Advance of Scientific Research on Vetiver System

Reviewer

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Vetiver Grass, A Little Recent History and Thoughts for the Future

1 SOME HISTORICAL PERSPECTIVES

1.1 How it all started

Fifty years ago, in the Fiji Islands, the Sugar Company was going to extend its cane fields into the hills. I was given the task of carrying out a soil conservation program to prevent erosion. Before coming to Fiji, I had been trained in the "latest" methods of soil conservation by the New South Wales (NSW) Soil Conservation Service (SCS), in Australia.

This was the system of constructed contour banks, diversion banks, and absorption banks waterways leading to low dams or the drainage network. It was the accepted system of soil conservation. Books had been written on the subject since the early 1930s, it was taught at all the Universities round the world, it was not questioned - this was the accepted method of preventing erosion.

Vegetative methods had been tried in the past in many parts of the world using trees, shrubs and grasses, but somehow they never really amounted to much or were never fully recognized, written about or talked about.

The constructed system of soil conservation started in the United States was initially confined to the temperate regions. Laws were enacted to ensure that land users complied with the system. It worked under well-controlled design criteria and maintenance programs monitored by the Government.

Nobody really questioned it, it was an engineered system and erosion was considered to be an engineering problem - end of story.

When I was faced with the problem in Fiji, it occurred to me that our system of soil conservation was going to be challenged by a vastly different set of circumstances. Here we were now, in a 1700 mm rainfall area with no idea of the maximum intensity to be expected. How do you design contour banks, waterways or dams and spillways when you have no idea what they are expected to control. You build them "big"!

I thought it was time we experimented with some vegetative methods of control at the same time as we were constructing our contour banks. Among the 20 shrubs and grasses that I tried as conservation hedges, one was Vetiver grass.

Fortunately it was not very long after we started the construction of our conservation banks using heavy earth moving machinery, that we experienced our first tropical down-pour, 500 mm of rain fell in three hours. This episode changed my outlook on soil conservation in the tropics, completely. Our constructed banks were devastated, where they had breached they caused more erosion than if they had never been used in the first place, they were a disaster. ***My vegetative hedges were not much better; they had taken a battering with the exception of this strange grass that I knew little about "Vetiver grass".*** Remember, I am talking 50 years ago, Vetiver's little hedge had not been affected at all by the storm, the ground around it had not been eroded, it had worked perfectly.

The sugar company, being a private Company, wanted erosion controlled, they were not interested in what the books said, if we thought that the vegetative system worked and was not going to be a problem, then use it. So started my long association with the vetiver system.

The Sugar Company insisted that all the contract growers use the vetiver system to control erosion on their cane farms. We tried to have the vetiver system made law in Fiji but the government "boffins" would not accept it as they did not know enough about it - "it may become a terrible weed"; "it may become a vector for diseases of other economic crops"; though anecdotally we knew it would not, as later proved by Truong and Creighton (1994).

As it turned out, the vetiver system in Fiji has done an excellent job in controlling and virtually preventing erosion in the cane fields for the last 50 years, aided by the fact that we also insisted that all sugarcane must be planted on the contour, or at least across the slope (Truong and Gawander, 1996).

I worked with vetiver in Fiji for 10 years and I knew that its roots formed a bio-dam extending down to at least three meters by observing gullies that had cut up the road banks to the vetiver hedges in cane fields.

We did not have the time or resources to carefully excavate the root system to its full extent as they have now, in Thailand, or to do the essential research that has now been conducted in Malaysia, by Dr. P. K.Yoon, in Queensland by Dr. Paul Truong and his colleagues, in Thailand by the staff of the Universities, several Government Departments and Institutions. Or in China and other countries now working with the vetiver system.

One mistake I made in Fiji was to insist, initially, that the hedges were carefully pegged out on the strict contour. This was a hang over from the constructed system of conservation, which conveyed the runoff to a waterway or a safe outlet in the drainage network. This was the greatest misuse of the vegetative system for two obvious reasons:

- The farmers could not easily follow the contorted contours with their plows and therefore were not happy adopting the system.
- The vetiver hedges do not convey the runoff, therefore they do not need to be on the strict contour, they filter the soil out of the runoff and let it pass on through, while slowing it down and taking the erosive energy out of it. Planting the hedges across the slope and not exactly on the contour not only saved a lot of planting material, but formed level terraces behind the hedges.

1.2 Advantages of the vegetative system

Let me list the many advantages of the vegetative system over the constructed system of conservation in the tropics.

Constructed system	**Vegetative system**
• Requires the use of heavy earth moving equipment or large gangs of labour at great cost.	• One farmer can plant it alone.
• The system has to be designed and surveyed in to the correct levels.	• Simply planted across the slope.

• The system does not fit the infrastructure if it has to reach a given outlet point.	• The farmer can place the hedges where they suit his needs.
• The hedges have to traverse other farmers fields to reach a safe outlet for the runoff.	• The system stays within the area it is being used in; no other farms need be involved.
• The constructed banks take up a strip of land at least five meters wide.	• Only takes a strip of land 50cms wide.
• Requires continual maintenance and rebuilding every five years	• Once established, requires little maintenance
• Diverts runoff, does not control it, thus creating a problem somewhere else down the catchment	• Captures runoff and controls spillover all the way down the slope.
• Needs waterways which are an added cost and an on going problem causing more erosion	• Needs no waterways.
• Have a limit of 1000m in length and then must be 'spilled' in to an outlet or they will 'overtop' and breach.	• Can be run for kilometers as they do not hold or convey runoff but slow and filter it.
• Transports silt to the outlet and ultimately to the river or sea.	• Traps silt in-situ.
• Strict contours too hard to follow with cultivation equipment.	• Planting across the slope, easily followed with cultivation tools.
• Cannot be breached for access or crossed by machinery.	• Can be safely breached or crossed without causing erosion.

For years, I traveled round the world working in various countries and preaching the gospel of 'moisture conservation in-situ'. However, working on one project in Indonesia where I couldn't find vetiver, I used lemon grass (*Cymbopogon nardus)* initially it looked good but it did not form a proper hedge (many of the plants dying in the first three years), and ultimately the runoff ran through it, eroded it, and it failed.

1.3 Rediscovery of Vetiver Grass

I could not find any source of vetiver grass until the 1980s when World Bank posted me to India where I joined Dick Grimshaw's team on "Watershed Development". In India, our watershed projects were going nowhere as they lacked a technology to stabilize the soil and control runoff. India, the 'home of vetiver' was the country I had always wanted to visit and especially work in, as this is where I should be able to get some answers to so many questions that had concerned me about the future of a vetiver system.

When I began work in India, I was really pleased when I found vetiver plants growing just outside New Delhi. This meant I could start again and really get the vetiver system moving. Ultimately we were able to get these large Watershed Development Projects converted to the vetiver system. But still all the evidence on the use and safety of vetiver grass was anecdotal. We desperately needed some quality research work carried out on *Vetiveria zizanioides*. When ever we introduced vetiver in to a State in India we met the same 'brick wall' - where is the scientific evidence?

Initially we met strong opposition in India to the introduction of the Vetiver system. Once again, it was a biological system and it had not been given scientific clearance.

It was not until we discovered vetiver hedges being used in the southern State of Karnataka to mark out farm boundaries, that resistance began to soften to its use in other States. The experience of the farmers coupled with our experience elsewhere enabled us to go ahead with our recommendations for expanding the use of the Vetiver System. But, we still did not have the backing of peer review, or good research data.

In 1989 I was asked to give a presentation on the vetiver system to our colleagues in the World Bank in Washington. At that Seminar was a member of the US National Research Council, representing the Board on Science and Technology for International Development (BOSTID), Noel Vietmeyer. Noel had been impressed and asked me to give the same presentation next day to the Rockefeller Foundation, the same institute that gave the green revolution to the World. But, once again without backing of good research data, little changed, though the World Bank was prepared to support the system and printed the first edition of my extension workers handbook, now know widely as "The Little Green Book".

However arising from that presentation came a request by Noel Vietmeyer for financing a world wide study of vetiver grass. This was supported by The World Bank, The Scientific Adviser of the US Agency for International Development, and The Soil Conservation Service of the US Department of Agriculture. The study was overseen by a specially appointed National Academy of Sciences panel, chaired by Norman Borlaug, Nobel Peace Prize winner in Agriculture.

The panel evaluated the experiences with vetiver grass of some 50 countries and received information from some 200 specialists, but could find no obvious flaw or hazard. In 1993, the National Academy published their results in the little blue book, "Vetiver Grass: A Thin Green Line Against Erosion".

However, the burden of proof still remained with the research workers.

It wasn't until Dr. P.K.Yoon, Plant Scientist of the Rubber Research Institute in Malaysia took up the challenge to do some detailed research in to vetiver, and our claims, that we started to get the results we needed. Dr. Yoon's Report "A Looksee at Vetiver" was a classic and our first breakthrough giving some credence to our claims of the value of vetiver.

Since then, research in to all the aspects of the use of and versatility of vetiver have followed. Our colleague Dr. Paul Truong. has documented some outstanding discoveries for other uses of vetiver apart from soil erosion control, in phytoremediation, reclamation of mine dumps, landfills, sewage, its tolerance of heavy metals and ability to filter toxins before they enter the watertable, to name a few. In Thailand, Diti Hengchaovanich's research confirming that vetiver's use for slope stabilization and erosion control can be the basis for road engineers to use the grass to stabilize road cuts and fills.

2 WHAT DO WE NEED TO KNOW?

After years in the field, I have been given the daunting task at this conference of addressing the advance of scientific research on the vetiver system, from the start already made. I am strictly a field man, but I do know, after years of being questioned about the abilities of vetiver grass, what I don't know, and what we need to know once and for all to appease the skeptics.

The diversity of the research work that has been done so far is quite outstanding. That one plant in the family of Gramineae can be so unique and offer so much to the human condition is quite astounding. Apart from all the other aspects of the use of vetiver grass and its products.

But from the point of view of a "layman" in the field, I need to know:

- Vetiver can take the toxins out of effluent, but the vetiver root system turns over almost seasonally. What happens to the toxins it takes up? How many seasons can vetiver take up toxins before they affect the plant itself? What happens to the toxins vetiver absorbs?
- Can vetiver be recommended as a sustainable control of septic tank outlets and prevent their nutrient load and toxins from entering the ground water or flowing in to the sea posing a problem for Aquaculture? Is this treatment, using vetiver hedges, sustainable over the long term?
- Vetiver has been found to be effective in stabilising coastal sand dune and beach sand, but can vetiver hedges stabilize sand dunes in semi-arid areas. We have to think of ways the vetiver system can be used to alleviate the suffering of farmers in the dry regions of countries like Ethiopia.
- Can vetiver hedges be established in arid areas using wide "V" ditches to harvest runoff and planting the hedges in the bottom of these ditches, here they would also trap nutrients for their own use.
- Do vetiver hedges repel or otherwise affect insect pests from field crops like coffee, etc.?
- There is far more off-take of leaf than can ever be used in handicrafts in areas with many hedges; we need to do some research into the value of vetiver mulch, especially for the benefit of organic farmers.
    - Does vetiver mulch have the anecdotal pesticidal and fungicidal qualities it is quoted to have?
    - How is it best prepared and used as a mulch after harvest? What are its mulching characteristics and limitations? Is there a business opportunity for subsistence farmers here - Baling vetiver, which would have excellent storage qualities, and then transporting it to organic farmers and selling by the bale. How long do bales of vetiver last in storage?
- There is fascinating research being done on the chemical products of vetiver, and their potential impact on human medicine, on insects like termites, and on ticks and other organisms, and other uses we can scarcely guess.

Each of these topics will improve production or services for vetiver users, and for those downstream. Thankfully, unlike most technologies, the vetiver system becomes organically more self-sufficient with time, and cheaper, requiring mostly labor rather than off-farm inputs. And I have not even mentioned big-picture research to document the enormous enhancement of environmental aesthetics and general quality-of-life that can come from living in a landscape protected by vetiver. That's what all the other research is all about. I have given you concrete examples of what I consider important and rewarding areas of practical research. These fall under more-general headings of bioremediation, water purification and sanitation, use in semi-arid and marginal lands, use as a moisture and nutrient trap, use together with other agricultural and engineering techniques such as IPM (integrated pest management), use of biomass, and use of special bioproducts that seem unique to vetiver. But let us not forget the main strength of this plant - improving the lives of the poor subsistence farmers throughout the world.

3 REVIEW OF PAPERS

As compared with other topics at this conference, only four full papers were submitted to the conference, which covers subjects as diverse as botanical studies, DNA typing to computer modelling.

3.1 Botanical studies

Hanping Xia and Bingbing Yang (2003) made observations for growth and development of 12 ecotypes of vetiver grass, which were collected from China and abroad. The results showed that there was a great diversity in growth patterns among the plant tested. For instance 'Karnataka' from India grew shortest and did not flower; 'Kandy' from Sri Lanka yielded the most tillers and the second least number of inflorescences next to 'Karnataka'. As for root development 'wild vetiver' from Guangdong, China produced the lowest root biomass and 'zomba' from Malawi the highest. Regarding the plant's appearance, 'Karnataka' seemed to be greener than the other ecotypes, especially in juvenile stage; but it produced shoots from the lateral buds of the culm when it matured.

In a second study, Hanping Xia *et al*. (2003), selected eight grasses: vetiver grass (*Vetiveria zizanioides* Nash), Bahia grass (*Paspalum notatum* Flugge), Aciculate chrysopogon (*Chrysopogon aciculatus* Trin.), Bermuda grass (*Cynodon dactylon* Pars.), common Centipedegrass (*Eremochloa ophiuroides* Hack.), St. Augustine (*Stenotaphrum secundatum* Kuntze.), Carpet grass (*Axonopus compressus* Beauv.), and Sour Paspalum (*Paspalum conjugatum* Bergius) for a comparative study on their tolerance to submergence. Plants were first raised in pots, and then put into a cement tank filled with water. After three years of observations, it was found that vetiver and Bermuda grass could tolerate the longest time of submergence, at least up to 100 days, and probably longer than that; Bahia grass ranked second, lasting up to 60-70 days, followed by Carpet grass, up to 32-40 days, and then Aciculate chrysopogon and Sour Paspalum, up to 25-32 days, and then St. Augustine, up to 18-32 days; the poorest species to resist submergence was Centipede grass, only 7-10 days. Moss seemed to be a factor influencing the tolerance of plants to submergence, inferring that muddy or polluted water kills plants more easily than clear water. This experiment, leading up to the final tolerance of vetiver and Bermuda grass and the tolerant mechanisms of the 8 species, is continuing. These findings are very important as information on vetiver's performance under water and how long vetiver can withstand flooding before it is killed. It is known that muddy or polluted water often kills plants such as in flooded sugarcane, once the silt gets in to the growing point, the plant dies. Such information is needed for erosion control on stream, river and lake banks.

3.2 DNA Typing

In a study on the genetic diversity of vetiver grass, the genetic relationships 13 ecotypes of vetiver grass from 8 countries were analyzed by means of RAPD molecular makers (Zhaoxia Dong *et al* (2003). The results showed that a total of 220 reproducible RAPD fragments were produced using 18 random primers. 111 fragments (84.55% of the total observed) were polymorphic, which indicated that there was very high genetic diversity and conspicuous genetic differentiation within the 13 ecotypes of vetiver grass. Through the results of Neighbor-Joining (NJ) cluster analysis, 13 ecotypes of vetiver grass were divided into 2 groups. One included 7 ecotypes, i.e. Sunshine, Zomba, Domesticated type, Wild type, Capitol, Lilongwe and Malaysia, these were strongly supported by a bootstrap value of 100% reflecting very close relationships of these ecotypes.

Bob Adams has shown that most of these ecotypes are genetically very uniform when compared to other vetivers. Now, Zhaoxia Dong and colleagues have shown that their two accessions seem to fit into this grouping too. It is time these genotypes receive cultivar names, to replace the descriptors "wild" and "domesticated". They have also compared the ecotypes to one-another and proposed some unique relationships that merit additional analysis. Their apparent confirmation of a great deal of genomic diversity at this level is, of course, great news. But it also only underscores how little we know about the genetic and physical variation of vetiver, and how important it is to continue research. The time will come soon when molecular biologists can understand which genes control which characteristics, but that will only be possible by also identifying as many genotypes as possible, and studying their behaviors in the field.

3.3 Computer Modelling

In recent years**, c**omputer models have been increasingly considered as an essential tool for managing environmental systems. The complexity of wastewater management has made computer models instrumental in the planning and implementation of industrial wastewater disposal schemes. Truong *et al.* (2003) presented the coming of age of VS application, where vetiver grass was calibrated and use for a computer model, MEDLI – Model for Effluent Disposal by Land Irrigation.

In Queensland, Australia, the Environmental Protection Authority has adopted MEDLI as a basic model for industrial wastewater management. MEDLI is a Windows based computer model for designing and analysing effluent disposal systems, which use land irrigation, for a wide range of industries such as piggeries, feedlots, abattoirs, sewage treatment plants, and food processing factories.

To date the application of MEDLI in tropical and subtropical Australia has been restricted to a number of tropical and subtropical crops and pasture grasses. These species have been specially calibrated for MEDLI use. Due to its extraordinary capacity for nutrient uptake, particularly Nitrogen and Phosphorus, vetiver grass has recently been calibrated for MEDLI application.

This paper introduces MEDLI, outlines parameters needed to run the model and illustrates its application, using the new vetiver calibration data, to develop and plan a sustainable effluent disposal system for a food-processing factory and an abattoir.

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