potential uses;
- the efficient propagation and handling methods for the rapid multiplication of vetiver grass;
- the development of different architecture required for various bioengineering;
- the field management practices of vetiver grass hedgerows to assure long term maintenance at minimum cost;
- phytoremediation practices that could be used for environmental mitigation of problems relating to pollution; and
- the selection and development of appropriate vetiver cultivars for fodder and other biomass purposes, and for the use of handicrafts and other potential uses.

10. In Thailand and in other countries that are currently using VGHT there is a need to think through appropriate measures to assure effective transfer of the technology to users, and to put them into place. In all cases the end user must be involved in the planning process and should receive adequate support and training to allow such strategies to be properly executed. Greater use should be made of public news media, handbooks, audio visuals etc.

11. The conference urges land development planners, executing agencies and engineering consultants to initiate programs that include VGHT technology. In particular to provide funds for technology transfer and research, and for the initial production of plant material for distribution to users.

12. The conference supports the need to expand the free transfer of information by continued support for The Vetiver Network and for the establishment of independent regional and or national networks. At this time it is recommended that networks are established for the Pacific rim, for south Asia, for west and southern Africa, and for Latin America and Europe. These networks, to be effective, should retain close ties, should be operated at minimum cost, and should cater to potential participants without hindrance or bias.

13. The conference urges governments and agencies to provide small grants to bonefide non government agencies for start up VGHT programs. In addition the conference recommends that international and bilateral agencies that are already helping to promote the technology should continue, but on an accelerated time frame.

14. The conference believes that VGHT will, in the 21st century, become a major biological technology for the mitigation of a wide range of environmental problems. To this end: (a) research and testing programs should be accelerated, and (b) the Second International Vetiver Conference should be held in South Africa in the year 2,000.

Abstracts Of Selected Research Papers Presented At The Conference

SOCIO-ECONOMIC ASPECTS

Status Of Vetiver Grass In Upland Farming Development In Indonesia (Contradiction Between Soil Conservation And Farmers' Utility Orientation)

Agus Hermawan. *Institute for the Assessment of Agricultural Technology Agency for Agricultural Research and Development (IAAT-AARD), Indonesia.*

There are two kinds of soil conservation techniques developed by Farming Systems Research (FSR) component of Agency for Agricultural Research and Development (AARD) of Indonesia, i.e. mechanical and vegetative. Vegetative soil conservation includes cropping pattern arrangement, tree plantation, grasses and legumes as terraces strengthen on strips and alley cropping systems. In that case, vetiver as grass barrier could control run off and decrease 'CP' factor and land erodability lower than control plot, as well as increase organic matter on soil. On alley system, vetiver could control erosion to 13.21 and 0.56 ton at second and third years respectively (on the average erosion on control plot was 120.08 ton/year), while height of ridge soil at third year was 29.7 cm lower than Flemingia (38.9 cm) and Caliandra (39.7 cm). But, adoption by upland farmers of vetiver plantation was low. Resources limitation of upland farmers led them on short term orientation, and they only adopt technologies that give direct benefit. In that case, farmers more prefer plant other grasses (such as king grass, elephant grass and setaria) or legumes (Fiemingia, Gliricidia, Leucaena, etc.) on alley system. Grasses and legumes were planted by famers for fodder and fuel wood, but not for soil conservation orientation., lower forage production and poorer palatability of vetiver grass, compared with other grasses and legumes, being the cause.

The Adoption Of Vetiver Extension For Highland Farmers

Vitat Tachaboon. *Hill-tribe Welfare Division, Public Welfare Department, Thailand.*

The objective of this study is to investigate the adoption behavior and the cultivation of Vetiver by farmers in the highlands by collecting data from the areas under the responsibility of the Hill Tribe Development Centers, covering 14 provinces with a sampling of 1,433 farmers.

It was found that 401 farmers or 27.98 percent of the sampled farmers had grown Vetiver since 1992, which occupied 35.45 percent of the holding areas of the Vetiver growing farmers. There were 18.70 percent of Vetiver growing farmers planning to grow more Vetiver in 1995.

As for the reasons to participate in the Vetiver growing project, 74.81 percent of farmers claimed that the reason was from the introduction of the project officials, there were 14.96 per cent wished to replace other alley crops, 66.58 percent to reduce soil erosion, 47.88 per cent to improve soil fertility and 17.95 per cent wish to keep using their land forever. Besides, there were 30.17 percent of farmers who joined the Vetiver growing project in order to obtain land ownership or land rights.

Studying the use of land between the Vetiver rows revealed that most farmers were using every field every year. For the use of Vetiver, 45.14 percent of Vetiver growing farmers made use of it, commonly used for feeding animals. Besides, 33.67 percent of growers also introduced Vetiver growing to the other persons, mainly their neighbors and relatives.

In terms of farmers' attitudes towards the effect of Vetiver growing; the study showed that both the Vetiver growers and non Vetiver growers had similar opinions that vetiver required more labour and time management.

The analysis of relationship between the adoption of Vetiver and certain socio-economic factors using Chi-square test revealed that the differences of ethnicity, social status, number of family labour and sources of information were significantly correlated with growing Vetiver. It was also found that the farmers who used to grow other alley crops grew higher proportion of Vetiver than the ones who had never grown alley crops before.

Studying the relationship between the information transferred from various sources and the reasons to participate in Vetiver cultivation showed that the farmers who received the information from the other sources that were not persons or that were not involved with persons had a smaller proportion of land use between the Vetiver row than the ones who received from the persons knowing vetiver. It was also found that the farmers who participate in the Vetiver project concerning erosion control had a higher proportion of land use under Vetiver than those who joined the project for other reasons.

Environment And Socio-Economic Values Of Vetiver; A Miracle Grass.

MD. Faziul Huq. *Proshika 1/1 -9A, Section -2, Mirpur-2, Dhaka- 1216, Bangladesh*

Vetiver is a familiar grass growing on the flood plain soil of Bangladesh. It is commonly grown as a fodder in the rural areas. In the rural condition, this grass has high economic value. Vetiver is a fast growing species of indigenous fodder. The plants become 2-3 feet high with leaves and soft body. The leaves and stems are soft and palatable to the animals. T he marshy and wet land is favorable for vetiver cultivation. The small scale dairy and livestock farmer cultivate this grass in their limited agricultural land in between two principal crops. Sometimes Vetiver is cultivated as a relay crop. The vetiver has high nutritive value for Dairy cattle and Beef fattening animals. The goat and sheep herders also use the fodder as a popular forage. The animals with other balanced feed and vetiver show a remarkable body of gain within a short period. Small scale farmers benefit both socially and economically. The cultivation of vetiver helps both soil erosion and fertility of the land which gives environmental protection. So the socio-economic value of vetiver is quite satisfactory for the poor farmers in a country like Bangladesh.

Socio-Economic Dimensions Of Vetiver In Rainfed Areas Of Karnataka (India)

K.N. Ranganatha Sastry. State Government of Karnataka, India

The vegetative measures for soil and moisture conservation is most warranted for various reasons like protection of ecology and environment, cost effectiveness, sustenance, simplicity in adoption, familiarity

Photo 4: *Nigeria, Bauchi State. Vetiver grass, Vetiveria nigritana, used for making handicrafts.*

Photo credit: Ahmed U Ibrahim

of operations among the farming community. This is being increasingly felt at academic, policy and planning levels. There is a need to translate this concept sufficiently at the execution level. Among the various species available for vegetative approach, Khus *(Vetiveria zizanioides)* has various uses because of its versatile features. It can function as an independent measure, can initiate vegetative measures with other species, supplement other species in vegetative measures. Because of simultaneous existence of xerophytic and hydrophytic characters (as revealed by structure of its tissues), it can adapt under various agro-climatic settings. The cost of multiplication of slips, planting, developing into a hedge and maintenance is far less compared to earthen and masonry measures. Once introduced into a region and the farmers are convinced, it can expand without the intervention of government agencies. These facts have been supported by tables, photographs and slides as experienced in Karnataka (India).

Uses Of *Vetiveria nigritana* In Northern Nigeria — A Case Study Of Bauchi State.
Ahmed U. Ibrahim. Bauchi State Agricultural Development Programme, Soil Conservation /Agroforestry Component, Nigeria.

The paper high lights the uses which *Vetiveria nigritana* is put to in Northern Nigeria. The locally available grass species in the region is known by the local farmers as a gift of nature to settle farm boundary disputes from many centuries ago.

The uses of the grass include, hedge rows, farm boundaries demarcation, thatch, mat, mulen, rope, hand crafts, and pest repellent. Supporting evidence with film slides and some empirical data are provided. *Vetiveria nigritana* has established it's potentials from it's vast uses as important in both soil/moisture conservation and source of revenue generation to the African peasant farmer.

Farm Household Center: A Basis For Extension And Transfer Of Vetiver Technology.
Kuscahyo Budi Prayogo. Agricultural Information Center, Central Java., Indonesia.

The existing situation related to vetiver extension activities in Central Java is discussed. Although Java is the leading producer of vetiver oil, in some places people are convinced that vetiver actually causes erosion. Farmers themselves think that vetiver is not profitable economically. These problems basically show t**he failure in executing extension and research approaches.** Upland watershed farming system need to be approached and analyzed from three key perspectives, i.e. technical factor, socioeconomic factors and agroecological factors.

Socioeconomic factors have great influence in determining farmers preferences in doing their farming system. Vetiver, as a single plant is considered unprofitable. That is the reason that farm household living in upland watershed are more likely to choose other grasses. However, as an integral part of an upland farming development, vetiver has the best role in controlling soil and water erosion. It is essential to reconsider the way researchers and extension workers do their activities in upland watershed.

Cost Comparison In Producing Vetiver Grass From Different Methods Of Production
Sumol Sopakorn, Wichai Suwanakert and Darunee Kaewvichien. Land Development Department, Ministry of Agricultural and Cooperatives, Bangkok, Thailand.

According to the high demand of using vetiver grass for soil and water conservation from many government agencies, it is necessary to find the best and quickest method of producing vetiver grass for good quality, low cost etc.

The study was carried out into 2 steps:

- planting vetiver directly into the plastic

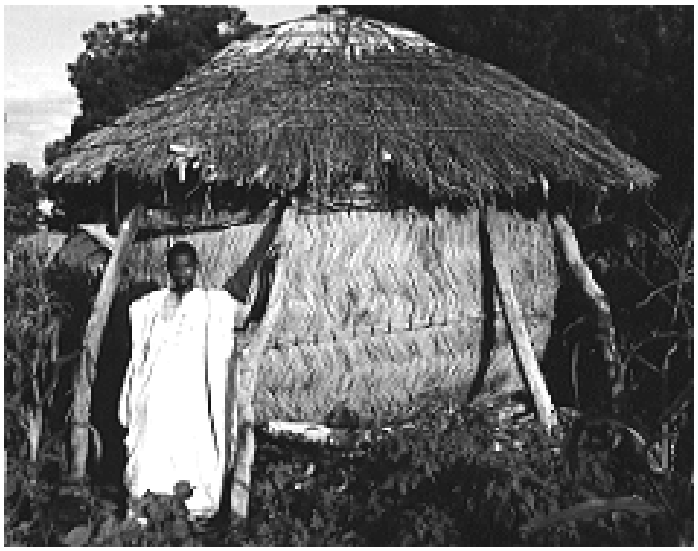

Photo 5: *Nigeria, Bauchi State. The wall of this grain store is made of vetiver grass, Vetiveria nigritana. The roof is made from Andropogan gayanus.*

Photo credit: Ahmed U Ibrahim

bag, the field and greenhouse.
- After the first step dividing the tillers of vetiver grass from the plastic bag, field and greenhouse and replanting in the plastic bag.

The results from the study showed that the cost of producing vetiver grass were:

Cost for the first step.

- Cost of producing vetiver's shoot in the plastic bag was 0.12 Baht.
- Cost of producing vetiver's shoot in the field was 0.08 Baht.
- Cost of producing vetiver's shoot in the greenhouse was 0.20 Baht.

Cost for the second step.

- Cost of producing vetiver's shoot again from the plastic bag was 1.65 Baht.
- Cost of producing vetiver's shoot again from the field was 1.61 Baht.
- Cost of producing vetiver's shoot again from the green house was 1.73 Baht.

Note 1 US$ = Baht 25

Alternative Dissemination Bridging The Gap

Stephen Rwangyezi. Ndere Troupe, Cultural Performers and Promoters, Offices at National Theatre Building, Uganda.

The Educational methods that were introduced in Africa during the second half of the 19th century by the first missionaries and which formed the basis for schools, were completely different from those that tradition had developed since the existence of the African continent.

Whereas in traditional Africa, education was informal-learning through work. play or conversation, and where every body was a teacher-at any time and anywhere, (except for specialised education like medicine which was done through apprenticeship), the European education emphasised selection and isolation of learners, keeping them in partial prisons called schools, run by "artificial creatures" code-named teachers, who were slaves to books called syllabi and to a bell that signified change of periods and subjects irrespective of whether the previous ones had been understood or not. Only the financially capable parents managed to send their children to these privileged Centres-Schools.

The result of the collision of these two completely different educational systems was class creation. The "Modern" system produced a powerful minority group of "social misfits" that control political power from remote centres called towns and cities. These people, unfortunately disregard the vast "Unschooled" rural based majority as primitive, obstinate, fatalistic, retrogressive and peculiarly impervious to any form of civilization-a condemned group to be ignored until they die off.

Far from dying off, however, the rural majority, interact with nature. Using crude methods, they produce the food and the children that keep feeding the cities and the whole country. They, however, view the elites as an unrealistic and not down-to-earth lot.

The mutual suspicion that developed between the products of the two educational systems is, in our opinion largely responsible for the gross lack of complimentality in addressing Africa's problems such as malnutrition, high mortality rates, political confusion, wars etc. etc.

If, therefore, we are to talk about development that is environmentally friendly, then we must talk about effective COMMUNICATION and DIALOGUE with the rural population. But since the majority of them neither read nor write, given that radio and television, leave alone electric power, are a luxury of the rich city dwellers, considering that the rural peasant is depending on their muscle power therefore with serious time constraints (cannot afford the luxury of spending 'endless' hours in boring lectures and seminars) we must find in *interesting, familiar* and *friendly* method to disseminate vital information and *stimulate* open and sincere *dialogue.*

Farmer Participatory Selection Of Vetiver Grass And The Most Effective Way To Control Erosion In Cassava-Based Cropping Systems In Vietnam And Thailand.

Reinhardt Howeler, CIAT, Thailand

Research has identified various effective ways to reduce erosion in cassava-based cropping systems, including the use of vetiver grass. However, few of these practices are presently used by farmers. To enhance the adoption of soil conservation practices by cassava farmers, a Farmer Participatory Research (FPR) methodology was used in two pilot sites each in Thailand, Vietnam, China and Indonesia to test and select the most effective practices. Farmers in Thailand and Vietnam selected vetiver grass contour barriers as one of 4 - 5 treatments they wanted to test on their own fields. After harvesting all trials and discussing the results, farmers in all three villages in Vietnam selected the vetiver grass treatment as the most effective in increasing income and reducing erosion. Although the trials in Thailand have not yet been harvested, farmers already observed that the vetiver grass treatment was the most effective in reducing erosion. In both countries, participating farmers, after seeing the benefits of vetiver grass, requested additional planting material to plant in their fields.

TOLERANCE OF VETIVER TO TOXIC CHEMICALS

Vetiver Hedgerows And Agrochemical Residues: A Case Study In The Cabbage Fields At Nong Hoi Development Center Chiang Mai, Northern Thailand.

J.Pinthong[1], S. Imphitaks[2], M. Udomchoke[2], A. Ramlee[1]
[1]Research Division, Royal Project Foundation
[2]Department of Agriculture Technology, THAILAND

The main objectives are to investigate the fate of agrochemicals used for growing cabbage in between the vetiver hedgerows (VHRs) and to evaluate the effectiveness of hedges in reducing the over supply amount of pesticides and nitrate fertilizer. The experiment has been conducted in the area of 15 x 72 square meters on 60 per cent slope. Split-plot in randomized complete block is assigned with three replications (blocks). Each block consists of six plots with and without VHRs at 3 and 6 meter vertical intervals and also agrochemicals at zero, one and double doses were applied. Seedlings were transplanted on July 13, and harvested in September 29. Random samplings were later taken from the lowest VHRs of the three whole plants at each plot; and from soils to one meter depth in between and at one meter behind the lowest VHRs. Included were sediments from the collection tanks below. From the

analytical data, the three pesticides were taken up into vetiver grass at different rate and contents. Those applied were in soil cooperated as Carbofuran insecticides. Alachlor herbicides sprayed 7 days after planting cabbages and Monocrotophos spraying twice at 34 and 42 day during the growing stage. Carbofuran was found in vetiver grass about 0.001 - 0.006 per cent; Alachlor 0.01 - 0.08, and Monocrotophos 0.19 - 0.53 per cent of the total fresh weight. In soils, only Alachlor has been detected around 3.38 to 7.69 per cent. It is believed that over 90 per cent of Carbofuran and Monocrotophos had decomposed and could have not been detected by the method employed. Probably, the same decomposition happened for Alachlor after spray to harvesting when the cabbage was about 78 days old. Alachlor and Monocrotophos were found both below and over Maximum Residue Limit, i.e.>0.02 and 0.20 ppm respectively. Carbofuran at normal and double close was lower according to FAO/WHO CODEX (<0.5 ppm). Losses of soil through VHRs of 5 months old found at the moderate rate of 22.4 ton per hectare. There was only Alachlor found in sediments about 0.02-0.5 per cent. The influence of nitrate fertilizer could not be possible as to have been detected by this period. A conclusion can be made at this stage that VHRs have substantially contributed to a process of captivating over supplying of agrochemicals as the living walls. As a result detoxification should have been possible and the better downstream water quality. This study is a preliminary one, thus it still needs further detailed investigation.

The Capability Of Vetiver Hedgerows On Decontamination Of Agrochemical Residues: A Case Study On The Production Of Cabbage At Nong Hoi Development Center Chiang Mai, Thailand.

Pinthong J.[1], Impithuksa S[2]., Udomchoke M[2]., Ramlee A.[1].1 Research Division, Royal Project Foundation.
2 Division of Agricultural Toxic Substances, Department of Agriculture.

The study was conducted in a cabbage field at Nong Hoi Development Center, Chiang Mai, in order to determine the movement and degradation of agrochemicals applied on cabbage which focused on their impacts on soil sediment and especially in vetiver. Split-plots in RCB was designed in the area of 15x72 in^2 at sixty per cent slope. Each block consisted of cabbage and vetiver hedgerows (VHRs) lined vertically at 3 and 6 m apart. Before and after transplanted on July 13, the pesticides, i.e. carbofuran, monocrotophos, and alachlor were applied in single and double doses. On September 29, an approximate 78 days after transplanted the cabbages were harvested and were brought to the laboratory together with soil, sediment (from the small reservoir below the experimental plots). and vetiver grass for analysis.

The analytical data revealed that most of the tested pesticides applied on cabbages could be translocated and up taken by crops, adsorbed by soil as well as sediment in different amounts. The vetiver was capable of pesticide absorption as indicating by the residues of carbofuran, monocrotophos and alachlor found at the percentage of 0.001 - 0.006, 0.09 - 0.25 and 0.01 - 0.08 of the total amount of active ingredient application, respectively. In soil, only alachlor was detected between 3.69 - 7.56 per cent. While, the percentage of residues found in cabbage for carbofuran, monocrotophos and alachlor were 0.005 - 0.01, 0.75 - 0.91 and 0.01 - 0.09, respectively. Moreover, alachlor residues detected from the single and double doses were exceeded the maximum residue limit (MRL). This event was also occurred in the cabbage applied with the double dose of monocrotophos. The loss of surface soil by run-off which could be evaluated in term of sediment was at the medium level 22.5 ton per hectare. Aside from the rate of leaching the sediment was also an accumulation site for alachlor and carbofuran residues at the percentage of 0.02 - 0.5 and 0.002 of the total active ingredient admitted, respectively. No data were available for the absorption of nitrate fertilizer by vetiver in the experiment. The study concluded that the vetiver hedgerows played an important role in contribution to the process of captivity as well as decontamination of agrochemicals especially pesticides and preventing them from contamination and accumulating in crops, streams and other ecosystems. Due to the lacking of data upon the relationship between vetiver and agrochemicals, altogether with this study which is a preliminary one, therefore further study for more details is still needed.

In Vitro Induction Of Salt Tolerance In Vetiver Grass

M. Nanakorn[1], S. Surawattananon[1], C. Wongwattana[2]
K. Namwongprom[1] and S. Suwannachitr[1]
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[2]Department of Biology, Faculty of Science, Srinakharinwirot University, Bangkok, THAILAND.

Vetiver grass (*Vetiveria zizanioides* Nash) ecotype Sri Lanka was induced for salt tolerance by culturing calli from young inflorescence on MS medium supplemented with 5 µ M 2,4- D and 0.5 -3.0% NaCl, at 0.5% intervals for 45 days. At 0.5-1.5% NaCl, 100% of calli survived. At 2, 2.5, and 3.0% NaCl, their survival percentage dropped to 82.5, 25, and 0%, respectively. The surviving calli regenerated to plantlets when transferred to hormone and NaCl free MS medium for 30 days. However, the regeneration percentage declined with an increased concentration of NaCl. The 1.0 - 2.0% NaCl treated calli regenerated only 10 - 20% while there was no regeneration in 2.5% NaCl. All obtained plantlets were tested for their salt tolerance by culturing on MS medium with NaCl at the same level as their calli were treated, in comparison with the untreated plantlets. The result showed that the survival percentage of treated plantlets at each concentration of NaCl was higher. They tolerate up to 15% NaCl while the normal plant can tolerate nothing higher than 1.0% NaCl.

Effects Of Some Adverse Soil Conditions On The Growth Of *Vetiver Zizanioides* L.

P.N.V.Truong and D.E. Baker
Resource Management Institute, Queensland Department of Primary Industries, Melers Road, Indooroopilly 4068, AUSTRALIA.

It has been widely reported that vetiver grass can be established and flourish under a wide range of conditions including some very hostile environments. However very few quantitative data have been reported to support these anecdotal observations. In a series of glasshouse and field experiments, it was shown that vetiver can thrive under a wide range of pH, it is highly tolerant to saline and sodic soil conditions, and Al and Mn toxicities. When adequately supply with N and P fertilizers, Vetiver can flourish between pH 3.3 and 9.5. The saline threshold level is ECse = 8 dS/m and for 50% yield reduction, ECse = 17.5 dS/m. These results include vetiver in a group

of highly salt tolerant crop and pasture species grown in Australia. Its growth was also not adversely affected by soil with exchangeable sodium percentage of 33%. With adequate moisture, N and P supply vetiver can flourish at soil Al and Mn higher than 68% saturation and 578 ppm respectively.

These results support observations that vetiver can be established under highly hostile environment and indicating that it is highly suitable for land stabilization and reclamation of extremely hostile environment such as mining and industrial wastes.

In Vitro Selection Of NaCl Tolerance In Vetiveria Species

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K. Sangnil[2] and S. Suwannachitr[1]
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[2]Department of Biology, Faculty of Science, Chiang Mai University, Chiang Mai, THAILAND.

The NaCl tolerance of vetiver grasses were examined in vitro. There were 5 ecotypes of *Vetiveria zizanioides* Nash: Surat Thani, Songkhla 3, Chiang Rai, Sri Lanka and Indonesia; and 5 ecotypes of *V. nemoralis* A. Cam US: Kampaeng Phet 1, Prachuap Kin Khan, Nakhon Sawan, Huay Diag and Gudbaak. The calli from young inflorescence were cultured on MS medium supplemented with 5 ILM 2,4-D and 0-4% NaCI at 1 % interval for 45 days. The Kampaeng Phet 1 clearly showed maximum degree of salt tolerance. The NaCI concentration that gave 50% reduction in callus growth was 1.95% and followed by Prachuap Kin Khan at 1.31 %. The surviving calli of the Kampaeng Phet 1 were regenerated to plantlets on hormone and NaCI free MS medium for retesting of NaCI tolerance.

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 programme in the state. 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 exchangeable 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.

Agro-techniques were developed for growing vetiver as hedgerow and flat beds in barren uncovered lands. The agro-techniques 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 poly house with mist irrigation. Application of endomycorrhizae cultures *(Glomus fasciculatum)* facilitated root growth and P uptake. Such selected and tailored slips are being used for hedge under sodic land afforestation and development programme. Capacity to provide planting material in commercial quantities has been developed. Farmers are 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 persons 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.

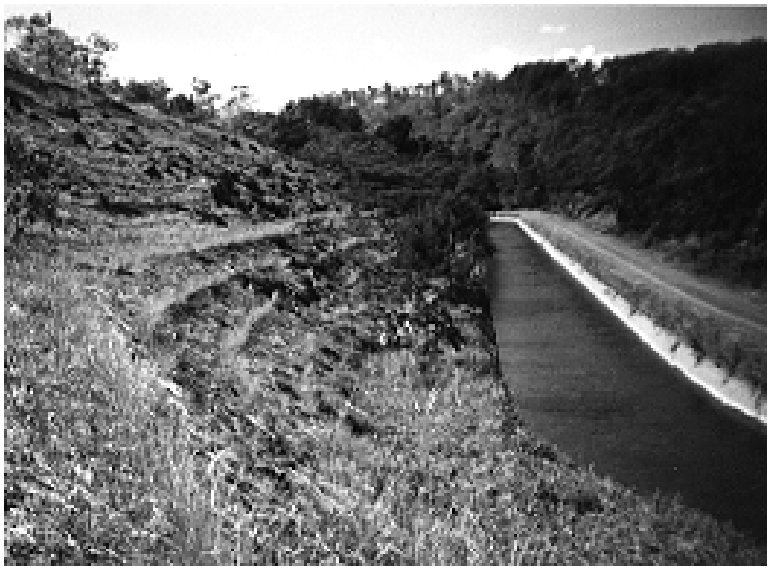

***Photo 6**: Newly planted vetiver on cut section above canal in Mindanao, The Philippines, used for bank stabilization and control of debris.*

Photo credit: Francisco E. Garrido

BIO-ENGINEERING ASPECTS

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.V. Truong University of Southern Queensland and Queensland Department of Primary Industries, AUSTRALIA

Although the Vetiver system has been used worldwide, few studies described the hydraulic characteristics of Vetiver hedges quantitatively. This paper describes the effectiveness of the Vetiver system in a quantitative hydraulic manner beyond the well documented anecdotal evidence.

The hydraulic characteristics of Vetiver hedges were first determined in a testing flume. From the data collected an empirical hydraulic relationship was developed between the depths and discharge. This relationship was used to calculate the maximum Vetiver grass hedge spacing required to control soil erosion on a flood plain.

From the model of flow through Vetiver hedges, design hedge spacing were selected for a field site in Queensland. The various catchment and farm characteristics

Photo 8: *Queensland, Australia. Vetiver hedge on Darling Downs Close up of photo 7. Note how the vetiver remains erect.*

Photo credit: Paul Truong

were considered before a hedge spacing of 91.5m was selected for the site. Six rows of Vetiver totaling over 3,000 m were planted on the contour at this spacing. Flood discharges and depths and sediment movement are being monitored at this site to validate the above theory and quantification of Vetiver on the flood plain and to monitor the effectiveness of the hedges. Early results from a small flow over the site show that the hedges reduce significantly the depth and therefore energy of flow through the hedges. At a low depression. 7.25 tonnes of sediment was trapped.

Vetiver In A Southern African Context

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Vetiver grass has been promoted and researched extensively in Southern Africa with considerable success. As a consequence it is being used in a range of applications including; combating of soil erosion, in farming and forestry, commercial planting for generation of essential oil, slope stability on engineering sites, and most significantly as stabilization hedges on slimes dams in the gold and diamond industry.

South Africa has numerous very large slimes dams which represent a by-product of deep level gold mining. These dams consist of an extremely sterile, highly acidic rock flour which becomes encrusted with salts in the near surface layers. Aside from being hostile to plant growth, the slimes dams present severe dust, aesthetic, and acid mine drainage environmental problems. These dams are also located in harsh climatic conditions including low rainfall and temperatures which range from -5˚ C in winter to plus 30˚ C in the summer. Trial survival planting has shown that Vetiver represents an ideal plant material for stabilization of gold mine and slimes dams. Vetiver has survived successfully for nearly 4 years on slimes dams in Welkom with minimal maintenance. Its use as a stabilization medium is now accepted by the Gold Mining Industry, and aside from the above, other commercial aspects (e.g. mulching, thatch grass, weaving material) applications are being widely considered in the new South Africa.

Slope Stabilization: Vetiver Application In Bio-Engineering Aspect

Karn Trisophon and M.R. Samjamjaras Rajanee, Department of Land Development, Thailand.

Tremendous earth work during the construction of Noppamaetaneedol and Noppapol Phumisiri Pagoda at Intanon summit has caused substantial change in the relief on the construction site. Falling earthwork had formed a steeper slope which was stable enough to sustain itself during the dry season. But in the rainy season, infiltrated water which was contributed by subsurface flow had gradually increased pore pressure and subsequently overcame shear stress of the soil. This caused slope failure. In order to reduce pore pressure, strips of gravel pit were built so as to induce inflow from the excess moisture content of the soil. The excess water was then drained into concrete dikes next to each pit. Even though most of the excess water was drained out, what was left was enough to make the portion of slope adjacent to the dikes become unstable. To remove this problem a row of vetiver was planted on the outer bank of each dike. Vetiver's outstanding root system had two roles. The first was to mesh up and mechanically add stability to the slope. The second role was to suck up the excess water and dissipate it via evapotranspiration process.

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

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It is well reported that the root properties of vetiver grass can help reduce soil erosion and enhance slope stability when properly planted on soil slopes. In general the root properties can be subdivided into root strength properties and root morphological parameters. Some previous studies on vetiver plant have elaborated the root morphological parameters qualitatively.

Photo 7: *Queensland, Australia. Vetiver hedge on Darling Downs (black soils, flat plain, subject to serious erosion when not protected. Vetiver hedges slow down flood velocity, and reduce erosion and crop and crp dammage.*

Photo credit: Paul Truong

However, the strength properties of vetiver roots, which also play a significant role in terms of erosion control and slope stabilization, have not yet been understood adequately. Vetiver is considered as a very deep-rooted penetrating grass variety which develops a fibrous profusely grown root system. The root penetration is mainly vertical and sometimes up to 3.6 m deep depending on the soil conditions. When a root penetrate across a potential shear surface in a soil profile the distortion of the shear zone develops tension in the root; the component of this tension tangential to the shear zone directly resist shear, while the normal component increases the confining pressure on the shear plane. Therefore, it is essential to understand about the root tensile properties in the process of evaluating a plant species as a component of slope stabilization.

This paper intends to discuss about root tensile strength of vetiver grass and its contribution to soil strength increase by means of experiments on root tensile strength determinations and root permeated soil shearing, which is a part of an ongoing research work specially design to assess both root strength properties and root morphological parameters in relation to slope stability and erosion control. Unbranched sections of vetiver roots in different diameter classes up to about the average maximum root diameter (3.5 mm) were tested in order to determine the tensile strength. The results were compared with the root tensile strengths of other tree species which were obtained from previous studies, and the effect of root diameter on the tensile strength of vetiver roots was established. To obtain the contribution of root tensile strength to the shear strength of soil, large scale direct shear tests were performed in 0.5 x 0.5 x 0.5 m^3 root permeated soil blocks along with root free soil blocks with same soil properties. The difference between the shear strength values of root permeated and root free soils, the shear strength increase due to the presence of roots, were then analyzed with the root area ratio, root diameter, root orientation and eventually with the root tensile strength to elaborate the significance of root tensile strength of vetiver grass and its influence in soil strength increase.

Calibration Of Rusle With Vetiver Grass As Live Sediment Filter In The Hills Of Puerto Rico.

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Vetiver is being evaluated and considered, along with other conservation practices, as a viable alternative for erosion control and reforestation of large clear areas. Research to calibrate the performance of vetiver as a live sediment filter is in progress; the Revised Universal Soil Loss Equation (RUSLE) is being used as the prediction model in very steep slopes subject to several management practices including denuded areas.

Vetiver barriers have been planted at 30 foot intervals in a 100 percent slope planted in an intercrop of pigeon pea and celery in the town of Jayuya, Puerto Rico. A sediment collection equipment was designed, built and installed before and after each vetiver barrier. Sediment accumulation behind the barrier is measured after every rain event with surveying equipment. The farmer has collaborated in all aspects of the work from planning. contouring, planting to data collection.

The result of this experimental work will be used to develop guidelines for use of vetiver in the hills of Puerto Rico and other tropical islands with similar ecosystems and under agriculture and in construction sites and along road banks to reduce the high level of sediment yields from most agricultural watersheds in tropical environments.

Root Characteristics And Root Distribution Studies Of Some Vetiver Grass *(Vetiveria zizanioides* L, Nash And *Vetiveria Nemoralis* A. Camus) In Thailand By Using P-3z Tracer Technique

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The root performances at different growth stages of some local vetiver grass was conducted at different experimental sites within the Royal Doi Tung project area. Soil injection technique with P-32 at various distances and depths of a vetiver plant hill was used. Radio activity of P-32 was monitored from the leaves at growth stages to evaluate rooting characteristics and pattern of root system.

Under field trial for studying root characteristics at Doi Tung Vetiver Crass Research and Development Centre, 2 vetiver grasses originated from Surat Thanee (*Vetiveria zizanioides* L, Nash) and Pimai (*Vetiveria memoralis* A. Camus) were studied. It was observed that at 1 and 2 1/2 month after planting of a Slip of vetiver grass, roots of both vetiver plants were found at 150 and 250 cm depths respectively. However, more root density was found at the depth 30 -100 cm. At 9.6 months growth stage of both vetiver plants, roots were found at soil depth 400 cm. and the highest root density was at the depth of 150, 250 and 350 cm. respectively. It was also found the roots of both vetiver grasses at the depth of 500 cm. when observation was made at 25 months old.

Vetiver grass, Viangchai, from Chiangrai was grown at side slope for the purpose of soil erosion control. Root systems was not extensive due to inadequate nutrients which was shown by the handed growth of vetiver plants. However, roots penetrating were as deep as 400 cm. when the plants were 17.6 months old. The results of root density were vague.

Vetiver grass from tissue culture from Surat-Thanee and Hua Ka Kaengere were used to study root distribution at field trial. It can be concluded that on the average root development of vetiver grass studies of Surat-Thanee would distribute horizontally from the plant hill 60 cm. (soil depth 80-90 cm.) at the age of 6 months. At 8 -10 months old the distribution was between 80-140 cm. (30-120 cm. depth) respectively. The root could spread in between 70-100 cm. apart from the testing at the depth of 150 cm. It could be observed that at 180 cm. depth, the root could distribute to the distant of 80 cm. away from the testing hill. For Hua Ka Kaeng the root distribution was not as good as that at Surat-Thanee. The root could spread uniformly between 40-60 cm. on average away from the testing grass (6 -10 months old).

The Introduction, Early Results And Potential Uses Of Vetiver Grass Hedge Row (VGHR) In the Mediterranean Region.

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The establishment and growth of VGHR were tested in the hostile, aerial and edaphic environment of Murcia, Spain. The climatic condition consists of hot summer, cold winter with sub-zero temperatures, low precipitation and negative water balance over more than half a year. The soil is calcareous, mostly clayey. Hilly topography is common with serious erosion rates of more than 5000 Tm/km^2 per annum.

The experimental sites were in El Chopillo with 300 plants and in Lorca with 32,498 plants on 5 trials testing soil protection and moisture conservation under different conditions. Despite cold winter with frost, trials established by container plants, from December 1994, had overall transplanting success of 95.9%.

Harvesting of plant tops in El Chopillo, produced 55 tiller and 1033 gm/plants after 14 months. In San Julian, the Malaysian and American Cultivar produced 304 and 377 gm/plant with 45 and 79 tillers respectively after 9 months.

Excavation showed that the root system in El Chopillo had reached a depth of 2.6 m. In San Julian, the Malaysian and American Vetiver had produced roots reaching down to 2.1 m. and 1.7 m. respectively. In all cases, the major root masses were at the top 0.5 m. In a 45% slope of 11 meter height, 2 blocks of 20 meters were planted with VGHR at 1 metre vertical interval in January 1995. The in-between block, left unplanted as control, suffered severe erosion by September 1995 despite the low rainfall. Significant soil had been trapped by the VGHRs.

Sub-zero temperatures in winter killed exposed tops but the buried crowns survived. In early spring, new tillers were formed, followed by good and vigorous growth in Summer and Autumn. The plant's response to the seasonal weather condition suggests 4 distinct phases:

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

The tropical Vetiver Grass adapted well to the weather conditions and appeared to behave like a temperate plant. This, and the good growth and root system suggest potential uses for Vetiver in the Mediterranean Regions. It also suggests that Vetiver could be established in the highlands of the tropics and the subtropics.

AGRICULTURAL USES OF VETIVER

Nutritive Value Of Vetiver Grass Silage Supplement With Some Silage Additive

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To improve the nutritive value of Vetiver grass, cv. Ratchaburi using a 30 day cutting interval, was ensiled by adding 0.5% urea (Treatment 2), 10% molasses (Treatment 3), 1 5% mixed ground cassava chip (Treatment 4), 0.5% urea + 10% molasses (Treatment 5), 0.5% urea + 1 5% mixed ground cassava chip (Treatment 6) and compared with untreated Vetiver grass (Treatment 1 as Control). After 30 days, the result was that Treatment 3, 4 and 5 had good quality in terms of palatability, pH, and percentages of dry matter, lactic acid, butyric acid, nutritive value and dry matter digestibility. Treatment 6 was judged of fair quality due to higher percentages of butyric acid. Treatment 1 and 2 were of poor quality.

Vettiver Grass (*Vetiveria Nemoralis*) As Substrate For Mushroom Cultivation.

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Preliminary study on the cultivation of four different species of mushroom (Genus *Pleurotus*) using dried vetiver grass (*Vetiveria nemoralis*) as substrate, was conducted during March 1994 - January 1995 at Som Dej Pra Sri Nakarin Royal Garden, Huai Sai Royal Development Center, Petchaburi Province. They are *Pleurotus sp*. Florida (Hed Hang Rom Kao), *Pleurotus sp*. from Hungary (Hed Nang Rom Hungary), *Pleurotus sp*. (Hed Bhuthan), and *P. abalonus* (Hed Pao Hu). Pasteurization and non-pasteurization methods were applied. Two formulae of the first method used for substrate preparation were : Coarse ground vetiver grass mixed with rice bran, sugar, magnesium sulphate (100 kg.: 4 kg.: 2 kg.: 0.2 kg.) and water as needed (mic 60-65%) and cut vetiver grass composted with 7% with rice bran. These mixtures were bagged, pasteurized and spawned.

It was observed that the first method produced higher yield in every species. The second method (non pasteurized), where cut soaked vetiver grass was bagged and spawned simultaneously produced fruiting bodies on only two mushroom species *Plourotus sp*. Florida and *Pleurotus sp*. from Hungary.

Vetiver (*Vetiveria zizanioides)* Straw For The Cultivation Of Oyster Mushroom (*Pleurotus Spp*)

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Possibility of utilizing vetiver (*Vetiveria zizanioides)* grass for the cultivation of *Pleurotus euos* (serk) Sacc., *P. salmoneo* - Stramineus L. Vass., *P. citrinopileatus* (Fr) Singer, P. Sajorcaju (Fr) Singer: *P. platypus* (Cooke and masee) sacc., was explored. *P. euos*, *P.salmoneo* - Stramineus and *P. Platypus* colonised the vetiver straw early (within 13 days) and yielded 355 to 405 g of mushroom/bed (Bio-efficiency ranged from 70 to 80 per cent). Paddy straw and paddy straw + Vetiver grass (1:1 w/w) gave significantly higher yields (437.1 and 434.7 g/bed respectively) than vetiver alone (385.9 g/bed).

Allelopathic Effects Of Vetiver Grass On Weeds

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Vetiver is a tropical perennial grass, widely distributed thoughout Thailand. Vetiver is cultivated for erosion control as well as a sort of barrier to prevent the invasion of weeds. Experiments were performed to investigate allopathic effects of vetiver grass on weeds. Methanol extract of ground dried stems and roots of 3 vetiver ecotypes were tested on 10 common weed species. It was found that root and stem extracts from 3 Vetiver ecotypes: Ratchaburi, Suratthani and Indonesia strongly inhibited seed germination and seedling growth of *Amaranthus gracilis*

Desf., *Abutilon hirtum* Sweet, *Pennisetum polystachyon* Schult, *Melochia corchorifolia* Linn. and *Ruellia tuberosa* Linn.. The degree of inhibition depended on the vetiver ecotypes, concentration of the extracts, and weed species dependent. The study also suggests the possibility of developing a natural herbicide from vetiver grass which will leave hopefully little or no toxic residue harmful to the environment.

Study On Compost Making From Vetiver Grass

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The studies on compost making from vetiver grass were carried out at 5 sites: namely Ratchaburi, Srisaket, Chiang Mai Land Development Station, Khao Hin Sorn and Pikun Thong Royal Development Study Centre. The design was observation trial with 4 treatments. The treatments were:

1 Making compost on the ground with LDI rhizobium and turn over.

2 Making compost in the hole with LDI rhizobium and turn over.

3 Making compost on the ground with high tech rhizobium.

4 Making compost in the hole with high tech rhizobium.

After 150 days the results showed that the ratio between carbon and nitrogen from treatment 1 is the best, followed by treatment 2,4 and 3 with the ratio of 20, 23, 26 and 29 respectively. It also found that the chemical and physical properties of T1 is the best followed by T2, T4 and T3. The pH value ranging between 6.9 - 7.2.

VETIVER AGRONOMY

A Comparative Study On Growth, Rooting System And Yield Of Difference Ecotypes Of Vetiver Grass.

Viroj Satanasolvapark, Chaiwat Sittibutr and Chaleol Jeerachanya, Land Devel opment Department, Ministry of Agricultural and Cooperatives, Bangkok, Thailand.

The comparative study on growth, rooting system, and yield of 10 ecotypes of vetiver namely Songkla 3, Sri Lanka, Kamphaeng Phet 1, Ratchaburi, Loei, Su rat Thani, Kamphaeng Phet 2, Naskorn Sawan, Prachuap Khiri khan and Roi Et was conducted at Amphur Muang, Narathiwat Province on Kho Hong soil series. The study showed that Ratchaburi gave the best performance in term of height tillering and crop yield followed by Prachuap Khiri Khan and Songkla 3.

A Global Perspective Of Vetiver

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The potential role of Vetiver grass in modifying unwanted effects of land-use-change and burning of fossil fuel is presented. In this century we have witnessed large scale soil erosion and climate changes. In the next century soil erosion and climate change are expected to be even more damaging to the well-being of mankind.

The role of Vetiver grass hedges in restricting the world wide soil erosion is outlined. Means of restricting global warming by increasing the carbon transfer from the global atmosphere to the vadose and phreaticenes using deep-rooted plants like Vetiver is outlined.

Various techniques for improving Vetiver plant survival in cold, saline and arid conditions are presented.

Genomic Manipulation For Eco- Friendly Plantation And Enhanced Productivity Of Essential Oil In Vetiver

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Profuse seed formation enriches vetiver population in its natural habitat but leads to a heterogenous mix of in-built genetic variability that may not be always desirable. Nevertheless, the vegetative mode of propagation attendant in this species promises a distinct advantage for realising uniform population and the resultant plant products. But this does not take care of the menace that is likely to take place on account of seed dispersal, disturbing genetic purity of the growing population as well as spread of vetiver to undesired destinations, lest the flowering tops are excised before seed-set. Therefore, an eco-friendly approach should aim at isolating the desired plant types that either do not bloom or bear only infertile seeds.

In India, tremendous amount of genetic variability exists in vetiver that can be clustered into five distinct groups on account of karyomorphological characteristics and 2C nuclear DNA content (range 2.0 to 2.6 pg). Although, non flowering/infertile plant types naturally occur in southern parts of India, their genetic manipulation to attain desirable attributes is greatly handicapped for lack of an amenable reproductive system. Therefore, resorting to artificial polyploidy is the obvious choice to meet the twin objectives of genetic manipulation for bringing a desirable change in agrobiological characteristics as well as causing a breakdown in sexual reproductive system.

Curiously, the artificial autotetraploids developed in this species have shown their superiority over diploid progenitors with respect to economic yield by 60% and enhanced soil binding capacity on account of thicker roots. The seed sterility associated with such autotetraploids and the expected triploids would not only restrict their unwanted spread, but facilitate channelisation of saved biological resource of the plant towards vegetative vigour and secondary metabolism.

Vetiver Grass In India

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ABSTRACT - 1

The paper summarises research results of the use of vetiver grass to improve the water holding capacity and moisture percentage of soil in wastelands. Water holding capacity and moisture percentage are the two important soil factors governing the productivity. Vetiver grass was grown in an area with known water holding capacity and soil moisture percentage for 20 months. A control plot was maintained without vetiver grass. Soil samples were collected once in a month in control and treated plots. Water holding capacity and soil moisture percentage were determined

by standardized methods. When compared with control plots, the treated plots show 20% increase in water holding capacity & soil moisture percentage over control. Positive correlation were made between root biomass and the two soil parameters studied.

ABSTRACT - 2

Fine roots significantly influence soil organic matter accumulation and nutrient cycling. Characterization of the activity of the fine roots is therefore a key approach to the understanding of the below ground system (Singh). At the global level, fine root production represents a large and relatively unknown portion of the production/decomposition carbon balance. Despite the central importance of fine root dynamics neither a clear and consistent pattern of fine root dynamics in communities nor an understanding of factors controlling those dynamics has emerged (Aber). Very little information is available on this subject. The present study on fine root productivity of vetiver was designed to unravel temporal and spatial patterns of their size distribution, growth, decomposition and overall role in the functioning of the below ground system.

Root sampling. involved collection of replicate soil cores, hand washing and sorting of roots from the soil matrix. Collections were made at monthly intervals. Ten randomly spaced samples (1.9 cm in diameter and to a depth of 15 cm) were collected separately in the study area. (l8 months old stand of vetiver). Annual fine root production of vetiver is estimated by max-min method of McClagherty et al (1982)

The annual fine root biomass was 190 kg/ha. Positive correlation was obtained between fine root biomass and organic carbon content of soil.

ABSTRACT - 3

The paper presents the impact of R D M (Rock Dust Mineralisation) technology on the biomass production of vetiver grass. The positive impact of R D M technology was well studied and well reported in many forest tree species and vegetable crops (Joanna Camp). The technology is simple, cost effective and environmental friendly. As far as known to us this study is the first research effort made on the impact of R D M technology in the productivity of vetiver grass.

The study was carried out in earthen pots. Twenty five pots were kept without R D M treatment (control) and twenty five pots were treated with R D M treatment. Biomass (Root & Shoot) production was estimated after 120 days. Productivity of vetiver in control pot is 0.225g/day and 0.383g/day in treated pots. Significant increase in the biomass was noticed in the treated plants. Since this was only a pilot study carried out for practical application the conclusion is tentative and R D M technology needs further investigation.

Effect Of Soil Water Levels And Nitrogen Fertilizer On Growth Of Vetiver Grown On Three Major Soil Series Of Northeast, Thailand.

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Experiments were conducted in greenhouse and in the field to elucidate the effect of soil water and nitrogen fertilizer levels on growth of vetiver on three major soil series of the Northeast, Thailand, namely: Satuk (Oxic Paleustults), Nampong (Ustoxic Quartzipsamments) and Roi-et (Aeric Paleaquults at Khon Kaen Province during 1993-1994).

For the greenhouse study, four levels of soil water (100, 80, 60 and 40% of field capacity) were applied with each level of 0, 2.5, 5 and 10 kg. nitrogen fertilizer per rai. three weeks old Songkla-3 vetiver seedlings were transferred into 5 kg. capacity pots. Soils were treated with respective levels of water and nitrogen. Experimental design was factorial in CRD. Plants were observed for growth and harvested at 3 months.

Roi-et soils gave the highest shoot dry matter followed by Nampong and Satuk soils. In general, increase in soil water as well as nitrogen fertilizer levels resulted in increase in shoot dry matter for all soils. There was no interaction between soil water and nitrogen fertilizer levels for Satuk and Nampong but Roi-et soils.

For field study, three soil series with three different locations were surveyed and selected. For each soil, 2 levels of soil water (control and irrigation) were applied with each level of nitrogen fertilizer (0 and 10 kg. N per rai). Plot size were 4 x 6 m. with 1 x 1 m. spacing. Experimental design was in RCBD with 3 replications. Growth was observed and measured. The plants were harvested when they were 8-10 months old. Shoot dry matter as well as other parameters were determined. In general, increase in soil water levels as well as nitrogen fertilizer resulted in increase shoot dry matter. Nampong soils gave the highest shoot dry matter followed by Satuk and Roi-et soils respectively. For Nampong soils, the effect of irrigation was extremely high for shoot dry matter when compared to the effect of nitrogen fertilizer where as on the other soils, the effect from both treatments were more or less similar.

Varietal Selection For High Root Biomass And Oil Yield In Vetiver

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Soil-erosion is a serious cause of ecological disturbances and environmental degradation. Its impact is more distressing in resource-poor countries which can hardly afford mechanical control of soil-remediation. Vetiver — a perennial grass with its fibrous roots offers an inexpensive yet effective and eco-friendly tool to combat soil erosion. Axiomatically, the larger its root volume, better is the capacity to conserve soil and soil moisture both. Besides, larger root volume will also ensure higher (dried) root yield which has multiple economic uses including those related to aroma and essential oil, the world renowned Khus oil (oil of vetiver). With this in view, we screened 45 indigenous germplasm collections of vetiver for fresh and dry root biomass, oil content and oil yield. Sixteen clones/lines were found to be promising. They were evaluated in initial station trial, where the best five strains (BDP-1, BMH-1, MBR-5, BMH-3 and MBP-6) were shortlisted and elevated to bench scale trial (BST). The elite strain BDP-1 had the largest root-volume (dry root yield = 97.0 q/ha) followed by BMH-1 (56.2 q/ha), BMH-3 (33.3 q/ha) and MBR-5 (28.7 q/ha), all registering 12 to 3.6 times more root yield than the commercial checks in BST. Fortunately, the oil content in their roots was also high, hence economically most viable. Thus BDP-1 with its largest root volume can serve as an excellent soil-binder besides being the most productive

oil strain of vetiver.

VETIVER GRASS HEDGE ROW TECHNOLOGY

Studies On The Effect Of Contour Vegetative Hedges On Moisture Conservation, Growth And Yield Attributes Of Millets, Cotton And Pulses Under Rainfed Conditions.

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To ascertain the performance of pulses, millets and cotton with different hedging systems on a slopey land under rainfed condition, a study was conducted with vetiver, subabul, cenchrus grass and desmathus as hedges. The results revealed that the growth of the cotton, redgram and greengram were best influenced by cenchrus hedge followed by vetiver hedges. Vetiver hedging system has shown very good effect on the yield of annual crops. The vetiver hedges conserved 21.80%, 20.98%, and 19.77% soil moisture at various stages of growth, and thereby helped all annual crops to produce higher yield. In dryland farming, hedging with vetiver is recommended for moisture conservation and higher yield of the intercrops.

Suitable Techniques For Establishment Of Vetiver Hedgerows In Semi-Arid Region Of Rajasthan-India

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Investigations were carried out in semi-arid region at Udaipur during 1991-1995 to study the effect of plant spacing, densities, polymers, manures, planting methods and time gap between uprooting from nursery and planting in field for effective establishment of Vetiver hedgerows on alfisols belonging to land use capability Class VI (non arable). and Class IV (arable). The soils are low in N, medium in P and rich in K content. Wider spaced (15 to 20 cm) planting proved significantly superior in respect to growth compared to 10 cm: presently in operation. Planting of 2 or more than 2 slips/ hill recorded highest increase in survival and growth. Among the polymers and manures. application of agrosoke polymer 30 g/m row length in furrows at planting recorded highest survival (95%) and significantly higher number of tillers/plant (116) and clump girth (79 cm): closely followed by FYM application - 600 g/m row length. Planting of vetiver in furrows opened at bottom of 'V' ditch is found suitable method as it recorded maximum survival as compared to planting on top of bund of 'V' ditch and on berm. Planting of polybag raised vetiver recorded maximum survival (98%) over field nursery raised (17%). Polybag raised vetiver also gave significantly better growth. In a two year (1992 & 1993) study planting of vetiver immediately or within 24-36 hours after uprooting from nurseries was found effective in better establishment of vetiver hedgerows.

Effect Of Applying Vetiver Grass On Sloping Lands In China.

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Planting grasses or shrubs along the contours is extremely effective for erosion control on slopes. In order to explore measures for speeding up the growth of vetiver grass, a fertilizer trial was conducted. According to observations, the growth of vetiver grass in the first year after being transplanted could the divided into three stages: the recovery stage, the rapid-growth stage and the trimming and gathering stage.

On farmland, the vetiver grass in the control plots survived very well and formed hedgerows rapidly, whereas the treatment of applying fertilizer showed no obvious effect. As most fertilizer disturbed the recovery of vetiver, if we must apply some fertilizer to farmland in order to multiply seedlings of vetiver, we had better use fertilizer after manure.

On sloping bare land, the organic manure is better than the chemical fertilizer, and treatment NPK + FYM had a more obvious effect. The lack of phosphorus would seriously disturb the survival, growth and grass-yield of vetiver. If we apply the NPK fertilizers, we had better apply them in split applications which is better than applying the whole NPK at transplanting.

Comparative Study Of *Vetiveria zizanioides*, *Vetiveria nigritana*, And *Andropogon gayanus* In A Trial Of Soil And Water Conservation.

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Using vegetation in a trial of soil and water conservation is an important challenge in arid and semi-arid zones. The objective of the study is to obtain data on the compportment of three grass species, *V. zizanioides* (unknown in the country), the local Vetiver *(V.nigritana)* and *A. gayanus*. On a bare ferrugineous soil (Lixisol), three stone lines were built along the micro-topography with a distance of 33 meters. The three species were used for vegetatization of the stone lines.

The results obtained show a few mortality of *V. zizanioides* (3%) compared to the local grass (18% for *V.nigritana* and 34% for *A.gayanus)* in terms of growing after plantation. Concerning plant height, local grass *(A. gayanus)* have a total longer of 203 cm when Vetiver grass (local and exotic) have just 103, 5 cm after 103 days. The weight of dried material is respectively 7570 g for *Andropogon*, 3548 g for *V. zizanioides* and 866 g for *V. nigritana*. The coverage of the soil in amount of the stone line is about 80 - 90% for Andropogon and 50 to 60% for Vetiver grass. The soil moisture evaluate ponderal method is twice more under *A. gayanus* comparatively to *V. nigritana. V. zizanioides* maintained more moisture in the soil than the local Vetiver. These data revealed the potential of *Vetiveria zizanioides* growing in soudano-sahelian zone and the possibility to use it for stone line vegetalization to combat erosion.

Studies On A Biological Erosion Control System Integrating Tree And Grasses To Manage Degraded Soils Of Foot-Hill Himalayas.

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Soil erosion is the single largest factor responsible for degrading quality and productivity of land in India. It is estimated that 45% of forest, 56% of farm, 86% of cultivable wastes and 95% of pasture lands suffer from erosion related problems. Though 39 million hectares have since been treated in the last 30 years, but each year area degraded far exceeds the area rehabilitated. Unless massive efforts are

made to mobilize farming communities, the march of degradation cannot be contained. This would, however, require the development of cost effective and easily adaptable packages linking conservation and production to motivate farmers. High cost and questionable performance of mechanical measures have also shifted emphasis to biological measures of land amelioration. It is planned that 40 million ha of wastelands be developed with vegetation models designed for each agro-ecological region integrating multi purpose trees and sod-farming, conservation effective perennial grasses having inherent ability to thrive on degraded sites and provide usable biomass and economic returns.

In the Himalayan foot-hill ecosystem of north India, *Acacia nilotica* is the most favored multipurpose tree species, Bhabar *(Eubiopsis binata)* and Kana *(Saccharum munja)* are important sod forming natural perennial grasses. Dub grass *(Cynodon dactylon)* also commonly thrives and meet conservation and forage needs. Vetiver grass *(Vetiver zizanioides)* occurs naturally in wet pockets and was strongly recommended in many of the internationally funded projects on conservation of natural resources. The research information on the integration of these remarkable plant species in a silvipasture system was lacking. Hence the study.

In a replicated and randomized field experiment started in July 1990 on a 1.2 ha of degraded gravelly soil near Chandigarh (30° - 45' N, 76° - 15' E, 350 m MSL) typically representing semi-arid climate; *Acacia nilotica* was uniformly planted from nursery raised tube plants at 8m x 5m spacing in 30 cm^3 pits. Four understorey grasses namely Bhabar, Vetiver (0.5m x 0.5m), Kana (1 m x 1 m), natural dub grass were raised in the interspace and compared with control having no grass. Interplot earthen bunds of 20 cm height were made to conserve rainwater. Runoff and soil loss was measured using Ramser samplers. The root system of the 3 planted grasses was studied by excavating soil monoliths at one and two years of age. Grasses were harvested twice a year in June and November and air dry weights recorded.

All the four understorey grasses affected the survival (except Vetiver) and growth of *Acacia nilotica* seedlings as compared with no grass treatment (Table 1). The depressing effect amongst grasses were non-significant. All grasses tended to reduce runoff and hence soil loss. The lowest water loss (2.2%) was recorded under natural grass followed by planted Vetiver grass (5.8%). The residual soil moisture left in 0 - 30 cm soil profile at harvest was highest (9.1%) in Vetiver grass. S. *munja* provided the maximum biomass, when Bhabar and Vetiver were almost at par. The roots of Kana were relatively more sturdy and thick but the root density was low. The roots of Bhabar and Vetiver grass were more fine, spongy, larger in number and hence their root density was much higher. The results of 3 years of study indicated that Vetiver was more conservation effective, Sacrum gave more biomass and Bhabar grass provided more of economic returns. The emergence of clear picture about their relative merits would take few more years of study.

Comparative Study Of Hedgerow Of Vetiver And Other Grasses With Mechanical Measures On Erosion Losses At 4% Runoff Plots

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Mechanical measures namely bunding (earthen embankment), terracing, trenching etc. used to stabilize high slopes have been found costly, area consuming and unstable structures needing maintenance cost on agriculture lands up to 4 percent slope. Therefore, erosion control measures of conservation agronomy and grass barrier were tried on runoff plots (l00 x 20m) on 4 percent slope equipped with H flume, stage level recorder and Coshocton Silt Sampler. Three grasses namely, Khus grass *(Vetiveria zizanioides),* Bhabar grass *(Eulaliopsis binata)* and Guinea grass *(Panicum maximum)* were planted in 60 cm wide strips on contour at 100 cm vertical interval. The soil loss (52 t/ha) and runoff (45%) of rainfall from cultivated fallow were reduced to 18 t/ha and 51 percent respectively by following contour cultivation of corn. There was further reduction in soil loss (10-12 t/ha) and runoff (40 %) by adopting strip cropping, intercropping, zero tillage and bunding. Introduction of vegetative barriers (live bund) gave and average (7 years) soil loss 5-6 t/ha and runoff 33% of rainfall. The performance of bhabar grass was comparatively poor. Corn yield in most cases remained unaffected (23-24 q/ha) due to minor variations in erosion losses. Dry matter production was highest from guinea grass (1540 kg/ha). The yield of following rainfed wheat was visibly higher in the upper reaches up to 5 m. due to deposition of fertile sediment (40 t/ha) and better moisture regime. Thus grass barriers were more effective than other measures of conservation agronomy and engineering. There is a tendency to change the slope into Puerto Rican terraces due to grass barriers.

Performance Of *Vetiveria zizanioides* In Rainfed Areas Of Vindhyan Plateau Of Madhya Pradesh, India.

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The seven year study since 1987-1994, on the performance of vetiver was carried out under World Bank aided Watershed Development Project at Rafi Ahmad Kidwai College of Agriculture, Sehore (M.P.) India. The seeds of vetiver from different locations in different years were tested under laboratory and field conditions for their germination. The viability of vetiver seeds reduce as the increase in storage period. Relatively higher germination 28.33% was observed in laboratory compare to 11.66% in field condition. The naturally germinated number of vetiver plants was observed 16.22 and 17.44/m^2 with up and down stream on existing vetiver hedge row respectively when the field was cultivated during winter and rainy season. While in uncultivated field during both crop season, the vetiver plant was 48/m^2.

In a study on application of fertilizer doses on the establishment of vetiver hedgerow. It was found that the application of 20 kg N + 20 kg P_20_5/ha as basal dose was most effective. The vetiver barrier caused higher soil deposition in upstream with the average soil deposition from 6.78 cm in two rainy season to maximum of 21.15 cm in seven rainy seasons. Four to five percent higher moisture conservation on upstream was recorded than the down stream.

In the screening of various locally available grasses in comparison to vetiver for establishing soil and moisture conservation. It was found that the vetiver recorded higher survival percent and higher soil particle binding capacity.

Environmental Considerations In Erosion Control: Use Of Vetiver Grass In Soil Moisture Conservation Program In Sardar Sarovar (Narmada River) Catchment In India.

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Soil and land form an integral part of the fragile life supporting system basic to mans existence. However excessive soil erosion with consequent high rate of sedimentation in the man made water bodies and decreased land fertility have become serious environmental problems with disastrous socio economic consequences. For reversing the trend, there is an urgent need for adapting economically viable techniques of soil moisture conservation. Quick method of erosion control through construction of engineering structures have neither significantly stopped erosion nor have significantly increased yields of crops through improved moisture conservation. They also do not work in the long run. While vegetative systems in conjunction with appropriate cultivation practices were in most cases found suitable.

The present paper discusses the use of Vetiver as an economically viable method in erosion control of arable lands and its usage in catchment area treatment program in Narmada river basin in India where 175,000 ha area is being treated with erosion control measures. Socio-economic problems associated with planting of vetiver on large scale in Narmada river basin are analyzed. Based on the experiences drawn, planting, of vetiver as an integral component of interactive subwatershed planning, is recommended for low cost erosion control in extensive areas of a river basin to mitigate the stresses on the local environment.

Use Of Vetiver Grass As A Filter In The Process Of Ground Water Recharge Through Open Wells.

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To solve the vital problem of constantly receding ground water in the plateau regions of Malwa & Nimar (Western Madhya Pradesh), an attempt has been made to collect surface runoff water filtering the water at various stages in to an unconfined aquifer specifically by passing through the network of vetiver grasses provided as biological filter on the bed and side of the drains. The studies were performed from 1990-95 at Jawaharlal Nehru Agricultural University campus Indore. Integrated Soil & Water Conservation Techniques were used to maintain the water level in the open wells viz., technique of water spreading and recharge through direct water injection. Water spreading techniques contributed 23% to the ground water recharge while injective techniques contributed 77%. An average annual recharge for the five hydrologic years (1990 - 91 to 1994 - 95) was 60308 m^3. Total amount of water drawn from the ground water sources (average annual value was 56554 m^3) for an average annual rainfall 0.977m during this period. Similarly. two year's average annual rainfall and draft of water from ground water sources recorded during 1988 - 89 to 1989 - 90 was 852 m^3 and 21710 m^3 respectively. After adoption of integrated water conservation techniques 34844 m^3, about **1.6 times increase** in the water reserves in the wells was achieved. It was found that out of 50308 m^3 water additionally recharged 34844 m^3 could be recouped which forms 69% of the average recharge value. Vetiver grass has provided an excellent filtering effect.

Constraints Of Using Vetiver In Watershed Management In Sub-Mountain And Scarcity Zone Case Study Of Nashik District (India).

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Soil and water are the most vital natural resources for the survival of mankind. Proper management of this natural resources on watershed basis gives excellent results. Engineering structure for managing, is expensive. Vegetative measures by use of Vetiver is quite inexpensive and it is promoted in a centrally sponsored scheme in India. Accordingly, twelve watersheds comprising two Agro Climatic Zones are undertaken in Nashik District, with a geographical area 52,952 Ha. Since 1991 - 92, 4855 tonnes of Vetiver slips *(Vetiveria zizanioides)* are used for drainage line and land treatment of watershed management. A case study of Vetiver in the use of soil and water conservation attributes are taken up.

The results of the case study indicate that the establishment of Vetiver and its survival percentage are directly correlated to rainy days, depth of soil and other managerial factors like, the problem of stray cattle. In scarcity zone the use of Vetiver as a conservation measure failed except in a few drainage line treatments. In sub-mountain zone drainage line treatments like live check dam and loose boulder structure show excellent results while land treatment has only limited success. Instead of planting vetiver merely as a barrier, a minor engineering support would give better result.

In sub-mountain zone, the survival percentage of Vetiver is the highest in live check dam, supported by minor engineering structure (65.50%). It is followed by loose boulder structure which is reinforced by Vetiver at 47.75%. Thirdly, land treatments named as contour vegetative hedges give the lowest survival at 41.50%. From the case study it is clearly observed that planting material plays an important role in the survival of Vetiver, in addition to managerial factors like the problem of stray cattle. The overall conclusion is that dry spell adversely affects the survival percentage of vetiver. The average rainy days in sub-mountain zone are 75 while in scarcity zone it is only 25. The dry spell thereafter and the problem of stray cattle causes the mortality of vetiver. However, vetiver in good survival situations gives excellent results in terms of soil erosion control and moisture conservation, which account for good land returns i.e. crop production.

An attempt is made in this case study to compile all available information and its correlation to field situation.

Effect Of Vetiver Hedge On Runoff, Soil Loss, Soil Moisture And Yield Of Rainfed Crops In Alfisol Watersheds Of Southern India

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Runoff and soil loss are the twin problems threatening the security and sustainability of crop production in the Deccan plateau of Peninsular India. Low cost and easily adoptable technologies need to be devel-

oped for conservation of natural resources. Experiments were conducted on shallow gravelly *Alfisol* having 2.5% slope during 1990 - 95 to study the effect of vetiver *(Vetiveria zizanioides)* hedges on soil and water conservation, and yield of rainfed crops, sorghum + redgram and castor. Vetiver hedge on contour reduced the runoff and soil loss by 65.75 and 75.59% (1993-94) and 66.65 and 76.98% (1994-95), respectively over contour cultivation alone. Vetiver + dead furrows (deep furrows) at 3.6 m interval reduced runoff and soil loss by 56.33 and 70.48% (1993-94) and 58.33 and 70.77% (1994 - 95), respectively over dead furrows alone. Vetiver hedge on contours increased mean soil moisture (up to 45 cm depth) by 5.13 to 8.55% over contour cultivation alone. The increase in soil moisture content with vetiver + dead furrows was 6.96 to 10.85% over dead furrows alone. The average soil moisture content 2 m above vetiver hedge was higher by 8.61 to 16.25%, compared to the soil moisture below (2m) Vetiver hedge. The percent increase crop yields due to vetiver hedge ranged from 7.04 to 22.37 over that of contour cultivation. Vetiver + dead furrows recorded 3.79 to 8.29% increased yields over dead furrows alone. The crop yield above vetiver hedge was higher by 15.55 to 17.98% over that below the vetiver hedge.

Growing of vetiver hedges on contours and adopting conservation tillage practices between them can thus be an effective method to reduce runoff and soil loss, and increase *in-situ* moisture thereby obtain higher crop yields in rainfed Alfisols of the central parts of Southern India.

Vetiver Vis-A-Vis Indigenous Plant Species For Conserving Soil And Water In Arid Lands

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Study on the performance of contour vegetative barriers as soil and water conservation measures has been initiated during 1991 on the farmer's field covering an area of about 50 ha near Jodhpur. The area receives an average rainfall of 360 mm per annum. Eight species of grasses, 3 shrubs and 3 under shrubs were tried on contours at 1 m vertical interval in 3% slopey fields. Vetiver was used as control. This grass though survived on few fields but failed to make an effective barrier due to adverse climatic and edaphic conditions. Locally adapted grasses such as *Cymbopogon jwarancusa*, *Cenchrus ciliaris* and *Cenchrus setigerus* performed exceedingly well and formed effective barriers against soil erosion in a span of 2 years.

Significant reduction in peak flow and runoff volume have been recorded in the barrier fields over control. The runoff volume reduced between 22 and 71 %. The barriers do not channelise runoff and allow greater opportunity time for the rainwater infiltration. The barrier fields store 12 to 16% of soil moisture as against 6 to 10% in the control fields. The soil loss reduced from 530 kg /ha in the barrier fields. Also the sheet and rill erosion were checked to a greater extent. All these resulted between 37 and 51% more yield of guar (*Cyamopsis tetragonoloba*) over control.

The contour vegetative barriers of local grasses were more acceptable to the farmers as these are less expensive, easy to raise, less labor intensive and provide fodder in the lean period.

The Function Of Vetiver In Agriculture Ecosystem

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The experimental results showed that vetiver could efficiently ameliorate many properties of soil. For example, it could lower the acidity and exchangeable Al of strongly acid soil by 0.5 - 0.7 and 0.3 - 0.6 cmol.kg, respectively. A significant increase in soil organic matter, total N, available N and K, and porosity was found after planting vetiver for 29 months. However, vetiver didn't enhance soil P. After vetiver was established, the moisture of soil was increased by 20.3 - 42.3% in 0 - 20 cm depth and by 4.2 - 13.4% in 20 - 40 cm depth, respectively. Furthermore, vetiver distinctly slowed down the dropping speed of soil moisture. The vetiver treatment averaged 60% and 93% less runoff and soil loss than the control, respectively, in 2 years. Vetiver also improved the microclimate of agricultural ecosystem, which increased the relative humidity by approximately 5%, and declined the air temperature by 1 - 2° C.

Studies On The Effects Of The Soil And Water Conservation Of *Vetiveria Zizanioides* In Eucalyptus Plantations

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In the new afforestation land of Eucalyptus ABL No.12 plantation, at Yangxi county, Guangdong Province, China, three experiment plots, included a row of vetiver grass in two rows of trees, a row of stylo grass in two rows of trees and only trees without any grass (the control plot) were set up in April 1991. The runoff plot had been established in each plot and the laws of changes in rain, height, surface loss rate of soil and water were observed and studied. The three-year observation results indicated that the surface runoff rate in vetiver grass was 20351 t/hm^2, which was 15.2% lower than that of stylo grass and 58.5% lower than of the control plot. The soil loss was 68.2 t/hm^2, which was 28.2% lower than that of stylo grass and 51.1% lower than that of the control plot. The loss rate of the solid and liquid nutrients were also much lower than that of the stylo grass and control plot. The vetiver grass hedge can not only resist erosion, but promotes tree growth as well.

Hedgerows And Mulch As Soil Conservation Measures On Steep Lands.

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A summary of the experience with vetiver and other grasses used in soil erosion research in Venezuela is presented. The need for accelerated data production through simulated tests in the field is highlighted. Four experiments were conducted under field simulated rainfall conditions at 1800 masl. in the mountain coastal range of Venezuela, with 5 m length and 0.5m width plots and an average rainfall intensity of 556 mm/h using a double nozzle rainfall simulator, on an Aquic Paleudult soil with different humidity contents and two 15% and 26% slopes respectively. In order to evaluate the efficiency of five different hedgerow conditions: 50 cm wide *Vetiveria zizanioides* 0 (Vetiver), *Agapanthus africanus* (Lily). *Nephrolepis sp.* (Fern). *Andropogon citraturn* (Lemon grass) and no hedgerow. and five levels of pine needles: 0 Mg/ha. 0.5 Mg/ha. 1.5 Mg/ha, 3 Mg/ha and 5 Mg/ha used as a mulch. Over-

land flow was simulated in order to obtain equivalent slope lengths using a 01/min, a 21/min, a 61/min and a 141/min flow, representing a 21/min flow equal to an 80% rainstorm runoff similar to that obtained under humid and saturated conditions on a 5 m length bare plot.

Hedgerows and mulch are good conservation measures, especially when they are combined. The residue requirements are less when the slope is protected by hedgerows. and larger intervals between hedgerows are possible provided there is mulch on the surface of the soil between hedgerows. Soil losses in wet conditions were reduced to less than 1 Mg/ha by combining any residue cover and a Vetiver hedgerow against almost 8 Mg/ha on the bare 5 m length plot. Equivalent slope lengths increased soil losses up 25 Mg/ha on a 40m equivalent length bare plot. For the same slope equivalent length condition there was a soil loss of only between 1- 2 Mg/ha with the highest residue level applied and a loss less than 1 Mg/ha when the residues and the hedgerows were combined. Vetiver grass and Nephrolepis (Fern) were the most efficient hedgerows because of their high density vegetative structure. Under dry soil and humid soil, slope effect was considerable but under saturated soil the slope effect was not evident. Runoff was also diminished by the residue cover and hedgerows but efficiency was poor under saturated conditions. Simulated rainfall allowed to reduce time and costs of exp eriments as compared with natural rain. A table is presented as a semi-quantitative model to design spacing between hedgerows taking into account rainfall erosivity, soil erodibility, crop-management intensity and a minimum distance between hedgerows of 10 m.

A Test Of Planting Vetiver Grass At Different Vertical Intervals Of Soil And Water Conservation On Sloping Land.

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The study of planting vetiver grass at 7 different vertical intervals for soil and water conservation was conducted in Huay Sai Royal Development Centre, Petchaburi Province on Hup Kapong soil series at 5% slope. It was found that when planting vetiver grass at the vertical interval of 0.5, 1 and 2 m. compared with no vetiver grass treatment, vetiver grass treatments can reduced soil loss to 43.55, 39.72 and 22.89% respectively. However they can reduced soil loss up to 53.98, 50.85 and 37.13% when comparing vetiver grass treatments with the treatment of planting cassava up and down slope after land preparation.

Establishing Vetiver Hedges To Alleviate Soil Erosion In The Rubber Replanting Area Of Southern Thailand

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A rapid increase in rubber plantation in southern Thailand, has lead to the movement of plantation area on marginal land, often steep land where the damage of soil erosion is great during heavy rainfall. To alleviate this impact, an experiment was established in a farmer's rubber-replanting area under traditional intercropping in Songkhla Province. Rubber seedlings are grown (spacing 3 x 7 m.) on a highly erodible sandy loam soil on land with slope of 12%. A randomized block design was used with 5 treatments (1 - sole cropping of rubbers or control; 2 - establishing vetiver hedges between rows of rubbers (R+V); 3- rubbers intercropped with upland-rice (R+P); 4 - establishing vetiver hedges between rows of rubbers intercropped with upland-rice (R+V+R); and 5 - establishing vetiver hedges between rows of rubbers intercropped with *Pueraria phaseoloides)* and (P + V + P) in 3 replications. Total plots were 15, each plot (5 x 1 2 m) consisted of 4 rubber seedlings. During the experimental period (October - December 1993) there was heavy rainfall of 1061 mm. In the control treatment, amount of runoff (649.88 lit/m and eroded soil (3.40 t/ha.) were highest, and they was a significant difference from the remaining treatments. There were no significant differences among the treatments of P + V, H + P, H + V + H and P + V + P. The highest percentage of the reduction of runoff and eroded soil occurred in the treatment of H+V+P, and they were 40% and 52%, respectively. Analysis of nitrogen (N). phosphorus (P) and potassium (K) in eroded soil, results showed that the removal of N and K were significantly highest in the control treatment. The results of the tests suggested that the occurrence of surface runoff during the rainy season should be counteracted by establishing vetiver hedges and adequate plant cover.

Effects Of Vetiver Grass And Leucaena For Soil Erosion Control In Sugarcane, Maize And Cassava Crop Practices

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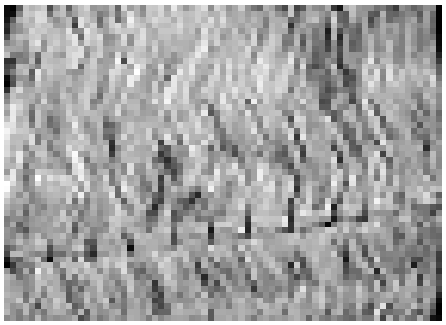
Four experiments on the effects of vetiver grass and leucaena in sugarcane, maize and cassava (grown early and at nearly the end of rainy season) crop practices were conducted during 1993-1995 in a farmer's field at Tambon Huai Bong, Amphoe Dan Khun Thot, Changwat Nakhon Ratchasima. The experimental plots were in a soil with sandy loam surface on three, four, five and six percent slope respectively. The experimental design of all experiments was randomized complete block with four replications. Each replication consisted of four treatments: one and two-rows of vetiver grass strip, one-row of leucaena strip and the control.

Results obtained from the experiments revealed no significant difference among treatments in the amount of soil loss due to erosion in the first and second year in sugarcane. On the other hand, in maize, the control treatment showed the highest amount of soil loss with an average of 7.236 ton/ha which was significantly higher than that of the one-row of vetiver grass strip treatment in the first year. In the second



QUIZ.

US $50 to the first person to quess correctly what the above photo is. Send your answer and some news about what you are doing with vetiver to Dick Grimshaw

year, the control still showed the highest amount of soil loss with an average of 16.753 ton/ha. This was highly significant different from all other treatments. For cassava grown in early rainy season, the different treatments did not show any significant difference in the amount of soil loss in the first year. However, in second year the amount of soil loss obtained from the control was 44.107 ton/ha which was about six times higher than that from the other treatments. In another cassava plot grown near the end of rainy season, the data showed no significant difference in the first year, however, in the second year the control gave the highest soil loss with an average of 23.03 ton/ha. This was significantly higher than that of the two-row of vetiver strip treatment. In these experiments it was found that the yields of sugarcane, maize and cassava in different treatments were not significantly different.

Vetiver Grass Hedgerows For Soil And Water Conservation In Tea Lands In Sri Lanka — A Success Story

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Soil erosion is severe in high rainfall Mid and Upland regions of Sri Lanka where the major crop is tea; 80% of this is seedling tea (tea from seeds). The old 'Up and Down' planting system adopted and absence of vegetative protection to existing mechanical measures results in severe soil erosion. Studies reveal 115 cm top soil lost during last century. This relates to 40 MT/Ha/yr. Unplanned land clearing causes 250 MT/Ha/yr soil loss. Land rested 2 yr. under Managrass (*Cympobogon confertiflorus*) without mulching results in 120-160 MT/Ha/yr. soil loss. New contour planted VP tea during 4 year growth exhibits 75 MT/Ha/yr. to 20 MT/Ha/Yr. soil loss mainly due to insufficient mulching.

Mechanical measures are generally not accepted due to high cost, repeated reconstruction, high maintenance, while Vetiver grass hedgerows popularly accepted due to low cost, easy application, low maintenance, permanency once established. No detailed research done on Vetiver hedge rows in tea, but significant results visually observed in its high efficiency of soil and water conservation. This is proved by its increasing adoption by tea estates for this purpose in Sri Lanka.

Vetiver — A Promising Grass For Soil Conservation In Vietnam

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In Vietnam the upland areas account for 25 million ha, which are located mainly on slopes of 25% to 45%. So soil erosion presents a real threat for agricultural production and environment. on the upland.

Studies showed that the anti-erosive measures based on imported "modern techniques" appeared to be less acceptable by farmers than improved traditional ones using living barriers. Among the plants used for this purpose, Vetiver is considered one of the most suitable one.

This poster paper describes the present status of Vetiver use for soil and water conservation.

Both advantages and disadvantages of this plant are also discussed based on the farmer feedback and field observations.

In Vietnam Vetiver can be grown either from seeds or by vetiver "splits", but the latter way vetiver is propagated vegetatively, by "splits" and not by seeds.

Vetiver is planted along the contour at 15 - 20 cm interval of the sloping land. The vetiver grass grows very fast and does not compete with trees for nutrients. Within two to tree years the plant grow together, forming vegetative hedge. Vetiver puts down a dense curtain of deep roots and, being so well anchored, a hedge can withstand even a shed of water flowing over it. Vetiver hedge can block the passage of soil, keep topsoil in site limit runoff, and over time, retard most surface erosion and in many cases can filter out the soil particles.

Since most of cropping systems on the upland retrieve nitrogen amendment, growing vetiver in mixing with some leguminous ones is highly recommended.

A Test On The Use Of Vetiver Grass With Some Soil Conservation And Improvement Measures For Sustainability In Cassava Based Cropping (Sword Bean)

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The test on the use of vetiver grass with some soil conservation and improvement measures for sustainability in cassava based cropping was carried out on Nam Pong soil series at Mahasarakam Province during 1993-1995. The treatments were: (1) Cassava without any soil conservation or improvement measure: (2) Cassava with sword bean as cover crop; (3) Cassava with sword bean and vetiver grass without seedbed; (4) Cassava with sword bean and vetiver grass with seedbed; (5) Cassava with sword bean and mango in vetiver row without seedbed; and (6) Cassava with sword bean and mango in vetiver row with seedbed.

The results indicated that treatment 3 and 4 which including soil conservation by vetiver grass and soil improvement by sword bean showed good result in reducing soil loss and increased the cassava's yield from 30 - 43% in the first year and 46 - 48% in the second year. There was a potential to plant mango in the system but termites had to be controlled.

Study On Optimum Rows And Different Plant Spacings Of Vetiver Grass For Soil Erosion Control On Sloping Land.

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The experiment was conducted in Saraburi Province during August 1993 - March 1995, at about 10% slope on Muak Lek soil series which is shallow and erosive soil. The treatments were comparing between with and without vetiver grass as soil erosion control. The results showed that there were significant differences in reducing soil loss and crop yield between with and without vetiver grass, but there were not significantly difference in reducing soil loss and crop yield among difference spacing of vetiver.

Vetiver Grass As Erosion And Land Productivity Control

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The use of vetiver as erosion and land productivity control was investigated in Boyolali

(Central Java) from 1990 to 1992. The method used were:

(1) Grass barrier with *Vetiveria zizanioides*; (2) Grass barrier with S*etaria spacelata;* (3) Bench terrace with *Setaria spacelata;* and (4) Control : Bench terrace without grass barrier.

Those treatments used as a strip cropping along border line of 1500 m plot area for each treatment. Corn, *Sesamur indicum* and bean were planted for two harvesting periods in the plot area. The result showed that the use of vetiver as a grass barrier could reduce erosion of 72.7% and stream coefficient of 12.5% compared to control. Moreover, corn production was increased by 104.7% at harvesting period I and 122% at harvesting period II, as for *Sesamur indicum*, it increased by 89.3% and bean production by 142.9%. Among the three grass barriers, only vetiver could produce brangkasan mucuna and give the highest grass height.

Use Of Vetiver In Soil Conservation In The Black And Red Soil Areas Of India.
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Mr. Greenfield of the World Bank initiated the 'Vetiver technology' of soil and water conservation in 1986, on the Black (Vertisol) and the Red (Alfisol) soils of India, which cover more than 15 million ha of arable land and which for generations, have been subject to severe erosion (6 to 15 T/ha annually). Since then, through a series of field studies, the characteris tics of this grass and the effectiveness of the technology have been evaluated. As compared to the existing technology (bunding), the Vetiver technology was observed to reduce soil erosion up to 65 percent, reduce run off loss from 50 to 60 percent and increase crop yields up to 25 percent, apart from being the cheapest.

However, even with all the ideal characteristics of the plant itself and the evidences in favor of the technology, it is not getting acceptance in the officially sponsored soil conservation programs in India. It is believed that the real causes are the extensive field coverage needed to achieve annual financial targets and the reduced scope for 'cuts' by officials. and contractors. Extensive awareness campaign among farmers and adoption of group farming system are suggested.

Field Reports

South Africa

The Use of Vetiver grass in the Revegetation of Kimberlite Spoils in respect to South African Diamond Mining.

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Introduction

Spoils from diamond mining and processing of Kimberlite may be either a coarse fraction of tailings or a fine fraction known as slimes. Tailings dumps may cover an area of 100 to 200 ha and be as much as 80 meters high with a natural angle of repose of between 30˚ and 35˚. Slimes dams may cover an area of similar size with walls 20 m high and a slope of 20˚.

Kimberlite by nature is dark in color, easily weathered, high in smectite clays and may be high in sodium. These chemical and physical characteristics make slopes of kimberlite spoil dumps highly erodible, hostile for pant: growth and consequently difficult to revegetate. The problem is further exacerbated by the fact that many diamond mines are situated in semi-arid environments that are subject to temperature extremes and low and unpredictable rainfall. Furthermore, some exotic plant species are well adapted to these harsh conditions and establish comparatively easily to the exclusion of preferred indigenous species.

Vegetation trials

Vegetation trials with a suite of different indigenous grass species have been disappointing. Germination tends to be *low* and seedling mortality extremely high due to high ground temperatures, inadequate moisture availability and constant erosion of substrate surface. Some success was obtained where kimberlite spoils were top dressed with soil to stabilize slope and provide a better growth medium. However, this is extremely costly and in many instances not possible due to the lack of soil and inaccessibility of mid-slopes.

Vetiver Trials

Trials with Vetiver have been conducted on both tailings dumps and slimes dumps at several different sites. In all instances where plants were successfully established, vetiver has been found to grow vigorously on kimberlite spoils and met both the mechanical and vegetative requirements for rehabilitation. More particularly:

- Rows of vetiver planted at appropriate intervals contained runoff and arrested erosion. Consequently costly mechanical contouring of slopes was not necessary.
- Deep rooting Vetiver was able to obtain sufficient moisture from kimberlite spoils and survive extended drought periods.
- Vetiver withstood ground surface temperatures of more than 50˚ C in summer and over wintered sub-zero temperatures.
- Vetiver was well adapted to growing in alkaline kimberlite soils high in sodium.
- Dense tall tufts of vetiver trapped organic matter and created an ideal micro-habitat (suitable substrate and shade) for the establishment of indigenous grass species.
- Vegetative propagation of vetiver ensures that there is no threat of the species escaping to become an exotic weed.

Conclusion

In conclusion vetiver has been found to have the necessary attributes for self-sustainable growth on kimberlite tailings dumps and slimes dams. The species is likely to play an increasingly important role in the rehabilitation of kimberlite spoils. As such nurseries are being established at several mines to meet expected future demand.

Fiji

Back From The Future: Do's and Don'ts After 50 years of Vetiver Utilization in Fiji.

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Abstract

The concept of using Vetiver grass for soil and water conservation purposes instead of conventional structures was first developed for the sugar industry in Fiji more than 50 years ago. The Vetiver system is now widely used as a standard practice for soil and water conservation, particularly on small farms. The Vetiver system is very effective in erosion control and it is well accepted that when properly implemented the system can improve sugar cane yield up to 55%. Over a 40 year period terraces formed from eroded soil upslope are up to 1.5 m high. However farmers are now reluctant to implement the Vetiver system and in some cases are removing the well established system, resulting in massive erosion and production loss. The reasons for low adoption, and in some cases rejection, are complex but include socio-economic, land use policy and agronomic practices. Problems associated with these issues are identified and possible solutions are proposed.

Introduction

Vetiver grass was first used for soil and water conservation purpose in the Fiji sugar industry early in the 1950's. The success of the Vetiver system is highly visible in the form of 1 to 1.5m high terraces built up from trapped sediment on numerous canefields on the west coast of Fiji. However, despite this highly effective means of soil and productivity conservation, farmers are now reluctant to implement the Vetiver system.

The Fijian experience provides an extremely rare opportunity to observe with reality, not by modeling, but with actual outcomes, what is the impact of the Vetiver system after 50 years of application. Lessons to be learnt and pitfalls avoided, so that this new technology continues to protect our environment and conserve our limited' resources for future generations.

Historical Background

Vetiver grass was first introduced to Fiji from India probably late in the 1800's to provide thatching material for houses and it is still being used for roofing and walls. Although it was commonly used to stabilize embankments, terraces and to delineate farm boundaries, its application as a soil conservation measure as we know today was developed early in the 1950's. On Viti Levu, which is the main island, the Fijian sugar industry concentrated along the west coast where suitable low slope land is very limited. As the sugar industry expanded, the main sugar production company, Colonial Sugar Refinery (CSR) was faced with a very severe soil erosion problem on sloping lands, particularly on the north western area around Rakiraki, where the land is very steep and rainfall is often of very high intensity.

A team of research agronomists and soil conservationists including John Greenfield at the CSR Agricultural Experimental Station first tried the accepted methods - engineered contour banks, diversion banks, leading to grassed waterways, but under tropical rainfall conditions these structures did not last a season. The search then turned to vegetative systems. Of the 19 plant species tested only Vetiver grass was selected and developed to an effective soil and water conservation system. This system was very practical and easily implemented (Fijian agricultural systems being labor intensive rather than mechanized) and very effective as a soil conservation measure. Vetiver also conserved water increasing subsurface recharge as runoff water slowly seeped through the hedge instead of being diverted off the field. This greater accession to subsurface and ground water has probably led to productivity improvements and an improved overall water management system with greater stream persistence in the dry season.

CSR rigorously enforced this soil conservation technique on all sloping lands until the company left Fiji early in the 1970's. Since then this system has not been enforced under the present land use policy of the Government, despite steeper lands (up to 66% slope) being used for sugar cane production.

Official records show that the first Vetiver contour hedge was established in 1952 in the Penang Mill area, near Rakiraki, and hedges over 40 years old are quite common in the area, but farmers have used Vetiver for slope and batters stabilization for more than 50 years.

Current Application and Effectiveness of the Vetiver System in Fiji

Vetiver grass is widely used in Fiji from simple road embankment and stream bank stabilization, to contour hedges in sugar cane lands, and slashed and burnt plots on the east coast. It is a common practice for farmers to plant Vetiver to stabilize farm roads, across depressions, to spread and slow down runoff water, and most often on contour lines to protect their vegetable crops from rill erosion. According to local farm advisers of the Penang Mill, Rakiraki, 'Vetiver grass Systems' provide a very simple and practical solution to the soil erosion problem on small farms where both educational and technological knowledge is minimal and labor intensive activities dominate.

In all sugar cane growing areas, from the low slope fields around Lautoka to very steep hillsides around Rakiraki, terraces formed by Vetiver hedges up to 1.5 m high are quite common. These terraces were formed by soil erosion upslope and subsequent trapping by Vetiver hedges downslope over a 25 - 40 year period. The spacings between hedges are relatively close (averaging 30 - 40 m apart). The quantity of soil eroded and then trapped by the Vetiver hedge to form these terraces clearly demonstrates the effectiveness of the Vetiver hedge systems and the huge soil losses that would otherwise have occurred off those steeply sloping lands.

In general, fields protected by Vetiver hedges often have higher productivity than those unprotected by the hedges. On the average, where the practice is used on steep cane lands in the Rakiraki region, good yields can be expected for up to 7 to 8 ratoon crops. The number of ratoon crops in unprotected fields is generally lower and yields are reduced. Farm advisers attributed the loss of production to both soil and water losses on unprotected fields. In a simple demonstration trial, sugar cane yield of 48 tons per ha from a field protected by Vetiver hedges, and was reduced to 31

tons per ha from unprotected fields. This represents a 55% loss in production.

With the clearly demonstrated benefit of the Vetiver hedges in existence for the last 40 years, it is of interest to note that Vetiver has not become a weed. In addition to the provision of thatching materials, far mers still are very reluctant to establish new Vetiver hedges. In some cases they have removed old, well established hedges, resulting in massive soil erosion and drastic reduction in yield and within a few years the once productive land was covered with weeds and stones. Reasons given for these actions varied but the central theme pointed to these three concerns:

- Vetiver hedges take up too much land;
- terraces formed by the hedges hinder farm machinery operation; and
- the hedges sometimes harbor pests such as rats.

On closer examination, the real reasons are probably more complex than these three superficial concerns.

1. **Land shortage**. After 40 years where hedges were not properly maintained, the single row of Vetiver spread from 0.3 - 0.4 m to more than 2.5m width. Depending on the land slope and the original spacing, cropping areas sometimes were reduced to 4 - 5 m between hedges. In addition the trapped sediment formed terraces up to l.5 m high, hindering farm machinery operations. As with other developing nations, Fiji is faced with a severe shortage of agricultural lands, so it is obvious and understandable that farmers are concerned about the loss of productive land, where the cropping area of an average sugar cane farm is only 4 ha.

2. **Land ownership**. In addition to land shortage, land ownership is also an important issue. Under the present system, most Fijian farm lands belong to the Native Land Trust Board which administers the lease of the land to farmers for agricultural use. As the case of most lease land, farmers are not often very receptive to long term soil conservation measures where benefits are not often apparent in the short run.

3. **Land use policy**. Under the CSR policy, sugar mills enforced strict land use guidelines. Mills only accepted sugar cane from farms that implemented soil conservation guidelines recommended for the districts. For example, Vetiver hedges system was recommended for farms with land slopes of 12% or more. The spacing of the hedges was determined by soil type and land slope. Under the present Government policy sugar mills cannot enforce these guidelines, and farm advisers can only "advise" farmers to implement soil conservation measures which are often ignored, the few exceptions being new farmers where soil conservation and other agronomic advice is well received.

4. **Inflexibility of the existing system** Although the present system still provides a very effective water conservation method, it was designed over 40 years ago when the main power source was draught animals. As farming practices have increasingly relied on modern technology, including farm machinery, the existing system in general can cause hindrance to farming operations. For example, draught animals can walk around or climb over an overgrown hedge and terrace, whereas tillage and harvesting machinery can not. Redistribution of trapped sediment upslope is a major task, if it is done manually but with the availability of tractors the job can be carried out much faster.

5. **Lack of development and extension support.** There has been very little support to assist farmers in overcoming problems associated with the implementation of the Vetiver hedge system. The three major concerns expressed by farmers, namely the loss of productive land, hindrance to machinery operation and harboring pests, can be all resolved if an effective hedge maintenance program was carried out. If the hedges were trimmed and accumulated sediment was redistributed every few years, the spreading of the hedges and the build up of terrace would be very effectively controlled. As a result of the above actions, thin and well trimmed hedges are less likely to harbor rats and other pests. In addition, the general extension effort regarding the benefit and impact of a soil conservation system such as Vetiver hedges has been very limited due to the shortage of well trained extension staff.

In summary, the pitfalls DON'TS listed above range from technical (Research, Development and Extension) to political (Land Use policy) and socio-economic issues (land shortage and ownership).

Proposed Do's

From the above summary it can be seen that solutions to these shortcomings range from fairly simple technical issues to complex socio-economic ones which require both economic resources and political will. While some of these can be solved satisfactorily, others will be slow and difficult to solve and those, which involve cultural, ethnic and political issues probably can never be resolved satisfactorily. However if these issues are known and properly dealt with now, most of the pitfalls mentioned above can be avoided.

If the Fijian experience can be used as a model, the following three issues deserve utmost and urgent attention:

Research, Development and Extension. The conventional engineering soil and water conservation systems such as contour and diversion banks, and waterways etc. have been adopted and implemented worldwide for a long time, but these systems still require continuing research, development and extension efforts to improve and to gain farmers acceptance. Likewise, a new concept and technology such as the Vetiver system will need these supports for a long time. Some of the topics that have to be taken into account are:

- **Suitable cultivars**. There are a vast number of different species, sub-species of the Vetiveria genus, and an enormous range of *V. zizanioides* cultivars that are grown worldwide. They should be screened and selected for various applications. The Thai Department of Land Development has done an excellent job in collecting and screening more than 40 Vetiver cultivars and species for regional applications, but it is suggested that they should go one step further by selecting suitable cultivars for different crops and applications. For example shade tolerant cultivars are needed for tree crop and orchards, tolerance to salt and heavy metal toxicities for land reclamation, non-seeding cultivars for agricultural crops, fast regrowth and tolerance to grazing pressure for pastures and rot resistance for thatching, just to mention a few. In short the selection program needs to be purpose-oriented.

- **Propagation and Establishment**. Although potting gives excellent results, it is slow and costly and should be limited to high value projects to ensure fast, reliable

establishment and growth. Direct planting is the method farmers would prefer, and it should receive full research, development and extension attention. Detailed guidelines such as slip size, age, hormone treatment, soil moisture, seasonal conditions (rainfall and temperature). Obviously different guidelines are needed for different crops and applications.

• **Maintenance**. In. the long term, maintenance is the most important aspect which greatly influence the acceptance of the Vetiver by farmers. As mentioned previously the concerns expressed by Fijian farmers relate to the lack of a proper maintenance program. For example, for sugar cane crop, Fijian farm advisers recommend that hedges should be slashed twice a year, one early in the wet season to encourage growth and once towards the end of the wet or the beginning of the dry season to remove excess material which encourages rats. Trimming is required every 3, 4 years and trapped top soil should be spread up hill during replanting (5-7 years). Alternatively, every second hedge can be taken out, trapped top soil respread, and replant Vetiver with each cane replant cycle. The maintenance guidelines should also include recommended methods of controlling unwanted Vetiver plants. Again maintenance programs need to be developed for each application.

• **Design layout for various crops and applications**. Design layout should be flexible enough to take into account different cropping practices and regional variations. Wherever possible likely future changes in practice and crop production should also be considered. In addition, having understood the function and potential of Vetiver hedges, its applications should be extended to other non-conventional areas, both in agricultural and non agricultural sectors, such as mine rehabilitation, water quality improvement and toxic wastes management. A good example of a further application in soil and water conservation, the Thai Department of Land Development work on the incorporation of Vetiver into a Leuceana-pigeon peas alley cropping system and water harvesting design for fruit trees in Chiang Rai.

• **Extension**. An extensive extension service is needed to ensure long term success. Extension staff should not only be competent in soil erosion and sediment control matters but also in the agronomy, tolerance and adaptability of Vetiver grass. But most importantly, the final application and layout should be a compromise between farmers' needs and the recommended standard design.

Land Use Policy.

Lessons drawn from the Fijian experience strongly indicate that a firm land use policy is required for long term success. As pointed out above, when CSR was responsible for a large part of the sugar industry in Fiji in the 1950's strict soil conservation guidelines were applied. CSR sugar mills only accepted crops from farmers that complied with the company guidelines. With well trained and a supportive team of farm advisers, farmers were happy to implement these guidelines and CSR was able to maintain the productivity of these highly erodible lands.

Land use policy guidelines need to be developed for each agricultural industry such as sugar cane, rice, horticultural crops, pastures etc. taking into account topographic, edaphic, rainfall erosivity characteristics as well as the farming practice of each region. When properly developed and supported by extensive extension/education program, most farmers would accept it. However, to be effective, legislative support is often required. For example, to obtain a contract to grow sugar cane on lands with slope exceeding 15%, farmers in southern Queensland, Australia, have to implement green cane harvesting, trash retention practices — a soil conservation practice where the crop is mechanically harvested unburnt and retaining the trash all year round.

Land ownership. This involves' the highly volatile socio-ethnic-economic-political issues associated with any land reform program which require firm commitment from political leaders. It will be slow and difficult, but it should be considered as a long term goal. People will be more willing to take better care of properties they own, particularly in societies where land ownership is linked with cultural and spiritual values.

Conclusion

Although the Vetiver soil and water conservation system has clearly demonstrated its effectiveness and benefit to the sugar industry in Fiji, its acceptance by farmers is not guaranteed. To ensure its long term success, continued input into the development and adaptation of the system to changing needs of various agricultural industries is required.

Reference

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Zimbabwe

The Hippo Valley Estates Magudu Vetiver Outreach Project

The Vetiver Outreach Project is perhaps the most, shining example of what purposeful environmental conservation can achieve. The Magudu area through which the Tokwane irrigation water flows, has through this project, been transformed into a lush green water course over a very short space of time. Communal farmers have been introduced to this scheme and they are very enthusiastic about the benefits it will produce.

For the benefit of those who are not abreast with current affairs in this area, the Vetiver Outreach Project is a soil conservation project which is being implemented on the Tokwane River in the neighboring Magudu Area. The aim of this project is to plant the fast growing vetiver grass on the river banks to pr event soil from being lost through erosion. It. is hoped that the communal farmers will learn from this project and implement it in their own areas. The benefits of this environmental conservation scheme are tremendous, and in particular the people in Magudu will receive more effective rainfall when there is less runoff, but greater infiltration.

This project started early this year. As part of the necessary groundwork, the local Chief, the District Administrator and Agitex officials were informed about this project, and they all agreed that this is a good project. The land was surveyed and Mr. Muyangani's 3.4 hectare plot was identified as the most suitable site for the project. The perimeter and contours were pegged,

***Photo 9**: Vetiver hedges on small farmers fields near Zomba, Malawi. Note that the field cultrivation is also on the contour.*

Photo credit: Glenn Allison

and a stretch of 1400 meters was planted with vetiver grass when the first rains fell in February. Two local people were then employed to water the young grass using 20 litre tins to carry water from the nearby dam, and all the grass which was planted germinated, survived and in fact even started catching the top soil when heavy rains fell shortly after the planting.

Our primary objective in this project is to teach the communal farmers to conserve soil, and indications are that many have been sold to the idea. A few have however appreciated the project. more because it will produce a good supply of grass for thatching than the fact that it will help in environmental conservation. This may be the other motive, but Hippo is not deterred and it will continue to reach out to the people as the name of the project. implies.

In the next stage, Hippo will supply "seed" to the local Agritex official who will set up a 0.1 ha vetiver grass nursery in his irrigation scheme and hopefully provide the local people with a source of seed to plant.

Papua New Guinea

The Establishment and Management of Vetiver Grass within the Traditional Garden System of Papua New Guinea.

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Vetiver grass was introduced to *PNG* in the late 1980's and established on a Department of Agriculture and Livestock (DAL) Research Station in the coastal lowlands. All the planting material used in the PNG Highlands originated from this plot. Nursery blocks were established on Government Stations in a number of rural areas of Simbu Province by Extension Officers of the Provincial Department of Primary Industries (DPI). To date, the only on-farm plantings of vetiver grass in the highlands have been in about 40 gardens in Simbu Province.

Vetiver grass extension in Simbu Province prior to 1994.

There was little information available on the culture of vetiver grass to the DAL Extension Officers who made the first on-farm plantings of vetiver grass in Simbu in l993/94. The slips were planted at 30 to 50 cm centers in straight lines across the gardens, most of which have slopes over 40% The lines were not planted on the contour. Slips that died were not replaced. Few of the clumps of grass in these plantings have formed complete hedges and many gaps still remain. Their effectiveness in preventing soil loss has been minimal. The growth rate of the grass was satisfactory on fertile soils, but slow on shallow soils. Little follow up extension was given to farmers to encourage them to persist with the grass or manage it in any way as DAL Extension Officers were provided with few resources for this purpose.

CARE Australia's program with vetiver grass extension since June 1994.

The Simbu Agroforestry and Land Use Project, is managed by CARE Australia on behalf of the Australian Government Aid Agency, Aus Aid. One of it's components *is* to investigate ways *to* use vetiver in gardens in the Province. After a review of the literature, observation of the plots already established, and discussions with officers of the DAL and village farmers, a vetiver grass extension program was commenced. On-farm plots were established and follow-up extension visits are made on a regular basis.

The extension message is constantly reviewed in the light of the increasing practical experience. Texts in Tok Pigin, a commonly spoken language throughout PNG, are being prepared to provide farmers with information about all aspects of vetiver grass culture and management.

The extension methods used.

- The extension effort emphasizes the grass's likely benefits to the farmer and to the gardening system. No funding is allocated by Government or SALUP to provide incentives for farmers to plant the grass.
- Few farmers have access to capital for the purchase of inputs such as fertilizer, or labor. Establishment and management methods that need no cash and little extra labor are emphasized.
- Farmers are taken to visit already established plots, on-farm field days

and discussions are held, radio programs on vetiver grass are broadcasts, and follow up farm visits are made so that farmers have all the information they need to incorporate the grass into their garden system successfully.

- Farmers are supplied with limited amounts of free planting material and encouraged to establish their own nurseries as existing nursery areas are small.

- Papua New Guineans are very innovative gardeners and will adapt and adopt worthwhile new technologies to suit their situation, if they have all the information they need.

- Women have a major role in garden management. and all extension effort must include them.

Recommendations for establishment and management of the grass.

Preparations prior to planting.

Diversion drain: If there is a long slope without tree cover above it diversion drains should be dug to protect the garden from large flows of surface runoff that may run across it while the grass is establishing itself. Serious loss of soil and landslides occurred in a number of gardens which had no protection from this type of surface runoff. The hedges were still in the establishment phase. It is likely that less damage would have occurred to the garden if diversion drains had been dug above them. Care must be taken to ensure that the diversion drain itself does not cause erosion at its outlet.

QUIZ.

$30 to the first person to quess correctly what and where the above scene is. Send your answer and some news about what you are doing with vetiver to Dick Grimshaw

Contouring: The vetiver grass slips should be planted on the contour if possible. Some washing of soil has been noticed from high points to low points along terraces about 1 m wide, formed behind hedges that were not planted on the contour. As the hedges are likely to last for many years and form sizable terraces, the extra trouble taken to mark out contours during the initial establishment is considered worthwhile and does not need to be repeated in later years as the hedges are permanent. Lines of crop plants will also be planted parallel to the hedges, on the contour and will contribute to erosion control. The contour can be marked out using a simple "A" Frame. It is a technology that can be mastered by local gardeners, with minimum of training.

Soil retention barriers

Soil retention barriers are a useful tool when establishing vetiver grass, particularly in very steep gardens. These barriers are built after the initial clearing of the garden and before planting of the crop. They are temporary structures that rot within 6 to 9 months of their construction, when soil accumulated on their up-slope side is normally lost down the slope. Vetiver grass slips are provided with an ideal seed bed for their establishment when they are planted in this accumulated soil and their roots prevent it's loss when the barrier rots. Some gardeners, against recommendations by SALUP, planted the vetiver grass hedges on the lower side of the soil retention barriers. Grass growth was satisfactory, but when the barrier rotted, soil held by the barrier fell on top of the grass and some was lost down the slope. It is too early yet to determine if the grass will survive this treatment. They are most effective if they are established on the contour at 2 m vertical intervals.

Vertical interval between hedges

The ideal is to plant the lines of vetiver grass at no more than 2 m vertical interval. I f the vertical interval between hedges is more than 2 m, the velocity of runoff water on steep slopes during heavy rain is likely to cause heavy rilling and scouring which can lead to land slides in extreme cases. A 2 m. vertical interval on a 45% slope allows a surface distance of only 2.8 m between hedges. Most gardeners consider this is too narrow a space to crop and a compromise must be made between the ideal and the practical. On the steeper plots farmers have accepted vertical intervals of up to 3 m.

Planting

Season Planting of vetiver grass should take place early in the wet season, if possible. Vetiver grass hedges have been planted throughout the year. While most slips survive when planted during periods of drought (usually less than 3 weeks in PNG), their growth is minimal and some deaths occur. Slips planted when there is regular rain establish much faster.

Timing in the gardening cycle Planting of the vetiver grass in a garden should take place just before the crop is planted. At this time conditions are ideal for quick establishment of the grass as competition from weeds is at a minimum, and the farmer can observe the grass regularly when caring for the crop. By the time the garden is fallowed the grass should be well established so that it can compete successfully with invading volunteer species and still be present when the garden is re cultivated.

Vetiver grass can be planted into stands of Kunai (*Imperata cylindrica)* (the most common local grass) by cultivating a narrow strip where the slips are to be planted. Kunai is an aggressive species and while most of the vetiver grass survives, its growth is very slow unless the kunai is regularly cut. Few farmers are prepared to invest the time and effort required. It is also difficult to separate the kunai from the vetiver grass when the garden is cultivated later. As very little erosion occurs in established stands of kunai, there appears to be no advantage in planting vetiver grass into such swards. Established hedges should be able to compete successfully with kunai that grows during the fallow period.

Spacing The effectiveness of vetiver grass in controlling erosion depends largely on it's ability to form a complete hedge without gaps, across the slope. If the gaps between the clumps of vetiver grass are to close quickly, under conditions in Simbu, the slips must be planted at no more than 10 cm centers. Given reasonable growing conditions, most of the gaps will close within 12 months. Slips planted at 30 to 50 cm centers still have gaps after 2.5 years of growth.

Mulching A mulch of leaves, dead grass, etc. should be placed around the slips when they are planted, particularly in dry weather. The mulch prevents the soil from drying out, keeps the surface cool, retains some soil, and generally improves conditions for the establishment of the grass.

Use of leguminous coppices A line of *Leucaena spp*. trees, which will be coppiced when they have grown, planted parallel to the vetiver grass hedge, will help to improve soil fertility in the garden. The trees which have been planted at 50 cm centers in a line 50 cm to 1 m from the hedge, have a threefold benefit. They contribute nitrogen directly to the soil from their roots and indirectly through the coppiced material which is used as a mulch, their roots help to hold the soil on steep slopes, and the trunks and larger branches of the plants can be used for firewood or construction timber. The traditional nitrogen fixing tree used in PNG is *Casuarina oligodon*. It cannot survive coppicing, though it can be pollarded. Its use is generally as a tree cover/soil improver during longer fallow periods. Coppicing is a new technique in the Highlands and more research needs to be done into the best species and methods to use. An extension program will be needed if it is to gain widespread acceptance as a worthwhile practice.

Hedge Maintenance.

Replacement of slips that die Any slips in the hedge that die should be replaced as soon as possible. The gaps left in the hedge take a long time close up as replacement slips suffer from heavy competition from already established clumps if replanting is not done quickly. Trimming existing clumps will help. Ensuring that the original planting material is of good quality will reduce the number of dead slips. To date, no culms over 20 cm long, that could be used layered in these gaps, have been observed on any clumps.

Trimming Occasional trimming of the hedge will increase the number of tillers in the clumps of grass. A simple experiment to test the effect of trimming the leaves of clumps at 10 cm above the ground was conducted. It indicated that tillering increased significantly as a result of cutting. The trimmed leaves can be used as mulch or as thatch. The large majority of houses in rural areas still have thatched roofs.

Landslips

After prolonged periods of rain in steep gardens some vetiver grass hedges have been lost through land slips. Experience in Simbu is too recent to know how effective the grass will be in preventing landslides once it has a fully developed root system. The soil in many gardens overlays rock or clay, conditions that restrict root growth and are highly conducive to land slides, particularly when the soil is saturated.

The future for vetiver grass.

Much has been learnt in the last three and a half years but more experience must be gained before a definitive answer about the place of vetiver grass in the traditional garden system can be given. Villagers from one of the areas where the vetiver grass has been planted said, when they were interviewed recently, that they needed to observe the grass for a longer period before they were prepared to form a definite opinion about it's usefulness. However, requests for vetiver grass planting material continue to be received from other farmers in this area, and most seem confident that it will be a useful tool in making sure that their children will inherit land suitable for growing their future food needs.

Vetiver grass has a place within the gardening system, but will only be one of a number of technologies that must be mobilized to ensure that crops will continue to be produced given the extreme terrain encountered in this region of the world. Miracles are needed, vetiver could well be one of them.

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Photo 10: *Filter strips in a quarry in Queensland, Australia, filtering sediment from water being discharged into a dam.*

Photo: Credit Paul Truong

Australia

Effectiveness Of The Vetiver Hedges In Soil Erosion And Sediment Control In Queensland

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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 favorable 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 l 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 1 m VI. Despite the extremely poor and hostile conditions of the coarse gravelly 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 mm in diameter. Twelve months later the old gravelly 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 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 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 50 m 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 ve ry 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 (Radloff pers. comm.).

CONCLUSION

With its wide ranging tolerance of adverse climatic and edaphic conditions the Vetiver hedge system offers a simple and low cost alternative to constructed soil erosion and sediment control measures.

On disturbed lands, where conventional methods of stabilization and reclamation are limited and costly, the Vetiver system offers a unique means of rehabilitation of these highly erodible lands.

More specifically with its high level of tolerance to extreme soil pH, soil salinity, Al and Mn toxicities, Monto Vetiver has great potential for reclamation work in **mining** and other industrial waste and contaminated lands.

Effects of Heavy Metals Toxicities on Vetiver Growth

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Abstract

Environmentalists are increasingly concerned with problems caused by contaminated land to the environment. Land con-

Photo 11: *Queensland, Australia. Rehabilitation of toxic municipal waste dump using vetiver grass.*

Photo credit: Paul Truong

taminated by heavy metals, as results of mining and industrial and urban wastes, require effective erosion and sediment control measures to stop its offsite pollution. Vetiver grass which is known to have high tolerance levels to some extreme soil and climatic conditions, is tested for its tolerance to a number of heavy metals common in mining and industrial wastes in Queensland. Results indicate that Vetiver is highly tolerant to high arsenic, cadmium, chromium, copper and nickel levels in the soil. Therefore Vetiver is highly suitable for the rehabilitation/reclamation of lands contaminated by these elements.

Table 1: Investigation Thresholds For Contaminants In Soils
Australian and New Zealand Guidelines for Assessment and Management of Contaminated Sites, January 1992 (ANZECC/NHMRC)

	THRESHOLDS (mg/kg)	
HEAVY METALS	**Environmental Investigation**	**Healthbased Investigation**
Antimony (Sb)	20	-
Barium (Ba)	-	-
Cadmium (C)	3	2
Chromium (Cr)	50	-
Cobalt (Co)	-	-
Copper (Cu)	60	-
Lead (Pb)	300	300
Manganese (Mn)	500	-
Mercury (Hg)	1	-
Molybdenum (Mo)	-	-
Nickel (Ni)	60	-
Tin (Sn)	50	-
Zinc (Zn)	200	-

Introduction

In recent years, environmentalists have been increasingly critical of the contamination of the environment by by-products of industrial and mining industries. The majority of these contaminations have been caused by high levels of heavy metals which can affect flora, fauna and human population living in areas in the vicinity of or downstream from the contaminated sites. Table 1 shows the levels of heavy metals required environmental and health investigations set out by the Australian and New Zealand authorities.

These concerns have resulted in strict guidelines to prevent the spreading of these contaminations and in some cases have delayed and even stopped some industrial and mining projects, until appropriate methods of decontamination / rehabilitation are implemented. High levels of heavy metals in the by products are unavoidable but they must be contained or at least preventing from spreading downstream.

The usual methods of decontamination are to treat the contaminants chemically or to physically remove them from sites. Both methods are often expensive and at time impos sible to carry out as the volume of contaminated materials can be very large, as in the case of gold and coal mine tailings.

If these wastes cannot be economically treated or removed, they must be prevented from spreading out. Wind and water erosions and leaching are the usual causes of off-site contaminations. Therefore, an effective erosion and sediment control program is needed and rehabilitation with suitable vegetation is the most practical and economical method. However, revegetation on these sites are often very difficult and slow due to their highly adverse growing conditions including toxic levels of heavy metals.

As Vetiver is capable of growing in a wide range of adverse conditions such as toxicities of Al and Mn, highly acidic, alkaline, saline and sodic conditions, this trial was set up to establish its tolerance to a number of heavy metals commonly occurred in mining and industrial wastes in Australia. These include arsenic, cadmium, chromium, copper and nickel

Table 2: Treatment Levels And Chemicals Used

Treatment	Heavy Metals ppm				
	As(1)	Cd(2)	Cr(3)	Cu(4)	Ni(S)
Control	0	0	0	0	0
1	100	5	50	25	100
2	250	10	10	50	200
3	500	20	200	100	300
4	750	60	600	200	400
5	-	120	-	-	500

(1) As Di sodium methyl arsenate (DSMA)
(2) As Cadmium sulphate (Cd S04)
(3) As Dipotassium chromate (K2CrO4)
(4) As Copper Sulphate (Cu S04)
(5) As Nickel Chloride 9NiC12)

Materials and Methods

A pot trial was carried out under glass house conditions over a period of 10 weeks. Table 2 shows the treatment levels in the soil of the five heavy metals used. These levels were chosen as they represent the range com monly found in contaminated sites in Queensland.

A complete nutrient solution was applied at the beginning and after 5 weeks to ensure adequate supply of nutrients to Vetiver growth. A close system was used and pots were watered to field capacity daily with de-ionized water. Tops and roots were harvested for yield and chemical analyses.

Results and Discussion

Heavy metals are generally found naturally only at very low concentrations. Elevated concentrations are commonly associated with pollution from human activities. Heavy metals can affect plant growth by interfering with enzyme activities or preventing the absorption of essential nutrients. Many plants are sensitive to heavy metals, those which are tolerant are generally tolerant of most heavy metals. Tolerant plants can be divided into three groups *(Robbetal*. 1983):

- excluder, plants with restricted transport
- index plants are those reflect soil concentration
- accumulation species which have higher concentration than the soil

Table 3: Toxic Thresholds Of The Heavy Metals Used In This Trial Under Hydroponic Conditions (Bowen, 1979).

Heavy Metals	Toxic Thresholds to Plant Growth (ppm)
Arsenic	0.02 - 7.5
Cadmium	0.2 - 9.0
Chromium	0.5 - 10.0
Copper	0.5 - 8.0
Nickel	0.5 - 2.0

Table 4: Toxicity Levels In The Soil Of Some Heavy Metals (Baker And Eldershaw, 1993).

Heavy Metals	Toxic Threshold(ppm)
Arsenic	2.0
Cadmium	1.5
Nickel	7.0 - 10.0

Table 5: Dry Matter Yield Of Vetiver As Affected By Various Levels Of Arsenic In The Soil

Soil Concentration (ppm)		Dry Matter Yield (g/pot)	Relative Yield (%)
Control	0	43.85 a*	100
	100	43.51 a	99
	250	18.93 b	43
	500	5.56 c	13
	750	0d	0
	LSD (5%)	2.95	

* Treatments with the same letters are not significantly different.

In general, results of this series of trial indicate that Vetiver is highly tolerant to this group of heavy metals. In a hydroponic trial, Bowen (1979) found that most vascular plants are highly sensitive to heavy metals toxicity (Table 3). Baker and Eldershaw (1993) also reported very low toxic thresholds levels in the soil for As, Cd and Ni (Table 4).

Table 6: Dry Matter Yield Of Vetiver As Affected By Various Levels Of Cadmium In The Soil.

Soil Concentration (ppm)		Dry Matter Yield (g/pot)	Relative Yield (%)
Control	0	43.8 a*	100
	5	37.86 a	86
	10	34.08 a	78
	20	33.50 a	76
	60	21.06 b	48
	120	12.24 c	28
	LSD (5%)	11.59	

* Treatments with the same letters are not significantly different.

Although no distinctive symptoms were recorded in this trial, leaf tips of all affected plants became chlorotic first and the chlorosis gradually spread to the whole leaf. In the cases of As and Cd the leaf tips first became red then chlorotic.

Arsenic:
Results shown in Table 5 shows that Vetiver yield was significantly reduced when soil arsenic level is at 250 ppm and higher. Although these results did not establish the exact toxic thresh old level for Vetiver, which is most likely between 100 and 250 ppm, this level is extremely high as compared with the threshold of 0.02 - 7.5 ppm (Tables 3 and 4). As arsenic soil levels at 20 ppm and 100 ppm may require rehabilitation (Table 1). Vetiver is a highly suitable species for reclaiming these sites.

Literature indicated that high level of As in the plant interferes with S and P metabolism (Kabata and Pendias, 1984).

Cadmium

Although results from Table 6 indicates that Vetiver growth was significantly affected by soil Cd level at and higher than 20 ppm which is extremely high as compared with the threshold shown in Tables 3 and 4.

Table 8: Effects Of Soil Copper Levels On Vetiver Growth.

Soil Concentration (ppm)		Dry Matter Yield (g/pot)	Relative Yield (%)
Control	0	20.53 a*	100
	25	17.89 a	87
	50	18.87 a	92
	100	11.42 b	56
	150	4.58 c	22
	200	3.80 c	19
	LSD (5%)	5.54	

* Treatments with the same letters are not significantly different.

shown in Table 3.

Vetiver is therefore highly suitable for reclamation of Cr contaminated lands as sites with soil levels at 50 ppm may require rehabilitation (Table 1).

Copper

Copper is a micro nutrient for plant, but it is highly toxic to plant at higher levels in the soil. Results of Table 8 indicate that the critical toxic level for Vetiver is between 50 and 100 ppm which is very high compared with the threshold shown in Table 3. However, reasonable growth (56%) continued at soil Cu level of 100 ppm. Sites with soil Cu level at 60 ppm may require rehabilitation (Table 1).

Table 7: Effects Of Soil Chromium Levels On Vetiver Growth

Soil Concentration (ppm)		Dry Matter Yield (g/pot)	Relative Yield (%)
Control	0	33.29a*	100
	50	28.71 a	81
	100	34.64 a	98
	200	25.80 a	73
	600	4.68 b	13
	LSD (5%)	10.75	

* Treatments with the same letters are not significantly different.

Although at much reduced growth (48%), Vetiver maintained slow but continual growth at 60 ppm. At this level Vetiver can be established in most contaminated industrial wastes and gold mine tailing with the highest Cd contamination in Queensland.

These results again indicated that Vetiver's highly suitable for rehabilitation of Cd contaminated land as sites with soil levels of 3 ppm and 20 ppm may require rehabilitation (Table 1).

Chromium:

Table 7 shows Vetiver growth is not significantly affected until soil Cr exceeds 200 ppm and the toxic threshold level is between 200 and 600 ppm. This level is extraordinary high as compared with the threshold of between 0.5 and 10.0 ppm

Nickel

Although Nickel is considered a trace element for most plants and is a constituent of the important enzyme urease, but it is extremely toxic to plant at high concentration (Kabata and Pendias, 1984). Baker and Eldershaw (1993) reported the toxic threshold level of Ni in the soil is between 7 and 10 ppm for most plants, but from our trials, 58% of growth can still be obtained at the soil level of 100 ppm. At this level Vetiver is highly suitable for the rehabilitation of Ni contaminated lands which has 60 ppm of Ni or higher (Table 1).

General Discussion and Conclusion

Although results of chemical analyses of plant material are not available at the time of preparing this paper, yield data have clearly demonstrated that Vetiver is highly tolerant to this group of heavy metals and therefore a highly suitable species for the rehabilitation of contaminated lands.

Table 9: Effects Of Soil Nickel Levels On Vetiver Growth.

Soil Concentration (ppm)		Dry Matter Yield (g/pot)	Relative Yield (%)
Control	0	35.29 a*	100
	100	20.56 b	58
	200	3.21 c	9
	300	7.32 c	21
	400	1.31 c	4
	500	0.90 c	3
	LSD (5%)	10.01	

* Treatments with the same letters are not significantly different.

Results of chemical analyses will establish whether Vetiver is an excluder an index plant or an accumulator. If Vetiver is an index plant or an accumulator with high level of heavy metals in the shoots, then the use of Vetiver in the rehabilitation of the contaminated sites will have certain implications.

On the positive side, Vetiver will not only provide a very effective means of erosion and sediment control at these sites, when harvested and removed from the sites and disposed off safely elsewhere, the level of heavy metals in the soil can be gradually lowered with time.

On the negative side, these heavy metals in the plant shoots can enter the food chain and would become a health risk if animals are allowed to grazed on the rehabilitated sites.

More research is needed to investigate the tolerance of Vetiver to mixtures of a number of heavy metals as under field conditions high heavy metal contaminations often occur in combination with others. Literature indicates that interactions between themselves and other plant nutrients can affect plant tolerant level greatly (Bowen, 1979; Kabata and Pendias, 1984; Lepp, 1981).

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Resistance Of Vetiver Grass To Infection By Root-Knot Nematodes *(Meloidogyne* Spp)

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Introduction

Vetiver grass *(Vetiveria zizanioides)* is well known for its tolerance to adverse soil conditions and is used as a contour hedge to prevent soil erosion on steep slopes in some countries. Anecdotal evidence also indicates that when grown adja cent to orchard trees for soil and water conservation purposes, Vetiver appears to improve tree growth.

In Queensland, Vetiver grass is being used to stabilize soil on slopes in sugarcane and pineapple plantations. Since root-knot nematodes *(Meloidogyne* spp.) can be a problem on both crops (Spaull & Cadet 1990, Caswell et all 1990), the status of Vetiver as a host of root-knot nematode was of interest. This work aimed to answer that question.

Materials and Methods

Two Vetiver varieties were screened for resistance against five root-knot nematode populations. The populations are representative of the main genetic groups of *Meloidogyne* in Australia and consist of four species (viz. *M. arenaria, M. incognita* [populations B 1 and B2], *M. javanica* and *M. hapla).* They were identified using DNA technology (Hugall et al 1994). The two Vetiver varieties used were Monto, a sterile selection, and a non-sterile type from Western Australia. The test plants were grown in the glasshouse in 200 mm pots in a sterile sand mix. Once they were established, five replicate plants were inoc ulated with 10,000 root-knot nematode eggs. A susceptible tomato cultivar (cv. Tiny Tim) was used as a standard for comparative purposes. Plants were harvested 6 weeks after inoculation, when egg masses on tomatoes were mature. Roots washed free of soil were immersed in a 1% NaOCl solution for three minutes and eggs were collected on a 38µm sieve and counted.

Results and Discussion

Both Vetiver varieties were highly resistant to all five root-knot nematode populations. Reproduction was approximately 1000-fold less than on the susceptible tomato. Vetiver also compared favorably with other grasses that have been found to be resistant to root-knot nematode in similar tests. Our results confirmed those of de Moura et al (1990) who found that Vetiver was "immune" to both *M. incognita* race 1 and *M. javanica.*

Conclusion

Since the grass was resistant to all major species of *Meloidogyne,* Vetiver is unlikely to exacerbate problems caused by root-knot nematodes when used as a cover, companion or hedgerow crop.

Soil Moisture And Sorghum Yield As Affected Vetiver Hedges Under Irrigated And Dryland Conditions.

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Soil moisture competition between Vetiver hedges and crop could affect crop yield. To date conflicting results have been stated and very few quantitative studies on this topic have been reported.

This paper presents the effects of Vetiver hedges on soil moisture and sorghum yield under various growing conditions. Treatments include hedge maturity (mature and newly planted), soil types (Vertisol and Alfisol) and moisture regimes (dryland and irrigated).

Gravimetric soil moisture and sorghum yield was recorded for each single row.

Under irrigated conditions on both soil types, mature hedges depleted more soil moisture than the sorghum crop and newly established hedges, but sorghum yield was

not significantly affected by the presence of either mature or young Vetiver hedges.

Under dryland conditions on Vertisol soil, the presence of a mature hedge significantly depressed sorghum yield of the first two rows adjacent to the hedges. Yield of row 3 and further was not affected.

The above results indicate that moisture competition does occur between mature hedge and the first few rows. However crop yield is only affected when soil moisture availability is very low. Under irrigation or adequate soil moisture conditions, yield of adjacent rows was not adversely affected by Vetiver hedges.

Panama

Report on visit to Western Panama

R.G.Grimshaw. The Vetiver Network

Regions of Western Panama have been identified as sites for soil and water conservation programs that will involve erosion reduction measures using biological systems. These include the use of grass hedge rows - primarily vetiver grass; on farm cultivation practices - primarily contour cultivation, and soil fertility and insitu conservation measures that focus on green manuring and leguminous cover crops - particularly applicable to the maize crop. This note will focus primarily on the use of vetiver grass as a hedgerow barrier.

***Photo #13**: Panama, Cerro Punta. This hedge was established on 100% slope to stabilize farm land in an area adjacent to the Amisconde National Forest. The system works and the farmer is happy with the results. Note how crops are now cultivated on the contour.*

Photo Credit: Dick Grimshaw

Existing uses of Vetiver in western Panama

In all the regions (Chiriqui, Veraguas, Herrea, Los Santos, Coclé and western Panama), see attached map, visited there was evidence of the existence of Vetiver grass (*Vetiveria zizanioides*). In most instances it can be found on household plots as single clumps of grass used for medicinal purposes. In fact it is apparent that in the past few years a large number of households have heard of the grass and have acquired it for this purpose. The local name is "Secate Valeriana". It was probably introduced from neighboring Costa Rica or Honduras. Some folk have had the grass for fifteen years or more. It should be noted that in no instance was vetiver reported as invasive, it was certainly not considered a weed, and no one had ever seen it flower. Many farmers showed very good powers of observation as to the grass's growing habits.

*P**hoto #12:** Panama, Los Santos Region. 2year old vetiver grass used for medicinal purposes.*

Photo credit: Dick Grimshaw

At Cerro Punta, in Chiriqui Region, the NGO group, AMISCONDE, was introducing vetiver grass for soil and water conservation. AMISCONDE had brought the planting material in from a coffee farm in nearby Costa Rica, and had established a small demonstration plot near its office. The Cerro Punta area is characterized by very steep hills., intensively cultivated with vegetable crops. Much of the cultivation is down the slope, and erosion studies indicate soil losses of more than 200 tons per annum. Much of this soil loss could be reduced if vetiver hedges were established on the contour across the slope. **Photo 13** shows one such hedge on a 100% slope. In this instance the farmer with the help of AMISCONDE technicians established a hedge on the lip of a small terrace. The hedge, about one year old is

well established and the farmer reports significant soil loss reduction, and much reduced rainfall runoff. The scene also shows how the farmer has developed vegetable beds on the contour. The farmer also cuts the hedge from time to time and use the cuttings as a mulch. These farmers are very much aware of potential soil loss as some of them dig small pits to trap sediment which they then dig and spread on their fields. The farmer is extending his hedge row plantings by using material from existing hedges and from additional material from Costa Rica.

Vetiver has been used to protect an irrigation pipes on steep hills. Many of these pipes, if unprotected, end up hanging in the air due to the erosion of the soil on which they originally rested. The hedge will also stop the pathways from eroding. Another use of the hedge rows on steep slopes is that they make a strong and stable pathway for farmers to get to their crops.

At Rio Sereno y Caizán a coffee farmer was using vetiver for stabilizing the edge of the coffee fields and the plantation roadsides. The growth of vetiver at these sites was extraordinarily good. It was all less than two years old, and had very good growth rates, probably due to the trapping of excess fertilizer from the adjacent coffee fields. The altitude was about 1,000 meters and rainfall about 1500 mm over a period of about 7 months. The coffee plantation owner was agreeable to set up a nursery for the up coming project. All the farmers and users of vetiver were information starved!! They were happy to be given copies of the Spanish edition of "Vetiver Grass - A Hedge Against Erosion" This booklet should be widely distributed in Panama as part of the soil and water conservation program.

On one occasion in Chiriqui vetiver had been damaged by a very large rodent (the size of a cane rat). The rodent had burrowed along side a row of vetiver in an effort to find a weak spot to traverse the vetiver line. In doing so it cut many of the vetiver roots. It is surmised that when fully mature hedge rows have been established it will be very difficult for the rat to penetrate the hedges, and therefore that latter might turn out to be an effective barrier against in field crop damage.

Proposed uses of Vetiver

On farm soil and water conservation. There are abundant opportunities to extend the practices just started in Cerro Punt to conserve the steeply cultivated lands that support high value vegetable and beverage crops. A 3 hectare site near Boquete that has slopes over 100%. Some large banks have been built across the slope to remove excess water, but these eventually fail with devastating results. This could be prevented if slopes were protected with vetiver. The vetiver lines would be planted about 10 meters apart, on the contour, starting from the top of the slope. These hedges, if planted 15 cm apart within the line, would be effective within a year, and would result in a slow down of runoff, and the retention of sediment and nutrients. Erosion would be further reduced by improved in field practices including mulching and across the slope cultivation. Water would no longer be concentrated and would be dispersed gradually across the slope.

Photo #14: *Panama, Cerro Punta. This scene is on the other side of the valley from that shown in photo 13. Note how crops are generally not cultivated on the contour. Slopes are over 100% and are eroding fast at an estimated rate of 500 tons of soil per ha per year.*
Photo Credit: Dick Grimshaw

In other areas such as Los Santos and Herrea soil slips are frequent due to shallow soils on a rather impermeable subsoil. These lands will erode rapidly and will slip. Vetiver grass hedge rows planted on the contour will prevent these problems. The predominant crop is maize. If the a leguminous cover crop of beans were planted with the maize then it would be possible to improve soil fertility substantially - as demonstrated in Honduras. The combination of vetiver hedgerows and leguminous cover crops would probably result in complete stabilization and soil fertility maintenance. Erosion would be reduced to less than 3 tons per ha, and run off would also be reduced. The result would be that current labor intensive slash and burn farming systems would be minimized, farms would be stabilized, land slips would no longer occur, and sediment loads in the streams and rivers would be very much reduced. Crop yields and incomes would improve substantially.

Waste land stabilization Vetiver has a good chance of growing on the hostile salt degraded soils near Chitré. These flat tidal areas have become totally denuded and are effected by wind and rainfall erosion. Vetiver should be test planted. If it grows, then vetiver hedges could be planted 50 meters apart. The effect would be to slow down runoff, improve infiltration and probably improve the washing out of salts. Grasses and other species are expected to establish naturally between the hedges. Trees such as Cassurina, and shrubs such as Atriplex (salt bush) should also be test planted to determine survival and growth rates.

Land slippage Most areas suffer from land slippage. Some are massive others are slight but could get very much worse. Some large slips have produced a massive amount of sediment directly into the rivers, and have been caused by deforestation for coffee, and further aggravated, in some cases by an unprotected road cuts. These slips could have been prevented if the land had not been deforested. Further soil losses could be prevented by planting vetiver hedges to stabilize the slip. A slip in Los Santos was probably caused by cultivation. This massive slip landed up in a nearby stream — just another example of

Photo #15: *This scene shows how the land in photo #14 could be laid out with vetiver hedges. The hedges should be placed 6 - 10 meters apart in the first instance.*

Photo credit: Dick Grimshaw

Photo #16: *Panama, Boquete area. This land slope was more than 100% (note the angle of the trees!!), cultivated to vegetables under a 2,000 mm rainfall regime. Vetiver hedge rows are the only way to stabilize slopes such as this one.*

Photo Credit: Dick Grimshaw

"point source erosion" The slipped area has naturally re vegetated, but could have been done quicker with the aid of vetiver grass hedgerows. In this case these slips were due to over grazing and the slip started probably along a cattle path. If these slips are not checked, massive sliding can occur at a later date. Vetiver grass hedges might stop this slippage, as the hedge roots could pin the shallow overlying top soil to the underlying parent material. Research needs to be carried out to determine hedgerow effectiveness and hedgerow architecture under different circumstances.

Stabilization of roads and river banks
Vetiver grass has been used for years in the Caribbean, Guatemala, Brazil, Bangladesh and Natal (South Africa) to stabilize road sides, drains, and river banks. In western Panama much of the sediment flow in rivers can be traced back to point source erosion sites. The collapse of a river bank or the fill area of a road will add tons of sediment to nearby streams and waterways. This has been identified in foregoing paragraphs in relation to land slips. A road side near Boquete that had collapsed and rebuilt could have been stabilized with vetiver to prevent slippage at a later date. A typical road site in the Chiriqui area has eroding side drains and rock debris fill from above. Much of this could be prevented if vetiver hedge rows were planted along the up side edge of the drain. The hedge would trap falling debris, and would keep the drain clean. Road drains erode because existing miter drains either don't exist or don't work. Often where they do exist they create gullying in the land adjacent to the road. This can be prevented by cutting a miter drain in the correct place, placing a vetiver hedge on the down side of the drain and extending it across the road side lateral drain (to act as a diversion), and protect the exit of the miter drain with vetiver hedges to prevent erosion.

River bank erosion can cause damage to property and structures. A property owner at the picturesque tourist town of El Valle had attempted to protect the garden from river damage using oil drums and concrete — not a very pleasing sight! and probably not a long lasting solution. Using containerized plants vetiver grass would probably provide a long lasting solution, and would look much nicer. River flow can also do great damage to road structures and can easily wash away gabbions. For long term stabilization river banks should be "graded" and planted to vetiver hedgerows using containerized plants. The gabbions and concrete should also be protected with vetiver. On the down stream side of the bridge there was a real mess caused by uncontrolled stream flow. Stream flow could be harnessed over a period of time by placing vetiver hedge rows (containerized plants) along what should be the stream bank. Over time sediment deposits would build up in front of the vetiver, and the vetiver would grow up through the sediment to form a new bank. Note planting of containerized plants should be at the end of the wet season when no further flooding is expected.

Readers should note that what is possible in Panama is possible through out all of the Central American countries. and is essential for farm land stabilization, if tropical forests such as the Amiscobe Forest is to be preserved.

USA

The following article is included to recognize the hard work put in by a team of scientists working for USDA to develop stiff grass hedge technologies for those parts

(the majority) of theUSA that is too cold for vetiver. It is believed that the standards set out in the following article have now been approved by USDA for farmer use.

Guidelines for the Establishment of Warm Season Grass Hedges for Erosion Control

C. L. Dewald, Jim Henry, Steve Bruckerhoff, Jerry Ritchie, Seth Dabney, Dan Shepherd, Joel Douglas, Dale Wolf. USDA/ARS/SCS

Soil erosion is a major problem around the world (3). An economical method to slow runoff and reduce soil loss is stiff, erect, densely-tillered narrow grass hedges. Such grass hedges are widely used in India, the West Indies, and other countries to reduce soil loss (10). The concept of using grass barriers for erosion control was proposed by USDA Soil Conservation Service (SCS) about 40 years ago in the United States but for a variety of reasons was not adopted.

In recent years there has been a renewed interest in the use of narrow stiff grass hedges as a conservation practice (7). Research has been done on application of grass barriers to reduce water (4) and wind (1, 11) erosion. Research has shown grass hedges to slow runoff, trap sediment, prevent gullying (4, 9), and enhance terrace formation (1). They are an inexpensive, biological, conservation technology compatible with current tillage systems (8).

In 1991 the USDA Agricultural Research Service (ARS) and the USDA Soil Conservation Service (S CS), now the Natural Resource Conservation Service (RCS) along with several universities initiated a program to study grass hedges to control runoff and reduce soil loss. In 1994, the SCS initiated a three-year evaluation of a national interim practice standard for the design and implementation of grass hedges as an accepted conservation practice.

Grass hedges differ from other common types of grass strips (i.e. buffer strips, filter strips) because they are narrow, planted with stiff, erect grasses, and capitalize on, rather than minimize, the formation of berms by deposited sediment. A dense uniform stand of coarse stems slows concentra ted runoff, causing backwaters as deep as 12 to 16" and allows time for deposition of eroded sediments. The deposited sediment fills in low spots in fields so that future runoff is more broadly dispersed and less erosive. The general concept of this technology is that narrow rows of grass hedges are planted in parallel lines across and perpendicular to the dominant slope of the field (7) (Fig. 1). The design, spacing and lateral extent for vegetative barriers in concentrated flow zones depends on anticipated runoff rates, topography, and other factors which have been detailed previously (4, 7).

Factors which influence the success of grass hedge plantings includes selection of the proper grass, use of high quality seed, proper seedbed preparation, precision planting, optimum timing and sound management practices during and following establishment.

Grass selection

Research has shown that a variety of perennial grasses that have coarse stems will work as hedges if they can be established as a uniform and dense hedge, and are tolerant of silt deposition. Warm-season grasses are probably better candidates for hedges because they are generally more robust and tend to have stiffer stems and, increased tillering within the hedge than most cool-season grasses. Grass hedges should consist of stiff, erect, perennial grasses which are adapted to local soil and climatic conditions. Grass barriers must have sufficient stem strength to remain erect against expected water flows.

Suitable barrier plants must satisfy several criteria. They must be tolerant to: (a) herbicides used on adjacent cultivated crops; (b) partial shading from cultivated crops; (c) inundation by sediment; (d) local climatic extremes (wetness, drought, freezing temperatures, etc.); and, (e) easily established from available materials; (f) long lived and manageable as a narrow strip; (g) nonweedy and not too competitive with adjacent cultivated crops; and (1) relatively tolerant to defoliation if crop residues are grazed. Switchgrass (Panicum virgatum L.) and eastern gamagrass (Tripsacum dactyloides L.) are two warm season, perennial native, non-weedy species with potential as hedges in much of the United States.

Switchgrass has a wide area of adaptation, determinate seeding habit, smooth (nonchaffy) seed characteristics for ease of handling, and prolific' production of coarse durable vegetation making it a leading candidate for use in grass hedges for erosion control. Research on switchgrass improvement has been conducted for many years and has resulted in no less than a dozen released improved varieties which has increased the adaptation potential of the species considerably (12). State Extension and/or local NRCS personnel should be consulted to determine the variety best adapted to a particular site and situation.

Eastern gamagrass has recently received considerable attention for use in grass hedges for erosion control. Problems inherent to the species, including indeterminant low seed production, seed dormancy and resulting problems in stand establishment (2) have slowed the progress in eastern gamagrass variety development, but the erosion resistance potential of the grass merits further research. The crowns of eastern gamagrass are formed by a proliferation of compact shoots consisting of vegetative and reproductive tillers in various stages of development (5). Shoots are interconnected through several tiller generations by a thick (1/2 to 1") woody proaxis (stembase) chain network which remains intact for several years acting as a considerable deterrent to erosion. The dynamic crown has the capacity to elevate coarse aerial foliage above sediment coverage and to anchor the plant in place with stout (1/16 to 1/8" diameter) brace roots.

Seedbed preparation

Poor seedbed preparation is a major cause of stand failures in grass plantings and therefore seedbed preparation should be planned and initiated well ahead of planting. Methods of seedbed preparation (the cultural treatments needed to produce a suitable medium for optimum germination and seedling emergence) will depend largely on the condition of the site to be seeded.

No-till seeding can be ideal, provided the seedbed allows the placement of seed at an optimum depth and the planting operation is capable of firming the soil above and around the seed to obtain good seed-soil contact which is necessary for retention of soil moisture in direct contact with seeds during the germination process.

No-till seeding into areas with excessive surface residues (50% or more of the soil surface covered) or with weed competition

is not recommended. Excessive surface residues and weed competition can often be reduced by mechanical means, burning and/or the use of broad spectrum herbicides prior to grass seeding. In cases where such remedial practices are not feasible it will be necessary to resort to tilled seedbed preparation methods.

Tilled seedbeds have the same rigid requirements for, successful grass hedge establishment as outlined for no-till seedbeds. An ideal seedbed will result in optimum soil-moisture-seed relationships during seed germination and early seedling establishment. A firm smooth soil surface, not excessively compacted, is required to facilitate precision planting and to optimize soil-moisture-seed relationships. The disk, offset or tandem, is probably the most common tool used for seedbed preparation when site conditions allow for its effective use. Harrowing and cultipacking following disking helps smooth and firm the seedbed.

Excessively loose and rough seedbeds hamper seeding success because seeding depths cannot be controlled accurately. Soils should not be worked when excessively wet, and any operation which results in the formation of clods should be avoided. Grass seeds are small and must be planted relatively shallow in order for the energy stored within the small seed to power the seedling emergence process. Firm seedbeds are essential as loose porous seedbeds do not provide adequate contact between seeds and the underlying soil water needed to ensure germination of seeds placed near the soil surface.

Use good quality seed

The use of good quality seed is essential to allow for precision planting and to help ensure success of grass hedge establishment. Seed should be purchased from a reputable seed source on a pure live seed (PLS) basis. The seed tag should list the percentage purity, other crop, inert, weed seed, germination, hard seed, dormant seed, and total germination of the product. It is very important to plant seed with high purity as this reduces the percentage of detrimental materials, (i.e., inert which interferes with planting efficiency, and other crop and weed seed which can compete with the grass seedlings during establishment). Most seed tags include percentage hard and/or dormant seed which are seed determined to be viable, but which fail to germinate following standardized preconditioning treatments. Percent germination, firm seed and/or dormant seed are summed and reported as total germination. Pure live seed is determined by multiplying the decimal value of % purity by % total germination. A high percentage PLS is an indication of over all seed quality.

Stratification by moist prechill occurs in nature as seeds fall from the grass plant in the Fall and lay dormant on or in the soil throughout the winter until soil temperatures are conducive for germination the following Spring. The natural stratification process is short circuited when seeds are harvested from the plant, stored dry over winter and planted in warm soil the following spring. In laboratory tests seeds of switchgrass and eastern gamagrass are subjected to standardized moist prechill (stratification) treatments designed to break dormancy and enhance germination. A do-it-yourself germination test that measures actual germination without artificial stratification is often more meaningful than laboratory tests. A “ragdoll” test can be conducted by placing 100 seed on the right half of a wet paper towel, folding the left half of the towel over the seed, and rolling it into a tight tube. Excess water should be allowed to drain from the ragdoll which can then be sealed in a plastic sandwich bag to prevent excessive drying. The ragdoll should be kept in a warm (70-85˚ F) place until germination counts are made 7 days later. Placing some seed you know will germinate (alfalfa, millet, clover) in a similar ragdoll will confirm that the test conditions are suitable for proper germination. The number of seed which germinate in the ragdoll is equivalent to actual % germination and can be multiplied by % purity, expressed as a decimal value, to calculate pure actual germination (PAG). Pounds of seed/A on a PAG basis can be calculated by dividing the laboratory PLS by the obtained PAG and multiplying by lb PLS recommended per acre. This usually amounts to an increase in seeding rate which gives added insurance for rapid establishment of a thick grass stand.

Eastern gamagrass seeds consist of grain (caryopses) enclosed in a hard woody fruit case which protects the grain and inhibits germination of the grain until stratification is induced (2). The protective fruit case makes up about 70% of the total weight of good quality gamagrass seed and a much higher percentage of poor quality seed weights. Good quality eastern gamagrass seed should have at least 95% purity, a PLS of 80% or better and 6000 or less seeds per pound. Stratified seed (i.e., moist prechill at 35 to 45˚ F for at least 6 weeks) should be purchased from reputable dealers to increase the success of grass hedge establishment.

When to plant

Spring planting should be done as soon as the soil temperature warms up to the point required for optimum germination of the seed being planted and if possible just prior to the greatest probability of substantial or prolonged rainfall. In some areas these two factors may not coincide, thus a compromise may be necessary.

Switchgrass and eastern gamagrass should be planted when soil temperatures stabilize in the range of 65 to 80˚ F at a 1" depth-below the soil surface. Faster germination and seedling emergence will occur w hen soil temperatures are near the upper limits of the temperature range (80 to 85˚ F) when soil moisture is not limiting. Planting dates will vary depending on locations but are generally between March 15 and May 15 in the South and May 1 to June 15 in the northern states. In relation to other crops, the warm season grasses should be planted later than corn, but prior to cotton or soybean planting time.

In general, later planting dates will allow more time for weed emergence and weed control prior to grass hedge planting, but this must be considered in relation to timing of rainfall probabilities. In more arid areas it may be better to plant as soon as the 1" soil temperature reaches 65˚ F; whereas later plantings are preferable in more humid zones.

Planting rates

Planting rates for grass hedge establishment should be two to four times more than rates recommended for pasture plantings because grass hedges are planted in narrow strips with their function requiring a rapid development of a dense stand of grass.

Switchgrass planting rates should approximate the critical area stabilization rate (i.e. about twice that of pasture plantings) which translates to a minimum of 44 potential

seedlings per square ft. of the planted area. This is equivalent to 8 to 10 lb. PLS per acre, but if a ragdoll test shows that actual germination is overstated on the seed tag, the seeding' rate should be adjusted upward accordingly. Grass hedges occupy only a small percentage of the total field area so that increased seeding rates are usually cost effective.

Eastern gamagrass should be planted at the rate of 10 to 12 lb. PLS/row mile of hedge and lb./A will vary depending on the row spacing to be used. The 10 to 12 lb. PLS/row/mile will be equivalent to 9 to 13 pure live seed per linear ft of row. The amount of seed needed can be determined by multi plying the miles of hedge rows to be planted times 10 to 12 lb. PLS (i.e., 1 mile of 2 row hedge 1 x 2 x 10 to 12 = 20 to 24 lb. PLS needed).

Planting procedures

Width of grass hedges should be a least 1 to 2 ft. wide to a maximum of five ft. Wider strips can be narrowed down with cultivation once the hedge plants are well established (Fig. 2 and 3). A single row of a dense grass stand is usually adequa te except in concentrated flow areas where at least two rows are required.

Switchgrass is usually drill seeded in rows 6 to 8" apart at a depth of 1/4 to 1/2". Seed placement should be uniform in rows with drills having a small seed attachment. Drills equipped with double-disk openers with proper depth bands facilitate placement of seed at the proper depth (Fig. 4). The depth bands should be secured to the disk openers at a distance of 1/2" from the cutting edge of the disk. Tension on the disk openers should be such that the depth bands roll on the soil surface and do not become submerged nor ride above the soil surface. Packer wheels on the drill which firm the soil over the planted seed are also very beneficial. Drag chains, though inferior to packer wheels, may also be used to cover and firm the soil around the seed, and a cultipacker or roller may be used immediately following planting if needed to firm the soil.

Stratified seed of eastern gamagrass should be planted 1 to 1-1/2" deep. Planting in deep furrows in soils subject to washing should be avoided as seed can be covered too deep. Planting shallower than 1" will have less favorable moisture - seed relations and emergence may be delayed. Row planters (corn, cotton, peanut, etc.) are easily adjusted to plant gamagrass in rows. The row planter furrowing out shovels or disk openers can be set to push away dry surface soil and insure the placement of the grass seed in a moist environment. The covering device should be set to cover the seed with moist soil and the packer wheel adjusted to firm the soil over the seed row. Stratified seed has increased weight due to extra moisture content and calibration is best done by counting the seed to determine the number dispensed per linear ft of row (i.e. 9 to 13 pure live seed/ linear ft of row is recommended).

Management practices

Washout or other problems may cause voids or skips in the grass hedge which require replanting. Reseeding by hand broadcasting and covering the seed by a hand rake may be practical for reseeding small voids. In concentrated flow areas, replanting washouts with veg etative transplants may be more effective than reseeding as transplants provide quicker cover and provide protection sooner than seedlings.

Both switchgrass and eastern gamagrass can be established vegetatively from crown material transplanted during the dormant season prior to spring green-up (6). Propagules can be obtained from adjacent established plants by splitting off portions of crown material with a shovel and replanting the crown material in the voids. Individual transplanting units of switchgrass should have at l east 4 to 5 viable shoots (stem base) while eastern gamagrass should have at least 3. The transplants should be spaced no more than 6" apart in the row to create a dense hedge.

Fertility levels of phosphorus (P) and potassium (K) which promote good growth of the companion cultivated crop will be adequate for grass hedges. Soil tests are required to determine P and K needs if they haven't been applied recently in the crop management program. Nitrogen should not be applied until after a good grass stand is obtained and plants have reached a height of at least 4" because N promotes weed growth and competition. After the grass is established it should be fertilized annually with 60 lb actual N/A preferably in April or early May.

Mowing at a 10 to 12" height is a good practice for control of tall weeds during establishment and for hedge maintenance thereafter. Usually an early-summer mowing is needed to prevent the grass hedge from lodging on the adjacent crop rows. Grass hedges should not be mowed shorter than 10-12" as this is a minimum height for hedge efficiency and lower cuttings during periods of active growth may severely reduce the vigor of the grass.

Burning can be an effective tool for grass hedge management, but the timing of burning is critical. Winter burning is not recommended as the dormant hedge still maintains a high degree of its water impounding function during this period (Fig. 5). Burning just prior to spring greenup of the hedge would reduce the time that the hedge would lose effectiveness and should be considered in relation to period of probable runoff. Burning stimulates grass hedge tillering and vigor, but caution in its use is recommended.

Summary

Grass hedges can be a relatively economical means to slow runoff water and reduce soil loss. There are several factors which will influence the success of grass hedge establishment including grass selection, seed quality, seedbed preparation, planting procedures, timing and management practices during and following establishment. Failure to consider any one of these factors may jeopardize the success of grass hedge establishment. Grass hedge establishment is not simple nor easy, but the rewards from a well established grass hedge should offset the effort. Good Luck.

(if readers would like to learn more about this technology, contact:
dabney@gis.sedlab.olemiss.edu
....Ed)

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QUIZ

US $20 for the first correct answer as to what the above image represents. Don't forget to send in a piece about what you are doing with vetiver grass along with your answer to Dick Grimshaw at the The Vetiver Network

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

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

Available from The Vetiver Network.

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