Notes on the Visit to Vietnam
2 – 22 Jan, 2005

Paul Truong

OBJECTIVES

1. To introduce the new VS technology of wastewater treatment to Vietnam for the **Wallace Genetic Foundation** project
2. To discuss/select demonstration sites for the **WGF** project on ***Water Quality Improvement***
3. To follow up on the progress of various vetiver projects carried out with the **Donner Foundation** grant.
4. To inspect various vetiver projects carried out with the technical assistance of VNVN.

OVERALL IMPRESSION

My overall impression is that VS has "invaded" Vietnam in a way I could not imagine or have seen anywhere else in the world.

Exactly six years ago, in January 1999, on the urging of Dick Grimshaw and Ken Crismier; Diti Hengchaovanich and I arrived in Hanoi on the invitation of the Vietnamese Ministry of Agriculture and Rural Development (MARD) to introduce vetiver and its applications in soil and water conservation in farmlands and steep slope stabilisation to VN. This was followed 8 months later by a very generous donation of three truckloads of planting material from the Thai Department of Land Development. The vetiver was collected from Nong Khai, it went through Laos and delivered to Nghe An in central Vietnam.

This was the first official introduction of vetiver grass to Vietnam for environmental protection purposes. Before that, vetiver is known to only a few people as an industrial plant used for some very small scale essential oil extraction. Six years later VS has been used extensively for road, dike and riverbank stabilisations throughout the country and to a limited scale in cassava cultivation in the north and coffee and cocoa plantations in the Central Highland.

Driving along approximately 500km northern stretch of the newly built Ho Chi Minh Route, which follows the old Ho Chi Minh trail, I could not believe what unrolled in front of me, rolling steep hills covered by neat rows of vetiver, mostly just vetiver but also in many places incorporated neatly with rocks and concrete structures. Over this stretch there were both new and old plantings, must be in the 100s, where VS was applied correctly I saw only one failure. This was due to underground seepage on a recent planting. Where vetiver was not used or used incorrectly the sight of erosion, landslips and landslides are of monstrous scale.

The most pleasing impact is at least three international NGOs are now using VS for their Natural Disaster Mitigation projects: The Danish Red Cross in north Vietnam, World Vision

and AusAid (Australian Aid) in central Vietnam for estuary and farm dike protection against flash flood in the rain season and salt water intrusion in the dry season.

VS has not only protected the environment but some government agencies have also used VS effectively to directly improve the living standard of people subjected to annual flooding in the Mekong Delta.

Based on what I have seen so far I do expect and hope that the introduction of the wastewater treatment application will have the same impact and momentum in Vietnam in the years to come.

All these were achieved by the dedication and hard work of Dr Le Viet Dung and his team from Cantho University in the Mekong Delta, Dr Tran Tan Van, PRVN Country Representative and VNVN Coordinator in the central and northern regions, Le van Du and Pham Hong Duc Phuoc from the University of Agriculture and Forestry HCM City in the central Highland, and significantly Elise Pinners, TVN Associate and Senior Advisor, with funding support from the Donner Foundation and the small grant program from the Dutch Embassy in Hanoi. My contribution has been only advisory since 2002, after the setting up of the Donner Foundation Projects.

PRESENTATIONS AND SEMINARS

Paul Truong, Tran Tan Van, Le Viet Dung and Elise Pinners presented a series of seminars throughout the country: Hanoi, Hue, Da Nang, Quang Ngai and Paul Truong in Cantho, to introduce the VS wastewater treatment technology to government officials, universities staff, international NGOs and industries groups.

At each presentation Paul Truong mentioned that with a grant from WGF, The International Vetiver Network wishes to introduce the wastewater treatment technology to VN by initiating a number of demonstration sites to show an effective and simple solution using VS to mitigate this very serious environmental hazard. The sites selected require in-kind contribution to the project at least equal to the contribution by WGF.

Jan 8: Cantho University staff and Dr Mai Viet Thuy, General Secretary of the Vietnam-Australia Foundation. Presentation on ***VS for Wastewater Treatment***

Jan 11*:* Quang Ngai, presentation on ***VS for Riverbank and Dike Stabilisation*** to provincial officials and KBR staff

Jan 13: Da Nang City, presentation on ***VS for Wastewater Treatment*** to City and provincial officers, Universities and NGOs

Jan 14: Hue City, presentation on ***VS for Wastewater Treatment and Erosion and Sediment Control*** to City and provincial officers, Universities and NGOs.

Jan 19: Hanoi, presentation on **VS for Environmental Protection** at the Research Institute of Geology and Mineral Resources (RIGMR) with audience from several government ministries and also **Ken Crismier.**

Jan 20: Hai Hau, Nam Dinh Province, presentaation ***VS for Riverbank and Dike Stabilisation*** to local and provincial officers and Danish Red Cross staff.

Seminar in Hue City and participants queuing up for Elise Pinners to down load the Powerpoint Presentations

SELECTION OF DEMONSTRATION SITES FOR WGF PROJECT

The aim is to select demonstration sites at strategic locations to maximise their exposures. A number of options were discussed with the VNVN and the followings are selected:

- A municipal wastewater treatment/disposal site
- An industrial wastewater treatment/disposal plant
- A city or municipal landfill leachate treatment/disposal site
- A rural site contaminated with herbicides, pesticides and other toxic chemicals.

The responses were very enthusiastic and all agreed that they would contribute to the site preparation, establishment, monitoring and if needed chemical analyses of water samples. Further discussions are to be held with participating organizations and Le Viet Dung and Tran Tan Van will decide on the final sites.

These experimental/demonstration sites will be designed to show the effectiveness of VS in reducing the nutrient loads and heavy metals in wastewater and effluent, agrochemical and toxin contaminants in eroded soil. The project will last for 2 years and preliminary results will be presented at ICV4 in October 2006.

1. ***A municipal wastewater treatment/disposal site.***

Vi Thanh is the capital city of the newly created Hau Giang Province in the Mekong Delta. As a new city, its infrastructure is very poor, particularly in runoff water and wastewater disposal/treatment facilities.

Storm water from the city streets and houses all run into numerous ponds and shallow canals scattering all over the city. These ponds are stagnant, as they have no outlets and therefore highly polluted and they are also used as rubbish dumps in some places. They are the breeding centres for vermin, parasites and mosquitoes.

As houses surround all these ponds, vetiver cannot be established near by to treat the polluted water. So we proposed to establish the vetiver on vacant land nearby and the polluted water will either be trucked or piped out to the treatment sites.

If successful the city will incorporate this technology to their new town plan, which is now under preparation for implementation in the next few years. They hope to use VS technology to treat all their runoff and effluent generated from the city.

A stagnant and highly polluted pond in the middle of the city, which sometimes collects rubbish too


2. An industrial wastewater treatment/disposal plant

Cantho city is the capital of the Mekong Delta, which is also the centre of several food processing industries. Among these seafood-processing factories are the major sources of pollution to the region watercourses and farmlands near these factories.

Vietnam Fish-One is a medium size seafood (mostly shrimps) processing factory, which exported USD65 millions to the US, Europe and Japan in 2004. Vietnam Fish-One Company is one of several and much larger factories of this type in the province.

Due to the high hygiene standards required in seafood processing, the factory produces a large volume of effluent daily all year round. This effluent is now first stored in several ponds and when full it is released to surrounding farmlands. The effluent is very high in nutrients and chemicals; its levels are well above the limit set out by the local EPA.

Although the company has tried very hard to lower the pollution level of its effluent, conventional chemical methods presently available in Vietnam are too costly, well beyond the means of a factory this size.

Following our presentation, the Management was very eager for us to set up the demonstration site at the factory and prepared to pay for most of the costs involved. If successful the company also prepares to buy the land around the factory for vetiver planting to treat their effluent and to sell the harvested shoots for goat and dairy farms in the region.

Vietnam Fish-One effluent storage pond on the left and outlet to the rice field on the right

3. A city or municipal landfill leachate treatment/disposal site.

Most cities and towns in Vietnam do not have any means to treat leachate from landfill depot As a result the discharged leachate either drains into local streams and river or infiltrates to the underground water storage.

Two landfills are earmarked for demonstration sites, one in Da Nang City and the other at A Luoi town near the Laotian border where the leachate is draining to a mountain stream, the water source for domestic supply and agriculture of several villages living along its course.

Leachate being discharged from storage ponds into natural watercourses at Da Nang (left) and at A Luoi Landfill sites

4. A rural site contaminated with herbicides, pesticides and other toxic chemicals.

A Luoi is a district in central VN mountainous region near the Laotian border. This district was the centre of some very big battles during the war. A Sho was also the main base of an Agent Orange (AO) spraying unit of the US Air Force in the northern section of South VN. The billboard erected on the edge of the airfield warns local people to keep out of the airfield as it is heavily contaminated with Agent Orange and also has high level of Dioxin. ***Hatfield Consultant,*** a Canadian consulting group, carried out a site survey about 10 years ago and it has identified several "hot spots", which had very high level of herbicides and dioxin.

At the time of my visit, 32 years after the spraying, the whole airbase of about 50ha is still bare of naturally established trees, only covered with low growing grasses during the rain season and the soil surface is mostly bare during the dry season, making the whole 50ha very vulnerable to soil erosion. As most organic chemicals tend to attach themselves to the silt, clay fractions or organic content of the soil, contaminated soil when eroded carries with it the contaminants and spreading it along the watercourse.

At A Sho, although the local authority has moved all the people out of the airfield area in the last five years, local people still use the land for grazing and runoff water for domestic uses.

VS will be used here to:

- Control erosion on the bare patches of ground in the air base
- Trap sediment in runoff water in gullies, small streams and drainage lines
- Determine whether vetiver can absorb any residual herbicides and its potential of breaking down Dioxin, as in the case of Atrazine.

RIVERBANK, DIKE, CANAL AND IRRIGATION CHANNEL BANK STABILISATIONS.

1. South Vietnam

River and canal bank protection from wave erosion

The success of the river and canal bank protection against wave erosion is best illustrated in the Cai Lay district. VS is being used widely in the district by both local authority and households to protect the rural road and their properties. In addition the shoots harvested are fed to goats and cattle. VS has passed the experimental and demonstration stage, now people set up their own nurseries for their own use and supply to the local authorities. This year the local authorities plan to have between 150-200km canal banks and rural road protected by vetiver.

In Vi Thanh, VS is very popular in reinforcing the wooden structure built to protect the banks from waves and the harvested shots are used for binding rice stalks and mulch. At one site, the protected area of about 5m wide is stable enough for the farmer to plant fruit trees.

At Cai Lay, this vetiver hedge saved the house on the left from collapsing into the canal during the last flood and a well-stabilized rural road along the main canal

At Vi Thanh, this vetiver hedge reinforced the wooden structure, and fruit trees planted behind, and next door, erosion on the unprotected bank

Dike protection from wave erosion and fast current in the flood zone.

The following 3 cases show how VS has affected the present life and future of the poor people living in this flood zone of the Mekong Delta.

Flood Protection Dike

The upper section of the Mekong Delta, bordering Cambodia is flooded annually, the flood level was up to 5-8m deep, spreading over thousands of square kilometers. The inundation can last for a few months. If unprotected the whole region: farmland, houses, road and bridges would be under water. To protect rice field and rural infrastructure the government builds large dikes surrounding these communities. These earthen dikes are subjected to continuous erosion: erosion at their bases in the dry season by boat traffic and wave erosion at their tops during the flood. These dikes are often the only surface above the water level during flood; their dry surface provides ground for farmers to dry their fishing gears, store their farm equipment and more importantly for them to grow some vegetables. Therefore the protection of these dikes against flood erosion is vital for the survival of the local farmers. Traditionally Eucalyptus has been used to stabilise these dikes, but in the last few years these trees were washed away by floodwater, taking big chunks of the dike batter with them.

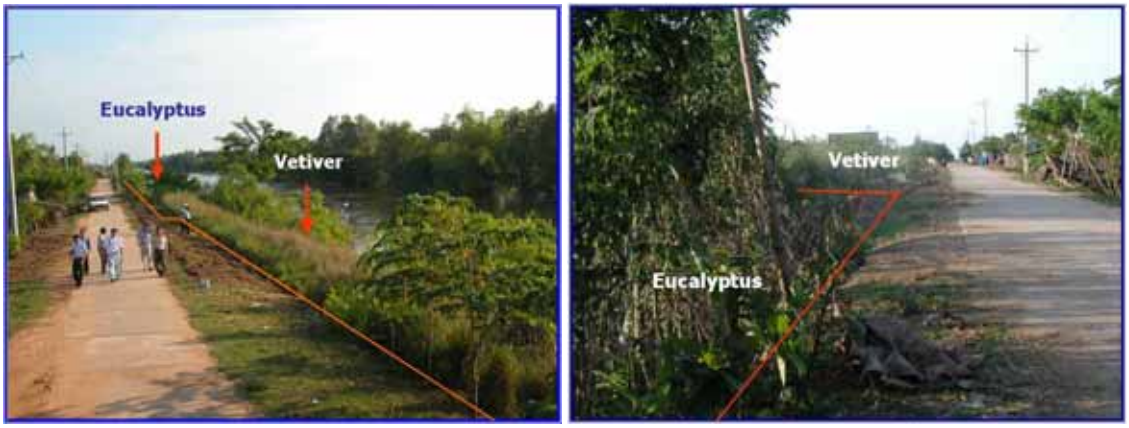
Following the very good results of some earlier trials, VS was used to stabilise a 17km long dike in the Tan Chau district of An Giang province. Twenty-two rows of vetiver were planted on the outside batter of this 15-20m high dike. The result was most spectacular after two flood seasons:

- Five metres of the dike surface on the section protected by Eucalyptus were washed away
- On the section protected by vetiver, dike surface stayed intact, providing a precious 5m strip for farmer to use during the flood.

Following the highly successful result at this site, the dike protection section of the local authority has adopted VS as the recommended method for all new dikes and those needed repairs.

A broken dike during flood and the batter of the 17km long dike protected by the VS

While Vetiver consolidated the dike batter, eucalyptus did not



Left: ***Unprotected dike during flood*** **and Right:** ***Dike protected by vetiver***

Five metres of ground were saved and used for vegetable or fruit trees

Eucalyptus was the preferred plant before the introduction of vetiver, although the tops are luxurious the ground level, where erosion occurs, was almost bare

Protection of Flood-Escaping Commune

To provide a more permanent and stable land for the people affected by the flood, the government has initiated a program of relocation people to the high ground by building up a large block of land above the flood level and encouraged those who live outside the protection of the dike system to move to the new flood free zone.

This relocation program is possible only since the introduction of VS, without the protection of VS this area would be eroded in a few years. At this commune, the entire block of land, built up to about 6m high, is protected by 8-10 rows of vetiver and this site has survived high water level and big waves from floods during the last 2 years and people started building on the land. Some are even confident enough to build brick houses, a big improvement from the makeshift houses they have to rebuild each year after the annual flood.

The local authority was particularly impressed when I informed them that these hedges could also be used to dispose of their effluent and wastewater,

The new commune protected by VS and the sign next to a brick house telling people to look after the grass for their own protection

The commune high ground protected by vetiver against wave erosion during flood

Introducing an Entrepreneur

This case will highlight the point Criss Juliard has been stressing: The success of a new product or technology depends more on the entrepreneurial initiative rather than government or NGO promotion.

Mr Nguyen Thanh Su was a Development Officer of the district of Tan Chau. In the last few years he has used and witnessed the results of various VS trial in the district in his official capacity. After observing the effectiveness in dike protection and its potential in the region he started his own business in dike construction and stabilisation.

While with government he and Dr Dung from Cantho University worked with the staff of the Dike Protection Office developing the guideline and specifications for VS application in dike batter stabilisation. These guidelines specified the lay out design and all details of the planting material, establishment and maintenance etc.

He established a very large vetiver nursery to provide planting stock for his business, and other contractors. At the time of my visit his nursery must have at least 500 000 plants grown from rootstock. But he found this method of propagation is too slow so he ordered 1 million tissue culture seedlings from Cantho University. My visit coincided with the delivery of the first 20 000 seedlings, which is the maximum weekly output of the University. But he is not happy with this supply rate and he has asked the university to expand its output as he will need another 4 millions seedlings in the near future for new dikes and resettlement communes. But Dr Dung told him that it is time now for him to set up his own tissue culture facility and the University will work with him and train his staff for him.

Another very important aspect of his business is providing jobs to rural people; he employs and trains large gangs of men to do the planting and subsequent maintenance as well as women at his nursery.

Therefore, VS has not only provided the protection against to devastating annual flood but also economic and social benefit to the poor people of this region.

Paul Truong delivered the first 20 000 plantlets and with Mr Su at his nursery

Jobs for rural women and large stock of vetiver at Mr Su's nursery

Protection of sea dike

At Go Cong, after a successful trial, VS is being used to protect the outer batter of a sea dike built to protect shrimp ponds and farmlands. As the building material was dredged on site so it is highly saline and erodible, mostly covered with samphires, a beach succulent. This dike is located on the edge of a 25m wide stretch of mangrove and seawater regularly reached the toe of the batter at high tide but occasionally it inundated the bottom 2 rows of vetiver. Plant growth is excellent in rows above the inundation mark, where vetiver still survived but growth was much reduced.

Fifteen-month-old vetiver on the outer batter of a sea dike in Go Cong Province

Protection of water supply canal

On the demonstration trial at Cu Chi, on the outskirt of Saigon, Le van Du from the University of Agriculture and Forestry has shown that VS was very successful in stabilising the upper section of a concrete irrigation channel. Vetiver was planted from 1 to 3 rows above concrete lining. The soil is a degraded, kaolinitic gray clay with a pH of 5.0 and highly erodible. Heavy rain eroded the surface above the concrete and seepage also cracked the concrete lining of the channel.

In a costing exercise, Du showed that the cost of using VS is only 1% that of concrete in controlling surface erosion and protection the concrete lining of this channel.

Cu Chi irrigation channel was successfully stabilized with vetiver grass

Protection of drainage canal on extreme Acid Sulfate Soil

In Long An province, VS is being used extensively for irrigation and drainage channel bank erosion control in a low-lying region near the Cambodian border.

2. Central Vietnam

Quang Ngai Province

Australian Government Overseas Aid Program, AusAID, is currently helping Vietnam in Quang Ngai Province under the "Natural Disaster Mitigation Project " in mitigating flash flood erosion in the rain season and seawater intrusion in the dry season. The coastal zone of the province is currently protected by a myriad of dikes of various sizes from sea dikes to shrimp pond dikes and hundreds of kilometers of drainage canal and channel. The batters of these infrastructures are highly erodible due both to high rainfall and fast flows. The erosion of these batters often led to the collapse of these structures, including those protected by the hard conventional methods such as concrete and rock. If not repaired, this would result in flooding of farmlands during the rain season and seawater intrusion during the dry period. This project aims at controlling erosion on these batters and also to improve the stability of the hard structures.

Kellog Brown & Root Pty Ltd, is the Australian Managing Contractor (AMC) of this project for AusAID. In the last two years Tran Tan Van and I have worked with AMC to test the suitability of vetiver in stabilising these batters and to develop a technical manual for its implementation.

Based on our design Mr Vo Thanh Thuy, Deputy Director of the Quang Ngai Centre for Agriculture Extension carried out a series of very extensive trials on all the potential sites of the province for AMC. Using our vetiver layout design, Mr. Thuy also incorporated a number of local species, including *V. nemoralis* into the trial, and most importantly some local species such as elephant grass, that have higher feeding value. This is an excellent idea, as vetiver will provide the structural stability of the dikes, the land area between rows can be used for fodder production, hence increase the acceptance of VS by the local and also ensuring the long-term survival of the VS.

The followings are major findings that Mr Thuy concluded and recommended in his interim report:

- To obtain accurate conclusion, the trial needs at least 2 years, 2 dry seasons and a flood season. However, after 7 month growth and a big flood, we have preliminarily reached these conclusions
- Vetiver can grow on a wide range of soil from poor coastal soil, red hill soil and salt affected soil.
- Vetiver is tolerant to drought, inundation and particularly under periodic tidal inundation, it still survived and grew
- Vetiver was slightly affected by stem borer and brown spot disease, no rat infestation and no rat hole recorded.
- Tillering and growth were prolific, in the flood season but it stops growing in winter due to low temperature and no sun. After 7 months, vetiver top was 130cm tall and its roots penetrated vertically to 75-100cm deep.

- Flood erosion control is very good during the 2003 flood. No erosion was observed when the water level reached half of the dike or on one batter when it was completely submerged. The canal was not eroded under fast flow and heavy rain
- However when the batter was built with saline and sandy material, especially when it toes slope was inundated by seawater, erosion occurred at its submerged toe.

Under estuarine conditions, vetiver growth was strongly affected when seawater reached the toes slopes at low tide and wave erosion occurred at the seawater edge due to its poor root development.

This problem has been overcome successfully by planting a row of mangrove fern just below the water edge to protect it from wave erosion and vetiver was planted 50cm above it.

The following photos show the excellent results of trial at the time of my visit, 2 years after planting.

Left: ***Disintegration of conventional dike protection methods such as concrete and rock***
Right: ***Mr Thuy (pointing) showed the inspection team one of his trial sites in Quang Ngai***


A drainage channels before and after VS protection


An estuarine dike before and after VS protection,
note the mangrove fern on the water edge below the vetiver hedge

An estuarine dike with and without VS protection (left),
the mangrove fern on the water edge below the vetiver hedge

A large river dike at Tra Bong, vetiver was planted in both directions to counter fast flow and heavy rain

Da Nang City

Da Nang now is the largest industrial city of central Vietnam and its lakes are highly polluted. At the presentation on wastewater treatment, the Director of the Natural Resources and Environment told us:

We believe that VS will solve our pollution problem in the city, so we do not need any more demonstrations we need you to help us to treat all the lakes and ponds in the city.

But unfortunately we had to tell him that this is beyond the scope of the WGF project as the City have at least a dozen of badly polluted lakes and ponds of various sizes ranging from 5 000 to 30 000 m2 in surface area.

Two of several large and highly polluted lakes in the city centre

VS has been used to stabilise several riverbanks in the city, some in conjunction with rock paving and some on its own. At one site it was used successfully to stabilise a bend on the river.

VS in combination with rock paving on a large riverbank at Da Nang (left) and the bank on the bend of the river was stabilized by vetiver alone


VS has also been used to stabilise a very steep and difficult cut batter of the road leading to the port.

Vetiver has successfully stabilized the steep and rocky part of this batter, while the more expensive hard structure was used on a gentler lower slope


Quang Tri Province

World Vision has initiated a project using vetiver grass for natural disaster mitigation in Quang Tri Province. With enough planting materials from their nurseries, World Vision has just started planting on a large sea dike in the province. This dike protects the farmland from flash flood and seawater intrusion.

A World Vision Project: A newly planted sea dike in Quang Tri province

Quang Binh Province

Elise Pinners and Tran Tan Van carried out this stream bank stabilisation project 3 years ago from a grant from the Dutch Embassy. This highly innovative project has shown that vetiver was very effective in preventing the steep slope of a sand dune from sliding down and blocking the flow of the stream. Its results have clearly demonstrated that vetiver can be used to stabilise sand dune from wind and water erosion.

This successful outcome has led to VS being adopted by World Vision in a project to control erosion on a sea dike in Quang Tri and Danish Red Cross for similar application in Nam Dinh Province, North Vietnam.

Stream bank and sand dune stabilisation: Before and 3 years later, note the natural establishment of endemic trees behind the vetiver hedges.

Farmers in the region now plant their own hedges to protect their lands

3. North Vietnam

Nam Dinh Province

In August 2004 **Danish Red Cross Vietnam (DRCV)** invited Dr Van to several communes and districts in Nam Định Province, including Hải Hậu district, to assess the effects of natural disaster in the region and to inspect the sites selected by DRCV for a pilot project using Vetiver grass.

Van noted: The natural disasters here are mainly coastal and river bank erosion. Floods do occur but mostly in the form of short inundation due to heavy rains/storms. As the area is open to the sea and with a good drainage system, flooding is not a very important issue. DRCV intended to combine vetiver grass with bamboo for protecting a dyke section that was badly damaged. As the uses of concrete embankment, bamboo or even mangrove are not effective, they therefore want to try the combination of bamboo and vetiver as the last resort.

Dr Van advised on the design and planting techniques and inspected the 4 sites selected by DRCV:

- A shrimp farm dike
- A riverbank section
- A river dyke section under the bamboos
- A seaside section of a sea dike
- A seaside section of a collapsed sea dike

The planting started early in September 2004 and in total about 1.5 km of Vetiver grass was planted.

At the time of my visit, about 4 months after planting, the results were mixed. On the whole, good establishment was achieved at all sites despite the dry and cold weather. Under these conditions, excellent growth was observed at sites where they were not inundated by seawater or washed away by big waves on the sea dikes.

The followings are my general assessment of the results to date:

- *Saline conditions* I was very surprised to see vetiver was able to establish and grew under such saline conditions, for example on the shrimp farm, it was planted on soil dredged up from the salt water pond. With only initial watering with fresh water, these freshly splitted slips have grown up to 1m in 4 months. But most remarkably, when the outer wall of the dike was inundated and submerged for several hours by the last high tide of the year, all plants survived, only leaf burns and the plants kept growing after the high tide receded. Plant growth on the inner wall was not affected by the high tide. These results indicate that more mature vetiver plants can tolerate and survive high salinity and inundation much better than younger plants.

  Therefore, to increase its tolerance to salinity, vetiver should be planted in spring, as soon as the high tide season is over. In addition, more mature plants have a better root system to protect the dike against erosion. Alternatively, more mature pollybaged plants should be used for estuarine and sea dike protection instead of freshly splitted slips.

- *Shading.* Shading affects vetiver growth severely, especially in young plants. Vetiver establishment and growth when planted with mature bamboo groves would be very slow; therefore it is more affected by tidal inundation. To partly overcome this problem, mature pollybaged plants should be used under shady conditions.

- *Fertilisers and weed control*. As the soil can be highly saline, fertiliser application is essential to good establishment and early growth. Poor growth at most of the sites can be due to poor or unevenly spread of manure at planting. I would recommend the use of chemical fertilisers high in N and P instead of manure on salt affected soils. Fertilisers should be put deep in the trench before planting to reduce weed competition.

  Poor vetiver growth at some sites can also be attributed to weeds, especially climbing vines. Weeding is needed until most of its leaves are higher than the surrounding weeds.

Good growth on the inner wall (left) and only leaf burns on the outer wall

Very poor growth due to shading and tidal inundation (left) and not enough fertiliser and too much weed (right).

- *Sea dike.* Even with fully mature plants, vetiver would not be able to withstand the pounding of big waves from the open sea, which have washed away solid hard structures. Although vetiver had established satisfactorily under these extreme conditions and have survived seawater inundation, it should not be tested here.

Massive erosion on an old sea dike (left) and vetiver established satisfactorily but was badly burnt by seawater inundation


But on another sea dike, vetiver has held its upper section firmly, despite its toes slope was undermined badly. These results have clearly demonstrated that vetiver can replace the rip-rap section of the sea dike.

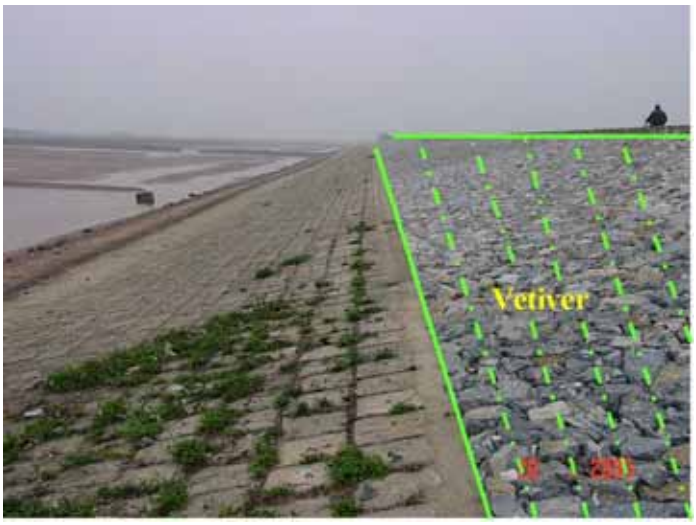
- *General Assessment and Recommendations.*

    - Although the trial was only 4 month old, it has shown that vetiver grass is highly tolerant to saline conditions, including occasional and temporarily inundation by seawater, which scorched the older leaves. On closer examination, these burnt plants still have green shoots so they will probably recover later.

- Some of the testing sites are extremely difficult and hostile, but vetiver have established and grown satisfactorily, indicating that when fully mature it will provide the protection against water erosion.
- Vetiver alone cannot be used to stabilise the sea-facing batter of sea dikes.
- Vetiver can replace the rip-rap upper portion of the concrete paving of sea dikes. This planting will substantially reduce the cost of sea dike stabilisation.
- Planting should be done as early as possible because older plants not only having better root system to hold the soil, they also tolerate saline conditions better.
- Using older pollybaged plants for shady and more saline sites
- Application of chemical fertilisers, instead of manure is recommended
- Weed control, where necessary, in the first few months after planting is recommended

A sea dike at Hai Hau, with and without vetiver protection

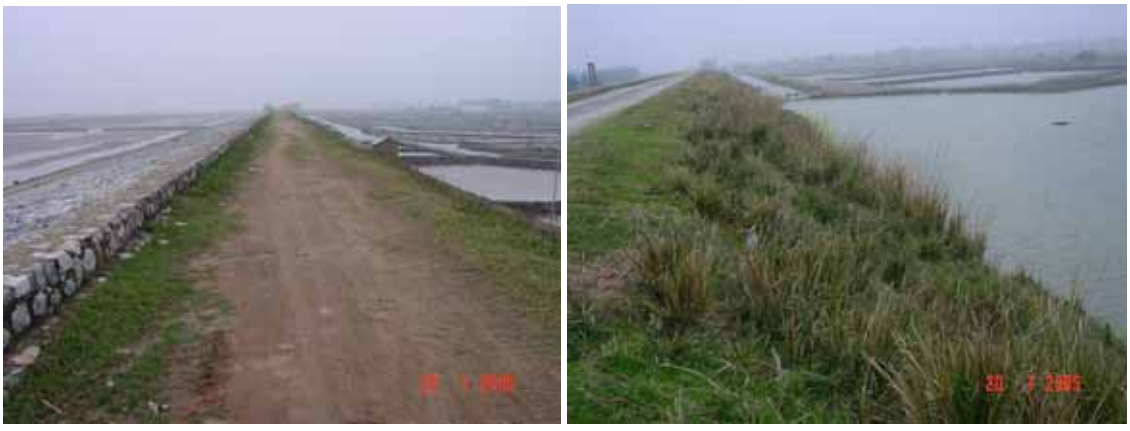
Vetiver can replace the upper rip-rap section of the sea dike



In Nam Dinh province and particularly Hai Hau district, the most severe disaster is coastal erosion, or more precisely, erosion of the sea dike system by huge sea waves. The sea dike is about 2.5-3.0m high; the crest is about 4 m wide with 1:1 gradient. Its sea facing wall is normally protected by hard rock and concrete structure but its inside wall is normally unprotected. Erosion on the inside batter, caused by runoff from the crest, is often very severe and can seriously damage the whole dike. The inside batter is often bare or covered with native grass or wild pineapple, which provide little protection. Therefore repairing is a major maintenance cost.

The Dyke Department of the Ministry of Agriculture and Rural Development in mid 2002 started a trial by planting about 10 very wide spacing rows of vetiver along 1km of the inside wall of the sea dike in Hai Chinh commune. Even with the incorrect planting, scattered instead of contour rows, the result was so good that a new section was planted the following year and since then a total length of about 3km of dike has been added to the first trial. At the time of my visit, it was 2 year old, very well developed, forming big clumps and the local people have already observed its advantages as compared to other local plants, including *V. nemoralis,* in controlling erosion and landslips.

Hard structure on the seaside and vetiver on the inside of a sea dike



ROAD AND ROAD BATTER STABILISATION

1. The Vetiver Road

Mekong University is a private university in Vinh Long Province in the Mekong Delta, where the soil is a sandy loam alluvial and highly erodible if not stabilized. The University is located on an old rice field and its foundation was built from soil dredged from several paddy fields, creating numerous lakes and ponds around the campus.

A road was built from the highway three years ago to provide access to the site. As this road runs between 2 very large ponds, vetiver was planted on both batters right down to the water edges to protect it from erosion and landslips. This road was so stable that in the last 3 years it has been used as the main service road to the university. Very large and heavy trucks and semi trailers only used this road for delivering all materials for the university construction and it is called the Vetiver Road by the university staff.

In contrast, a very nice road running parallel to the Vetiver Road and its batters are paved with concrete slabs, but this road is off limit to heavy traffic, because it has been easily damaged even with light traffic.

When I showed this to Ian Sobey, the project engineer of KBR in Quang Ngai, he pointed out that although vetiver did a good job in stabilising the batters, the main reason for the stability of the Vetiver Road is that vetiver keeps its foundation dry by preventing water from the ponds on both sides seeping through to its foundation. Water seepage is the main reason of road failure in general but particularly on alluvial soil of the Mekong Delta.

The Vetiver Road before and after trimming

Batter of t*he Vetiver Road (left) and of the nice road (right)*

2. The Ho Chi Minh Route

On the HCM route, extensive vetiver planting was done by two private companies for surface run-off protection and slope stabilisation. The Thien An company working on the northern half, from Quang Tri Province to the north with expertise from Mr Vu Thang of NISF and Thien Sinh - Nam An company, on the southern half, from Thua Thien-Hue to Kon Tum, with expertise from Dr. Phuoc. In general the use of Vetiver grass is very effective as compared with concrete/gabion retaining wall or "do nothing" options.

The Northern Section

The vetiver planting on this section is contracted to Thien An company. On a visit on this section in June 2004, Dr Van reported:

Initially we thought the northern half result might not be as good as that on the southern half as the contractor was less experienced. But our concerns turned out to be wrong.

We saw extensive planting of Vetiver grass, must be tens of kilometres. The planting appeared to be carried out even more quickly and earlier than in the south. Many sites are now covered with vetiver grass, which is at least one year old and they are cut and watered regularly.

The result appears particularly good in Ha Tinh, where the slopes are flattened to the bedding angle of the bedrock, ensuring no big slides occur. The grass grows well on the thin weathering crust of the schist, preventing mostly surface erosion. A few shallow landslides did occur but they are small. Obviously the grass helps. So after a year, the cut slope is green again and is now blended well with the natural vegetation cover. Some innovative designs were even made but I don't think it will improve our concept. It brings just some change in the general view of the landscape. On the other hand, it doesn't make any harm yet.

In Quang Binh, the grass is tried mostly close to the Da Deo pass and the result is not that good. I can even say the trial there failed. The reason was simple. The contractor doesn't know the geology of the site and he doesn't know how to stabilize the slope. He left some slopes very steep. And when the slopes fail, he flattened them down to even less than 40

degrees. Then the slopes continue to fail and the contractor doesn't know what to do with it. As the soil/rock there is very clayey, strongly crushed and there is continuous water seeping out from under the surface. So nothing would stabilize the slope unless it is properly drained.

Under these conditions, the grass was and is planted on both steep (before) and flattened slopes. Most of those steep slopes continue to fail even with vetiver grass. The view is very miserable.

This scene continued for about 3-4 km. But in general, compared to many more kilometres of success in Ha Tinh, we can say that the contractor has succeeded, showing some good professionalism and even creativeness.

From these results with vetiver planting on the road batters, I think the Ministry of Transport engineers are happy with the result now have enough confidence to use the grass for its other road projects. The only thing I don't know is that whether or not it makes both the officials and contractors happy because of its low cost.

Dr Van and I drove up this 500km stretch of road from Thua Thien-Hue, Quang Tri, Quang Binh, Ha Tinh, Nghe An and Thanh Hoa provinces. We could not go any farther as the route is still being constructed.

Six months on from the above report, we discovered with amazement and delight that the planting was much more extensive than Van first thought as it is now more mature and can be seen easily from the distance. The scenery was spectacular as steep cuttings after steep cuttings and hills following hills are covered with neat vetiver rows blended beautifully with the landscape dominated by Karst limestone outcrops. In total I must have seen more than half of this 500km stretch, which is now planted with vetiver and more planting is in progress on the rest of the northern section as well as the southern section, and eventually most of this more than 3 000km route will be protected by vetiver.

The first thought that came to my mind was: "Yes, VS would definitely work had they all applied correctly"

The age of the planting varies from about 2 year old to freshly planted. Due to the cold weather the top leaves of the older plants were brown off, but where the top was trimmed back showing its green under growth and the view was really breath taking from the distance. We saw slopes successfully stabilised by vetiver alone, some in combination with gabion and concrete structures and some spectacular attempt, on almost vertical rock wall, which Van called "*Some innovative designs"* were tested. When properly designed and planted, of over hundreds of plantings on various soil types and gradient along this road, we saw only one failure and this was due to deep seepage that Van mentioned earlier. The consolation was that even when VS was not properly applied the failures were much less severe than on unprotected slopes. But the most remarkable sight was where a minor landslip occurred on a very steep and rocky slope. The vetiver row stopped the concrete drain from slipping further down and resulting in this thin concrete pavement buckled and cracked.

This was in sharp contrast with unprotected slopes or those that have not been planted, the failure, slippage and landslides are equally spectacular. The following photos will show you what I meant.

Beautiful landscape along the way with some very spectacular vetiver plantings

Either in combination with some rock structures

Or equally effective by itself

Vetiver was tested and proved effective even on some very steep and rocky outcrops

A minor landslip occurred on a very steep and rocky slope. The vetiver row stopped the concrete drain from slipping further down and even cracked this thin concrete pavement

This is the only vetiver site that landslip happened, but it is fairly minor. The slip was due to seepage and immature plants.

But with crazy slope like this, no wonder why erosion occurred …..

….. then landslip and landslide followed.

All the plantings mentioned above were on cut or positive slopes; I did not see any planting on the fill or negative slopes, which were created either during the construction phase or from soil sliding down and blocking the road during massive landslips. These materials were then pushed across the road. These unconsolidated slopes were all on the angle of repose, which was normally higher than 45 degrees and therefore highly erodible and unstable. With torrential rain these slopes were then either washed down or slid down, blocking and filling up the mountain streams, which supply water to local people for irrigation and domestic use.

This unconsolidated slope collapsed, blocking and filling up the mountain stream

The Southern Section

Thien Sinh - Nam An company with, with expertise from Dr. Phuoc, is doing the vetiver planting on the southern half of HCM route, from Thua Thien-Hue to Kon Tum. On a visit on this section early in 2004, Dr Van reported:

In general, organization of the planting is very professional, with a project site manager and a lot of workers in good uniforms. I did not see the manager and talked to the field staff. So the followings are mostly from my own observations.

- Vetiver grass is being used quite extensively in the southern half of the route. In the last 5-6 months, several tens of kilometres of grass have been planted and the planting work is still continuing.
- Vetiver grass is being multiplied in several site nurseries along the route. Planting has been done mostly in Quang Nam province although I saw also some sites in Kon Tum. I could see that most of the plantings started about 5-6 months ago as the plants were still green and had no flower. My overall impression is that the use of Vetiver grass is very, very effective. At least, much better than just concrete retaining wall or "do nothing" options.
- Planting was carried out very professionally like a construction site, before planting at each site, the drawn up design has to be approved by the supervising committee and holes were dug by hand but watering by pump.
- The grass is now planted more cautiously, i.e. mostly on flat slopes (max. 45-47^{o}) and its toes are protected with a concrete retaining wall. In this regard, it acts mostly as a surface run-off protection measure.
- The grass seems to grow in the weathering crust of quite a few rock types including granite, schist etc.

- However, I did not see any plantings on the negative side of the slope (fill slope), which is very, very big pity. The common practice is to excavate the road and to push the waste soil onto the negative side of the slope, which will gradually be washed away to the river and streams. The sediment will move far downstream, causing accelerated erosion and siltation there.
- And ahead is Thua Thien-Hue province, where the topography is very rugged, strongly dissected hence slopes are very steep and high. I don't know how Nam An will plant their grass there. I think the grass can grow on the benches.

Some successful repair plantings on the southern section near Kontum

Left: ***Vetiver should not be planted on this high slope (55m vertical drop) without benching, but so far so good as this batter is on a less erodible soil.***
Right*: A well designed and planted batter with benches and on erodible soil among more stable rock surface*

Some examples of unprotected fill (or negative) batter along the southern section

The followings are Van's comments on a few current slope-stabilizing measures.

1. The most popular method is to flatten the slope to the designed gradient. Compared to what I saw 2 years ago, I think the contractors now have gone to the other extreme. Previously they had very steep slopes but now in many cases they have very flat slopes, even less than 45^{o}. High slopes are made into several steps, with concrete drainage sluice. I saw at many sites slopes up to 50 m high, made into up to 10 steps, some steps are as high as 12-15 m. On site where the rock base is solid and the weathering crust is thin, the slope angle varied from 50-75^{o}. These slopes are left uncovered in most cases.

2. The second most popular method is to build concrete/rock retaining walls, some as long as a few hundred metre long and as high as 5-6 m. I do not like this method, not only because these walls look very ugly, providing you with a false feeling of safety. More importantly, they are passive, waiting for the slope to fail. You can imagine a retaining wall, built a few metre out from the toes of the batter, waiting for the failed material to fill the gap. I saw quite a few cases where the slopes failed pushing and breaking the wall. But at many other sites, the retaining wall is redundant, as the slope with rock bedding cannot fail anyway. When I asked people from the Transportation Institute, who claimed that this measure is the cheapest. I tend to doubt that they hardly know about other measures. In fact, the passive concept is wrong from the beginning. But who listens and cares about this. The contractors continue to receive and to make money from the government and the slopes continue to fail.

3. The third measure is to combine vetiver grass and retaining wall. After the retaining wall was built and some minor slips occurred, vetiver grass was planted to stabilise the slips. Thus the retaining wall protects the toes of the newly formed slope. In fact, most of the time, I saw vetiver grass planted only in combination with the retaining with slopes with less than 45-47^{o} gradients. The grass acts mostly as a surface run-off protection measure and failures still do occur at some sites. I think if the grass is used only for this purpose and it can be very good.

   Instead of the passive "waiting" rock/concrete retaining wall and grass combination, a combination of just concrete rib/frames with the grass in between may work better and

much cheaper as the ribs/frames (may be even with some anchoring) rest directly on the slope surface, pressing against it and making it tight (being thus “active”).

4. The fourth measure is to combine retaining wall with concrete surfacing rip-rap. They make on site low quality, square, flat interlocking concrete pieces, about 30x30x3 cm, with a round hole, about 15 cm in dia. in the centre. Placing these pieces to cover the slope surface and put in some local grass in the hole. This measure is mostly used for embankment section, but it is not very effective. Sub-surface erosion still washed away the soil and planting the local grass is really difficult as the concrete absorbs the heat from the sun and no grass can survive under such heat.

5. The fifth measure is to plant “co? lau” on the slope, but it is not popular and not very effective.

Some examples of the useless concrete retaining walls

They often collapsed and need constant repair

These walls work when the upper slopes are stable (left , but then there is no need for them under those conditions (right).


Conclusion

After some disastrous failures earlier on due to bad design and wrong application, the contractors and Department of Transport engineers heed our warning and have lately become less daring and more cautious with their designs and plantings so more successes have been achieved in the last few years.

This is probably the largest VS application in infrastructure protection in the world. The entire HCM route, over 3 000km long, will be protected by vetiver, planted on a variety of soils and climate: from skeletal mountainous soils and cold winter in the north to extremely acidic Acid Sulfate Soil and hot and humid in the south. I can say that without VS the HCM Route will never be realized.

ADOPTION BY INTERNATIONAL NGO

Two of the most active international NGO in Vietnam, World Vision and the Danish Red Cross, have adopted VS as a major components of their Natural Disaster Mitigation projects in north and central Vietnam.

- World Vision has initiated a project for Natural Disaster Mitigation in Quang Tri Province, using vetiver grass. Dr Van spent 2 days introducing VS to the farmers, showing them the sites in Quang Binh Province. The farmers bought the grass from there and raised several nurseries in the district. With enough planting materials from their nurseries, World Vision has just started planting on a large sea dike in Quang Tri province. This dike protects the farmland from flash flood and seawater intrusion.

- In the North, Danish Red Cross intended to combine the grass with bamboo for protecting a dike section that was badly damaged by flood and waves. They cannot see any effective measures including concrete embankment, bamboo or even mangrove, and therefore came to the combination of bamboo and vetiver as the last resort.

RESEARCH BY CANTHO UNIVERSITY

The schools of Environmental Sciences and Agriculture of Cantho University have an active research program on VS at both basic and applied levels. The following are some examples:

- **Piggery Wastewater: Master of Science degree by Nguyen Thanh Phong,**

Abstract:

This study investigated the change in BOD, nitrogen, phosphorus of piggery wastewater, with cultivated the vetiver grass (*Vetiver zizanioides L.)* and the water hyacinth *(Eichhornia crassipes).* In addition, the growth of vetiver grass and water hyacinth under piggery wastewater culture was also monitored. Results showed that, after 8 days of planting, water hyacinth could not survive when grown in wastewater with BOD of 245.8 mg/l. In contrast, vetiver grass grew and developed well during the experiment, in the same piggery wastewater culture, vetiver grass reduced 40 % of BOD, 13.8% of nitrogen and 8.8% of phosphorus. The presence of vetiver grass reduced the growth of algae, the algal growth rate was reduced by 4.7 times as compared with that of control. At the end of experiment the vetiver grass increased in fresh weight and dry weight by 96% and 92% respectively, height of stem (135%), length of root (96%) and new shoot (263.8%). With the increased in growth parameters of Vetiver grass, the accumulation of nitrogen, phosphorus in root and stem of vetiver grass also increased significantly. The experimental duration was 32 days.

Water hyacinth died after 8 days and vetiver growth after 32 days in piggery wastewater

- **Landfill Leachate: Master of Science degree by Nguyen van Tung**

Abstract:

The objective of the project was to investigate the growth of vetiver grass and water hyacinth in the garbage leachate and the changes of concentration of total nitrogen, total phosphorus, biological oxygen demand (BOD), dissolved oxygen (DO), lead (Pb) and chlorophyll- a (indicator of algal growth) in leachate under hydroponic conditions.

The following results were achieved:

- The shoot height of Vetiver grass increased (155.42%), the root length increased (17.5%), new roots increased (48%), the total tillers increased (24%) and the biomass of vetiver grass increased (42.86%). On the contrary, the mass of hyacinth decreased (88.88%).
- The purification rate by Vetiver grass: BOD_5 (83.98%), total N (80%), total P (50%), chlorophyll- a (54.39%), and in contrast the chlorophyll- a in the control treatment increased (16.86%)
- Vetiver grass absorbed 60.85% of total N and 16.23% of total P.

Conclusion

- Vetiver grass developed strongly in garbage leachate with BOD of 293,3mg/l and can be used to treat organic pollution, especially for algal growth.
- Water Hyacinth cannot survive in the garbage leachate in this investigation.
- The results suggest the use of this practice to treat garbage leachate

Water hyacinth died while vetiver flourished in leachate and root growth after 24 days

Mean values of Chlorophyll-a between different treatments (µg/l) over time

Treatments	Days of treatment				Mean
	Day 0	Day 8	Day 16	Day 24	
Vetiver	22,6	31,9	4,1	10,3	17,2[c]
Water Hyacinth	22,6	28,6	26,6	15,7	23,3[bc]
Control	22,6	64,4	100,9	26,3	53,6[a]

- ***Soil compaction***

Soil compaction is a major problem in orchard in the Mekong Delta, as in Thailand it limits root growth resulting in the crop being susceptible to drought and flood. The soil science

group at the university is conducting research on the effect of vetiver roots on the compacting layer of a citrus orchard in the province.

Vetiver planted around tree crop
and soil compaction test conducted by postgraduate students


- ***Tissue culture***

The university has developed a very successful tissue culture program both as a training course and also a commercial supply to various nurseries in the Mekong Delta. The current rate of production is 20 000 plantlets a week and delivery has started on the first one million plants, an order of another four million plants has also been received. Due to the shortage of space the university does not want to increase its output and it prefers to cooperate with large nurseries to set up their own production facility.

- ***Insect pests***

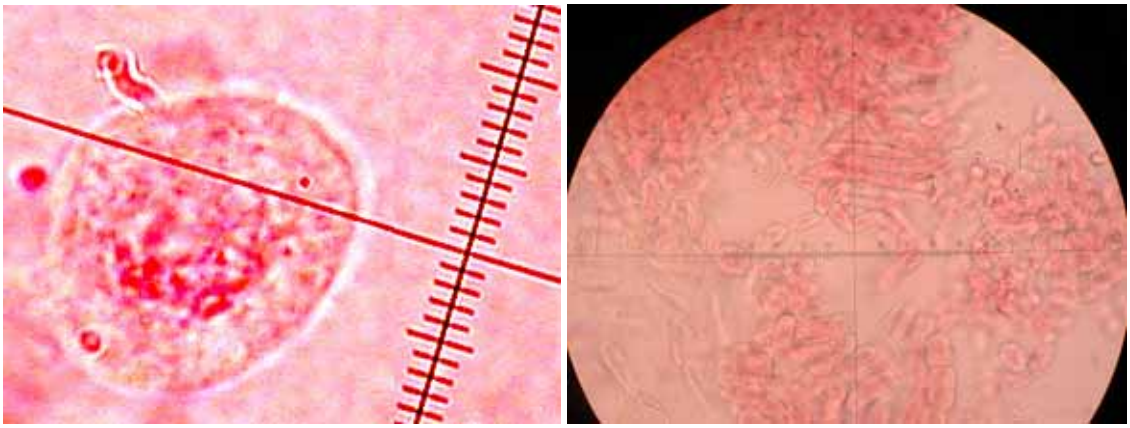
Dr Dung is currently monitoring the insect pest of vetiver and their effects on the near by rice crop. The "push pull" effect reported by Prof van den Berg at ICV3 has also been observed in the Delta.

Two insect pests: Chilo polychrysus and an unidentified moth


- ***Genetics***

The research program at the university also include a chromosome study

Vetiver chromosomes under electron microscope



OTHER ISSUES

- **Regional Conference**

In Guangzhou the advantages of small regional conference to promote the new technology quickly instead of waiting for ICV, were discussed. Now Dr Dung proposed to have a regional conference in VN to present their works and to prepare for ICV4 in October 2006. The proposed date is late this year or early next year in Cantho, capital city of the Mekong Delta. The main aim is for the Vietnamese scientists and contractors to exchange their experience but they also hope to attract Thai, Philippines and Chinese delegates too.

They hope to get about USD7 000 - 10 000 external funding to invite the Vietnamese from all over the country and foreign delegates will be provided with free accommodation and meals but they have to pay their own fares. The University will provide in- kind contribution at least equal to the external sources. I think it is very good idea and would strongly support their idea.

In Guangzhou Keith Chapman, FAO Bangkok, promised me a grant of $5 000-10 000K for a regional conference in VN in 2004, but as I was very busy I did not pursue any further in 2004. Therefore Narong and I will contact Keith again to see whether FAO can come up with the grant. In the mean time hopefully can TVN and PRVN contribute some towards the costs.

- **Technical Manual/Guidelines**

The success of the Green Book cannot be overstressed and I think it is time now we have to put out a **Technical Manual/Guidelines** - I call it the Brown Book - as we are now dealing with some nasty stuff!!- to promote other uses of VS such as steep slopes, riverbanks, coastal dune, estuary and sea dykes, mine rehab, effluent and leachate etc just to name a few. The reason I came up with this idea was everywhere I went in Vietnam, people often said:

We have found VS is very effective, but for us to apply with confidence and most importantly, for government approval we need a technical manual or guidelines from TVN such as the Green Book, which was approved by the Ministry of Agriculture and Rural Development for soil and water conservation in farm lands. But now for new applications we need new guidelines.

The following will illustrate my point: In the last two years Dr Van and I have been working with Kellogg Brown & Root Pty Ltd. the Australian Managing Contractor (AMC) of the Natural Disaster Mitigation project for AusAID, to test the suitability of vetiver for erosion control of riverbanks and dikes and to develop a technical manual for its implementation.

This project aims at mitigating flash flood erosion in the wet season and seawater intrusion in the dry season. Although we have conducted on site trials for the last two years with excellent results and the Provincial People Committee (Provincial Government) are happy with the results of the trials but so far they have refused to give AusAid the permission to use vetiver for the project, which covers the whole province. This is because they are still waiting for directive from the Ministry but the Ministry will not give them the go ahead because they need a formal technical manual or guidelines.

Therefore I proposed to AMC that we can prepare a technical manual or guidelines on Riverbank and Dike Stabilisation for them to submit to the Ministry, otherwise AMC has to return all the funds allocated for this work back to AusAid! We are now waiting for AusAid approval to go ahead with the preparation of the manual.

I am working with VNVN now on the format of this manual and hope to use it as a model of a chapter for Brown Book. I am sticking my neck out here again as the Coordinating Editor of the Brown book and will call for inputs and contributions for all vetiverites, to make it a technical manual/guidelines and Narong has agreed to join me as Co-Editor.

As for the format of the book, I am thinking of an Add-on version, with individual chapter to be added as it comes to life, rather than a solid book, which will have to wait for a long time to finish. As for the cost of preparation and publication can we get back to World Bank or may be USAID this time?

I hope AusAid will sponsor the first two Chapters: Steep Slope Stabilisation, and River and Dike Stabilisation. Dick Grimshaw and Elise Pinners are working on extra funding to finish the book.

Itinerary

Jan 2, 2005: Departing Brisbane

Jan 3: PM Arriving HCMC from Singapore

Jan 4: with Le van Du, HCMC University

- Go Cong sea dike
- Cu Chi irrigation channel

Jan 5: Depart for Cantho, visit vetiver site at Cuu Long University in Vinh Long Province

Jan 6: Inspecting demonstration sites: A seafood processing factory and municipal wastewater treatment site at Vi Thanh Province

Jan 7: Inspect flood mitigation dikes at Tan Chau, An Giang Province

Jan 8: AM Meet Cantho University staff and Dr Mai Viet Thuy, General Secretary of the Vietnam-Australia Foundation.
PM give presentation on **VS for Wastewater Treatment**

Jan 9: Return to HCMC and Fly to Da Nang and drive to Quang Ngai

Jan 10: Visit irrigation channels and shrimp pond trial sites in Quang Ngai conducted by KBR for AusAid

Jan 11: In Quang Ngai,

- AM give presentation on **VS for Riverbank and Dikes Stabilisation**
- PM visit sea dike project built by KBR

Jan 12: AM travel to Da Nang
PM meet Da Nang Ministry of Natural Resources and Environment (DONRE) staff. Visit several highly polluted ponds and landfill site in the city for future wastewater treatment projects

Jan 13: AM give presentation on **VS for Wastewater Treatment**
PM visit a riverbank stabilisation project and very steep road batter then travel to Hue.

Jan 14: Hue city

- AM give presentation on **VS for Wastewater Treatment and Erosion and Sediment Control** and meet with DONRE staff to discuss the possible selection of an Agent Orange contaminated site in A Luoi. The main objective was to stop the spreading of soil contaminated with dioxin by erosion and sediment control with vetiver grass.
- PM travel to A Luoi

Jan 15: A Luoi,

- AM meet district officials, visit old US Air Base at A Sho, which was highly contaminated by Agent Orange and a landfill site.
- PM return to Hue

Jan 16: Travel to Quang Tri, visit a sea dike stabilisation project by World Vision

- Travel to Quang Binh, check the old project of sand dune and river bank protection
- Travel to Phong Nha, check VS on Ho Chi Minh Route along the way

Jan 17: Travel to Ha Tinh, Huong Khe, Vu Quang, Nghe An, Thanh Hoa and Hanoi, checking vetiver plantings along HCM Route(northernpart)

Jan 18: Hanoi meet officials from Ministry of Agriculture, Ministry of Transport and MONRE .

Jan 19: AM visit Red River bank stabilisation sites

PM give presentation on **VS for Environmental Protection** at the Research Institute of Geology and Mineral Resources (RIGMR) with audience from several government ministries and Ken Crismier

Jan 20: AM Travel to Hai Hau, Nam Dinh Province on the invitation of the Danish Red Cross
PM visit several shrimp pond and sea dike stabilisation trial conducted by the Danish Red Cross

Jan 21: AM visit a large and collapsed sea dike stabilisation trial
give presentation on **VS for Riverbank and Dikes Stabilisation**
PM return to Hanoi

Jan 22: AM final meeting with Elise Pinners and Tran Tan Van
PM Fly back to Australia.

Jan 23: Arrive in Brisbane