VETIVER/BIOCHAR Solution

Sand Stabilization
High Speed Train Medina-Mecca

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Contents

A harsh Environment !

Dust Storms at the Red Sea

Moderate Resolution Imaging Spectroradiometer, MODIS sensor Terra satellite, NASA.

25 July 2005

Plant Characteristics for Revegetation in Harsh Environments

(Slide 1)

For a plant to be useful for agriculture and bio-engineering, and be accepted as safe, it should have as many as possible of the following characteristics:

1. Its seed should be sterile, and the plant should not spread by stolons or rhizomes. Therefore, it should not be invasive and become a weed.
2. Its crown should be below the surface so it can resist fire, over grazing, and trampling by livestock.
3. It should be capable of forming a dense, ground level, permanent hedge, as an effective filter, preventing soil loss from run off. Apparently only clones will grow 'into' each other to form such a hedge.
4. It should be perennial and permanent, capable of surviving as a dense hedge for decades, but only growing where we plant it.
5. It should have stiff erect stems that can, at minimum, withstand flowing water of 1 foot (30 cm) depth that is moving at 1 foot per second (0.3 meters/second).
6. It should exhibit xerophytic and hydrophytic characteristics if it is to survive the extremes of nature. Vetiver grass, once established, is little affected and highly tolerant of droughts or floods.
7. It should have a deep penetrating root system, capable of withstanding tunnelling and cracking characteristics of soils, and should have the potential to penetrate vertically below the plant to at least three meters.

Plant Characteristics for Revegetation in Harsh Environments (Slide 2)

8. It should be capable of growing in extreme soil types, regardless of nutrient status, pH, sodicity, acid sulphate or salinity, and toxic minerals. This includes sands, shales, gravels, mine tailings, and even more toxic soils.
9. It should be capable of developing new roots from nodes when buried by trapped sediment, and continue to grow upward with the rising surface level, forming natural terraces.
10. It should not compete with the crop plants it is protecting.
11. It should be capable of growing in a wide range of climates:
    a. From 100 mm of rainfall to over 6,000 mm
    b. From air temperatures of -15º C (where the soil does not freeze) to more than 55º C.
12. It should be able to withstand long and sustained droughts (more than 6 months).
13. It should be cheap and easy to establish as a hedge and easily maintained by the user at little cost.
14. It should be easily removed when no longer required.

The Vetiver System (VS) meets all these (14) characteristics!!!

Special Morphological Characteristics

Stiff and erect stems up to 2m tall and over 2.5m with flower heads. It flowers but does not produce seeds.

The Vetiver System (VS)

- The Vetiver System (VS) is based on the use of vetiver grass *(Chrysopogon zizanioides L.)* for a wide range of applications.
- VS was first developed by the World Bank for soil and water conservation and now being used in over 100 countries!
- R&D conducted by Universities, Research Institutions, Government Agencies showed that:
- Vetiver is sterile and non-invasive
- Tolerant to the most adverse soil and climatic conditions!
- Tolerant to high levels of pesticides and herbicides
- Tolerant to a wide range of heavy metal toxicities. Therefore VS has been successfully used as a bioengineering technology for infrastructure and environmental protection purposes in Australia, USA, Asia, Africa, South America and Southern Europe

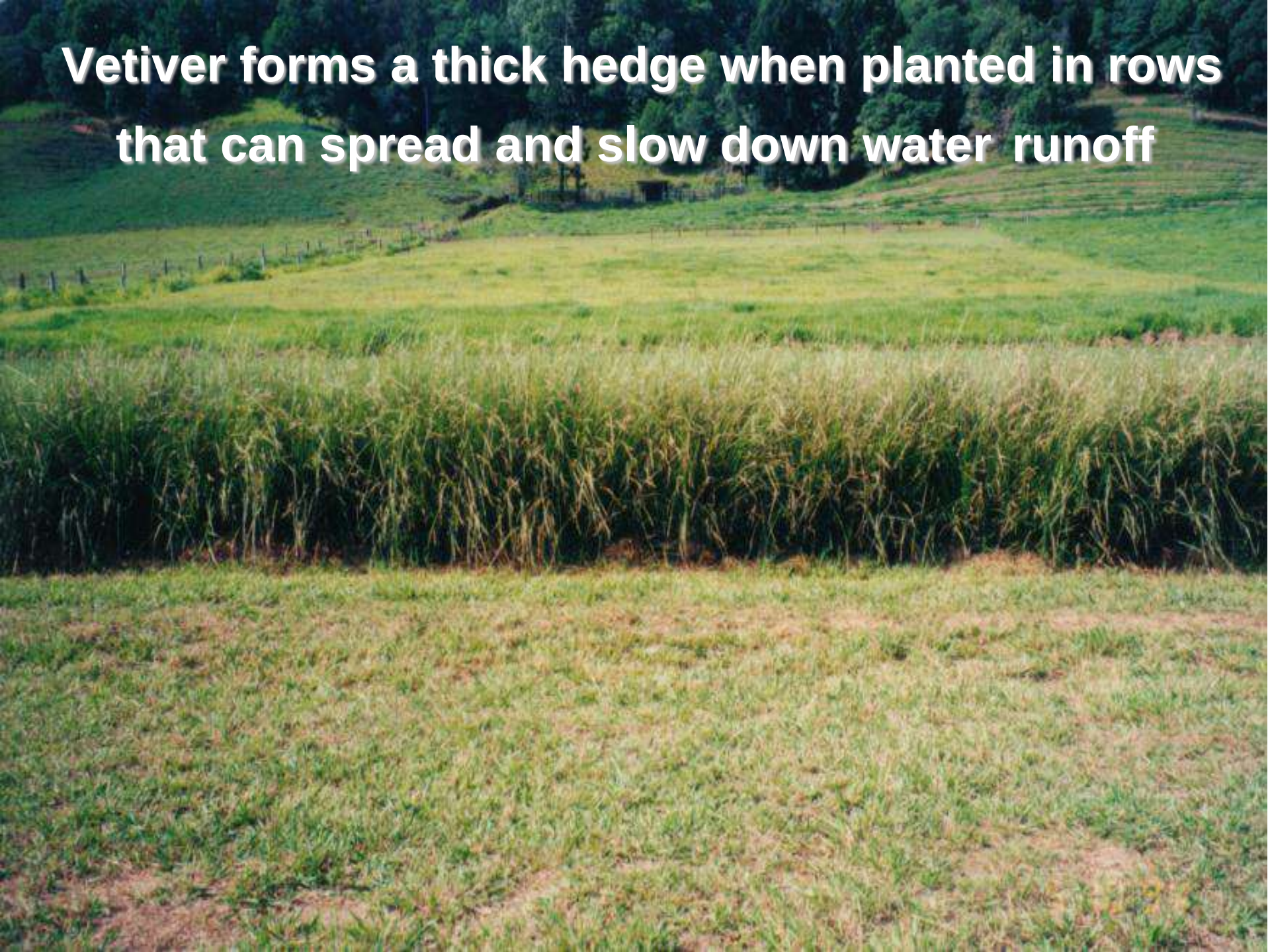
The Vetiver Network International (TVNI): **http://www.vetiver.org/**

Suitable Regions for Vetiver Development

Vetiver characteristics

- Vetiver grass (Chrysopogon zizanioides) originates from southern India where farmers used VS for over 200 years.
- Farmers have long since appreciated these characteristics:
- Planted as a slim, closed hedge, the stiff stems:
  - Reduce water speed,
  - Reducing soil loss
  - Reduced water runoff.
- Improves soil moisture and fertility.

- Soil accumulates behind the hedge and naturally builds a terrace.
- The strong, deeply penetrating root system grows down, not sideways
- Roots do not compete with crops right next to the hedge.
- The root system is unique: roots penetrate 3-4 meters, making it drought resistant.
- Established hedges resist overgrazing & fire.
- Vetiver does not easily establish under shade!
- Vetiver resists most pests, and attracts others (pulling Chilo stem borer away from maize) without itself being affected.


Vetiver forms a thick hedge when planted in rows
that can spread and slow down water runoff

Very deep, up to 4m, Massive and Penetrating Root System

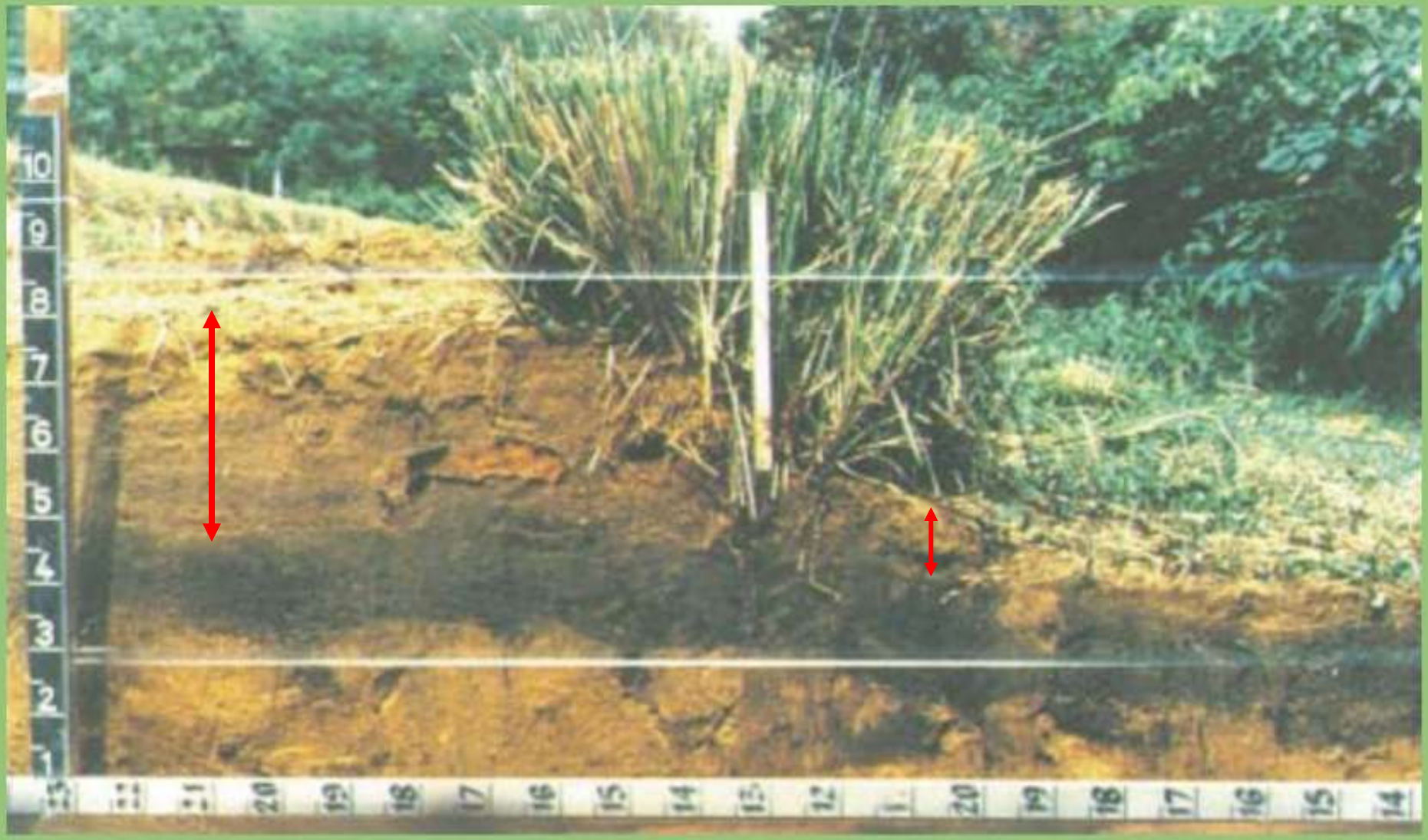
Special Physiologicical Characteristics

- Growing vigorously in water on a dam wall in Northern Australia.
- Vetiver can survive more than 50 days when completely submerged


Extremely drought tolerant in central Australia, note
all native grasses are brown off, except vetiver

Vetiver forms a dense and very effective hedgerow

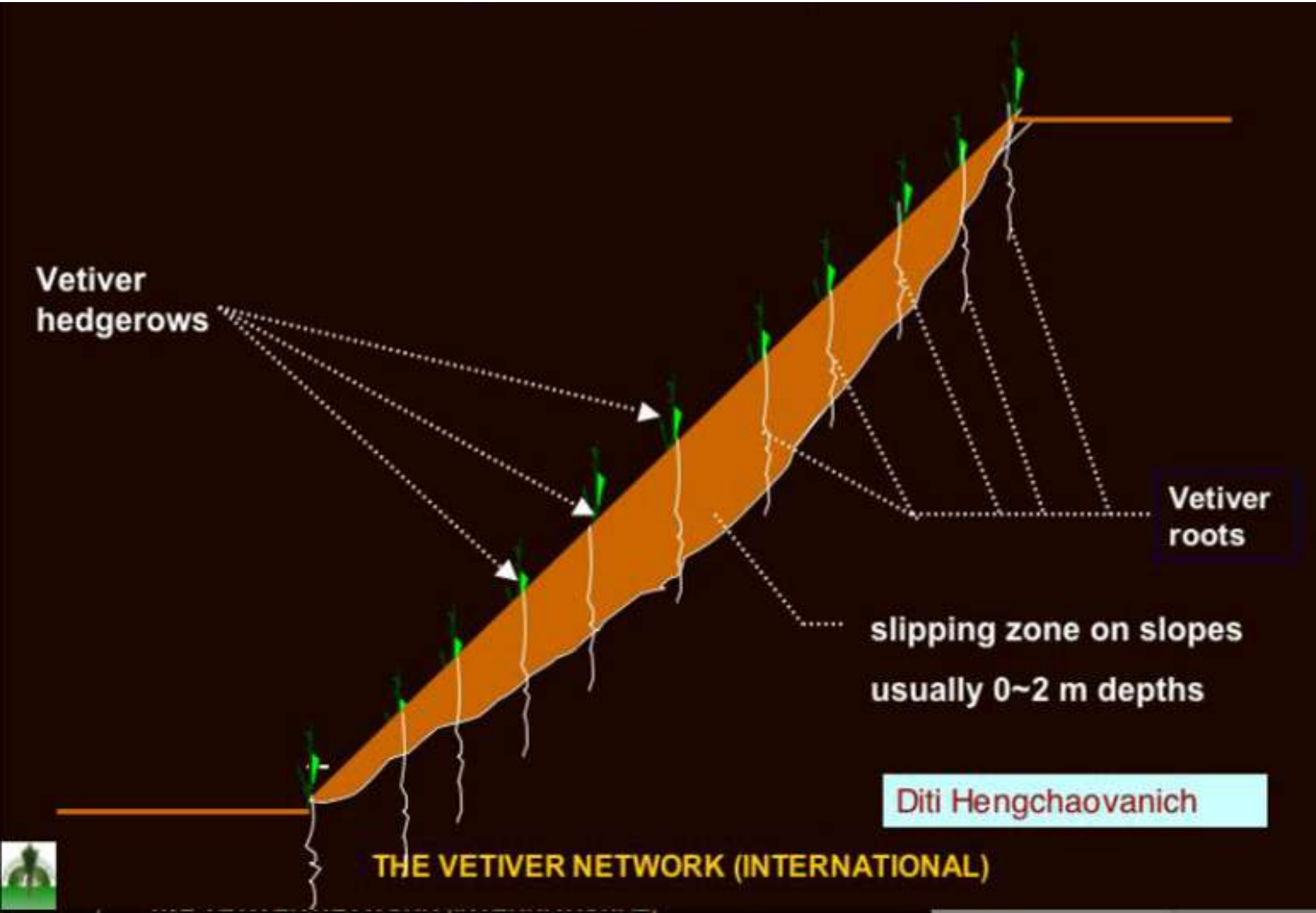
A Very Effective Barrier to Trap Sediments



Sediment accumulation behind vetiver hedge in Northern Vietnam

It also provides in-situ mulch, stops runoff and erosion, and reduces the slope by forming natural terraces

Soil Stabilization Mechanisms by Vetiver Grass



Closely Spaced Hedgerow (at Left) Assures a Properly Dense Hedge – 15 cm Between Plants at Planting

Multiplication

Splitting to get slips

Pull apart a clump with both hands, so that roots remain on each side. A *slip has at least two viable, healthy tillers*. Cut leaves to 20cm.

Vetiver grass: Planting process

Vetiver strips, 1 m long, Replaces Planting Individual Plants

Vetiver Roots
After 6 months, Senegal.

Vetiver strips, 1m long, to replace individual slip planting

The Key to Successful Vetiver Applications for Infrastructure Projects is the Availability of Good Quality and Abundant Vetiver Planting Material

Vetiver nurseries in:

Senegal

China

Thailand

VETIVER PLANTS FORT SALE!!!!!

Vetiver can be sold as bare rooted planting slips or in pots (polybags). Gross income per ha can exceed US $10,000 per ha. Thus there is a real incentive to have vetiver used for non agricultural applications. Vetiver plant production as a farm crop has great potential.

Vetiver-Planting Machine

Mechanical planter: A modified seedling planter or mechanical transplanter can plant large numbers of vetiver slips

The Vetiver Network International recommends the use of the suitable species (*C. zizanioides*) in comparison to other, less suitable species

***Vetiveria zizanioides* L (Nash) has been recently reclassified as *Chrysopogon zizanioides* L (Roberty)**

Vetiver Recovers After Fire

After a fire vetiver hedge remains vertical and quickly recovers with new growth

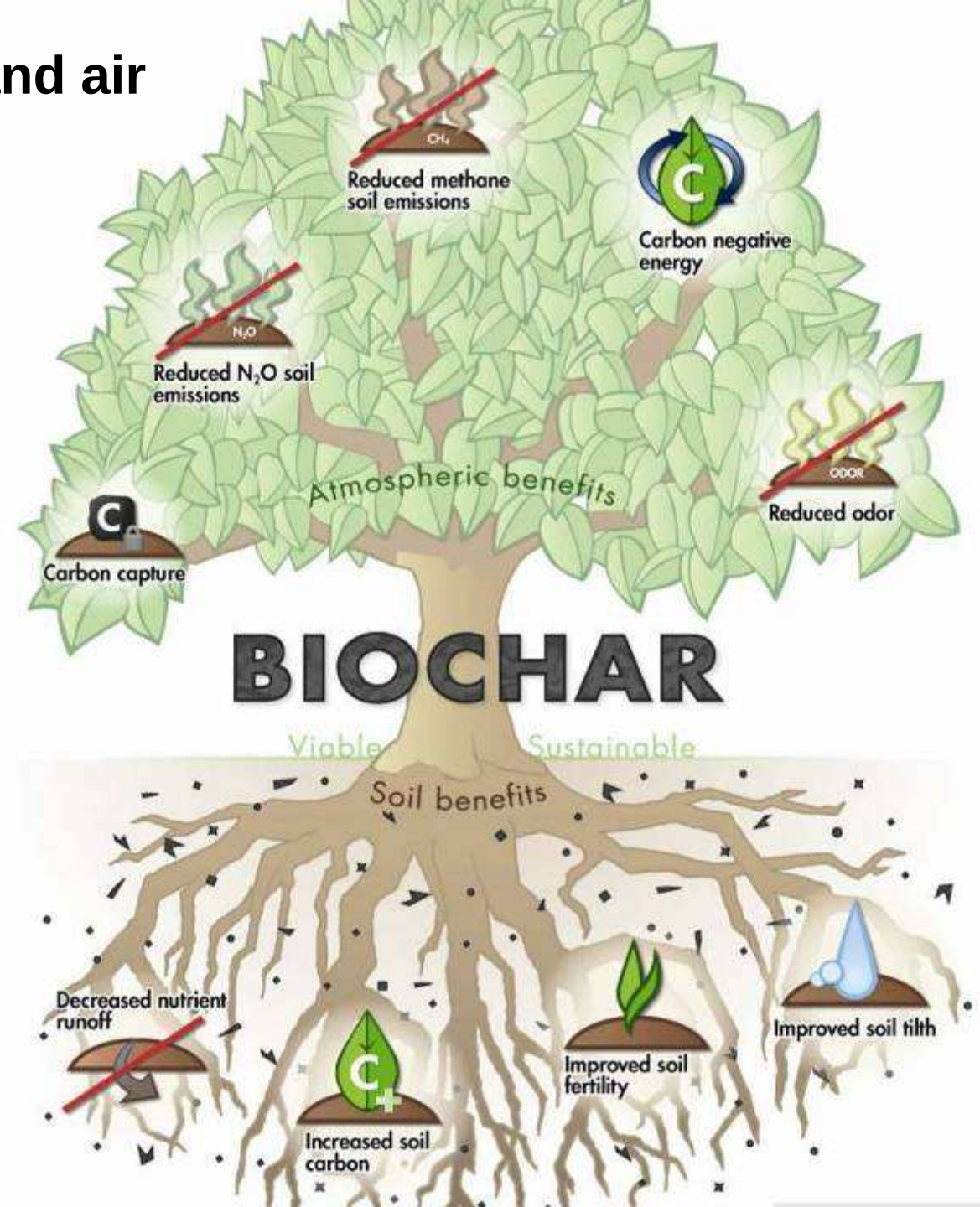
Stabilization of Railway Slopes in Sandy Sediments. China

What is Biochar?

Characteristics and Applications

Contribution of Biochar to a Successful Vetiver Plantation

Biochar benefits soil and air



Terra Preta: Beneficial Features

- Biochar has its roots in Amazonian Terra Preta.
  It is a "new technology" that is more than 2,000 years old.

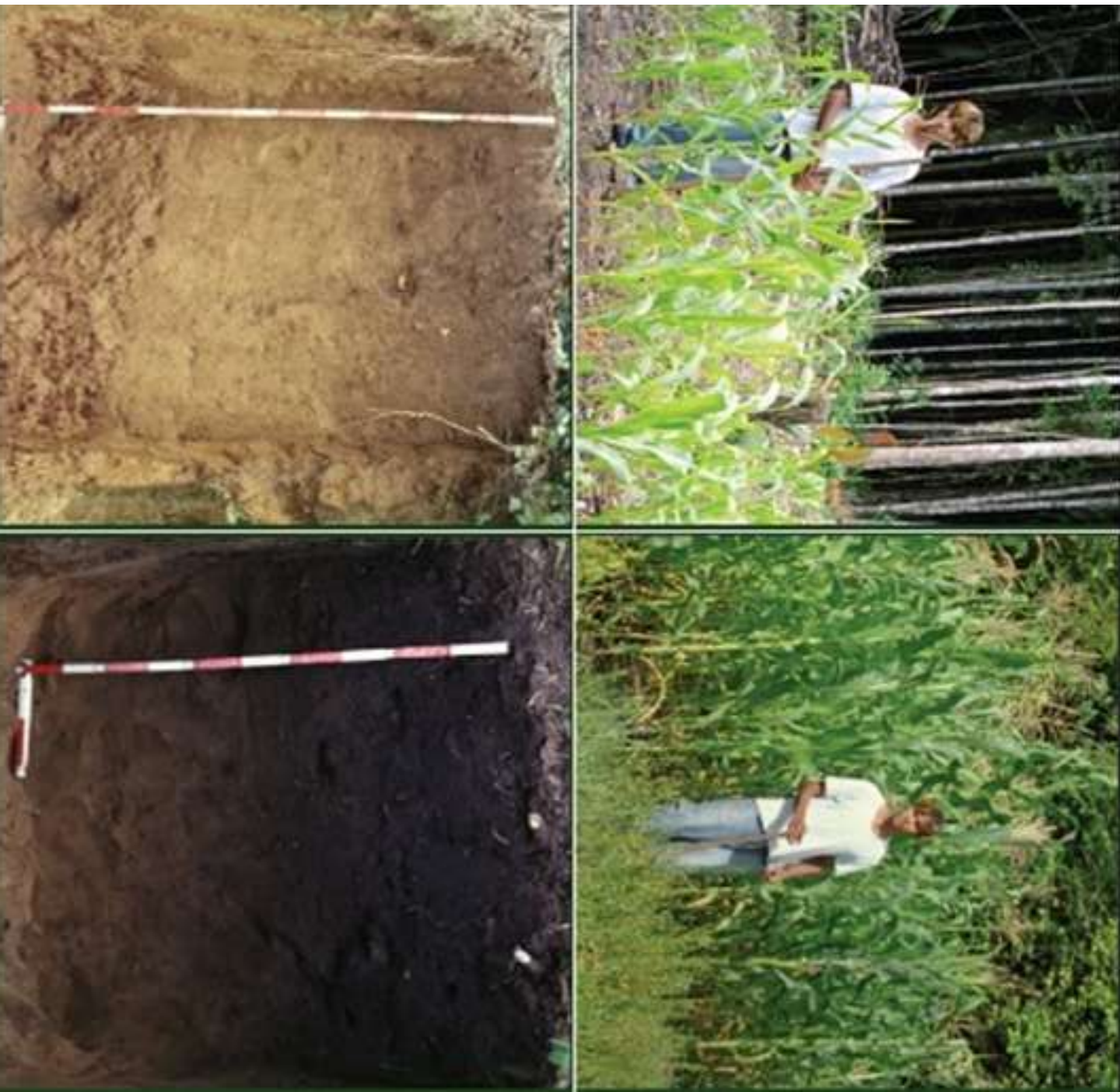
- It is a catalyst that creates a fertile soil, although it contains no fertilizers or nutrients.

- Stimulates high agricultural productivity without chemical fertilizers

- The Amazonians used Terra Preta to obtain good harvests that kept large populations

- It contains up to 9% CO2 and other greenhouse gases (GHGs) that are desirable to keep on the ground, to clean the atmosphere, thus preventing global warming.

Improved Production with Biochar



Terra Preta Examples: Amazon Basin

What is Biochar?

- Biochar is the charcoal produced from waste biomass (vegetal/animal) under controlled temperature and reduced oxigen conditions (pyrolysis). This process also produces useful fuels
- Biochar has many applications as a soil enhancement. It is a natural habitat for soil microorganisms that enrich the soil permanently.
- Biochar also stores carbon in the soil for very long periods due to its stability
- Link to International Biochar Initiative (IBI):

http://www.biochar-international.org/

Producción de Bio-carbón

Biomasa seca

Sistema conversión térmica

Biochar

Benefits of Biochar

Potential benefits that biochar offers for agriculture include:

1. **Improved soil fertility and crop yields**
2. **Increased fertilizer efficiency use**
3. **Improved water retention, aeration and soil tilth**
4. **Higher cation exchange capacity and less nutrient runoff**
5. **Clean and efficient biomass energy production from crop residues and forest debris**
6. **Combined heat, power, and biochar production from pyrolysis**
7. **Leads to net sequestration of carbon from the atmosphere to the soil thereby increasing soil organic carbon (SOC)**
8. **Greater on-farm profitability**
9. **Can be financed through carbon markets and carbon offsets**
10. **Decreased nitrous oxide and methane emissions from soils**
11. **Provides powerful tool for reversing desertification**
12. **Provides alternative for slash-and-burn agriculture**
13. **Can work as component of reforestation and aforestation efforts**
14. **Can produce electricity, bio-oils, and/or hydrogen fuels**
15. **Can use wide variety of feedstock including crop residues such as wheat and corn straw, poultry litter, cow manure, forest debris, and other farm-based biomass resources**
16. **Acts as a liming agent to reduce acidity of soils**

Soil Improvement with Biochar

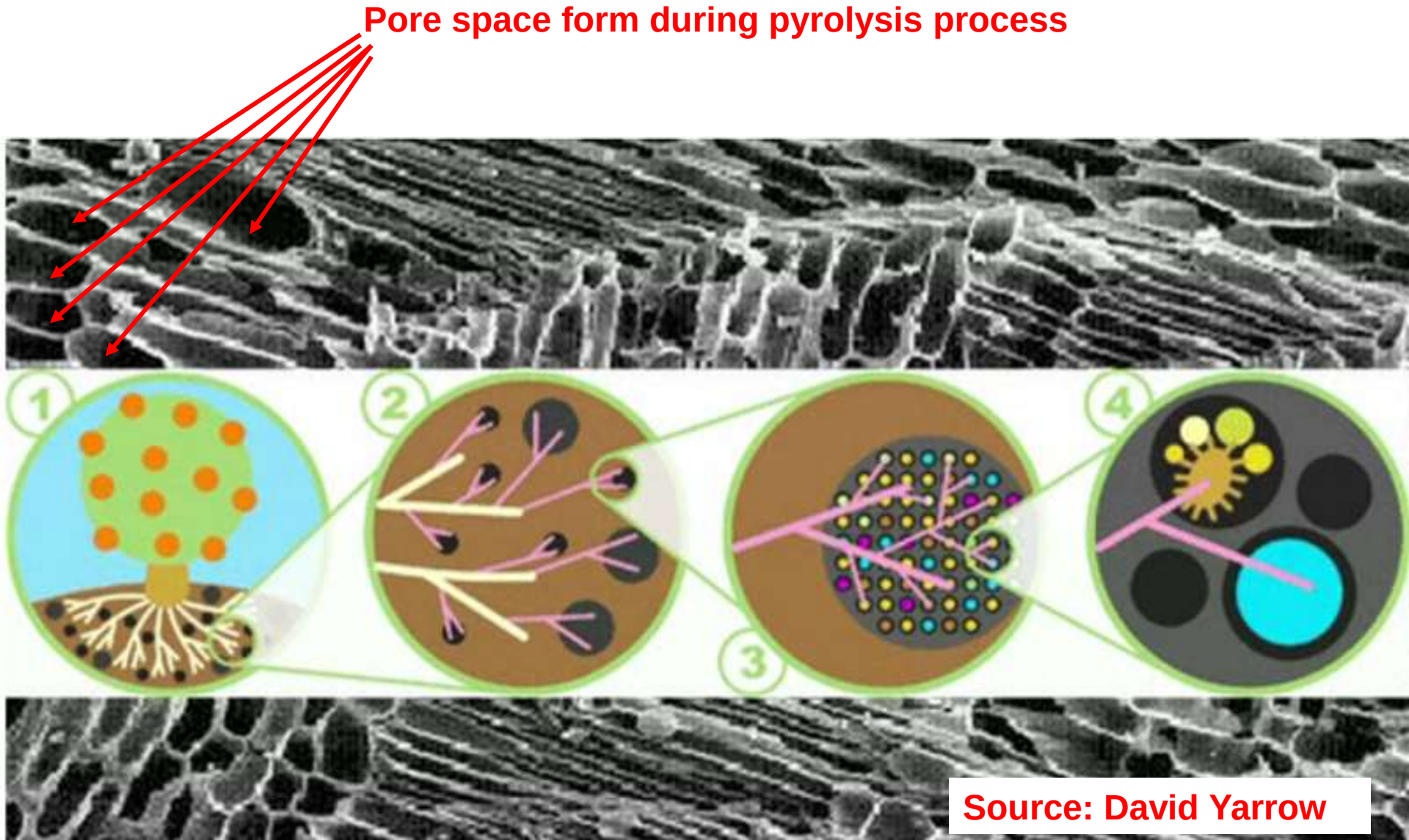
Biochar enhances soils by converting agricultural waste into a powerful soil enhancer that holds carbon and makes soils more fertile. Biochar obtains the following results:

- Reduced leaching of nitrogen into ground water
- Possible reduced emissions of nitrous oxide
- Increased cation-exchange capacity resulting in improved soil fertility
- Moderating soil acidity
- Increased water retention
- Increased number of beneficial soil microbes
- Biochar can improve almost any soil. Areas with low rainfall or nutrient-poor soils in arid areas will most likely see the largest beneficial impact from the addition of biochar.

Biochar forms a good habitat for beneficial soil microorganisms

- Healthy soil is alive with helpful bacteria, fungi, earthworms, beneficial nematodes and countless other microorganisms. This soil food web supports all aspects of plant growth.
- Under a microscope, Biochar reveals high porosity that serve as good habitat for microbes, stocked with nutrients, water and oxygen.
- Biochar increases SOC attracting soil bacteria that make soils more fertile.
- This is how Biochar enhances soil for increasing fertility and higher crop yields

Porosity: Habitat for Microorganisms



Comparison: Corn Crops

Caso Práctico:

Hope Mine, Colorado. USA

Restauración de Terrenos Afectados por Actividades Mineras Mediante Biochar

Soil Pollution

- Activated charcoal is widely used to purify air and water of their pollutants.
- Charcoal is widely used to remove unwanted odors, toxins and flavors from foods.
- It should not seem strange then that charcoal is also widely used to decontaminate soils from a host of toxic compounds that daily filter down from the air above, including those in rain and irrigation systems. And, if charcoal cleans all manner of food products, it is reasonable to think charcoal would be incorporated into agricultural methods to adsorb poisons from the very soils that we grow our food in.

Zanzibar Red Colobus Monkey Eating Charcoal

Photo: Martin Harvey. CORBIS

The red colobus monkeys, *Procolobus kirkii*, eat charcoal, (Zanzibar, Tanzania). These endangered animals have specially adapted stomachs which enable them to feed principally on leaves. They eat charcoal from burnt tree stumps and branches to detoxify poisons obtained from their leafy diet and convert it into proteines

Excellent possibilities in the clean-up of polluted soils

Detalle de la Aplicación

Proyección de Bio-carbón

Talud cubierto con Bio-carbon

Cinta transportadora

Depósito de Bio-carbón

Bio-carbón: Restauración de Terrenos Mineros Hope Mine, Aspen (Colorado). USA

- Mejora de la fertilidad del suelo promoviendo el vigor y la extensión de la vegetación
- Estabilización de taludes mediante el desarrollo de la vegetación endémica de la zona
- Eliminación de la erosión
- Almacenamiento estable de GEI
- Control de los lixiviados
- Inmobilización de los metales pesados* (As, Cd, Pb, Zn) hasta su degradación natural contribuyendo sensiblemente a:
  - Mejorar la calidad del suelo
  - Mejorar la calidad del agua

***El alto poder de intercambio catiónico y aniónico neutralizan los metales pesados**

Comparación: Hope Mine, Colorado. USA

Julio 2010 – Antes del tratamiento

Durante los últimos 60 años, el terreno permaneció con este aspecto. La contaminación del suelo impidió el desarrollo de la vegetación.

Aspecto actual después del tratamiento con Biochar más Hidrosiembra

Agosto 2011

Vetiver/Biochar International Team

Multidisciplinary team formed by experienced members with many successful projects completed with Vetiver/Biochar technologies and with the additional support of the Vetiver and Biochar organizations:

- **Dr. Paul Truong**, Technical Director, Vetiver Network International and Head of Veticom Consultancy, Brisbane, Australia.
- **Mr. Roley Nöffke**, CEO, Hydromulch (Pty) Ltd, South Africa.
- **Prof. Mohammad I. Al-Wabel**, PhD. Director, Saudi Biochar Initiative, Soil Sciences Dept. King Saud University, Riyadh, Saudi Arabia.
- **Mr. Mohammad Asiri**, Vetiver Technical Expert, Saudi Arabia
- **Dr. Antonio de la Cruz**, Manager, Greenresults, Environmental Geology. Vetiver/Biochar Expert and Proposal Coordinator, Spain.

Vetiver Case Studies

Vetiver Applications for the Stabilization of Sands and Sandy Sediments

1.- Dune Stabilization and Erosion Control for Road Construction, Madagascar

2.- Slope and Erosion Control of Sandy Sediments, Kuwait

3.- Dune Stabilization for Agriculture Protection, Vietnam.

4.- Dune Stabilization for Village and Crop Protection, China.

Dune Stabilization, Madagascar

Dune Stabilization for Road Construction to Rio Tinto Mine. Fort Dauphin, Madagascar.

Mr. Roley Nöffke, CEO, Hydromulch (Pty) Ltd, South Africa, as Principal Contractor.

Objective: Dune Stabilization to Prevent the Invasion of the Road

Very harsh conditions: Wind blast and shifting sands

Construction of the haul road through the dunes of old forest area

A very large scale project!

The magnitude of dune planting & stabilization process with wind break netting to control the devastating effects of wind blasting

Planting Vetiver in the Dunes!

Vetiver planting in progress between the rows of wind-break nets

Young Vetiver Plants Stabilizing the Dunes

Vetiver progress stabilizing the dunes

Vetiver stabilisation of the cutoff berm constructed to reflect surface water runoff back into the concrete drain at the toe of the cut slope.

The Ehoala Dune cut and fill slope stabilised with Vetiver grass at Rio Tinto Fort Dauphin Madagascar


Progressive advancement of Vetiver growth
along the extent of the dune

8 month root growth on this extremely infertile sand dune

A closer inspection reveals the bio-diversity of the vegetation.

The side slopes (fills) of the haul road stabilised with Vetiver and hydroseeding. Note emergence of native species as a result of the topsoil layer that was placed.

New Road and Successful Dune Stabilization

Dune Stabilization: Vetiver growth has covered even the wind-break nets


Before
DSC05223
November 2006
Ehola dune cut during construction phase – An area of 5 hectare in extent had to be stabilized.


Vetiver planting
April 2007
Wind Barrier Netting
erected and Vetiver grass
planting completed


August 2010
Stabilised dune cutting showing native species diversity
3.5 Year Later


Before and After

Stabilization of Sandy Sediments, Kuwait

Road Slope Stabilization and erosion control in Calcareous Sandy Sediments. Surra, Kuwait.

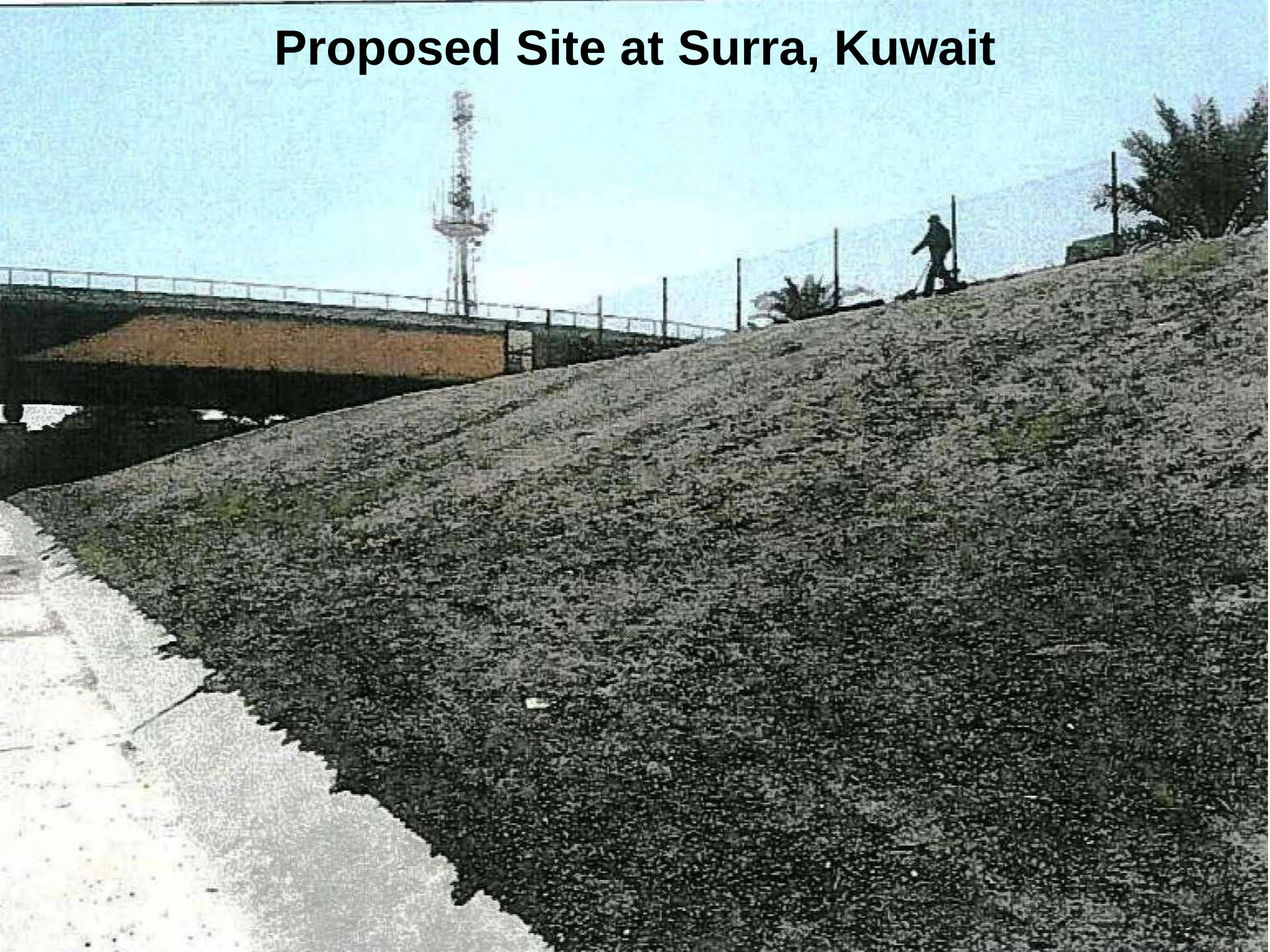
Dr. Paul Truong, Technical Director, Vetiver Network International (TVNI) and Head of Veticon Consultancy, Brisbane, Australia.

Road Slope Stabilization and Erosion Control in Calcareous Sandy Sediments. Surra, Kuwait.

- The Kuwait Institute of Scientific Research (KISR) carried out a series of Pilot Studies to evaluate the Potential Applications of the Vetiver System in the Arabian Gulf Region. This included the *Evaluation of Vetiver Plant Performance in Roadway Embankment* projects.

- The following slides show the performance of vetiver grass on a road batter over the 8 month period at the Surra site.

Proposed Site at Surra, Kuwait



Experimental Site After Land Preparation at Surra

Experimental Site After Planting - July2011

Notice irrigation lines

One month after planting

Plate 4. Overview of the roadway embankment site at Surra (15 August 2011).

Two months after planting, excellent establishment

Three months after planting, excellent growth with fertiliser application prior to planting

Four months after planting

Six months after planting, with plants at least 1.2m high at roots 0.8 to 1m deep

Eight months after planting, these plants roots at 1-1.2m deep should be able to survive without irrigation and provide a permanent protection against erosion and sand drift

Six months after planting

Coastal Dune Stabilization, Vietnam

Objective: Protection of Agriculture Areas

Vetiver planted to stop the advance of this dune to agricultural land

Two months after planting with irrigation

Ten months after planting with irrigation

Dune Stabilization for Village and Crop Protection, S.Eastern China.

Experiment of the Application of Vetiver to Sand-fixing in Subtropical Deserts

Hang Chess, Fans Waits
(Nanchang Water Conservancy and Hydro-Power College, Ministry of Water Conservancy Nanchang 330029, China)
Yu Li
(The Grain Bureau of Jiangxi Province)
Guohua Hu
(Nanchang Science Committee)

http://www.vetiver.org/TVN_IVC2/PD2-3A~1.PDF

- "From 1950 to 1980, 8 villages of Guangshang and Fushan Townships in Nanchang county and Houtian Township in Xinjian county were destroyed and covered by shifting sands, causing the loss of 660 Hm2 of farmlands and damage of a series of water conservancy facilities due to sedimentation. Hence, desertification is a very urgent hazard to be controlled"

- "To stabilize the sand dunes, vetiver grass was introduced to Fushan Township of Nanchang City in March 1998. It was planted in lines. Although the sands lacked of nutrients 91% of the planted vetiver survived and grew well. Besides, vetiver promoted other weeds to grow. **Therefore sandy dune was fixed**. The successful experience is valuable not only to Poyang Lake area but also to other river banks and coastal region which covers a large area in Southeast China".

Conclusions

- **Vetiver/Biochar is an environmentally friendly technology that have stabilized sand dunes under adverse climate conditions in different parts of the world by the Proposal Team.**
- It reduces or eliminates the need for large infrastructure works (rock, cement, iron) requiring mining and transport, sometimes over long distances with high impact on the environment.
- Vetiver/Biochar is **economically more cost-effective**, and allow larger scale application and increase local employment.
- Roots capable of reaching down 2-3m in the first year; Many experiments show that slope Vetiver grass can reach up to 3.6m in first 12 months
- The soil binding makes it very difficult for soil to be dislodged
- Vetiver roots can penetrate compacted soil profile such as hardpan and blocky clay pan common in tropical soils, providing a good anchor for filling topsoil that regenerates native vegetation.
- This integrated technology can provide many environmental applications to Saudi Arabia and the rest of the Middle East where it is still little known!