USE OF VETIVER FOR EMBANKMENT AND STABILIZATION

by

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INTRODUCTION

Since time memorial, plants have been used to protect slopes and embankments and to minimize soil erosion. There is record that the Minister of Flooding in China used bioengineering as far back as 1592. Also, the Germanic speaking countries have practiced this approach since the 1930s. In Malaysia, ferns, grasses, leguminous creepers, leguminous and non-leguminous shrubs and trees have been tested by the plantation sector since 1930s. Malaysian highway engineers are well noted for their good use of hydroseeding with grasses and leguminous covers to protect embankments. In the 1980s they have also widened the use of fast-growing indegenous pioneer shrubs and introduced tree species. Now we should consider using *Vetiver* Grass Hedgerow Technology (VGHT). Why? Because it works practically on the ground!

To get the full benefit, users must fully understand that the VGHT

exploits	o Unique Characteristics of *Vetiver* grass
uses	o Selected Cultivars
requires	o Good Biological Systems as
	o Good Propagation Techniques
	o Quality Planting Materials
	o Good Planting Techniques
	o Appropriate Planting System
	o Appropriate Management Inputs
	o Good Field Implementation and Supervision
	o Necessary Post Planting Management
conforms	o Specifications for Quality VGHR
considers	o Holistic Approaches
	o Social, Economic and Environment Friendly (SEE)

The various components of the VGHT are discussed in the following sections.

UNIQUE CHARACTERISTICS OF VETIVER GRASS HEDGEROW

Among the many unique characteristics of Vetivar Grass Hedgerow (VGHR) are :-

a) **The VGHR root system is very deep and vigorous**

With the use of correct cultivars, appropriate fertilizers and other agronomic inputs, quality planting materials produce rapid growth with very intense network of roots. These were clearly demonstrated by excavations in Malaysia, Thailand, Vietnam and Spain. In Malaysia, 3-month old plants had massive root development reaching down to more than 1 meter. In the Mediterranean climate of Spain, the VGHR was established with roots reaching down to 2.1 meters, after 9 months establishment and growth. After 14 months in the field, the roots reached 2.6 meters depth and this was despite having to go through a winter period when sub-zero temperatures killed the tops. In Vietnam, under very difficult soil conditions and six months of dry weather, one-year old plants produced roots of 1 meter depth. The massive root system of nearly 2 meters of one clump extracted after one year's growth in my project in Malaysia even attracted the attention of our Prime Minister. The root system of a 20-month old VGHR in Malaysia showed that the roots interlocked to form the intense underground web of *Vetiver* roots. During my visit to the Royal Project in Thailand in 1994, I had the opportunity to see the massive root systems of many excavated plants, a root system of about 3 meters was harvested from a one-year old plant. In the first International *Vetiver* Conference in February 1996, the Thai researchers unveiled a 5 meter long *Vetiver* root - the world record !

In addition, my work had also shown that *Vetiver* roots can penetrate even very difficult soil. Good and vigorous root system have been obtained in very difficult lateritic soil; at the lower-level, the roots grow between the pebbles. In heavy iron oxide soil, the *Vetiver* roots search their way through any weak spots. The amount of roots was small because *Vetiver* roots cannot grow well in it, but the manner which it seeks its way through the " cracks " showed its inherent strength.

Thus, the *Vetiver* root system is unique in the depth it can penetrate and the intensity and network it can form. All those features will help the VGHR to anchor itself so firmly in the ground that it cannot be dislodged by the strongest floods.

b) VGHR is compact, alive and self-adjusting

VGHR is neat, compact with good active culms and no dead centres. Only with such a good hedgerow could soil-wash be trapped effectively. VGHR has been proven to be much more effective in preventing soil erosion than normal turfing.

Another important biological characteristic of VGHR is its response to the level of the soil trapped. The crown of the hedgerow climbs with the accumulation of the trapped soil on the *up-slope*, leveling as the slope levels. This self-adjustment ensures that the hedgerow is not buried. The VGHR is alive; it grows taller as the silt builds up on the *up-slope* due to the formation of new tillers from nodes higher up the culm.

It is most important to fully comprehend the characteristics of the *Vetiver* grass hedgerows technology. VGHR is not a dead structural barrier. It is a vegetative barrier, alive and self-adjusting. Its roots penetrate deep into the ground anchoring itself firmly while the tops grows, rises up and bends with the soil that it traps. The tops do not completely block the flowing surface rain-wash, it merely slows it down and spreads it out, therefore allowing it more time to infiltrate into the soil. It acts to reduce the erosive force of the run off. The tops trap the debris and the surface soil-wash, thus reducing soil erosion.

All the above discussions of the major unique characteristics of *Vetiver* grass show it to be an ideal choice for use as a biological barrier to reduce surface as well as sub-soil erosion. It is these basic characteristics that we must fully exploit to maximise the VGHR efficacy.

THE IMPORTANCE OF USING ONLY SELECTED CULTIVARS

The *Vetiver* Newsletters have repeatedly warned against the use of untested planting materials. There are three main reasons:

i) Untested planting materials may not perform well as many unselected planting materials occurring in the wild are of poor vigor with poor rooting system.

ii) Of grave concern is the import of seed-bearing cultivars which could become a weed . My trials have shown that *Vetiver* is even more difficult to eradicate than lalang. (*Imperata cylindrica*)

iii) Of even greater danger is the import of a cultivar which could be an alternative host for any pest and disease of economic importance to the major agriculture crops, thus jeopardizing the agricultural sector of the country.

In my work, all the accessions collected were carefully screened for viable seeds and for pest and disease problems before being used in the field. When in doubt, specimens were sent to the British Mycological Institute for detailed identification of the pathogen. We even inoculated the selected accessions to test their resistance to major diseases existing in Malaysias. After the enormous effort of screening 23 accessions, only 5 met the criteria of not producing viable seeds, resistance to important pests and diseases in Malaysia and have good growth, good morphological characters and good vigorous root system,

Vetiver grass occurs naturally in abundance in many countries as India, Bangladesh and Thailand. Unscupulous contractors after quick and excessive profits may resort to getting cheap but untested materials from suppliers in these countries.

All major users of VGHR must check the *PROVENANCE* of the *Vetiver* grass to be used; *THIS IS THEIR RESPONSIBILITY TO THEIR COUNTRY.*

GOOD BIOLOGICAL SYSTEM FOR ESTABLISHING VGHR.

To ensure that only the best VGHR is used for erosion control, the best biological system must be developed. These requires the following:-

1. Production and Use of Quality Planting Materials

It is an axiom in agriculture that only quality planting materials must be used to achieve best results. For *Vetiver*, this must always begin with mature and active tillers from non-flowering nurseries. Materials from the flowering clumps establishes slowly. Aged tillers with culm formation are slow growing; too young tillers give low establishment success.

2. Good Root Regeneration in Container Plants.

The old cut-roots in slips form few and insignificant secondary roots and are only useful for initial anchorage. For new growth, new roots are only formed from new tillers or from nodes of old culms. Any planting using slips with cut-roots will be very slow to establish and grow; besides having variable success. They may be used on more gentle slopes where replacement are easy, especially if established by resident farmers or with ready and abundant supply of labour. However, in infrastructural works only container plants should be used, especially in the rain-fed tropical conditions with heavy rainfall. In such situations, replacement for failures or washouts, may be most expensive and may not even be practical to implement.

The age of the container plants determines greatly the rate of establishment of VGHR. Container plants raised in the nursery for 3 - 6 months give the best results; too young plant are less vigorous and too old plants were bag bound and slow to take off. Attempts to reduce nursery time by using more tillers as starting materials per container plant generally gave poor results.

3. Use of Unorthodox Rooting-Media in Container Plants.

When polybag plants can be raised at site nursery, the use of polybags with good soil produces quality planting materials. However, often in infra-structure project sites, on-site nurseries are not available or difficult to set up for a one-off use. Transporting of container plants with soil tend to be very expensive. Other lighter potting materials were tested, including saw dust, padi husk, empty oil palm branches, etc. with generally disappointing results. So far, foam is the most promising unorthodox root-media (Photo 1).

The foam system was tested in large scale plantings in East-West Highway in Malaysia. The planting materials were transported from central nursery to field sites over a distance of 400 Km; the transporting cost was reduced by 75% compared to that of polybag plants with soil medium. In addition, the fast distribution in the field, the minimal transplanting shock and the fast growth and establishment were demonstrated (Photo 1a - d). The first major infrastructural project using VGHR by the Public Works Department (PWD) of Malaysia on 4 slopes in the East West Highway was most successfully completed (Photo 2 - 5).

4. Use of Different Accessions.

Different Accessions would perform differently. In addition to different rates of biomass production and different morphological characteristics of the tops, the quantity, quality and depth of penetration of the roots under field conditions would be important.

The biomass production of 23 Accessions was studied and found to be very variable. The top 5 fastest growing Accessions included the *Taiping* Accession used in all my earlier trials and the Accession now used mainly in the industry in Malaysia. More detailed studies have shown that there is a wide range of morphological characteristics and culm production rates. For example, the *Kartakana* Accession from India has rather flat culms, with very pronounced culm shoot production, resulting in the outer culms of VGHR bending over and tend to be lodging. Such characteristics would not be good for gentle slopes because the VGHR tend to be less tidy and less compact with time. However it is ideal for steep slopes and highly erodible soil as the many culm shoots will ensure the top of VGHR will ride with the accumulation of trapped soil and will not be buried. The early growth is the fastest of all the 21 Accessions. The *Sabah* Accession has very thick culms and also good culm production but the early growth is slow.

A good accessions is Accession *Parit Buntar*, with tall and thick culms but with few culm production, though it tillers very well. This plant stands erect and does not lodge over. This accession will be good for the gentle slopes because it retained the neat compact VGHR.

For the best performance it will be best to combine different accessions using their special attributes, e.g. Accession *Kartakana* planted with Accession *Parit Buntar*. Understandably, the field implementation may be more difficult; but a system can be structured for easy implementation.

5. Proper Establishment and Management of Quality VGHR.

A critical point to note is that the VGHR must be planted as soon as portions of the earthworks are completed (Photo 2 and 5). This required good co-ordination between the engineers and the plant specialists to ensure that quality container plants are in ready supply.

For maximum efficiency, the VGHR must be spaced and aligned correctly. The VGHR must be contour lined with vertical intervals of 1m or 2m between rows. The orientation must be such that it is at 90° to the direction of flow of rain wash. Thus, in the project to protect a culvert inlet, the VGHR were aligned in many directions, all positioned to ensure greatest reduction of the force of rain wash and maximum trapping of soil wash and other debris (Photo 4 and 5).

With the use of quality container plants, the speed of achieving a functional hedgerow is the between plant planting distance. The closer the planting, the faster interclump gaps will close over. In the extremely hostile conditions of Murcia in Spain, 5 and 10 cm were tested with good results in the demonstration trials.

However, for general purpose, in Malaysia 15 cm is preferred because the system uses less plants. Trials have shown that increasing the between plant distance to 30 cm resulted in a delay of 8 months for the same functional VGHR to be achieved.

The use of fertilizer enhances the early establishment of VGHR. In infra-structural developments, slow release fertilizer and controlled release fertilisers are preferred because the one-off application removes the need to visit the site repeatedly and often.

6. Use of Selective Herbicides to Maintain Quality *Vetiver* Hedgerows

As with all agricultural crops, weed management is an important aspect in the maintenance of quality VGHR. In Malaysia, the most damaging weeds are broad leaves plants such as *Asystasia intrusa, Chromolaema odorata* (Siam weed), *Mikania micrantha* and leguminous creepers normally grown as covers in agricultural plantations. These are the most noxious weeds because they swarm over, strangle and shade out the *Vetiver* hedgerows. The grasses are less important. The various selective herbicides and rates recommended to control weeds areas follows :

Asystasia intrusa	2,4 - D amine 1.5 l / ha
	Starane $_{200}$ 0.375 / ha
Chromolaena odorata	Ally 20DF 150g
	2,4 - D amine 1.5 l / ha
	Starane $_{200}$ 1.25 l / ha

Mikana micrantha	2,4 - D amine 1.0 l / ha
	Starane $_{200}$ 0.51 l / ha
Pueraria phaseoloides	Ally 20DF 100g
	Starane $_{200}$ 0.375 / ha

7. **Regeneration Of Aged VGHR**

There are cases where the VGHR deteriorates with age. This is usually due to partial shading by weeds, especially shrubs and scrambling weeds. Sometimes these weakened VGHR were attacked by termites, exarcerbating a poor situation. Such VGHR may be rejuvenated by :

(i) topping with a mechanical grass cutter to the level of the soil

(ii) Controlled burning. The crown of *Vetivar* grass is buried in the ground and not harmed by fire. For faster and better burn, the leaves may be scorched with a contact herbicide such as Grammozene 1 - 2 weeks before the burning

The timing of the above operation is important and should be carried out during the dry season when there is little surface rain wash and low risk of erosion.

SPECIFICATIONS FOR QUALITY VGHR

Civil engineering is centred around quantifiable and predictable mathematical models and equation. Accordingly many engineers shy away from biological systems as they are considered to be too variable. If ever VGHR were to be used to complement civil engineering, it must be treated as any other engineering component with stringent specifications that are consistent and monitorable, verifiable and enforceable by the superintendent engineer in charge of the work. Such specifications were drawn up by the writer and used in the establishment of VGHR on four slopes in East West Highway in Malaysia. For information, this is reproduced in the appendix. It details the protocol for a good biological system and ensured the successful use of VGHT on protection of slopes and embankments.

These specifications are particularly critical because the success of *Vetiver* planting for engineering purposes is dependent on the quality of planting material and the implementation of proper planting technique. Unfortunately, far too many contractors have jumped on to the bandwagon in Malaysia. In their greed to maximize profits, they have used poor quality and untested materials and doubtful planting practices. There were many failed plantings seen in the North - South Highway, East - West Highway, Klang Expressway, etc. These failures of *Vetiver* plantings give an undeserved bad name to VGHT. Hopefully these specifications and their stringent implementation, will ensure that VGHT performs as expected and contributes to the realisation of a social economic and enviroment - friendly (SEE) system to protect slopes and embankments.

HOLISTIC APPROACHES OF VGHT.

A natural slope, where the dynamics of the various forces are balanced, is always stable. This mature ecosystem has developed a natural cover of mixed vegetation which adequately protects it. However, when man disturbs Mother Nature by his many activities, the equilibrium is upset leading to erosion, instability and slope failures. Unfortunately, to progress, hilly land has to be cleared for agriculture, human settlements, etc. or be cut for infrastructural developments. To minimise these adverse effects, the damage to Mother Nature must be repaired as soon as possible. For this, the system must be socially acceptable, economically justified and environment friendly (the SEE System). The best holistic approach would be to imitate nature and to be in harmony with nature as practised in "Tao", "Tai chi" and "Chi". These centuries old philosophies present deep insights into the real happenings in nature.

In "Tao" water is always stronger than rocks;

water wears away rocks and other solid structures.

In "Tai Chi" strength does not imply rigidity.

It is the exact opposite : strength must mean

integrating the means for flexibility.

In "Chi" the forces circulating

within a system must be guided in the correct path.

VGHR is firm (not rigid) due to its neat and compact form with lots of up-standing good active culms and with no dead centre. Its strength lies in its flexibility, of being able to grow, to bend, to adjust and dissipate the prevailing intrusive force by allowing excessive hydraulic force to go through but with much reduced energy. It does not have to absorb the whole force. It is easy to use VGHR if one appreciates the " Tao " philosophy of doing little (or nothing) , the " Tai Chi " philosophy of using small forces to progressively neutralise a great force and the " Chi " sensitivity on how to deal with the ever changing directions of the destructive forces. With these appreciations, we will be better able to understand the requirements demanded of the *Vetiver* grass hedgerow technology.

> *There is no substitute for knowing HOW*
> *things happen and for acting accordingly.*
> *Everything is bound by this principle.*

The clearest most helpful word is *HOW*. Yet, this is the most difficult. Understanding this would lead to developing simple practical approaches of VGHT.

APPENDIX 1

SPECIFICATIONS FOR QUALITY VETIVER HEDGEROW

	Items	Descriptions
1.	General	The Vetiver hedgerow is used as bio-engineering system to complement structural works. Therefore it shall be of good and consistent quality.
2.	Plant Materials	The plant shall be *Vetiver zizaniodes* (Rumput wangi) of the South Indian domesticated type. Only non-seeding types shall be used. The North Indian wild types which flowers regularly and set fertile seeds shall be absolutely avoided.
3.	Starting Materials	i. Vigorously growing young tillers shall be used. Older materials with culm formation shall not be used or ii. Culm - branches
4.	Container Plants	i. Vetiver hedgerows shall never be planted from cut - root (bare-root slips). Only container plants shall be used. ii. Central supply nursery may be required to provide continuous supply to site nursery. A central supply nursery should be irrigated and Slow Release Fertilizer (SRF) and Controlled Release Fertilizer (CRF) should be used.
	Roots	The container plants must have active root - mass regenerated in the container media : i. For foam medium. The foam shall be in polybag of 3"x 5" (7.6 cm x 12.7 cm) dimension. The roots - mass shall enmeshed the foam. ii. For soil medium The polybag shall be of 5" x 7" (12.7 cm x 17.7 cm) dimension filled with good quality (sandy loam) top soil. The root - mass shall completely bind the soil so that the soil core does

		not collapse when the polybag is removed prior to field planting.
	Tops (shoot system)	The tops shall have 5 or more actively growing tillers which have been regenerated or produced in - situ in the container. Old tillers extracted from the ground nursery and senescent tiller must not be included in the count. At delivery to site nursery, the tops should be cut to a height of 30 cm.
	Age of container plant	Any container plants which is "bag-bound" and with aged roots shall be rejected.
5.	Site nursery	A site nursery is mandatory unless the central supply nursery, which produces the container plants materials is near the work site. Maximum care should be exercised in handling and transporting of container plants to minimize transporting disturbances. The above mentioned site nursery, should be irrigated. The supplied container plants from the central supply nursery shall be arranged at 15cm x 1 meter spacing in the site nursery. These plants shall be reconditioned in the site nursery for not less than 7 days prior to field planting. Only those plants which have fully recovered from transporting disturbances shall be used for field planting. To enhance transplanting success the use of anti- tranpirants and foliar feed are encouraged.
6.	Field planting	i. The specified Vetiver container plants shall be planted in rows as specified in the drawings or as directed by the S. O. ii. A 6" width x 9" depth (15cm x 23 cm) trench shall be excavated to receive the container plants. iii. In difficult soil types, the trench to be filled, may require borrowed top soil as directed by the S. O. iv. The between - plant distance (center to center) shall not be more than 15 cm. v. Appropriate fertilizer(s) to ensure good continuous nutrient supply for 2 years shall be applied immediately upon field planting.
7.	Establishment and maintenance	i. All failures and wash-outs shall be reinstated within the first month.

ii. All slow growing clumps which do not recover from transplanting disturbance shall be replaced within the first month. This is shown by lack of growth of the topped tillers and non-production of new tillers.

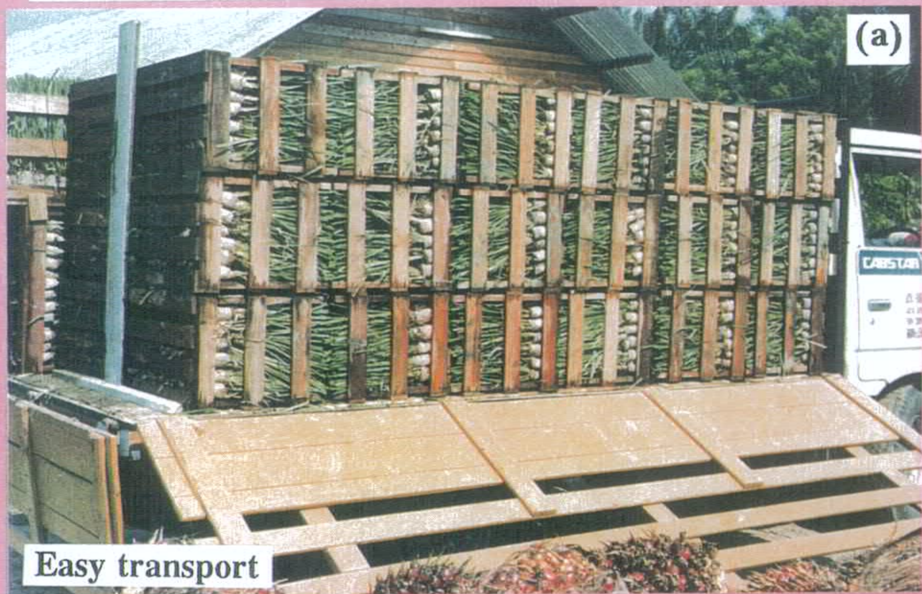
iii. Topping (grass-cutting) to maintain 40 cm vertical height should be carried out at the second, fourth and sixth month after field planting. Thereafter, the interval between toppings would be determined by needs, as directed by S. O.

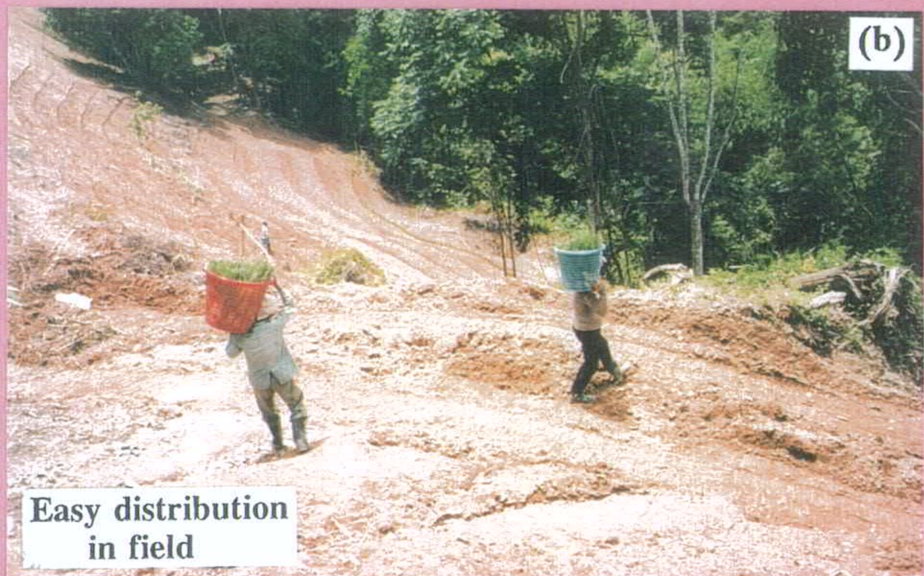
iv. To ensure the good growth of Vetiver hedgerows, such hedgerows must not be shaded by other weeds especially scramblers

8. Quality of hedgerows on delivery

At the third month after planting at the site, the plants must be actively growing. The hedgerows should have no failures or runts.
At the sixth month after planting at site, the hedgerows should be fully functional with uniform growth and tops of plants between clumps closed over, all to the satisfaction of S. O.

PHOTO 1. FOAM PLANTS PRODUCE QUALITY VGHR


(a) Easy transport


(b) Easy distribution in field


(c) FAST GROWTH 4 WEEKS


(d) No transplanting shock fast establishment 2 months

PHOTO 2. VGHR PROTECT HIGHWAY EMBANKMENT *SLOPE A*

PHOTO 3. VGHR PROTECT HIGHWAY EMBANKMENT *SLOPE B*

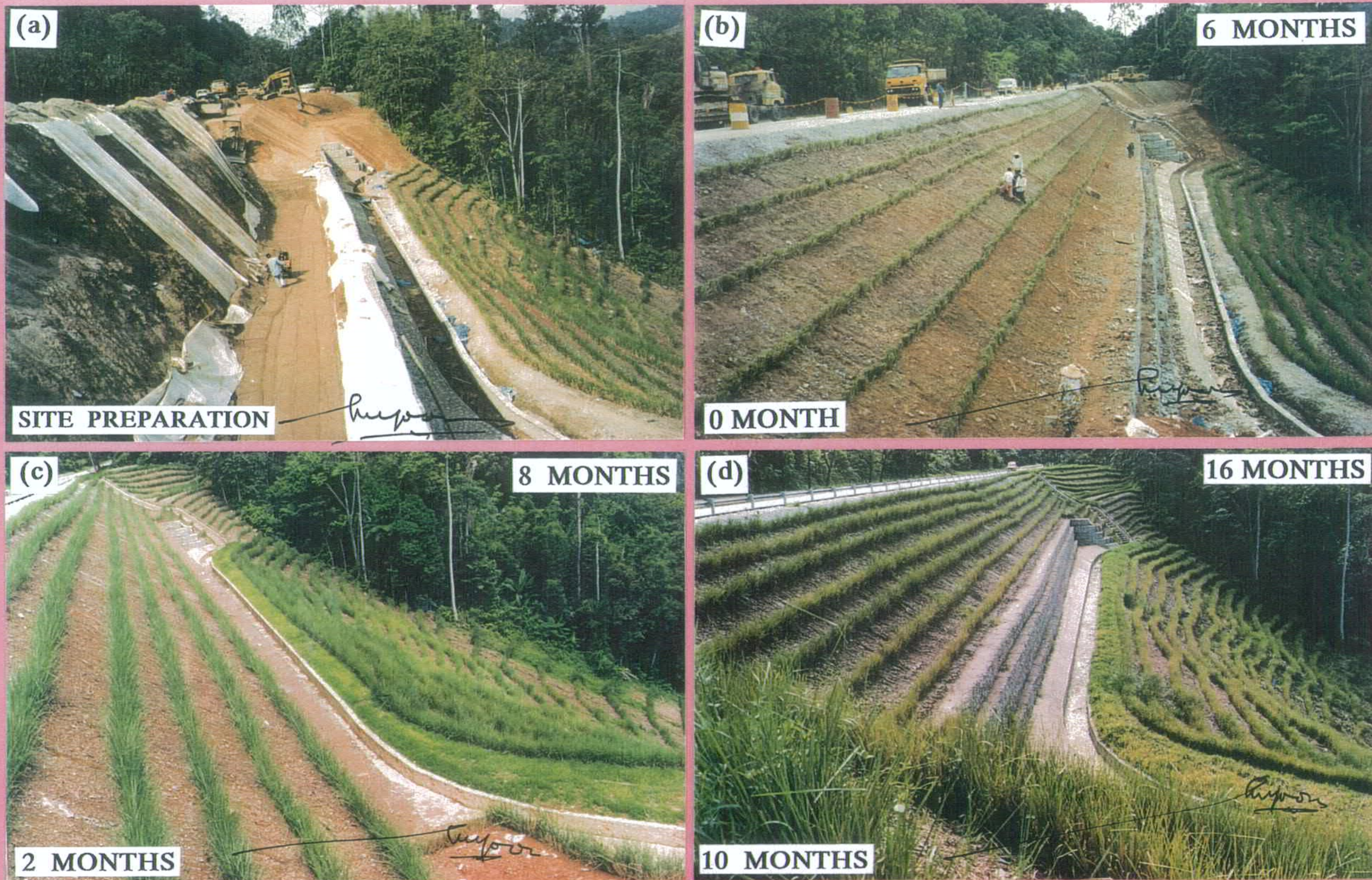


PHOTO 4. QUALITY VGHR PROTECT CULVERT INLET *SLOPE C*

PHOTO 5. QUALITY VGHR PROTECT CULVERT INLET *SLOPE C*