# A Look-see at Vetiver Grass in Malaysia

## First and Second Progress Reports, combined and reorganized by subject

P.K. Yoon, Rubber Research Institute of Malaysia (RRIM), 1989–1993

## About this edition

P.K. Yoon's "look-see" at vetiver in Malaysia was one of the first systematic sets of field trials on vetiver anywhere. It covered multiplication, quality planting material, hedgerow establishment, spacing, shade, fertilizer, erosion control on cut and filled earth, highway embankments, fire, weeds, rubber plantings and estate use.

The work was issued as two progress reports: the First Progress Report (1989 to February 1991) and the Second Progress Report (1991–1993). Both were published on vetiver.org as framed web pages. This edition brings the two together in one document and arranges the material by subject, so that, for example, the first and later results of the bag-size and spacing trials sit side by side.

The text, tables and photographs are Yoon's, unchanged apart from the order. Each section notes which report and chapter it comes from. Photo, table and figure numbers refer to the numbering in that original section; the photographs follow the text of each section as they did in the original pages. A video series that accompanied the Second Progress Report is listed in the appendix.

Edited for The Vetiver Network International (TVNI), October 2026.

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# Acknowledgements and prefaces

## Preface to the First Progress Report

*Source: First Progress Report*

My knowledge of Vetiver grass starts from 12/4/1989, when I first saw a clump of rather undistinguished-looking grass collected by my colleague, Encik Ahmad Azly, at my request. It looked so ordinary and so frighteningly similar to the horrible "Lalang"!

However, I have been stimulated by the Handbook: " Vetiver Grass - The Hedge Against Erosion "

And having spent more than 30 years visiting rubber plantings and having seen massive erosion problems especially on steep hills, I was prepared to have a look-see at any economic method.

1989 was the time to get to know the plant and to multiply it for distribution. 1990 was the main period for distribution, start some ad hoc trials and set the stage for 'proper' trials in co-operating estates. This report summarises mainly efforts of 1989 and 1990. 1991 should see better progress.

Research and Development must be well targeted and take cognisance of local situation. Whereas, Vetiver is promoted by the World Bank as a low-cost hedgerow system for controlling soil-loss and improving soil moisture, this may be true only for the poorer developing countries. Malaysia is well developed agriculturally and money is readily available for any cost-effective technologies. My research targets assess the potential values of Vetiver from both ends of the economic spectrum and, therefore, the early results and discussions presented could he easily adapted to suit different input requirements.

What limited information available on this project is due to the following:

The Director, RRIM, Dr. Abdul Aziz bin Sheikh Abdul Kadir, for his permission to look for the " PLANT " and to carry out ad hoc observations; Encik Ahmad Azly of RRIM, for finding the first clump of 57 tillers; My fellow workers: Molly Lew, Phun Yin Ho, Lee Yee Chuen, Ku San Leong Hing Tong, P. Santhy, K.Jayasunthar, Cheng Sau Chan for their strong support; The following Industry members: (1) Heah Seok Yeong Realty Sdn Bhd (2) Sinkyo Sdn Bhd (3) Vitapro Sdn Bhd (4) United Malacca Rubber Estates Bhd (5) Asia Oil Palm Sdn Bhd (6) K.L. Kepong Sdn Bhd for providing most of the funds; The Managers and staffs of the following estates: (1) Leong Hin San Estate (2) United Malacca Rubber Estate (3) Nyalas Rubber Estate (4) Pinang Tunggal Estate (5) Sungei Rinching Estate (6) Sungei Chinoh Estate (7) Hwa Li Estate (8) Sungei Gapi Estate (9) Pahang Oil Palm Estate

for their co-operation and help in the set-up of trials.

Finally, I consider this investigation as " look see" and merely add it on to my normal job responsibility of Research and Development of rubber. For this, I appreciate the support and encouragement of my wife and children; in particular, my daughter, Su-Ming, who helped me to compile this report.

To all the above, I say "Thank you".

## Preface and acknowledgements to the Second Progress Report

*Source: Second Progress Report*

This report would not be possible without the following:

The Director, RIM, Dr. Adbul Aziz bin Sheikh Abdul Kadir, for his permission and encouragement to carry out ad hoc observation; My fellow workers, Lee Yee Chuen, Ku San, Phun Yin Ho, Phun Hon Kheong, Gerard Sta Maria, and S. Subramaniam, for their strong technical support; Chin Then Voon, Abdul Aziz Alias and Shamsudin Atan who helped in planting the Vetiver hedgerows in the RRIM Smallholders' Laboratory, Bandar Sri Iskandar; Mat Borhan Harun and Goh Teoh Hoh of Institute of Highway Research, Malaysia, who helped in the excavation and examination of the soil profiles; The following industry members:

Heah Seok Yeong Realty Sdn Bhd Asia Oil Palm Snd Bhd Rahman Hydraulic Tin Bhd Vitapro Sdn Bhd K.L. Kepong Sdn Bhd United Malacca Rubber Estates Bhd

For providing most of the funds;

Sungei Chinoh Estate Hwa Li Estate Pinang Tunggal Estate Sungei Gapi Estate

For their co-operation and help in the setting up and maintenance of the trials;

My dedicated team of "report compiler", Molly Lew, Phun Yin Ho, Cheng Sau Chan, Ong Siau Hwa and Yoon Su-Ming, who spent long hours over many days to compile this report.

To the above I say "Thank you".

These "Look –See" investigation are additional to my normal job responsibilities of research and development of rubber. Although it eats into my "off-hours" and "off-days", the satisfaction is tremendous. I therefore appreciate the support and encouragement of my family for their understanding to allow me to spend such times away from home. In particular, I dedicate this report to my wife, Wong Lai Kien.

I met Vetiver grass on 12/4/1989 and spent the rest of the year getting to know her. In 1990 some ad hoc trials were started. The first Progress Report summarises the efforts up to February 1991. After that Report was circulated by the World Bank:

I was honoured to be asked to organise the First International Vetiver Workshop in Kuala Lumpur, sponsored by The World Bank and The Rubber Research Institute of Malaysia. This was held between 13 – 16 April 1992 at the RRIM Experiment Station, Sungei Buloh, and attended by 87 participants from nine countries _Australia, China, India, Malaysia, New Zealand, Sri Lanka, Thailand, U.S.A. and Vietnam – representing government, public and private research institutions, development agencies and field practitioners. I was also requested to make the following consultancy visits:

to investigate potential uses of Vetiver for the King's Projects in Thailand from 27 – 31 January, 1992; to join the World Bank appraisal mission on river bank protection and coastal embankment rehabilitation project in Bangladesh from 30 June – 18 July 1992; to assess the potential uses of Vetiver as biological protection of highway embankments in Sabah, Malaysia, and in East-West Highway, Peninsular Malaysia for the Public Works Department, Malaysia.

In the local scene, I was invited to lecture to: Members of the Institute of Engineers, Malaysia; The Director-General and staff of Malaysian Highway Authorities; Director and staff of the Institute of Highway Research, Malaysia; Site highway engineers in Sabah and site engineers of East-West Highway. In addition, I was visited by many interested parties, both locally and from overseas, and received many correspondence and feed-back from interested parties, especially from those in the Vetiver Network where my report was abstracted.

All the above interactions and activities serve to stimulate my interest and increases my awareness of the potential of Vetiver hedgerows. It also makes me conscious of the many problems and how little we know about the plant. From all these I was able to better target my simple investigations to solve specific needs or answer specific questions.

In the conduct of my trials, collection of quantitative data is difficult in many cases because of staff constraint and logistics problems. Also, much of Vetiver's adaptive performance cannot be easily quantified. I have, therefore, resorted to sequential photography which can give a clear picture of the performance of Vetiver under various conditions. Consequently, I have built up a large library of photographs on different aspects of Vetiver hedgerow technology. However, such records, involving many photographs, would be too expensive to reproduce. Accordingly, I attempted to video-record the photographs. Originally, I was hoping that the video recording will serve as my Second Progress Report. But as this is the first time I am using a video camera, the quality of reproduction is rather poor, the colour is distorted and the definitions are not clear. Therefore, this hastily written report includes only certain selected photographs and the reader can refer to the appropriate portions in the video tapes where the subjects have been assessed in broader and/or greater detail. For convenience, the attached list summarises the subjects and the appropriate tapes and positions to locate for video play.

The First Progress Report summaries mainly the efforts of 1989 and 1990. In the preparation of this Second Progress Report, which starts thereon, materials that were already in the First Progress Report are generally left out. However, those trials, which were initiated, as stated in that report will now be discussed in fuller detail, as additional data are available.

This Second Progress Report concentrates on five main themes presented as five separate parts.

They are:

Production an Quality Planting Materials Establishment and Management of Quality Vetiver Hedgerows Use of Vetiver Grass as in situ Mulch in Rubber Plantings Uses of Vetiver – Case Studies Observations to Show Special Characteristics of Vetiver Hedgerows

Readers may find that there is much emphasis on quality planting materials and quality hedgerows. The quick establishment of quality hedgerows is critical under tropical conditions with heavy monsoon rain. It will be justifiable to use quality hedgerows for protection of expensive structures such as highway embankments, culverts, etc. Quality hedgerows will cost more but they may not be necessary under many other circumstances. I am not after a perfect system, only aiming for a cost-effective system to suit prevailing needs. The readers will have to calculate the Benefit-cost Ratio under their own respective requirements.

The results of the trials and other ad hoc observations carried out so far and the many feed-back informations have shown clearly that Vetiver hedgerows have tremendous potential for many areas of human activity. In the next few years we should translate them to reality in practical applications. The trip has just begun, but we can see the ultimate glorious goal at the end of the journey!

# 1. Planting material: multiplication and quality

## 1.1 Introduction: multiplying the first clump

*Source: First Progress Report, Chapter A*

On recognising the potential value of Vetiver, after reading the handbook published by The World Bank, considerable time was spent before we managed to locate clump of 57 tillers In Taiping, Perak, on 12 April 1989. After that, the first priority was to multiply the plant rapidly before we could do any observation and distribution to interested parties. This Chapter summarises the efforts used.

## 1.2 Multiplication using tillers

*Source: First Progress Report, A-I*

### a. Planting Methods

Three planting methods were used:

(1) Planting in polybags

Initially all tillers were planted in polybags with sizes of 7" x 15" and 10 x 20". One nugget of Kokei (6 gm) slow release fertilizer was introduced into each bag and Sumisansui irrigation system was used (Photo1 ) . Plants were divided as soon as they were observed to be bag-bound. The results showed the following rates of production:

| Months | 7" x 15" | 10" x 20" |
|---|---|---|
| 3 | 13.8 ± 1.03 | - |
| 4 | 17.1 ± 1.14 | 25.5 ± 1.55 |

PHOTO 1. VETIVER MULTIPLICATION USING TILLERS IN POLYBAGS



(a) One tiller is planted in each polybag.
Note the Sumisansui irrigation system installed.

(Ref: 4/1990)



(b) The plants are 3 months old and suitable for splitting.

(Ref: 4a/1990)

(2) Planting in soil-beds

(a) 2 rows of tillers were planted with in-between distances of 6". Sumisansui Irrigation system and one nugget of Kokei (6 gm) fertilizer per tiller were used (Photo 2) . Harvesting could be done at 5 months, yielding on 2 occasions:

| No. of Clump | No. of Tillers |
|---|---|
| 486 | 21.1 ± 0.59 |
| 185 | 20.6 ± 0.92 |

(b) 6 rows of plants were established with in-between distances of 6". Sumisansui Irrigation system was used (Photo3) . Fertilizer application was dried chicken dung. Growth up to 3 months was satisfactory but, thereafter, the plants in the central rows tend to grow and multiply slower because of shade-effect. This system should be used only if there were land constraint; otherwise, the 2-row system is much better.

(3) Planting In soil

A large block of approximately 20,000 sq. feet was ploughed and rotovated. Tillers were directly planted with a planting distance of 6" x 6". One round of dried chicken dung was applied at one week after planting. This approach ensures low establishment cost. There was little maintenance cost; with planting in the normal rainy season, watering was not needed. Also, there was no weeding or any pest and disease control measures. Photo 4 shows the plants growing well after 2 ½ months and managed to compete with other weeds. Sampling of 100 clumps at 4 months showed average of 11 tillers per clumps (farmer's report). This rate of production was considered satisfactory because of the low input.

**PHOTO 2. VETIVER MULTIPLICATION USING TILLERS PLANTED IN SOIL-BEDS**



(a) 2 rows of tillers planted with Sumisansui irrigation system.

(Ref: L1/1990)



(b) After 3 months' growth.

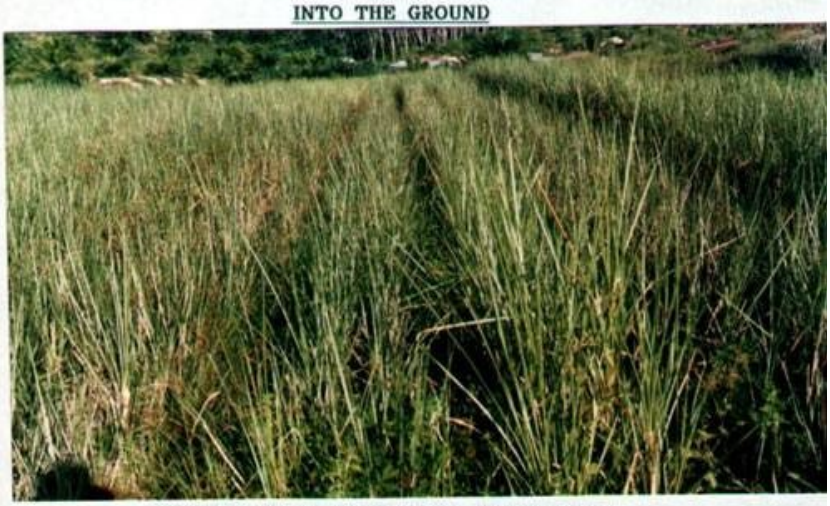
(Ref: 4/1990)

PHOTO 3. VETIVER MULTIPLICATION USING TILLERS PLANTED IN SOIL BEDS



6 rows of tillers are planted with Sumisansui irrigation system.
Planted: 30/5/1990
Photo taken: 24/6/1990 (Ref: 10/1990)

PHOTO 4. MULTIPLICATION USING TILLERS PLANTED DIRECTLY INTO THE GROUND



Growth after 2 1/2 months. There was no weeding nor any maintenance after planting.
(Ref: 22/1990)

## b. Maintenance

In Malaysia, labour cost is high. Therefore, the following system has been developed.

| | |
|---|---|
| **Fertilizer** | **use of one nugget of Kokei (6 gm) slow release fertilizer per plant. This is sufficient for 3 months. For longer periods of up to 6 months, a second nugget is required.** |
| | Dried chicken dung is very effective. |
| Watering: | The Sumisansui irrigation system is cheap to install and ensures good and uniform watering ( Photo 1a ). |
| | Timing the planting to coincide with the rainy season minimises the need to water. |

| | |
|---|---|
| Topping: | The regular monthly topping to 40 cm to encourage tiller formation using a mechanised grass-cutter which is readily available in all estates and most smallholdings ( Photo 5 ). |

With the above system the cost of production is reduced to a minimum.



*Photo 5.* Mechanised topping to save cost. Each 50 metre bed of 6 rows of clumps planted 6″ apart, can be cut in 5 minutes.
Planted: 30/5/90
Photo taken: 5/8/90 (Ref: 13/1990)

**c. Harvesting for Multiplication**

(1) Polybag-plants

After topping at 40 cm, the plants were sawn off with about 3 inches of roots (*Photo 6a*). The soil could be easily removed by knocking the cut-top of the polybag against a log or a standing pole (*Photo 6b*).





*Photo 6a.* The plant is sawn off with 3-inch root system.

*Photo 6b* Vetiver clumps ready for despatch.

(Ref: 15/1990)

(2) Plants in soil-beds and in ground

After topping, the roots are severed using an oil-palm harvester (*Photo 7a*). The clumps can be easily removed (*Photo 7b*). Prior to replanting, the roots are chopped to 3″ with a parang.

PHOTO 7. HARVESTING OF VETIVER PLANTED IN SOIL-BEDS



(a) The plants are 5 months old. The roots were severed by an oil palm harvester.



(b) Each clump can be easily pulled out after the roots are severed by oil palm harvester.

(Ref: 6/1990)

## 1.3 Multiplication by culm-branches

*Source: First Progress Report, A-II*

When Vetiver clumps are repeatedly topped at 40 cm and when they are more than 3 months old, the cut-culms produced many branches at the internode. These branches can be detached for planting.

A trial was set up to study the multiplication and growth of these culm branches which were separated into various types as follows:

A - most vigorous with young shoots; (with roots)

B - less vigorous with young shoots; (with roots)

C - most vigorous (with roots) - single plant

D - less vigorous (with roots) - single plant

E - least vigorous (without roots) - single plant

F - Terminal shoots

G -Young shoots plants that were growing horizontally, (with small roots/without roots)

All types produced good root system under mist (Photo 8) and transplanting success into polybags was nearly 100% as shown below:

| Type | No. | % |
|---|---|---|
| A | 91/91 | 100.0 |
| B | 168/168 | 100.0 |
| C | 180/180 | 100.0 |
| D | 302/302 | 100.0 |
| E | 234/235 | 99.6 |
| F | 253/253 | 100.0 |
| G | 163/163 | 100.0 |

The multiplication and growth of the various branch types will be discussed later.




## 1.4 Multiplication by culm-cuttings (with conclusion on multiplication)

*Source: First Progress Report, A-III*

It is recommended that clumps of Vetiver be cut-back to 30-50 cm to encourage tillering. Early observations suggest that too short cut-backs result in die back of many culms under Malaysian conditions. An ad hoc trial, testing 30, 40, 50 and 60 cm cut-back height suggested 40 cm to be the best with least set-back to growth, minimum die-back and good tillering.

The tops are normally discarded after cut-back at 40 cm height. However, if the Vetiver clumps are 3 months or older, the cut-tops include many culms. Each culm, has varying numbers of internodal buds which can be induced to sprout and produce new plantlets under mist.

Three methods of rooting under mist were tested.

(1) Layering of culms. The whole stem was buried in sand-bed with the following results after 5 weeks:

| | **No .** | **%** |
|---|---|---|
| (a) With leaf-sheath intact | 38/164 | 23.2 |
| (b) With leaf-sheath removed | 110/387 | 28.4 |
| (c) With leaf-sheath slit | 46/129 | 35.7 |

(2) Rooting of individual node with leaf-sheath intact (Photo 9).

Rooting success:

| **5 weeks** | **9 weeks** |
|---|---|
| 375/7350 = 5.1% | 499/3407 = 14.6% |

(3) Rooting of individual node with leaf-sheath slit.

Rooting success:

| **5 weeks** | **6 weeks** | **8 weeks** |
|---|---|---|
| 55/169 = 31.4% | 89/169 = 52.7% | 129/169 = 76.3% |

PHOTO 9. VETIVER MULTIPLICATION BY CULM–CUTTINGS



Detaching of cuttings from culm.



Culm–cuttings rooting in sand–bed under mist.

(Ref: 6/1990)

Treatment (3) of rooting each nodal culm, cutting with the led-sheath slit was the most promising.

An assessment of 5-month old clumps in the ground yielded 16.4 + 1.35 cuttings. The number of cuttings from each clump is highly variable as shown in Figure 1.

It is for note that the above work was done under mist. However, based on experience with other crops, similar results would likely be obtained if materials are rooted in sand-bed under polythene sheet to keep the atmosphere moist; this has not been specifically tested because of time constraint.

CONCLUSION

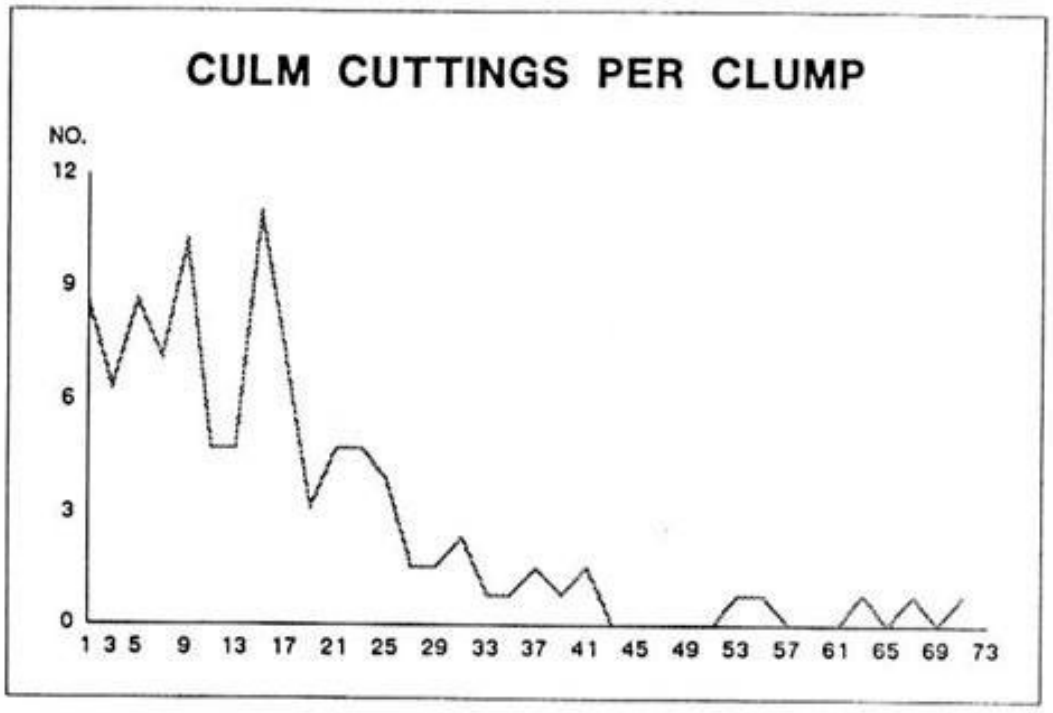
Vetiver is easy to multiply at low cost. Under normal conditions, multiplication by planting with tillers will give satisfactory results. However, refined methods of vegetative propagation by culm branches and culm cuttings may be considered from 2 view points:

They will be of little value in mass vegetative propagation because they may not be commercially cost-effective. They will be of value in the following scenarios:

Initial stage of multiplication of a newly found cultivar. Initial stage of multiplication of a newly imported cultivar. Where base cultivars are imported at high cost from other countries.

Certainly these methods are much cheaper than the tissue culture method . However, once the base source for multiplication is established, the normal method of splitting the tillers should suffice. In the early phase of my work, all methods using all plant parts are used. This accounts for the large amount of materials produced and distributed (see Chapter B).

FIGURE 1 THE NUMBER OF CULM CUTTINGS OBTAINED FROM VETIVER CLUMPS




## 1.5 Layering of culms

*Source: Second Progress Report, 5.4*

In the first Progress Report, it was pointed out that buds in the nodes of old culms can be induced to produce new plants. Layering of the culms, either detached or still attached to the mother clump, was used to produce culm branches for multiplication.

The same method of layering could be used to establish new plantings. A trial was carried out to determine the success of such an approach. 245 culms were pegged onto the ground by a “-shaped steel wire. The following table summarises the frequency of the number of new plants produced by the layered culms.

| **No. of new plants produced per culm** | **Open** | **Shade*** | | |
|---|---|---|---|---|
| Culm count | % Frequency | Culm Count | % Frequency | |
| 0 | 14 | 14.1 | 28 | 19.2 |
| 1 | 27 | 27.3 | 49 | 33.6 |

| | | | | |
|---|---|---|---|---|
| 2 | 15 | 15.2 | 36 | 24.7 |
| 3 | 11 | 11.1 | 16 | 11.0 |
| 4 | 11 | 11.1 | 7 | 4.8 |
| 5 | 11 | 11.1 | 5 | 3.4 |
| 6 | 4 | 4.0 | 3 | 2.1 |
| 7 | 3 | 3.0 | 1 | 0.7 |
| 8 | 1 | 1.0 | - | - |
| 9 | 2 | 2.0 | - | - |
| 12 | - | - | 1 | 0.7 |
| Total culms | 99 | 100.0 | 146 | 100.0 |

*Note this plot was shaded by overgrown rubber plants. Sorry, no measurements of % shade was taken.

Very good results of new plant production were obtained in the open ( Photos 30a and 30b ). Only 14.1% of the culms failed to produce any plants. 27.3% of the culms produced two new plants each while 33.3% produce 3-5 new plants each. Beneath the canopy shade of the Hevea plants, the production of new plants was poorer with also less new plants per culm.

The distances where the new plants were produced on the culms were measured ( Photo 31 ) and partly mapped schematically in Figure 1 . The details are given below:

| | | **Off-spring tillers** | | |
|---|---|---|---|---|
| Distance (m) | Open | Shade | | |
| | Count | % | Count | % |
| £ 0.5 | 22 | 8.4 | 39 | 15.9 |
| > 0.5 – 1.0 | 141 | 53.8 | 98 | 39.8 |
| > 1.0 | 99 | 37.8 | 109 | 44.3 |
| Total produced | 262 | 100.0 | 246 | 100.0 |

It is clear that few new plants were produced with 0.5 m of the hedgerow. New plants tend to be produced at the furthest end; the youngest portion of the culm. This could be partly due to the shade effect imposed by the overshadowing hedgerow. However, the more likely reason is the age of the buds on the culms; young buds tend to sprout faster.

A simple demonstration of the use of layering to protect the embankment was set up in Sg Chinoh Estate. The 15-month-old Vetiver hedgerow was at the crest of the embankment ( Photo 32 ). The old culms were pegged down by “-shaped steel wire ( Photo 33 ) or split bamboo ( Photos 34a & 34b ). The results from this simple demonstration attracted a lot of attention during the First International Workshop in Kuala Lumper 1992 ( Photos 35a & 35b ). The method using the split-bamboo did not give satisfactory results as the lower portions of the culms tend to curve up; few new plants were produced at those portions and those plants so produced, hanged in the air and did not take root ( Photos 36a & 36b ). The culms pegged down by the “- shaped wire produced very good results ( Photo 37 ) and the slope on the embankment was soon covered by Vetiver plants ( Photo 38 ).

The distinct Vetiver hedgerow is a good biological barrier for soil and moisture control and there will normally be little need to blanket cover an area. Biologically, Vetiver is a clump grass of erect habit with no running rhizomes or stolons. However, this trial shows that Vetiver can be converted into a runner, if necessary, by layering the culms. We can change nature to suit our need!

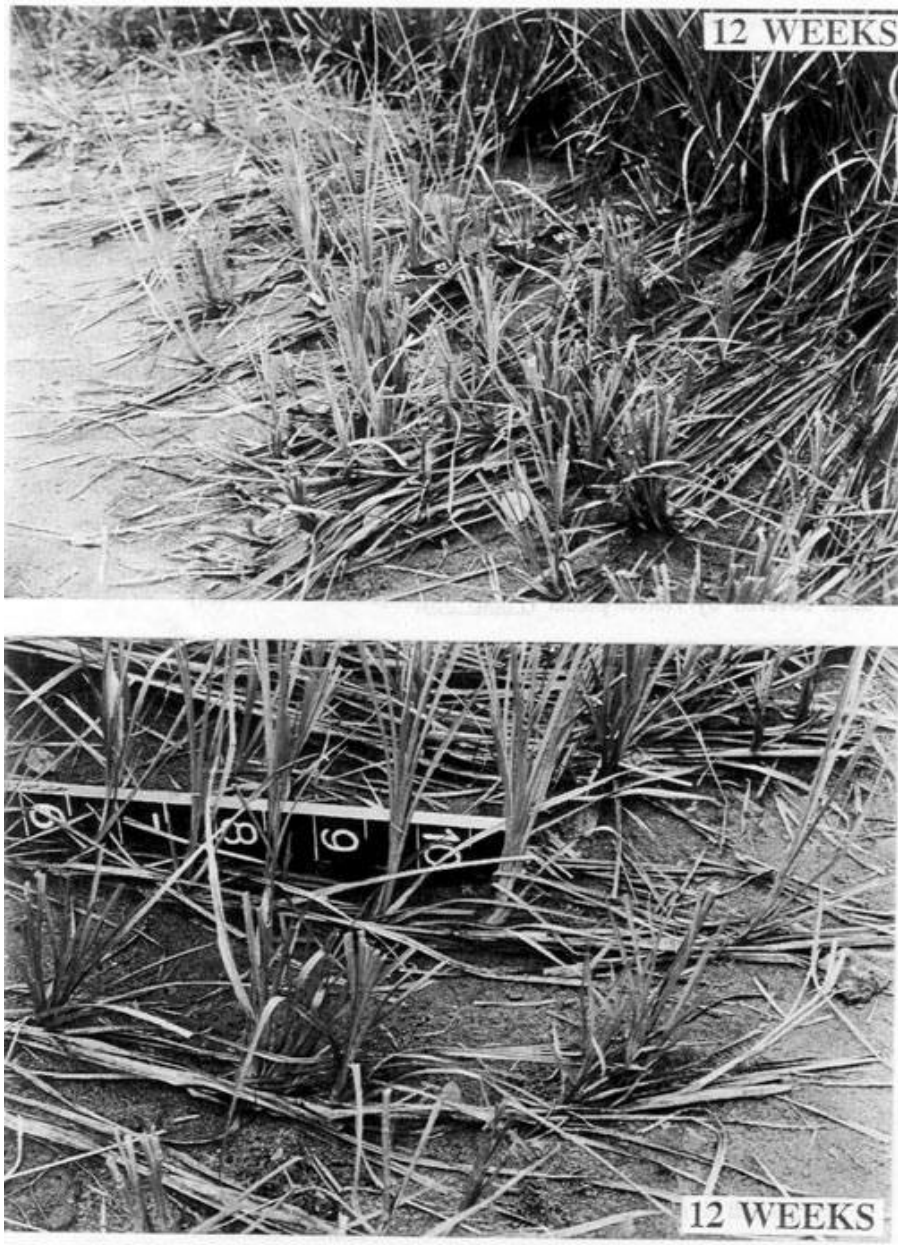



*Photo 30a & 30b.* Show the new plants produced by culms pegged on to the ground by ∩-shaped steel wires. The plants are topped to show the positions of the new plants. Note the other plants are more vigorous than those nearer the hedgerow.

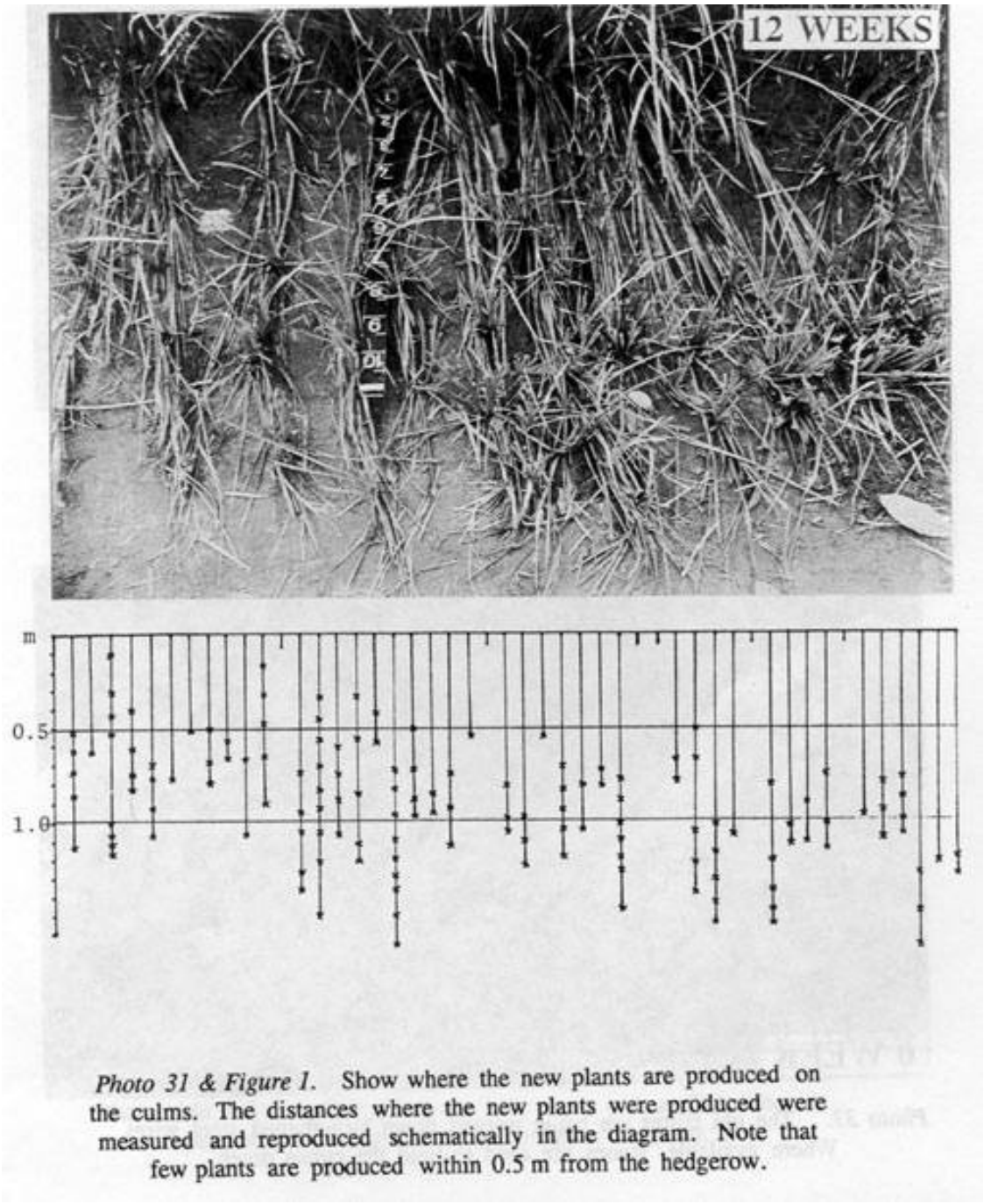



*Photo 31 & Figure 1.* Show where the new plants are produced on the culms. The distances where the new plants were produced were measured and reproduced schematically in the diagram. Note that few plants are produced within 0.5 m from the hedgerow.




*Photo 32.* This is a 15-month old hedgerow on top of an embankment. Note the many old flowering culms.




*Photo 33.* The old culms are being pegged down by ∩-shaped steel wires. Where available, stones are used to hold the culms down.




*Photos 34a & 34b.* Old culms are held down with a slit bamboo pegged into the ground by cut v-forked branches.




*Photos 35a & 35b.* Delegates examining the results of the layering trial after 12 weeks.







*Photos 36a & 36b.* Show new plants produced by the layered culms after 14 weeks. Note that the lower parts of the culms do not produce any new plants; also new plants produced are hanging in the air and do not take root.




*Photo 37.* Shows good production of new plants by culms that were pegged down by ∩-shaped steel wires.




*Photo 38.* The embankments are well covered by *Vetiver* plants produced from culms of the top hedgerow.

## 1.6 Different starting materials and tiller types

*Source: First Progress Report, C-VI*

Vetiver plants can be grown from tillers, culm-branches and culm-cuttings. Within each group there are differences mainly due to physiological age. This Chapter looks into the effects of different planting materials on subsequent multiplication and growth rates.

### Different tiller types

Preliminary observations have suggested that each clump of Vetiver produce different types of tillers; thus their growth and tiller formation would be quite different. This would lead to high variations in response of experimental treatments where assessment is by tiller formation and dry mater production. This could be on the causes of non-significant effect of fertilizer, soil types, etc. previously reported. The experimental error may by higher than the treatment effect.

To overcome this, the tiller types must be sorted out and the within-population studied before planning any experiment. The starting material must be the same tiller type and fine-tuned to minimise experimental errors. The four major types are illustrated in Photo 28a .

Type A - Most mature and multiplies fast. However the culm will produce variable numbers of culm-branches. Dry matter production will be highly influenced. This type is not good for experimentation (Photo 28b).

Type B & C - Mature tillers but with no culm formation. Suitable for raising plants for experimental purpose (Photo 28c).

Type D - Youngest tillers. Tend to give variable growth (Photo 28d).

### Different culm-branches

Chapter 1 shows that different types of culm-branches can be rooted easily under mist then transplanted easily into the soil. The rate of tiller production was studied and the results given below:

| | **No. of tillers** | | |
|---|---|---|---|
| Types | Mean | Min. | Max . |
| A | 14.2 ± 0.51 | 6 | 33 |
| B | 15.2 ± 0.47 | 7 | 32 |
| C | 13.1 ± 0.39 | 5 | 25 |
| D | 12.1 ± 0.38 | 6 | 27 |
| E | 10.1 ± 0.30 | 5 | 20 |
| F | 14.8 ± 0.37 | 8 | 25 |
| G | 9.6 ± 0.34 | 4 | 20 |
| Combined | 12.7 ± 0.17 | 4 | 33 |

The distribution curves of the various tiller types are illustrated in Figure 15. This study clearly shows the significant differences of tiller production by the various culm-branch types, which will also leads to differences in dry matter production. For experimental purposes the different types of culm-branches should be grouped separately.

**PHOTO 28. EFFECT OF DIFFERENT TILLER TYPES ON MULTIPLICATION AND GROWTH**



(a) Different tiller types.



(b) Type A – Tillers with culms. Very good for multiplication. Produces variable culm-branches. Not good for experimentation.

(Ref: 7/1990)

**PHOTO 28. EFFECT OF DIFFERENT TILLER TYPES ON MULTIPLICATION AND GROWTH**

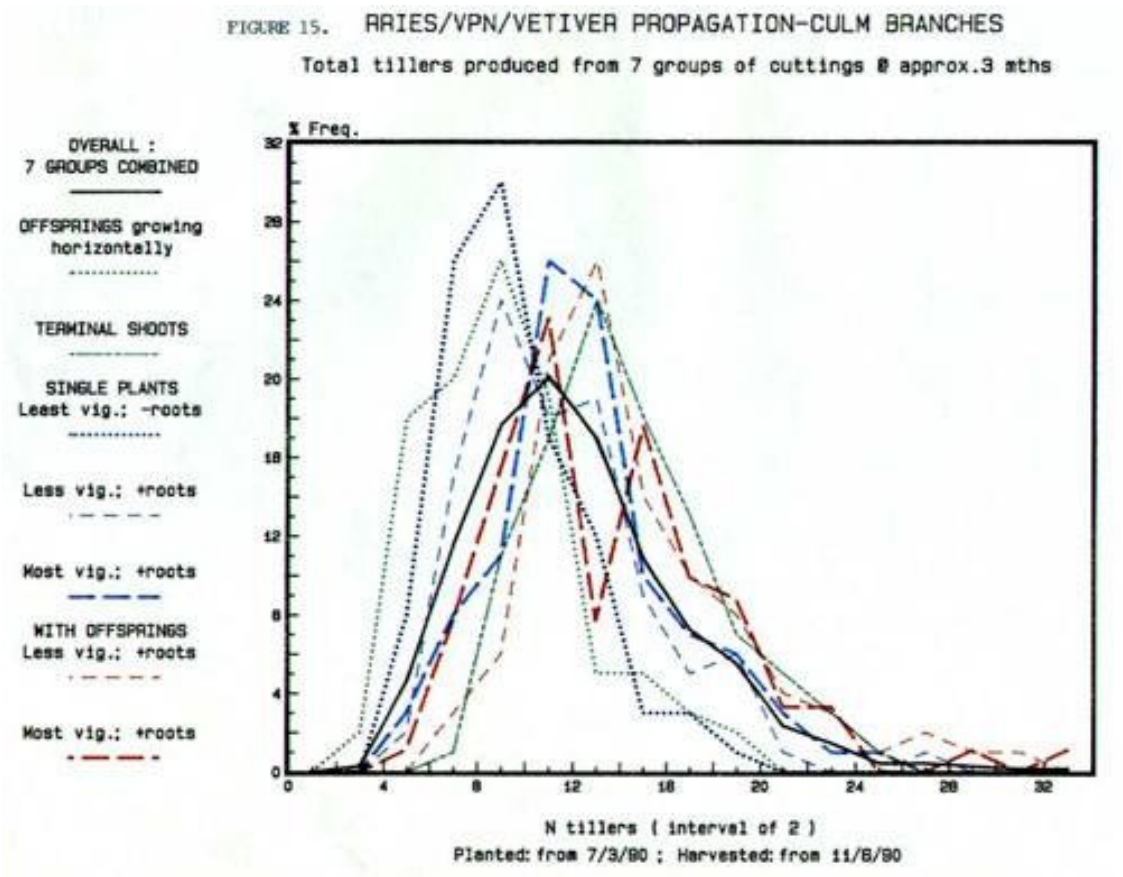


(c) Types B & C – Mature tillers. Good for multiplication. For experimental purposes, all side shoots were removed.



(d) Type D – Young tillers. Good for multiplication

(Ref: 7/1990)




## 1.7 Producing quality planting materials: introduction

*Source: Second Progress Report, Part 1*

The quick establishment of good hedgerows is important for tropical conditions where heavy monsoonal rain will wipe away any poor planting. This is particularly critical for structural works such as highway embankments, road shoulders, bridge abutments, culverts etc.

To be able to produce quality hedgerows, quality planting materials must be used. Good planting materials must still begin with young and active tillers. In the First Progress Report, I have devoted a lot of attention to propagation techniques and have also pointed out the effect of various tiller types on subsequent growth. Readers can refer to that for more information. This part concentrates on:

Root regeneration Effect of age of polybag plants on subsequent growth Effect of tillers numbers at planting on growth Effect of cultivar and bag sizes on growth Raising Vetiver plants in biodegradable containers

As this is a very important topic, a 120 – minute video recording was done to detail all the features. Regrettably, due to the author's inexperience (first time using a video camera), the quality of the final tape after editing and repeated copying is rather poor; lacking in definition and colour quality.

A small percentage of the photos used in the video is therefore presented in the following pages to illustrate only the main features.

## 1.8 Root regeneration in slips

*Source: Second Progress Report, 1.1*

This section examines the regeneration of cut-roots in slips. The old roots do not regenerate, they do not even form any secondary roots. As the old roots do not regenerate, they are only useful for anchorage. New roots are only formed from the new tillers or from the nodes of the old culms. Therefore any planting

such as using slips with cut-roots, would be very slow in establishment and growth. It would be better to raise the tillers in containers and regenerate the roots first before taking them out.



*Photo 1.* Rooting of cut-tillers in mist frame.



*Photo 2.* Shows 2-month old roots newly produced from nodes of old culms or new tillers. The original cut-roots do not regenerate.



*Photo 3.* After 10 days in the mist frame, new roots have emerged from nodes of culms or new tillers.



*Photo 4.* At 3 weeks, note the new roots from the new tillers and nodes of culms. The original old cut-roots do not regenerate; there is no new growth.

## 1.9 Age of polybag plants and later growth

*Source: Second Progress Report, 1.2*

Early work have shown that plants at 4 months have good root systems for transplanting and take off immediately to produce good hedgerows quickly. This section investigates the optimum duration for raising container plants in the nursery. Plants raised up to 11, 16, 23 and 51 weeks in the polybags were transplanted into the ground. Weekly examination shows very good regeneration and early growth of root system of 23 weeks and also 16 weeks. Those polybag plants raised for 11 weeks show early growth but was less vigorous. Growth of 51 weeks old material was very poor. Previous experience has also shown that older (70 weeks) polybag plants perform even worse.

The very old container plants are not good for subsequent growth in the field, as the old roots are so bag/bound that they do not regenerate. The optimum duration seems to be 23 weeks, but it may not be economically satisfactory to keep plants for such a song time in the nursery; besides there may be urgent need for quality planting materials.




*Photo 5 (i-iv).* Shows root systems of plants raised in polybags for 2, 3 and 4 months compared with those of freshly-cut bare-root tillers.




*Photo 5 (iv).* Shows the massive amount of root system after 4 months in polybags.

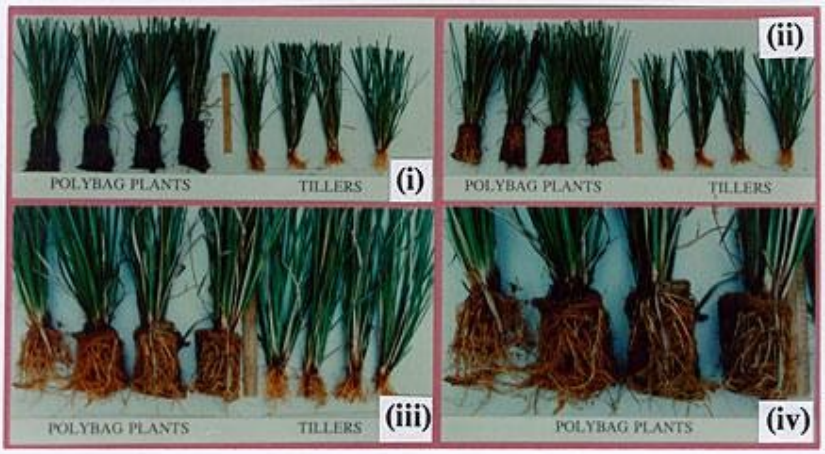



*Photo 6 (i-iv).* Root systems of plants raised in polybags (4 months) compared with those of freshly-cut bare-root tillers.
*(i)* Shows plants with polybags intact. *(ii)* Shows plants with polybags removed. *(iii)* The soil is washed off to expose the roots.




*Photo 6 (iv).* Shows very good root system of plants, excepting the first plant. Therefore, culling is still necessary even in polybag nurseries.




*Photo 7.* Plants were raised in polybags for 11, 16, 23 and 51 weeks. The root systems at 1, 2 and 3 weeks after transplanting to soil are shown. Generally, plants aged 23 weeks produces good root growth. Plants aged 16 weeks have acceptable root growth while plants aged 11 weeks have poorer root growth. The very old plants of 51 weeks perform poorly after being transplanted to ground.



*Photo 8.* This shows a 70-week old plant under good nursery practice of irrigation and application of slow release fertilizer every 14 weeks. The vigorous polybag plant was transplanted to the ground. However, note that the new roots are only produced by the new tillers. The roots in the polybag are too bag-bound and are senescent; they do not regenerate.

## 1.10 Number of tillers at planting

*Source: Second Progress Report, 1.3*

The target is to improve materials for transplanting out earlier than 4 months in the nursery but still maintaining the same good root mass at the time of transplanting. This attempts to find out whether quality planting materials can be produced in a shorter time by using more tillers as starting material.

Trial 1 This trial compares the use of 1, 3 or 5 tillers at the time of planting into polybags. Harvesting of plants were carried out at 4, 6, 8, 10 and 12 weeks after planting. On each occasion, 10 plants were randomly selected from each treatment, roots washed, photographed, the number of new tillers counted and the dry weights determined. The data are summarised in Table 1 and Figure 1 . Readers are referred to the detailed discussions recorded in the video tape. Plants starting with 5 tillers have lower number of new tillers compared with those started with 3 tillers or 1 tiller. Besides it is difficult to get 5 tillers in a clump without resorting to usage of the more matured culms; and the older the materials, the slower they are at producing new groth. Therefore, to use 5 tillers will include using older culms which are not the best for use in the production of quality planting nursery. The usage of 5 tillers is also a wastage of materials with little advantage gained. Polybag plants with 1 tiller as starting material produces new tillers faster. This supports my earlier work that we should use good young active tillers for early growth. The amount of roots produced by polybags with starting material of 3 tillers have more root mass after 8 weeks than those of 1 tiller after 10 or 12 weeks. Where root system is concerned, 8 weeks with 3 tillers can easily substitute for 12 weeks with 1 tiller starting material. Trial 2 Polybag plants produced from 1 tiller and 3 tillers were planted into the ground. There was not much difference in plants started with 1 tiller compared with those from 3 tillers. However, those plants started with 3 tillers are more uniform than plants started with 1 tiller. On that score alone, it would be advisable to use 3 tillers as starting materials. Trial 3

This compares the performance of polybag plants with bare root slips. Those slips with more than 5 tillers were faster growing than those with only 3 tillers, but even those started with more than 5 tillers have much less roots than container plants. For container plants there was not much difference in growth from those started with 3 tillers, compared with those started with 1 tiller, the reason being that these plants were left for 15 weeks in the nursery. The 3 tillers starting materials was more meant for 8 weeks nursery time when it would have gained an advantage over starting materials of 1 tiller.




*Photo 9.* Shows root systems of plants in polybags after 8 weeks, with starting materials of 1, 3 and 5 illers. Plants raised with 1 tiller do not have good root systems and are very variable. Good root systems are produced when polybag plants are raised with 3 or 5 tillers.

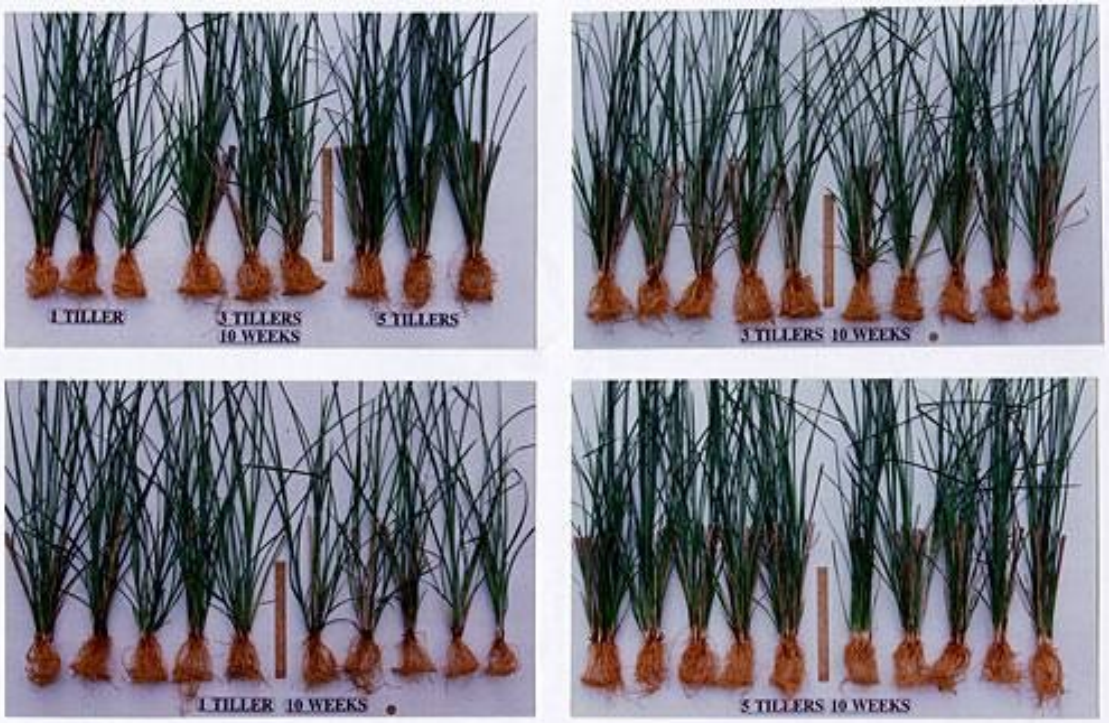



*Photo 10.* After 10 weeks in the nursery, the 1-tiller polybag plants still show variable root systems; only 5 out of 10 plants can be considered satisfactory. Most root systems in the 3-tiller and 5-tiller polybag plants are satisfactory.




*Photo 11.* Plants with starting materials of 1 and 3 tillers were raised in polybag for 10 weeks before transplanting to the ground. Growth rates at 1, 2, 3 and 4 weeks after transplanting are shown. There are no distinct differences in root growth between them, but the 3-tiller plants appear to be more uniform.




*Photo 12a.* Shows poor growth with bare-root tillers at 2 weeks after transplanting to the ground. Better root growth are obtained with 1 and 3-tiller polybag materials.




*Photo 12b.* Compares root systems of bare-root tillers with container plants at 3 weeks after transplanting to the ground. Plants raised in polybags produce more roots.




*Photo 12c.* Shows comparison at 4 weeks after transplanting to the ground. The polybag plants continue to show better root growth.




*Photo 12d.* Comparison at 5 weeks after transplanting. The roots have hit the hard pan and cannot grow deeper. Nevertheless, the polybag plants have better root growth than bare-root tillers.

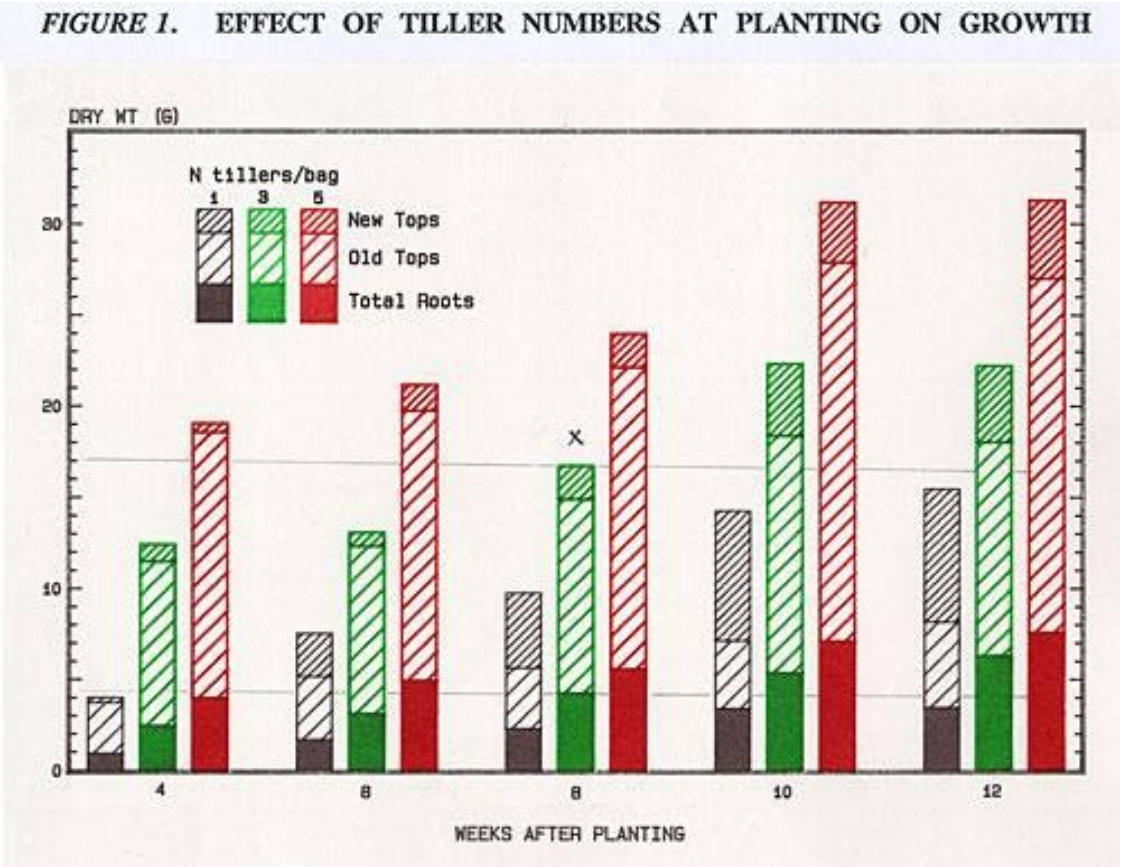
## TABLE 1 EFFECT OF TILLER NUMBERS AT PLANTING ON GROWTH AT VARIOUS WEEKS AFTER PLANTING

| Weeks | Tiller number | Number of new tillers | Dry weights (g) | | | | |
|---|---|---|---|---|---|---|---|
| Tillers | Total | | | | | | |
| New | Old | Tillers | Roots | Total Plant | | | |
| 4 | 1 | 2.2 | 0.28a | 2.78c | 3.06c | 0.94c | 4.00c |
| | 3 | 2.6 | 0.93a | 9.06b | 9.99b | 2.43b | 12.42b |
| | 5 | 1.8 | 0.48a | 14.59a | 15.07a | 3.99a | 19.06a |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | s.e. ( ± ) LSD (P<0.05) | | 0.196 - | 0.434 1.26 | 0.553 1.60 | 0.168 0.49 | 0.684 1.98 |
| 6 | 1 | 4.9 | 2.37a | 3.46c | 5.84c | 1.70c | 7.54c |
| | 3 | 2.3 | 0.76b | 9.24b | 10.00b | 3.08b | 13.08b |
| | 5 | 3.3 | 1.42ab | 14.82a | 16.24a | 4.95a | 21.19a |
| | s.e. ( ± ) LSD (P<0.05) | | 0.340 0.99 | 0.608 1.77 | 0.697 2.02 | 0.244 0.71 | 0.897 2.60 |
| 8 | 1 | 5.8 | 4.12a | 3.34c | 7.46c | 2.29c | 9.76c |
| | 3 | 3.2 | 1.82b | 10.67b | 12.49b | 4.23b | 16.72b |
| | 5 | 3.5 | 1.84b | 16.58a | 18.42a | 5.57a | 23.99a |
| | s.e. ( ± ) LSD (P<0.05) | | 0.566 1.64 | 0.936 2.72 | 1.194 3.47 | 0.371 1.08 | 1.529 4.44 |
| 10 | 1 | 4.3 | 7.12a | 3.74c | 10.85c | 3.39c | 14.24c |
| | 3 | 5.3 | 3.96b | 13.03b | 16.99b | 5.34b | 22.33b |
| | 5 | 5.4 | 3.29b | 20.80a | 24.09a | 7.11a | 31.21a |
| | s.e. ( ± ) LSD (P<0.05) | | 0.945 2.74 | 0.611 1.77 | 1.097 3.18 | 0.293 0.85 | 1.282 3.72 |
| 12 | 1 | 6.2 | 7.29a | 4.72c | 12.01c | 3.44c | 15.45c |
| | 3 | 5.2 | 4.19a | 11.76b | 15.96b | 6.26b | 22.22b |
| | 5 | 5.4 | 4.27a | 19.46a | 23.72a | 7.58a | 31.31a |
| | s.e. ( ± ) LSD (P<0.05) | | 1.187 - | 0.692 2.01 | 1.309 3.80 | 0.388 1.13 | 1.658 4.81 |

Means with same subscript alphabet are not significantly different at P<0.05

*FIGURE 1.* EFFECT OF TILLER NUMBERS AT PLANTING ON GROWTH



## 1.11 Cultivars and bag sizes

*Source: Second Progress Report, 1.4*

The cultivar used in all the earlier trials was collected from Taiping. Since then, we have made other collections. Those cultivars with enough materials for study and especially for destructive sampling come from Parit Buntar, India, Sabak Bernam, Sabah and Raub. A trial was set up to study the different growth rates of these cultivars and how they are influenced by bag sizes.

At 15 weeks, harvesting was carried out with 10 plants per treatment. Only the 4 smaller of the bag sizes were harvested then as the larger bag sizes of 6" x 13", 7" x 15" and 8" x 12" are considered too large for practical use. There is a decrease in the number of tillers and top dry weight production from the largest bag to the smallest bag. The results are summarised in Table 2 . The Indian cultivar is the best performer. It is 30% better than Taiping cultivar in the top dry weight, 13% higher in the root dry weight ( Table 3). Overall it was performing 33% better in dry matter production when compared with Taiping cultivar. In the case of Parit Buntar cultivar it was 17% better for the tops.

The topping of the materials for all 7 bag sizes at 40 weeks, suggests that there is not much difference in dry matter production between those raised in 5" x 7" polybags and those in the larger polybags nor with the smaller bag of 4" x 6". But the 3" x 5" polybag produced better tops (Table 4). The Indian cultivar is 69% better and Parit Buntar 23% better than the Taiping cultivar (Table 3).

This is a preliminary trial. Even so, there are clear indications that cultivars like India and Parit Buntar may perform better than Taiping cultivar.




Cultivars: Taiping, Parit Buntar, India, Sabak Bernam, Sabah, Raub

Bag Sizes: 3" x 5"; 4" x 6"; 5" x 7"; 6" x 9"; 6" x 13"; 7" x 15"; 8" x 13"

*Photo 13.* Planting of various cultivars in different bag sizes to study their effects on growth.







*Photo 14.* Show the various cultivars at 19, 27 and 40 weeks after planting. Note the photos were taken with a wide-angle lens, thus distortion has occurred. Note the stress symptoms shown by cultivars of Sabak Bernam, Raub and Sabah.

| **Cultivar** | **Tillers count** | **Mean dry weight (g)** | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean per bag | Tops | Roots | Total | | | | | | | | | | | | | | | | | | | |
| 3x5 | 4x6 | 5x7 | 6x9 | Mean | 3x5 | 4x6 | 5x7 | 6x9 | Mean | | 3x5 | 4x6 | 5x7 | 6x9 | Mean | | 3x5 | 4x6 | 5x7 | 6x9 | Mean | | |
| India | 7.0 | 8.4 | 9.6 | 10.2 | 8.8 | 15.3 | 22.4 | 25.6 | 27.4 | 22.7a | | 5.1 | 5.1 | 7.0 | 7.1 | 6.1a | | 20.4 | 27.6 | 32.6 | 34.5 | 28.8a | |
| Parit Buntar | 5.0 | 3.8 | 5.4 | 6.8 | 5.3 | 13.4 | 13.5 | 21.5 | 27.9 | 19.1b | | 3.0 | 2.7 | 4.1 | 7.9 | 4.4b | | 16.3 | 16.2 | 25.7 | 35.8 | 23.5b | |
| Tai | 6.4 | 8.6 | 7.4 | 7.4 | 7.5 | 12. | 16. | 18. | 18. | 16. | ± | 3.0 | 5.6 | 6.1 | 7.0 | 5.4 | ± | 15. | 22. | 24. | 25. | 21. | ± |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ping | | | | | | 3 | 5 | 3 | 0 | 3 cd | 0.79 | | | | | a | 0.24 | 3 | 1 | 4 | 0 | 7b | 0.96 |
| Sabah | 5.4 | 5.8 | 8.8 | 9.6 | 7.4 | 11.0 | 12.0 | 21.5 | 27.2 | 17.9 bc | (2.2) | 2.7 | 3.5 | 5.8 | 6.3 | 4.6 b | (0.7) | 13.7 | 15.5 | 27.3 | 33.5 | 22.5 b | (2.7) |
| Sabak Bernam | 5.8 | 6.6 | 7.2 | 9.2 | 7.2 | 10.7 | 14.6 | 22.9 | 23.3 | 17.9 bc | | 1.9 | 2.7 | 4.3 | 5.6 | 3.6 c | | 12.6 | 17.3 | 27.2 | 29.0 | 21.5 bc | |
| Raub | 6.0 | 5.6 | 7.0 | 7.2 | 6.5 | 10.9 | 11.8 | 19.3 | 20.1 | 15.5d | | 2.1 | 2.7 | 3.5 | 5.1 | 3.3 c | | 13.0 | 14.5 | 22.8 | 25.2 | 18.9 c | |
| | | | | | | d | c | b | a | | | d | c | b | a | | | d | c | b | a | | |
| Mean | 5.9 | 6.5 | 7.6 | 8.4 | | 12.3 | 15.2 | 21.5 | 24.0 | | | 3.0 | 3.7 | 5.1 | 6.5 | | | 15.2 | 18.9 | 26.7 | 30.5 | | |
| | | | | | | | | | | | | | | | ± 0.20 | (0.6) | | | | ± 0.78 | (2.2) | | |

Means with same subscript alphabet are not significantly different at P<0.05

## Destructive sampling expressed as percentage of V. ex Taiping Cultivar

| | **15 weeks (Mean over 4 bag sizes)** | **40 weeks Tops mean** | | | | |
|---|---|---|---|---|---|---|
| Cultivar | %Total tillers | % Dry weight | %dry weight | | | |
| | per bag | Tops | Roots | Total | 4 bag sizes | 7 bag sizes |
| India | 117 | 139* | 113 | 133* | 157* | 169* |
| Parit Buntar | 71 | 117* | 81 | 108 | 109 | 123* |
| Taiping | 100 | 100 | 100 | 100 | 100 | 100 |
| Sabah | 99 | 110 | 85 | 104 | 38 | 46 |
| Sabak Bernam | 96 | 110 | 67 | 99 | 45 | 52 |
| Raub | 87 | 95 | 61 | 87 | 39 | 46 |

Significantly highr than V. ex Taiping cultivar

| **Bag sizes (inch)** | **India** | **Parit Buntar** | **Taiping** | **Sabah** | **Sabah Bernam** | **Raub** | **Mean** | |
|---|---|---|---|---|---|---|---|---|
| 8 x 12 | 120.4# | 85.3 | 56.3 | 35.1 | 34.1 | 30.7 | 60.3 a | |
| 7 x 15 | 97.7 | 76.9 | 63.7 | 27.9 | 34.6 | 29.3 | 55.0 ab | |
| 6 x 13 | 87.3 | 73.1 | 45.7 | 30.7 | 33.6 | 30.0 | 50.1 b | |
| 6 x 9 | 86.4 | 64.1 | 40.6 | 27.5 | 33.5 | 30.1 | 47.0 b | ± 3.93 |
| 5 x 7 | 111.5 | 78.2 | 56.0 | 19.6 | 29.3 | 22.5 | 52.8 ab | (11.4) |
| 4 x 6 | 82.9 | 48.6 | 56.8 | 18.7 | 19.2 | 17.6 | 44.0 bc | |
| 3 x 5 | 62.7 | 48.1 | 45.8 | 17.8 | 17.2 | 15.9 | 34.6 c | |
| Mean | a | b | c | d | d | d | | |
| | 92.7 | 67.8 | 55.0 | 25.3 | 28.8 | 25.2 | 49.1 | |
| | | | ± 3.64 | (10.5) | | | | |

Notes: 1. Cutback at 20 cm height

# One sample only because the rest were used for further multiplication of this promising cultivar. However, statistical analysis excluding this bag size also gave similar result.

Means with same subscript alphabet are not significantly different a P<0.05

## 1.12 The cultivars collected

*Source: First Progress Report, G-I*

All the observations reported herein were based on one cultivar. At the moment, we have five cultivars as detailed below:

| Cultivar | Location found | Date required | No. of tillers | Comments |
|---|---|---|---|---|
| A | Taiping | 12/4/89 | 57 | All information from this. Widely distributed to interested parties. Experiments including destructive sampling carried out. |
| B | Parit Buntar | 15/1/90 | 14 | Just distributed to interested parties for multiplication. |
| C | India | 4/7/90 | 4 | Multiplication in RRIES. |
| D | Raub | 4/9/90 | 10 | Multiplication in RRIES. |
| E | Sabak Bernam | 14/9/90 | 36 | Multiplication in RRIES. |

When there are sufficient plants for experimentation, the earlier trials will concentrate on comparative study of:

Effect of shade tolerance Growth rates (especially growth of root system). Response to fertilizer, spacing, soil types, etc. Value for fodder and mulch.

## 1.13 Biodegradable containers

*Source: Second Progress Report, 1.5*

All the container plants discussed so far uses plastic bags whichare not biodegradable and therefore not environmental friendly. We therefore investigate other biodegradable containers to access whether they can be used as substitutes for polybags. Two types were tested:

Paper pots imported from Japan Bags made from old newspapers

At 6 weeks the growth of plants in newspaper bags was satisfactory. However, the newspaper bags has started breaking down and by the 12 th week, most of the paper bags were broken. Therefore, we have to find a system to prolong the life of newspaper bags or try other types of papers. This should be the subject of future investigation. Growth of plants in paper pots was very good if they were underlaid with polythene sheet, but if they were not underlaid and left touching the ground, the growth was poor. Paper bags were also found to be satisfactory for continued growth up to 3 months at which time the plants were ready for planting. However, it costs 10 times more than polybags and therefore is not economical to use.

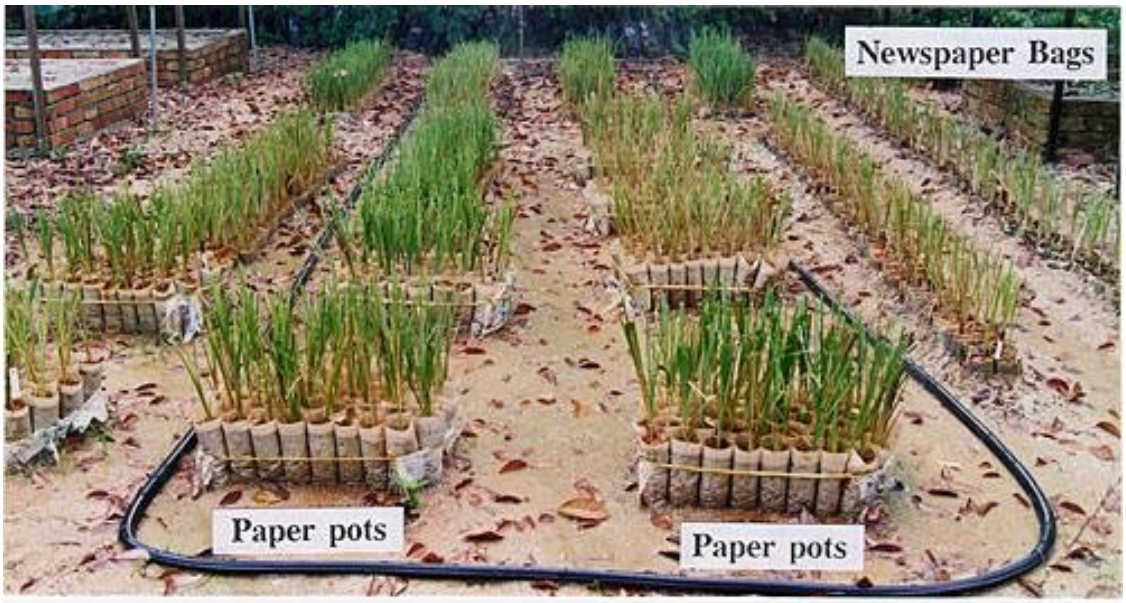



*Photo 15.* Raising *Vetiver* container plants in biodegradable paper pots and newspaper bags.




*Photo 16a.* Planting in newspaper bags 5" x 6.5".




*Photo 16b.* At 6 weeks after planting, the growth looks satisfactory but note the newspaper bags are starting to break.

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*Photo 17a.* Planting in paper pots 2.75" x 2.5". Note the good quality tiller type used.




*Photo 17b.* After 6 weeks the plant growth was satisfactory when paper pots were underlaid with a polythene sheet.

30




*Photo 18a.* Tillers just planted in paper pots 3" x 7".




*Photo 18b.* Condition after 6 weeks. Growth is good if it is underlaid with a polythene sheet.

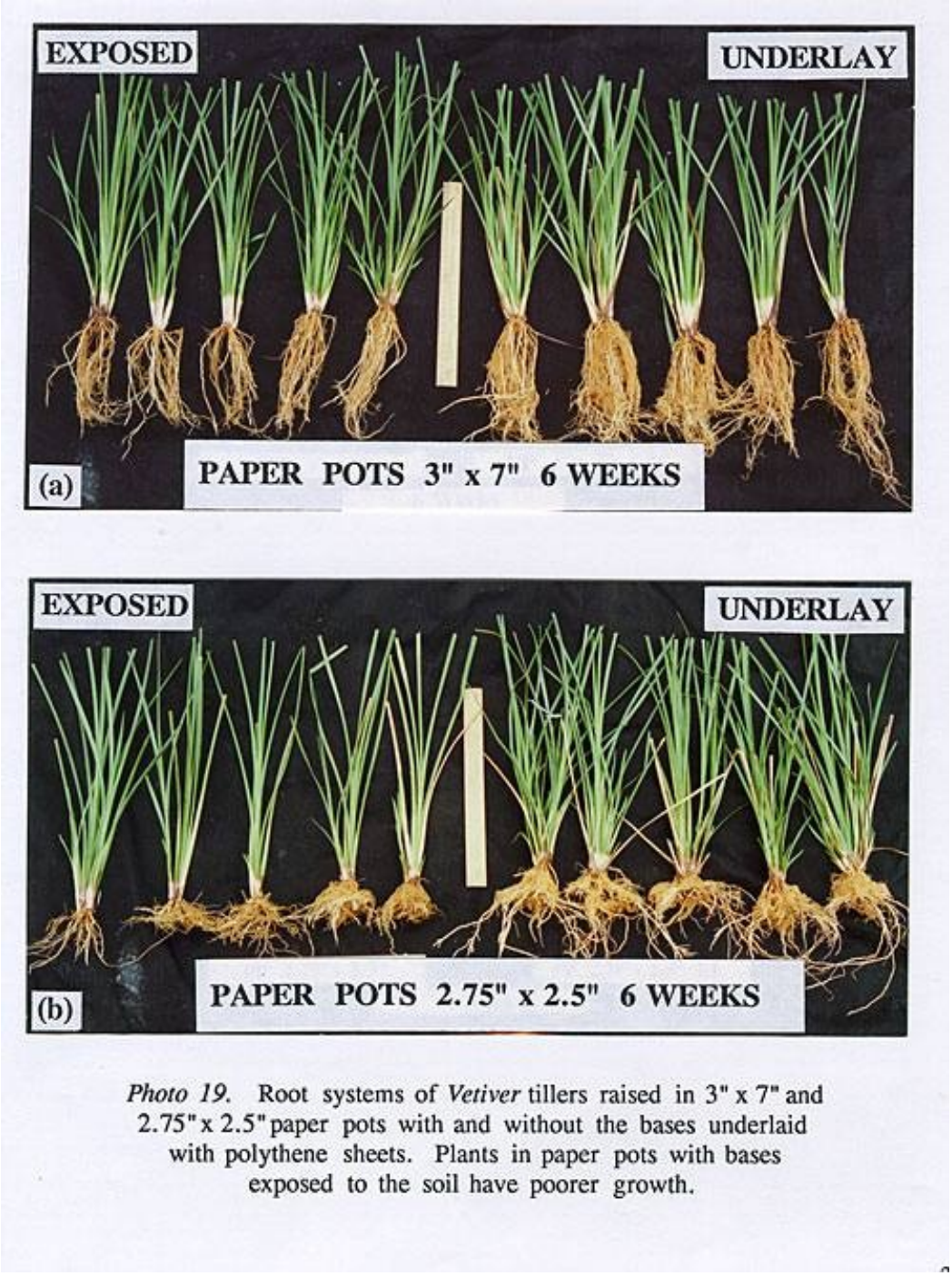



*Photo 19.* Root systems of *Vetiver* tillers raised in 3" x 7" and 2.75" x 2.5" paper pots with and without the bases underlaid with polythene sheets. Plants in paper pots with bases exposed to the soil have poorer growth.

## 1.14 Unorthodox rooting media

*Source: Second Progress Report, 1.6*

Why this approach? The most important reason is the cost of transporting polybag materials. The use of polybags with good soil produces quality planting materials. However, unless the polybag plants can be raised at site, transporting of these planting materials tend to be very expensive. Because of that problem, we tested other potting materials, which are lighter and at the same time may perform better. Many materials were tested including saw dust, padi husk, empty old palm bunches, etc. with generally disappointing results. So far, foam is the most promising unorthodox root media.

We investigated the influence of light conditions, testing growth under full sun and 65% daylight. The various durations under mist frame and irrigation sprinklers to produce the desired quality of the planting materials was also studied.

Previously I have reported that Vetiver is sensitive to shade but nurseries are still set up underneath trees or by the side of houses, etc. where light condition is not full daylight. In addition to the poor growth of the shaded nursery plants, the poorer quality appears to continue into the ground after transplanting; growth in the first 4 weeks was distinctly inferior to plants raised in full sun. Vetiver is shade sensitive, and nursery plants should never be raised under shade.

Usage of foam method ensures much better subsequent growth when compares with bare-root tillers. In addition, the usage of the foam ensures easy and cheaper transporting costs and easy and cheaper distribution in the field. The development of the foam system * is most encouraging. More work will be carried out on more detailed comparative studies.




*Photo 20.* Rooting plants in foam under mist.




*Photo 21.* Raising plants in foam under Sumisansui sprinkler.




*Photo 22.* Plants raised in foam after 10 weeks in full sun. (Note: The method of preparing such materials in foam system is the subject of a patent application.)




*Photo 23.* Growth of plants raised in foam at 4 weeks after transplanting to the ground.







*Photo 24a & 24b.* Plants were raised in foam in full sun for 6 weeks before transplanting to the ground. These photos show the root growth at 5 weeks after transplanting.







*Photo 25a & 25b.* Foam plants were raised in full sun for 8 weeks before transplanting to the ground. Root growth at 3 weeks and 4 weeks after transplanting.







*Photo 26a & 26b.* Foam plants were raised in full sun for 10 weeks before transplanting to the ground. Root systems at 1 week and 2 weeks after transplanting.







*Photo 26c & 26d.* Foam plants were raised in full sun for 10 weeks before transplanting to the ground. Root systems at 3 weeks and 4 weeks after transplanting.




*Photo 27a.* Shows condition of plants raised in foam in full sun for 10 weeks. Note the good roots binding the foam in both 1-tiller and 3-tiller plants.




*Photo 27b.* Shows condition of plants raised in foam in 65% daylight for 12 weeks. Note the very poor growth especially those with starting material of 1-tiller.



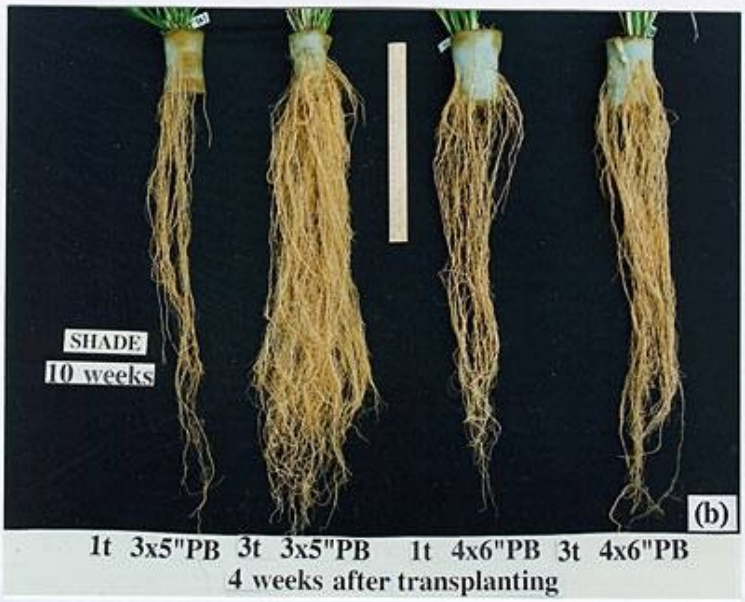




*Photo 28a & 28b.* Foam plants were raised in 65% daylight for 10 weeks. These photos show the root systems at 3 weeks and 4 weeks after transplanting to the ground. Note the poor root system especially of plants starting with 1-tiller.







*Photo 29a & 29b.* Foam plants were raised in 65% daylight for 12 weeks before transplanting to the ground. Root growth of 1-tiller plants at 3 weeks and 4 weeks are poor.




*Photo 30a.* Growth rates of plants raised in foam are better than those of bare-root tillers at 3 weeks after transplanting to the ground.




*Photo 30b.* Growth rates of plants raised in foam are better than those of bare-root tillers at 4 weeks after transplanting to the ground.



*Photo 31.* Excavated plants air-dried and kept under shade.




*Photo 32.* Shows the root systems of plants raised in foam for 8 or 10 weeks. in full sun are better than those raised in polybags for 10 weeks. The bare-root tillers are slowest in growth.

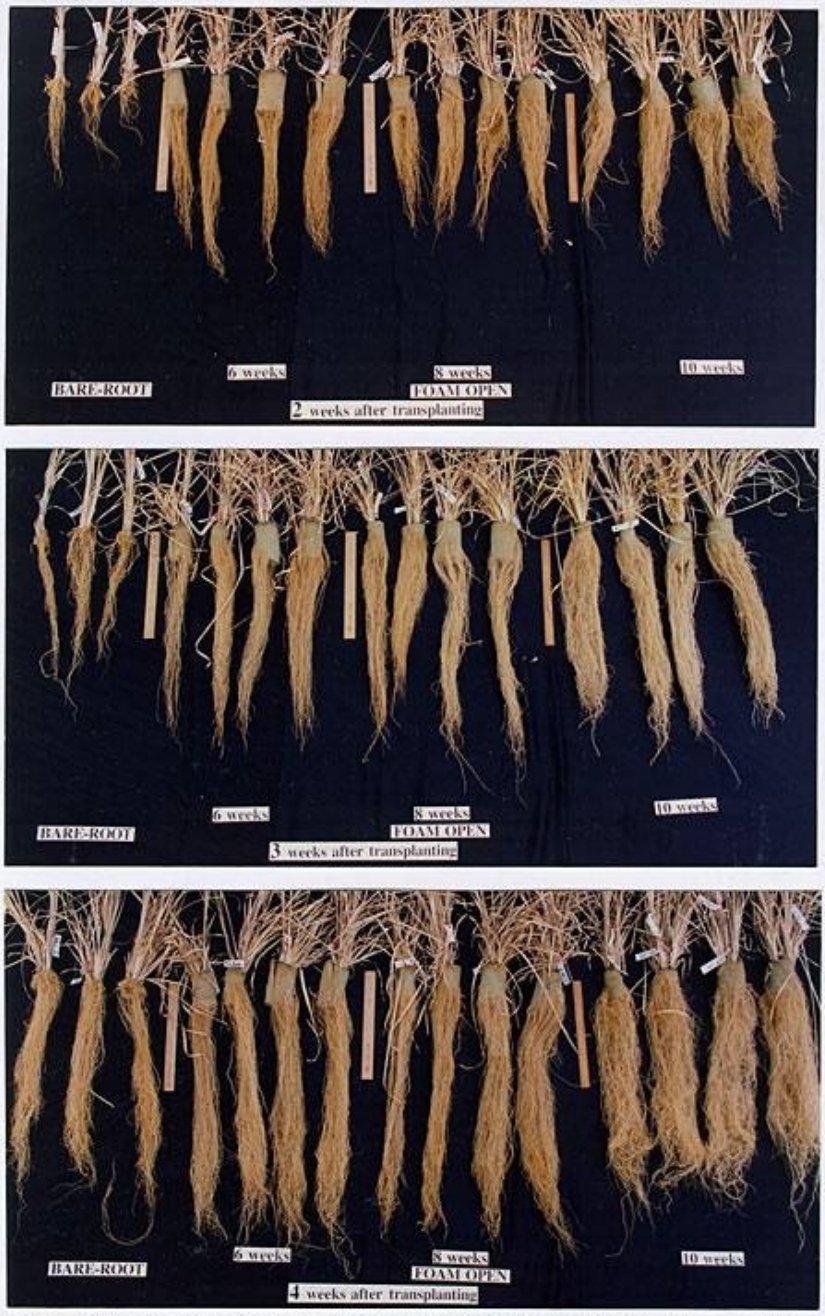



*Photo 33.* Growth rates of plants raised in foam for 6, 8 and 10 weeks are better than those of bare-root tillers at 2, 3 and 4 weeks after transplanting to the ground.

## 1.15 Distribution of planting material

*Source: First Progress Report, Chapter B*

To be able to assess the potential value of Vetiver, the first priority was to multiply the first clump of 57 tillers rapidly and to distribute to end-users for testing. In general, planting materials were given to interested parties who approached us; on a first-come-first supplied basis. The amount given to each party varied from a minimum of about 1,000 tillers to over 50,000 tillers where co-operating trials were to be started immediately. The earliest recipient was Leong Hin San Estate with 2,000 tillers in December 1989 (Photo 10) and the latest was Vitapro Sdn. Bhd. with 60,000 tillers in October/November 1990 (Photo 11)

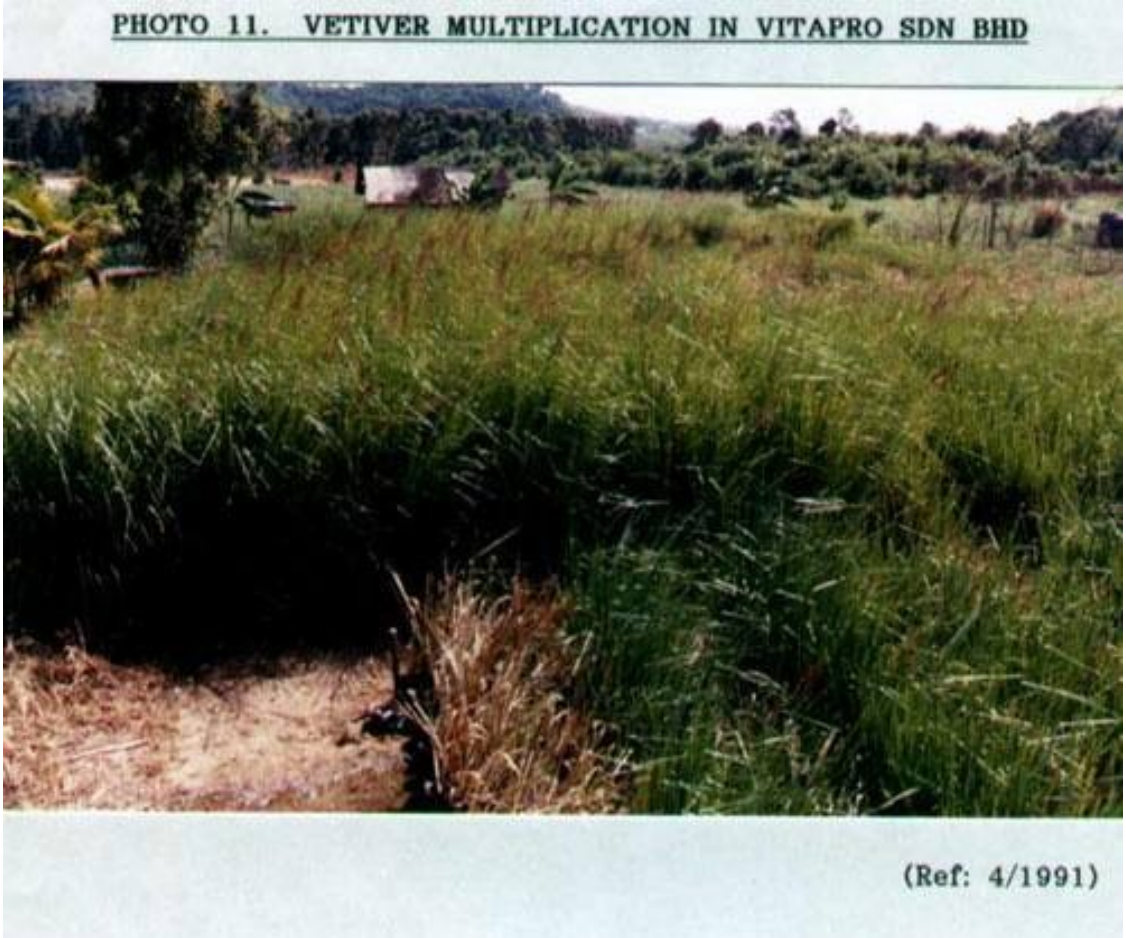
**PHOTO 10. VETIVER MULTIPLICATION IN LEONG HIN SAN ESTATE**





One tiller was planted in each polybag with one nugget of Kokei. These plants are exactly 3 months old.

(Ref: 3/1990)




Some of these recipients are now serving as 'secondary' multiplication centres to supply to other interested parties after my clearance.

Two methods are used:

(1) Polybag plants are taken to the farms (Photo 12). This is useful if there were long distances to travel, polybags or soil-beds are not ready, insufficient labour force and when the farmers need extended time to split and plant the materials. It is also used for direct planting in experiments in co-operating farms. This allows us to cull and use more uniform plants.

PHOTO 12. DISTRIBUTION OF VETIVER BY POLYBAG PLANTS



(Ref: 15/1990)

(2) Production in soil beds are cheaper and preferred (Photo 13) . Cut-clumps are better for mass transport at much lower costs. For example, the same lorry can take more than 15 times the number of tillers as clumps when compared to those in polybags (Photo 14 ). However, this method can only be used if the polybags or the multiplication beds are ready for receiving the plants and there are ample labour forces available.

PHOTO 13. VETIVER RAISED IN SOIL-BEDS FOR DISTRIBUTION



(Ref: 24/1990)

PHOTO 14. DISTRIBUTION OF VETIVER BY CUT-CLUMPS




(Ref: 24/1990)

II. AMOUNT OF VETIVER DISTRIBUTED

Generally, plant materials were given to interested parties who approached us. Large amounts were sent to those who funded my experiments. The materials distributed between December 1989 to November 1990 amounted to approximately 200,000 tillers. This increasing amount of plants distributed is illustrated in Figure 2 . The main recipients are listed in Table 1 . This only records plant materials distributed from my own nursery, and not from 'secondary' nurseries.

Currently, we have ample stocks to satisfy all foreseeable requests for nucleus supply of more than 1,000 tillers each. Materials available are sufficient to embark on large-scale trials. We expect to produce and use at least 300,000 polybag plants in early 1991. In addition, plants are being multiplied in 'secondary` nurseries of end-users.

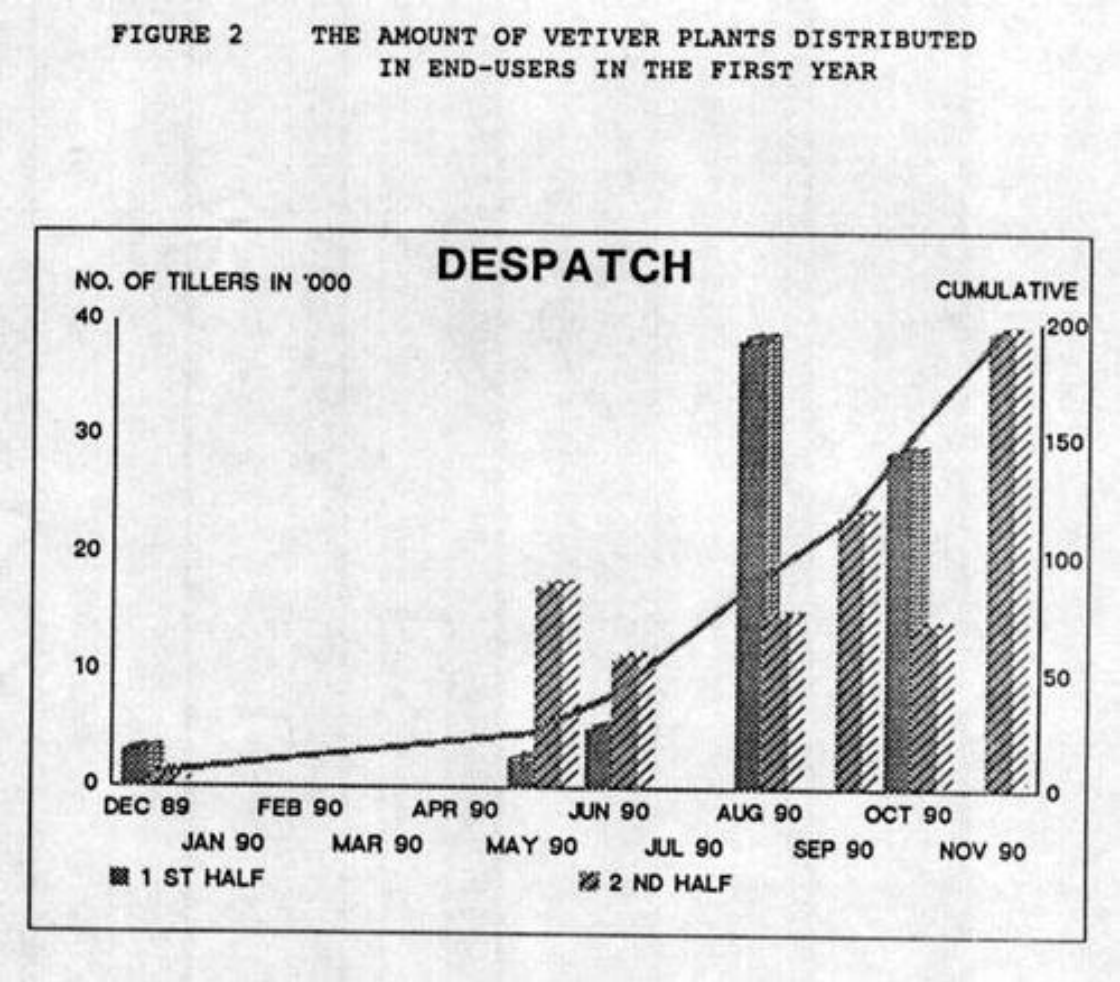



TABLE 1 VETIVER DESPATCHES TO MAIN RECIPIENTS

| No. | Recipient | Despatch Date | Total Tillers |
|---|---|---|---|
| 1. | LEONG BIN SAN ESTATE | 12/89 6/90 | 2,000 5026 |
| 2. | UNITED MALACCA RUBBER ESTATES | 12/89 | 1000 |
| 3. | NYALAS RUBBER ESTATES | 12/89 | 1000 |
| 4. | PINANG TUNGGAL ESTATE | 05/90 08/90 | 6615 |
| 5. | AGROMASS SDN BHD | 05/90 | 2000 |
| 6. | SG. RINCHING ESTATE | 05/90 | 5250 |
| 7. | SINKYO SDN BHD AND 13 SMALLHOLDERS | 05/90 08/90 | 40400 |
| 8. | SG. CHINOH ESTATE | 05/90 08/90 | 59751 |
| 9. | BUKIT LAGONG ESTATE | 08/90 | 1842 |
| 10. | PAHANG OIL PALM ESTATE | 08/90 | 934 |
| 11. | HWA LI ESTATE | 08/90 | 965 |
| 12. | ASIA DEVELOPMENT ESTATE | 10/90 | 1600 |
| 13. | SG. GAPI ESTATE | 10/90 | 6700 |
| 14. | MALACCA SMALLHOLDER | 10/90 | 1200 |
| 15. | SYARIKAT KERATONG SDN BHD | 10/90 | 1969 |
| 16. | SEREMBAN SMALLHOLDER | 10/90 | 1400 |

| | | | |
|---|---|---|---|
| 17. | VITAPRO SDN BHD | 10/90 11/90 | 59629 |
| | TOTAL | | 199,281 |

# 2. Growth requirements

## 2.1 Introduction

*Source: First Progress Report, Chapter C*

To be able to use a plant, it is important to know its growth rates under various conditions. Growth can be measured by the rate of tillering, shoot dry matter production, total dry matter production and root development.

Among the important factors influencing growth are the effects of shade, fertilizer, density of planting, management practices, etc. This chapter attempts to summarise preliminary findings to-date. It also attempts to discuss and study the growth rates of the root system and investigate the using of mini rhizotrons for this purpose. A more detailed report can be produced later.

## 2.2 Shade

*Source: First Progress Report, C-I*

To be able to use a plant as a cover crop for any extended period under perennial crops, such as rubber or oil palm, dictates that the plant must be shade-tolerant under the canopy of the main crop. Three trials were started to test such effect.

### a. Trial 1

Plants raised in polybags for 6 weeks, were put under shade (80%) of rubber plants at nursery spacing of 6' x 6' and in the full sun.

At three months after treatment, samples of leaves were taken from two levels of the leaves to determine specific leaf areas. Results are given in the following Table 2.

| | **20-40cm** | **40-60cm** | | |
|---|---|---|---|---|
| | Shade | Sun | Shade | Sun |
| Mean | 157.0 | 139.8 | 151.4 | 142.1 |
| s.e.( ± ) | 3.98 | 2.07 | 4.00 | 2.55 |
| n | 10 | 10 | 10 | 10 |
| t-test | *** | P<0.1 | | |

Shading significantly increases the specific leaf area suggesting significant response of the plant.

At three and four months after treatments, ten polybags each were sampled and the soil washed off (Photo 15). Results of number of tillers and dry weights are given in Table 3. This shows that shading significantly reduces:

Tiller formation Plant weight Shoot weight Root weight

But did not modify the % of the root / shade ration significantly.

Therefore, we can conclude that Vetiver (at least the cultivar I have been working with) is not shade tolerant. It is, however, not expected to be since most grasses are likely to be climax plants. The good feature is that the % root / shoot stayed rather constant and we should be able to modify agricultural methods to make the best use of this point.

### b Trial 2

The plants from Trial 1 were used in this trial. Half the plants grown under shade were shifted to the open, while the reverse approach was applied to plants grown in the full sun. After three months, 15 polybag plants were harvested (Photo 16). The results are summarised in Table 4 and illustrated in Figure 3. They showed the following:

Plants from the open performed poorly under shade. Plants in shade conditions continued to grow poorly with poor tillering under continuous shade. Plants from shade condition performed well once they are exposed to the open.




*Photo 15.* Vetiver plants after growing 4 months in shade and in open.

(Ref: 9/1990)




*Photo 16.* Vetiver plants after the reverse transfers of shade → open conditions and open → shade conditions

(Ref: 10/1990)

TABLE 3 EFFECT OF SHADE ON MULTIPLICATION AND GROWTH OF VETIVER (Trial 1)

| **Parameter** | **Harvest 1 : at 3 months** | **Harvest 2: at 4 months** | | | | |
|---|---|---|---|---|---|---|
| | Shade | Sun | Sig. Level of t | Shade | Sun | Sig. Level of t |
| Number of tillers | 5.6 ± 0.95 | 14.6 ± 1.16 | *** | 4.9 ± 0.4 | 14.8 ± 0.80 | *** |
| Total shoot dry wt. (gm) | 22.2 ± 3.08 | 157.8 ± 17.03 | *** | 17.2 ± 1.54 | 163.1 ± 16.05 | *** |
| Total root dry wt. (gm) | 5.5 ± 1.04 | 50.8 ± 6.72 | *** | 8.4 ± 1.61 | 91.7 ± 13.18 | *** |
| Total plant dry | 27.7 ± 3.97 | 208.6 ± 23.10 | *** | 25.6 ± 2.68 | 254.8 ± 26.58 | *** |

| | | | | | | |
|---|---|---|---|---|---|---|
| wt. (gm) | | | | | | |
| % root / shoot | 25.2 ± 2.59 | 31.9 ± 2.49 | P<0.1 | 49.3 ± 9.61 | 57.1 ± 7.77 | NS |

Note: 2-tail test is used *** P<0.001 NS: Not significant

TABLE 4 EFFECT OF SHADE ON MULTIPLICATION AND GROWTH OF VETIVER (Trial 2).

| | | | | | **Dry weights (gm)** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Comparisons | Mean No. of tillers | Dead shoot | Live Shoot | Root | Shoot | Total Plant | Root %---------- Plant | Dead Shoot %---------- Total Shoot | |
| T2 vs T1 | Cont. open Cont. shade Sig. of t | 32.0 18.7 * | 0.53 0.21 ns | 454.2 89.8 * | 75.9 19.3 * | 454.7 90.0 * | 530.6 109.3 * | 14.5 18.0 ** | 0.09 0.19 ns |
| T2 vs T3 | Cont. open Open ® shade Sig. of t | 32.0 24.8 ns | 0.53 4.06 ** | 454.2 54.5 ** | 75.9 17.7 * | 454.7 58.6 ** | 530.6 76.2 ** | 14.5 23.6 *** | 0.09 7.62 ** |
| T2 vs T4 | Cont. open Shade ® open Sig. of t | 32.0 39.9 ns | 0.53 2.65 * | 454.2 195.4 * | 75.9 43.0 P<0.1 | 454.7 198.1 * | 530.6 241.1 * | 14.5 17.9 * | 0.09 1.52 ** |
| T1 vs T3 | Cont. shade Open ® shade Sig. of t | 18.7 24.8 * | 0.21 4.06 ** | 89.8 54.5 ** | 19.3 17.7 ns | 90.0 58.6 ** | 109.3 76.2 * | 18.0 23.6 *** | 0.19 7.62 ** |
| T1 vs T4 | Cont. shade Shade ® open Sig. of t | 18.7 39.9 *** | 0.21 2.65 ** | 89.8 195.4 *** | 19.3 43.0 *** | 90.0 198.1 *** | 109.3 241.1 *** | 18.0 17.9 ns | 0.19 1.52 * |
| T3 vs T4 | Open ® shade Shade ® open Sig. of t | 24.8 39.9 ** | 4.06 2.65 ns | 54.5 195.4 *** | 17.7 43.0 *** | 58.6 198.1 *** | 76.2 241.1 *** | 23.6 17.9 *** | 7.62 1.52 ** |

Note: T1 – continuous shade T2 – continuous open T3 – open ® shade T4 – shade ® open t – test using pooled or separate variance estimate

FIGURE 3 EFFECT OF SHADE ON MULTIPLICATION AND GROWTH OF VETIVER (i)

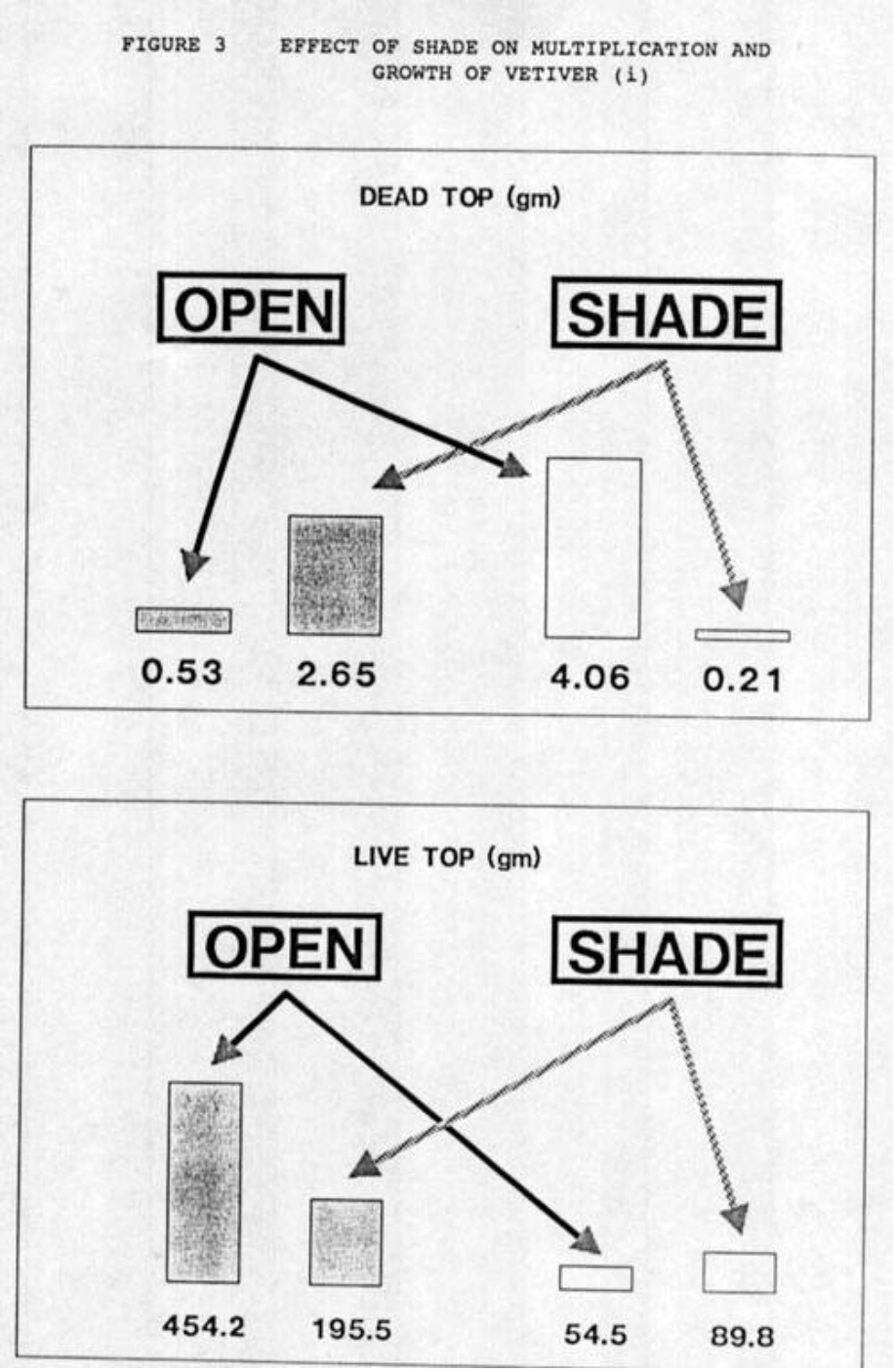
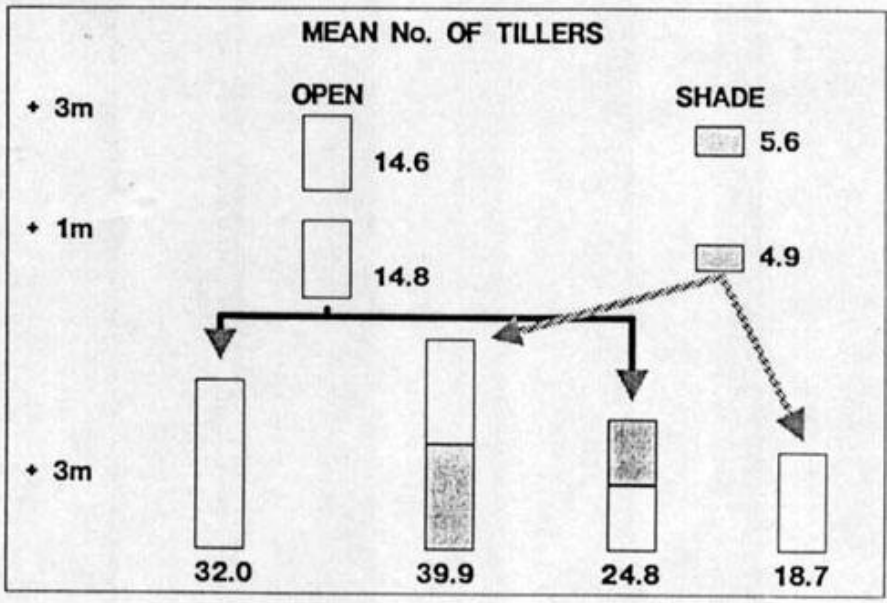


FIGURE 4 EFFECT OF SHADE ON MULTIPLICATION AND GROWTH OF VETIVER (ii)



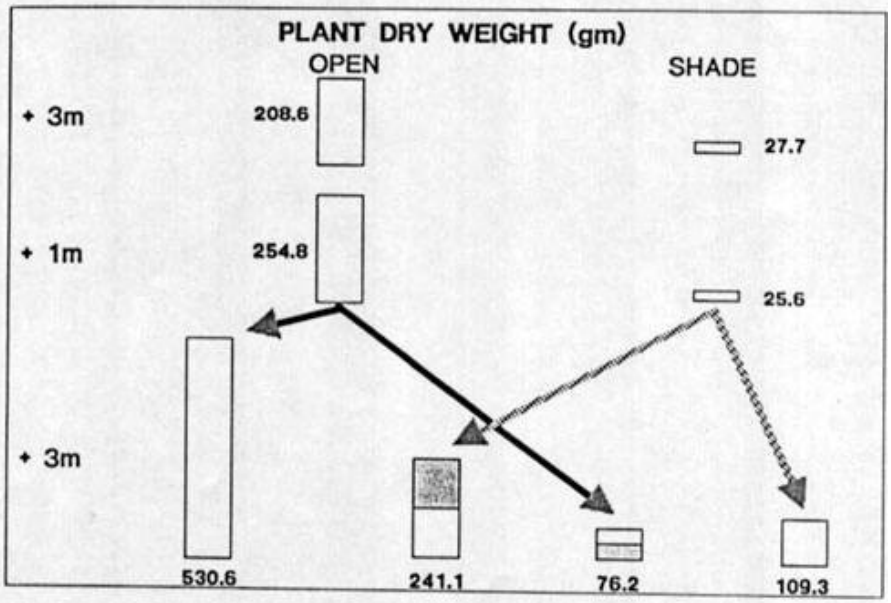
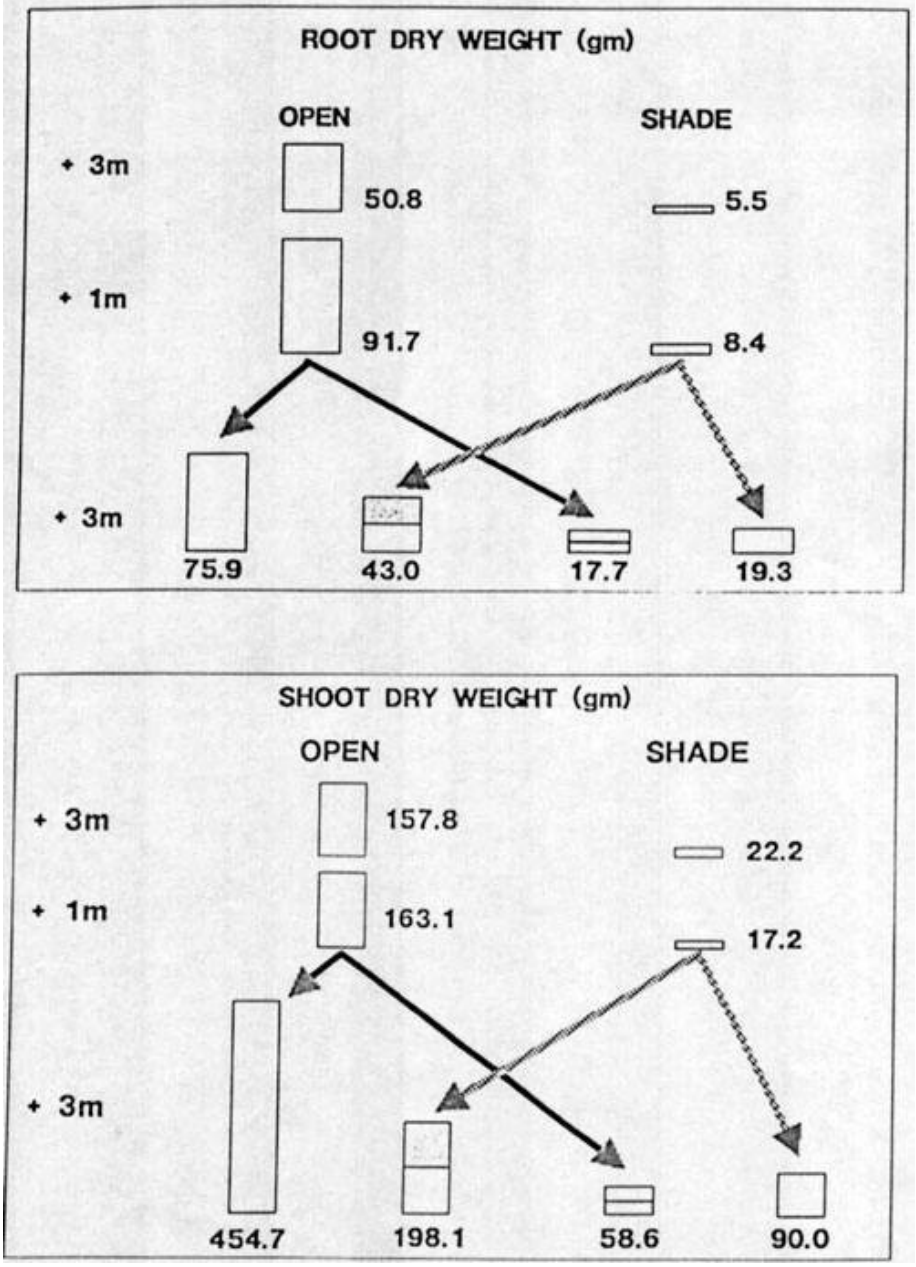



FIGURE 5 EFFECT OF SHADE ON MULTIPLICATION AND GROWTH OF VETIVER (iii)




Therefore, the conclusion is:

"Vetiver is not shade-tolerant" but can survive under shade (intensity?) for a period (?) and could easily rejuvenate if the shading canopy is removed.

In effect, such information allows us to plan the following:

Plant the Vetiver before or at the same time as the planting of the main perennial crop of oil palm or rubber. Leave the Vetiver along the terracing to grow or sustain itself. When the main crops of oil palm or rubber have grown over, the rows of Vetiver can either perish as in oil palm area or periodically be re-established as in rubber during wintering. In either case, the Vetiver would have done its job of reducing soil erosion.

c. Trial 3

This trial studied the growth of plants under very intense shade of (87%) of rubber nursery and also examined three possible methods of establishing plants in the field.

The three planting methods are:

polybag completely removed exposing the core of soil and roots ( Photo 17a ). base removed and with four slits cut with 10 cm clearance from top and bottom ( Photo 17b ). base of polybag removed ( Photo 17c ).

Photo 18a shows the condition of plants at planting and Photo 18b shows the condition after two months in the open. In contrast, Photo 19a shows the condition of plants after two months in the shade of rubber canopy ( Photo 19b ).

Value of the three planting methods will be discussed separately. Here, it is of significant note that all three methods of planting have no influence on the intense shade effect, vis. All plants under rubber performed badly at two months ( Photo 19a ) compared with those in the open ( Photo 18b ). Eventually, all the plants under the intense shade died off.

PHOTO 17. METHODS OF ESTABLISHING POLYBAG PLANTS IN THE FIELD



(a) Polybag completely removed

(b) Base of polybag removed with 4 slit-cuts





(c) Base of polybag removed

(Ref: 4/1990)

PHOTO 18. EFFECT OF SHADE ON VETIVER GROWTH (1)



(a) Treated plants buried in soil in the open.

(Ref: 4/1990)



(b) Plants growing in the open for 2 months.

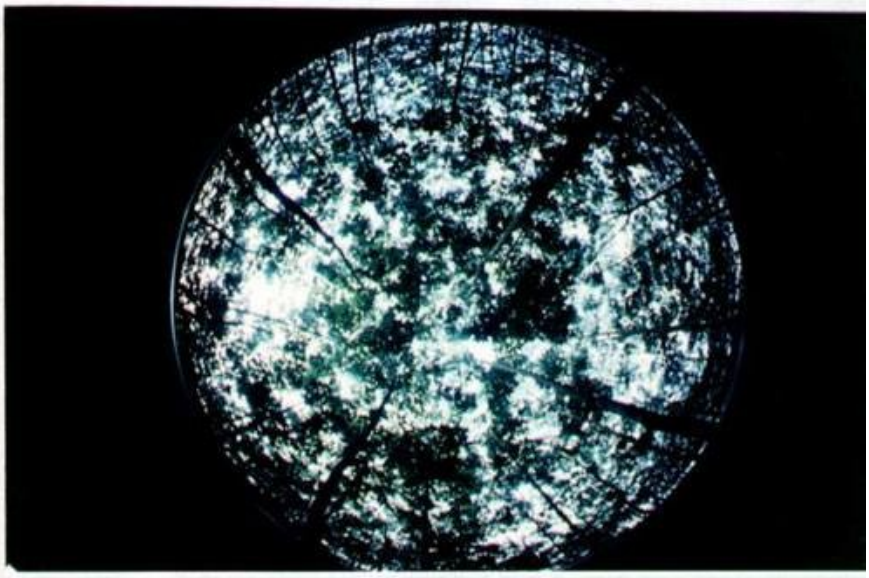
(Ref: 9/1990)

PHOTO 19. EFFECT OF SHADE ON VETIVER GROWTH (ii)



(a) After 2 months in the shade, the Vetiver plants are dying.

(Ref: 4/1990)



(b) Hemispherical photo showing canopy of rubber nursery with intense shade of 87%.

(Ref: 4/1990)

The following points are of note:

Normally, the % shade under mature rubber is not so intense The attempt to raise polybag plants to establish under established shade has to be re-examined. Direct planting in situ in the ground before shading by the main crop may modify the response.

CONCLUSION

The following points should be noted:

Very intense shade was used. This is of value to study shade tolerance at the preliminary stage; but normal shade in rubber is not so intense. Because of (1), it is important to study response to various intensity of shading. This is easy to do, using available plastic nets but we have delayed this to combine with studies of different cultivars for more meaningful results. Polybag materials were established under

existing shade. The root system at establishment was confined within the bag and therefore may not be best expressed. Would the planting "in situ" before canopy closure performed the same? Nevertheless, all evidences point to Vetiver being shade-sensitive. At what level of shade would tolerance be possible? However, because of (4), the possible value of Vetiver may be manipulated in the following manner: Because of the shade sensitivity and the possible competitive effectiveness of Vetiver against perennial crops as rubber, oil-palm, fruit trees, etc. Vetiver should be used for: i) early function for soil and moisture conservation. ii) allow the Vetiver plants to fade out because of shading so as to remove any possible competitive effect with the main crops. Trial 2 showed that plants poorly grown under shade were rapidly revived upon exposure to light. This suggests shade survival may be dependent on the degree of shading, and with the periodic dose of more light as during winter period in rubber. Vetiver will not be shaded out in crops that do not produce dense canopies or are relatively short. Examples are cocoa, tea, etc.

## 2.3 Soil types

*Source: First Progress Report, C-II*

Plants were grown in polybags filled with 5 soil types:

| Soil Series | Soil Taxonomy (1990)* |
|---|---|
| Munchong | Typic Hapludox |
| Rengam | Typic Kandiudults |
| Durian | Typic Kanhaplaudults |
| Sg. Buloh | Typic Quartzipsamments |
| Sogomana Typic | Tropaquepts |

*(The above soils classification was according to Soil taxonomy (1990) following Keys to Soil taxonomy, 4 th Edition. SMSS Technical Monograph No. 6. Blacksburg, Virginia.)

A uniform fertilizer application of 1 Kokei (6gm) nugget was used for all treatments. Photo 20 shows the growth of plants after three months. The results, summarised in Table 5 and illustrated in Figure 6 show:

Rengam soil produces the biggest number of tillers; the other four types of soil have similar production. Rengam gave the best dry matter production followed by Munchong. Sogomana is clearly the worst soil type.

This trial shows that while there is soil type effect on tillering and dry matter production, Vetiver performs fairly well even in the worst soil type. It should be noted that the trial is on polybags with filled soil; future work in soil in situ may show different results. Effect of nil fertilizer and different levels of fertilizer would be of interest to show whether difficult physical characteristics may be ameliorated by additional input.

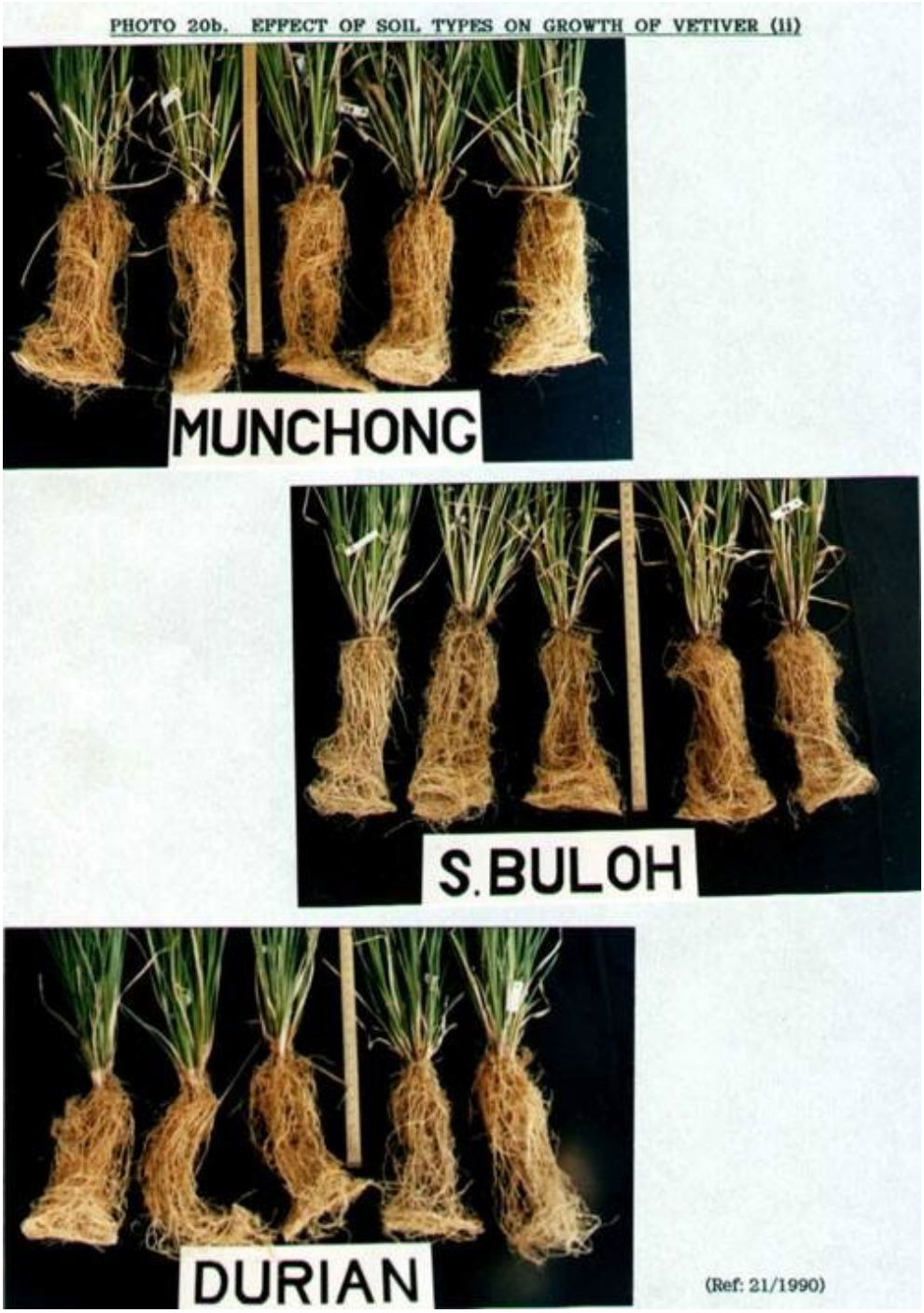
PHOTO 20a. EFFECT OF SOIL TYPES ON GROWTH OF VETIVER (i)





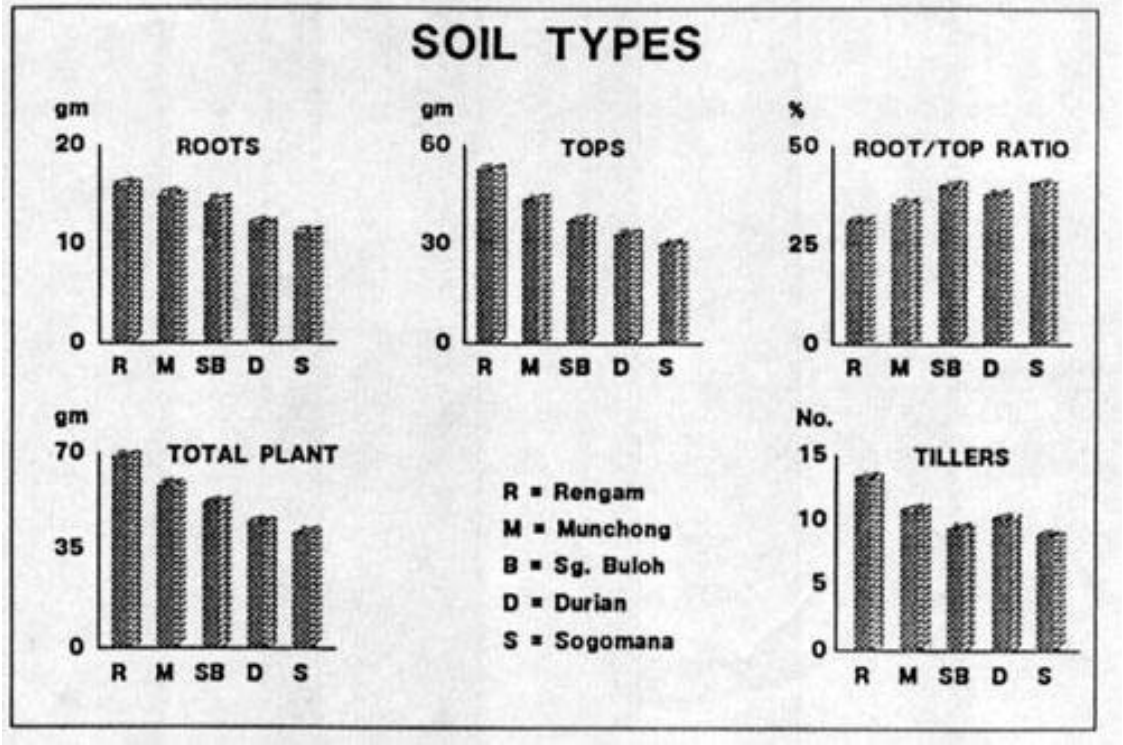


(Ref: 21/1990)




| | | Dry Weight (gm) | | | |
|---|---|---|---|---|---|
| Soil | Tillers No. | Shoot | Roots | Total Plant | Root %------ Shoot |
| Sogomana | 8.8b | 29.9c | 11.2c | 41.2c | 40.2a |
| Durian | 10.1b | 32.9c | 12.1bc | 45.0c | 37.6ab |
| Sg. Buloh | 9.3b | 37.4bc | 14.3ab | 51.7bc | 39.6a |
| Munchong | 10.7b | 43.3b | 15.0a | 58.3ab | 35.4b |
| Rengam | 13.2a | 52.6a | 16.0a | 68.6a | 31.0c |
| se ( ± ) | 0.11 | 3.22 | 0.98 | 4.12 | 1.38 |
| LSD (P<0.05) | 0.3 | 9.0 | 2.8 | 11.6 | 3.9 |

FIGURE 6 EFFECT OF SOIL TYPES ON GROWTH OF VETIVER




## 2.4 Fertilizer

*Source: First Progress Report, C-IV*

Whereas it is generally claimed that Vetiver will grow under nutrient-stressed conditions and whereas it is also generally expected not to fertilize Vetiver hedgerows under normal practice, it is critical to know the response of Vetiver to fertilizer. This is especially so under special conditions where Vetiver hedgerows need to be established very rapidly. Examples are highways, dams, waterway constructions and housing areas in humid tropics with intense rainfalls. The different requirements of cut-earth and filled-earth are entirely different and have to be assessed.

Maximising production at economic cost is also important in relation to possible production of fodder.

### Trial 1

This trial compares five treatments in four replicates as detailed and illustrated in Photo 23.

The use of slow release fertilizer is conditioned by two factors:

easy to control at application and therefore would not confound results. This is most critical for experimental purposes. Economical to use in Malaysian context where labour is expensive.

Response to fertilizer application is by measuring the dry weight of cut-off tops at 40 cm at three months and four months after application (Photo 24) and the number of tillers produced at four months. The results as summarised in Table 9 and Figure 9 show:

Fertiliser aids in dry matter production and tiller production. However, even without fertilizer application, the plants grow and multiply. Increasing fertilizer application rates did not increase growth and

multiplication rates significantly suggesting that the cheapest application rate of one Kokei nugget is sufficient.

PHOTO 23. EFFECT OF FERTILIZER ON GROWTH OF VETIVER (TRIAL 1)




(Note: Numbers are replicates)

(Ref: 7/1990)

| Treatments | Fertilizer |
|---|---|
| T-1 | Nil |
| T-2 | 1 nugget Kokei (1 x 6 gm) |
| T-3 | 2 nugget Kokei (2 x 6 gm) |
| T-4 | 4 nugget Kokei (4 x 6 gm) |
| T-5 | 1 nugget Nurseryace (1 x 6gm) |

Field Arrangement

| Rep 3 | Rep 1 | Rep 2 | Rep 4 |
|---|---|---|---|
| T-2 | T-5 | T-1 | T-3 |
| T-5 | T-3 | T-4 | T-1 |
| T-3 | T-1 | T-2 | T-4 |
| T-1 | T-4 | T-5 | T-2 |
| T-4 | T-2 | T-3 | T-5 |

PHOTO 24. EFFECT OF FERTILIZER ON GROWTH OF VETIVER (TRIAL 1)

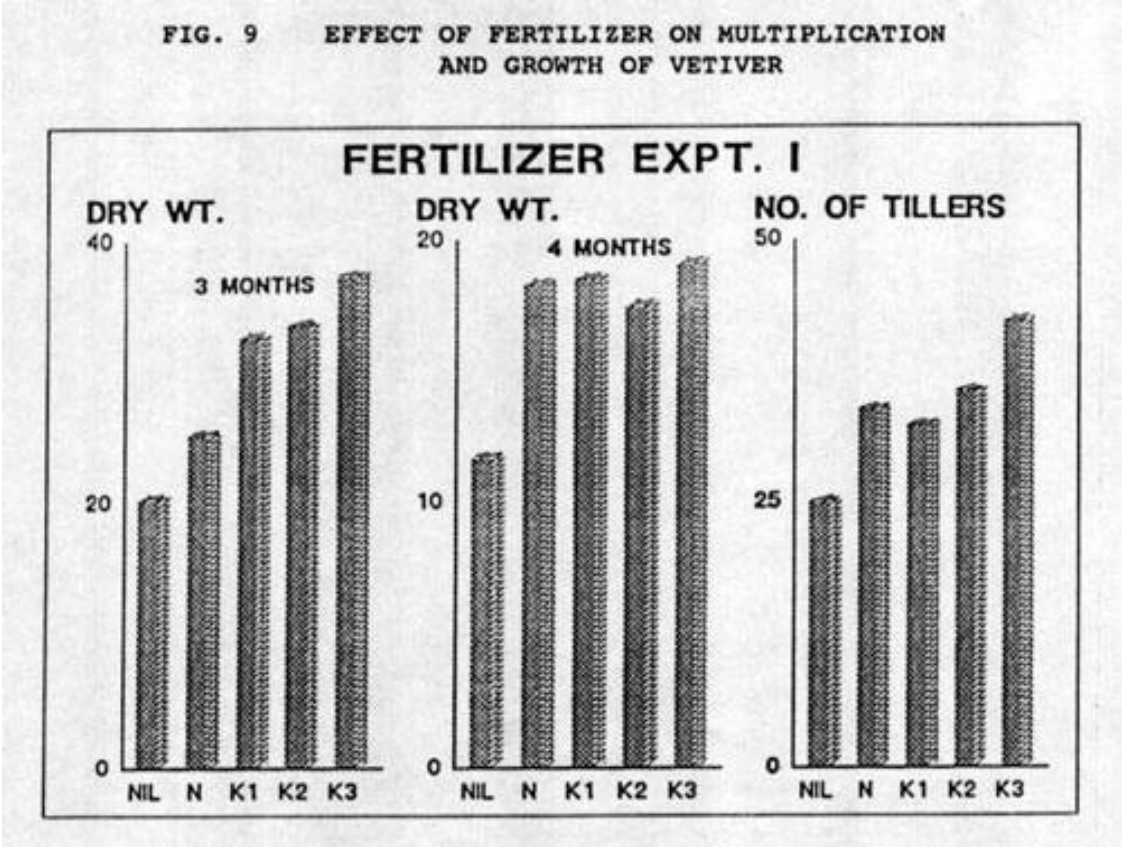


The tops are cut-back at 40 cm after 4 months treatment to determine the dry matter production

(Ref: 19/1990)

| | **Dry weight (gm) of tops at 40 cm height** | | |
|---|---|---|---|
| 1 st cut back (3 months) | 2 nd cutback (> 4 months) | Tillers No. | |
| Nil | 20.2 c | 11.7 b | 24.9 c |
| Nursery Ace | 25.2 bc | 18.3 a | 34.0 b |
| Kokei (1 nugget) | 32.7 ab | 18.5 a | 32.4 b |
| Kokei (2 nuggets) | 33.6 ab | 17.5 a | 35.8 b |
| Kokei (4 nuggets) | 37.2 a | 19.1 a | 42.3 a |
| s.e. ( ± ) | 3.01 | 1.52 | 0.137 |
| LSD (P<0.05) | 9.3 | 4.7 | 0.4 |

FIG. 9 EFFECT OF FERTILIZER ON MULTIPLICATION AND GROWTH OF VETIVER




### Trial 2

This trial tests three treatments:

(1) K 1 + O : One Kokei nugget at beginning of trial.

(2) K 1 + K 1 : One Kokei nugget at beginning of trial followed by another nugget after two months.

(3) K 1 + K 2 : One Kokei nugget at beginning followed by two nuggets after two months.

Photo 25a shows condition of plants just after the second fertilizer application; Photo 25b compares plants grown under two treatments. Photo 26a and 26b show cut-of at 40 cm to measure dry matter production of tops. The main results are summarised below:

K 1 + K 2 increases the rate of height growth; while there was no difference between K 1 + O and K 1 + K 1 (Figure 10). Dry weight of tops at three and four months were improved by a second round of fertilizer, but the two rates of application do not produce different dry matter production (Table 10 and Figure 11). Tiller production was not affected by fertilizer treatment (Table 10 and Figure 12 ). Dry weight of shoots and whole plant was increased by the second round of fertilizer application (Table 10 ). Root production and % root/shoot were not affected by fertilizer application (Table 10 and Figure 12). In general, increased fertilizer application resulted in higher nutrient value of the leaves and roots (Table 11).

CONCLUSION

These two trials show that fertilizer improves the growth and tiller production. However, increasing the amount of fertilizer application does not result in corresponding increase in productivity. Therefore, a minimum amount of fertilizer application of one Kokei nugget is sufficient for polybag plants raised to three months. Only for longer periods in another nugget necessary.

PHOTO 25. EFFECT OF FERTILIZER ON GROWTH OF VETIVER (TRIAL 2)



(a) Condition of plants after second application.

(Ref: 11/1990)




(b) The second application of fertilizer has improved the growth.

(Ref: 19/1990)

**PHOTO 26. EFFECT OF FERTILIZER ON GROWTH OF VETIVER (TRIAL 2)**



(a) 5 sub-samples of 10 polybag plants per treatment are topped at 40 cm height for dry matter determination




(b) After sampling, all plants are topped to continue growth for the subsequent sampling.

(Ref: 19/1990)

FIGURE 10 EFFECT OF FERTILIZER ON HEIGHT GROWTH OF VETIVER

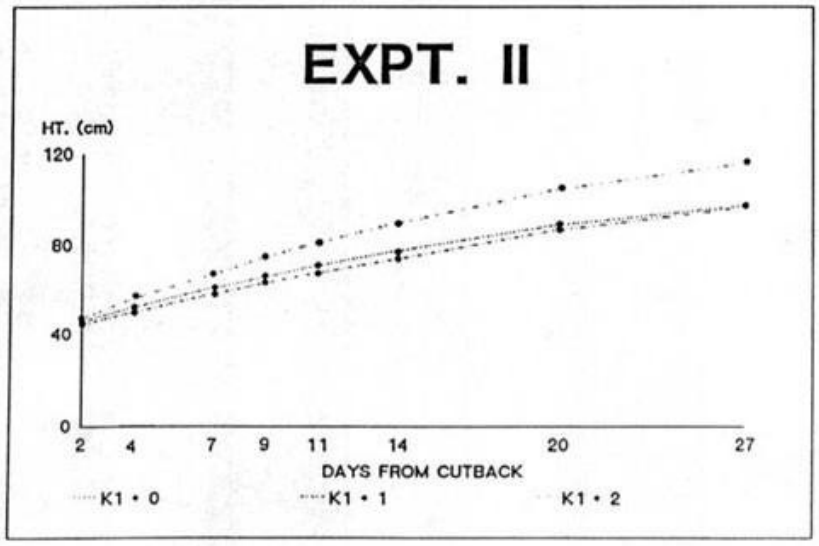



FIGURE 11 EFFECT OF FERTILIZER ON DRY MATTER PRODUCTION OF TOPS

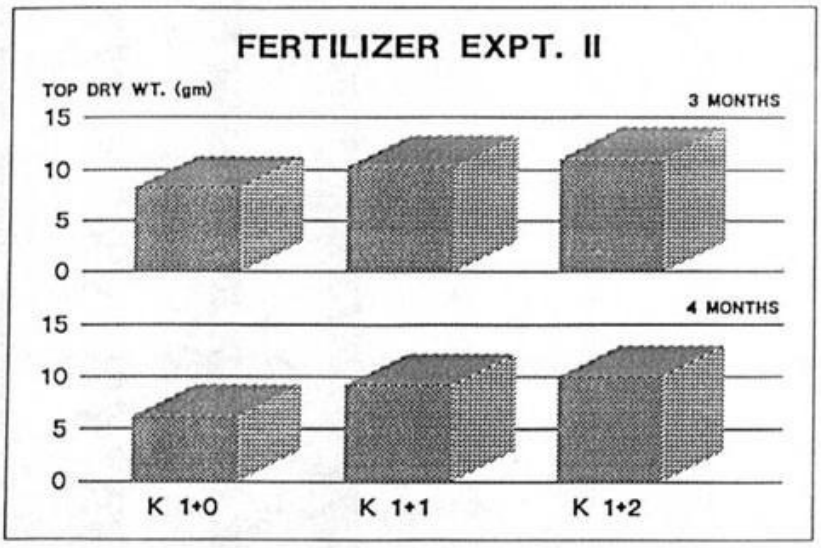


FIGURE 12 EFFECT OF FERTILIZER ON TILLERING AND DRY MATTER PRODUCTION

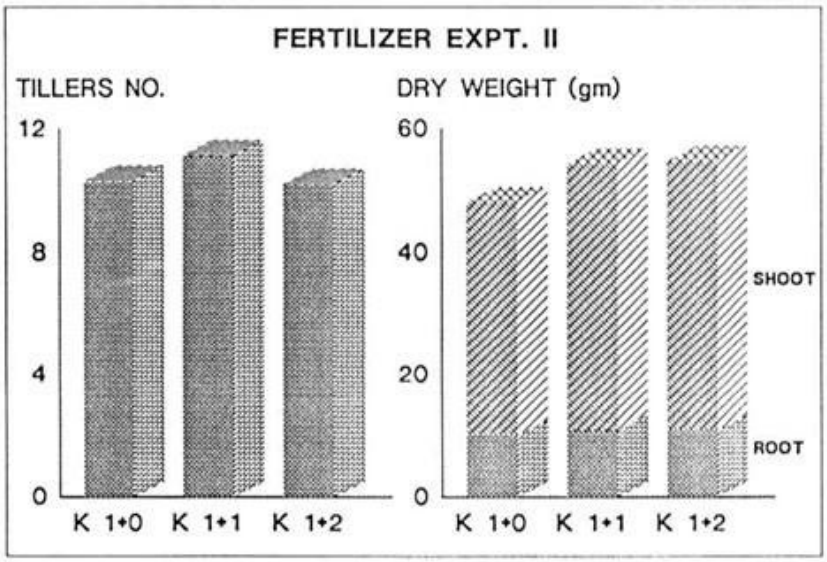
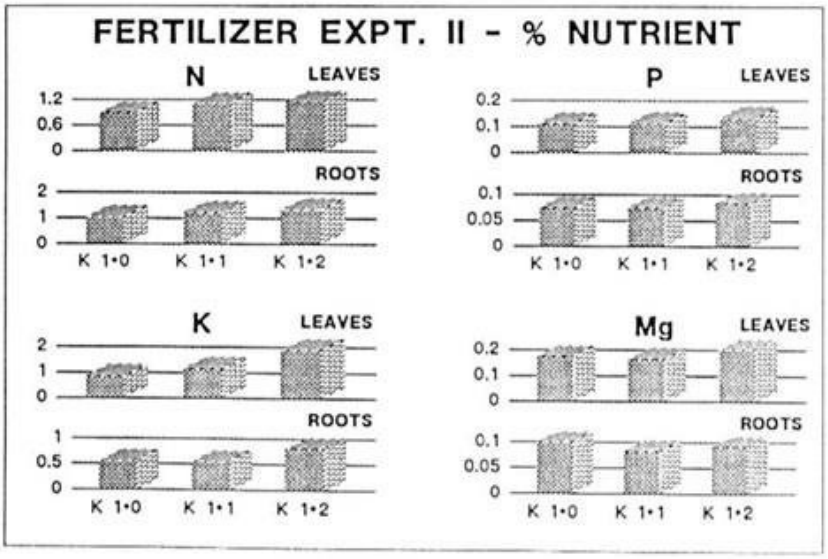



FIGURE 13 EFFECT OF FERTILIZER ON NUTRIENT CONTENT OF VETIVER




| | **Dry weights (gm) of tops at 40 cm height** | | **Dry weight (gm)** | | | | |
|---|---|---|---|---|---|---|---|
| Fertilizer | 3 mths | 4 mths | Tillers No. | Shoot | Root | Total bag plant | % Root/Top |
| K1 + 0 | 8.24 b | 6.11 b | 10.3 a | 38.1 b | 9.96 a | 48.1 b | 26.8 a |
| K1 + 1 | 10.25 a | 9.15 a | 11.1 a | 43.6 a | 10.67 a | 54.2 a | 25.4 a |
| K1 + 2 | 11.04 a | 9.92 a | 10.2 a | 43.9 a | 10.72 a | 54.6 a | 24.9 a |

| **Treatment** | **Samples** | **%N** | **%P** | **%K** | **%Mg** |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| K (1 +0) | Leaves Roots | 0.86 1.01 | 0.107 0.073 | 0.84 0.54 | 0.170 0.098 |
| K (1 + 1) | Leaves Roots | 1.09 1.19 | 0.110 0.073 | 1.14 0.53 | 0.161 0.081 |
| K (1 + 2) | Leaves Roots | 1.13 1.30 | 0.130 0.082 | 1.84 0.79 | 0.197 0.089 |

## 2.5 Root systems and mini-rhizotrons

*Source: First Progress Report, C-VII*

The root system of plants grown in the ground may be observed by excavation (Photo 29).

However, this approach is cumbersome, labour intensive and expensive. Even the use of a backhoe is of limited value (Photo 30a). During the washing of the root system, the water has to be removed periodically (Photo 30b).

The use of simple mini rhizotrons would assist in such observations, though the initial cost is high. With the generosity of an industry member, the following mini rhizotrons were constructed.

8’ height by 4’ width (Photo 31). 4’ height by 16’ width (Photo 32). 4’ height by 32’ width

Text below Photo 32 summarises the experimental details of one trial. Photo 33a and 33b illustrates the set-up of mini rhizotrons with the mechanical help of a backhoe. Photo 34a and 34b shows the set up after 3 weeks of growth. Photo 35a shows a close up view of the root system at planting while Photo 35b shows the growth of roots marked after 6 weeks; such markings were made on the perspex periodically.

Observations on these are continuing and more detailed reports will be written later.

PHOTO 29. EXCAVATION OF VETIVER ROOT SYSTEM (1)





The observation and measurement of root system is very laborious

PHOTO 30. EXCAVATION OF VETIVER ROOT SYSTEM (ii)



(a) A back-hoe was used. Note the amount of soil that had to be removed first.



(b) During the washing with jet of water, the dug-hole will be filled and the water must be removed periodically.

(Ref: 4/1991)

**PHOTO 31. MINI RHIZOTRONS TO STUDY ROOT GROWTH**



This mini rhizotron is 4' x 8' height and attempts to observe root growth in filled earth and cut-earth.

(Ref: 15/1990)



The condition of the mini rhizotron and growth of Vetiver after 6 months.

(Ref: 6/1991)

**PHOTO 32. STUDY OF ROOT SYSTEM BY MINI RHIZOTRON**



Planted: 3/8/1990
Photo taken: 3/8/1990 (Ref: 13/1990)

Design: Randomised block
3 Treats x 3 Reps.

| Treatments | Between Plant Distance |
|---|---|
| T-1 | 6" |
| T-2 | 9" |
| T-3 | 18" |

Field Arrangement

| Rep 1 | Rep 2 | Rep 3 |
|---|---|---|
| T-1 | T-3 | T-2 |
| T-3 | T-2 | T-1 |
| T-2 | T-1 | T-3 |

PHOTO 33. CONSTRUCTION OF MINI RHIZOTRON (1)



(a) A back-hoe is used to cut into the side of a slope

(Ref: 11/1990)



(b) This shows the side of the slope cut by back-hoe, with a perspex sheet (1" x 4' x 8'). The earth wall will be smoothened manually before final assembly of the mini rhizotron.

PHOTO 34. CONSTRUCTION OF MINI RHIZOTRON (ii)



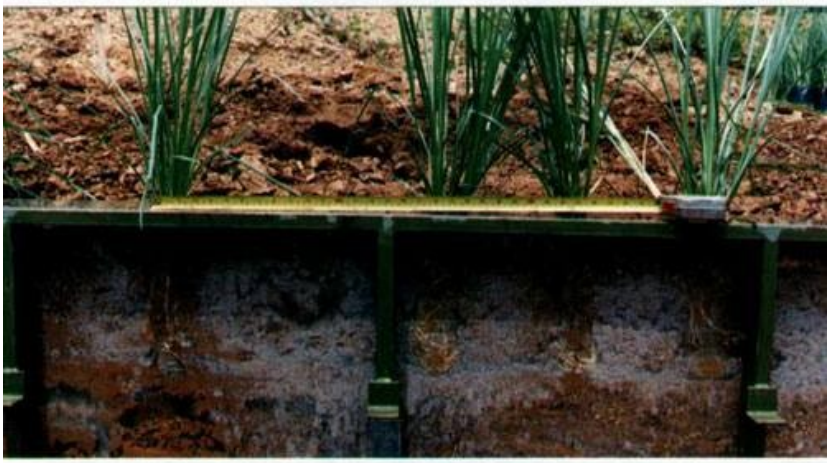
(a) The root system is protected from the hot sun by plywood.



(b) The perspex sheets are attached to a metal frame. The whole structure can be removed for washing.

(Ref: 18/1990)

PHOTO 35. GROWTH OF VETIVER IN MINI RHIZOTRON



(a) Condition of plants at establishment

Planted: 3/8/1990
Photo taken: 3/8/1990 (Ref: 13/1990)



(b) Growth of root system after 3 weeks marked with waterproof ink.

Photo taken: 25/8/1990

(Ref: 15/1990)

# 3. Establishing and managing hedgerows

## 3.1 Introduction: why quality hedgerows

*Source: Second Progress Report, Part 2*

It would be cheapest to plant Vetiver slips directly into the ground. However, such an approach invariably results in:

requirement for replacement of dead plants filling of gaps of less vigorous growing slips slower establishment less uniform establishment

Under certain conditions, such as highway embankments, steep slopes in housing estates, etc., it would be more advantageous and possibly more cost effective to use container plants. This ensures virtually 100% survival, fast establishment and good uniformity, producing the best hedgerows in the shortest time. In addition, to assess the Profitability Index or the Benefit-cost Ratio, consideration must be given to the cost of repair of any failed structure and the inconvenience-cost of failure which disrupts other economic activities. For example, a failed road embankment could cut off transport affecting the economy of many activities.

The approaches affecting production of quality hedgerows are:

Effect of Bag Sizes on Establishment of Quality Vetiver Hedgerows Effect of Spacing cum Fertilizer on Growth of Vetiver Hedgerows Use of Selective Herbicides to Maintain Quality Vetiver Hedgerows

These are discussed in the following sections.

## 3.2 Bag sizes for hedgerow establishment – first results

*Source: First Progress Report, C-III*

While it would be cheapest to plant Vetiver slips directly on to grow, such approach invariably results in:

requirements for replacement of dead plants filling of gaps of less vigorous growing slips slower establishment less uniform establishment

Under certain conditions as highway embankments, steep slopes in housing estates, etc., it would be more advantageous and possibly more cost-effective to use polybag plants. This ensures virtually 100% survival, fast establishment and good uniformity; producing the best hedgerows in the shortest time.

The cost of establishing hedgerows using polybag plants will be affected by cost of:

bags filling the bags digging the trench planting the polybag plants.

A trial was therefore started to assess the maximum reduction in bag sizes possible without compromising the quality and speed of hedge formation.

Four bag sizes were used and the details of trial are given and illustrated in Photo 21. Fertilizer application was 1 Kokei per bag at the time of planting. The planting distance was kept at a constant six inches between clumps.

The times for digging the trench and for planting were taken. This is given in Table 6. Timing studies show that only the larger sized bags of 6" x 13" take significantly longer time to be planted and for the deeper trench to be dug. The other plants in the smaller sized bags have similar time requirements.

To assess growth rates, two measurements were taken at monthly intervals:

The tops above 40 cm were cut (Photo 22). The dry weights are given in Table 7 and illustrated in Figure 7. Other than in the first month, the amount of dry matter production is similar for plants originating from all bag sizes. Gap measurements show that the original larger polybag sizes produce smaller gaps (Table 8 and Figure 8) . However, the gaps diminish with time and the differences between the different treatments also narrowed.

Tentative conclusion at this stage suggests that the smaller sized bags of 4" x 6" could be the most economical size for fast and good establishment of Vetiver hedgerow. The experiment continues.

**PHOTO 21. EFFECT OF BAG SIZES ON GROWTH OF VETIVER HEDGEROW**



(Ref: 23/1990)

Design: Randomized block
5 Bag sizes x 4 Reps x 20 plants/treatment

| Treatments | Bag size |
|---|---|
| T-1 | 4" x 7" |
| T-2 | 4" x 6" |
| T-3 | 6" x 9" |
| T-4 | 5" x 7" |
| T-5 | 6" x 13" |

Field Arrangement

| Rep 1 | Rep 2 | Rep 3 | Rep 4 |
|---|---|---|---|
| T-5 | T-3 | T-2 | T-4 |
| T-4 | T-5 | T-4 | T-3 |
| T-1 | T-1 | T-5 | T-2 |
| T-3 | T-2 | T-3 | T-1 |
| T-2 | T-4 | T-1 | T-5 |

TABLE 6 EFFECT OF BAG SIZES ON RATE OF ESTABLISHMENT OF VETIVER HEDGEROW.

| | **Actual field planting Time taken per plot (20 points) in minutes Mean (min : sec)** | | |
|---|---|---|---|
| Bag sizes (inches) | Digging | Planting | Total |
| 6 x 13 | 9.32 (09:19) a | 11.31 (11:18) a | 20.63 (20:38) a |
| 6 x 9 | 6.00 (06:00) b | 8.69 (08:42) b | 14.69 (14:42) b |
| 5 x 7 | 5.42 (05:25) b | 8.13 (08:08) b | 13.55 (13:33) bc |
| 4 x 7 | 5.21 (05:13) b | 9.05 (09:03) b | 14.26 (14:16) b |
| 4 x 6 | 3.93 (03:56) b | 7.25 (07:15) b | 11.18 (11:11) c |

| | | | |
|---|---|---|---|
| s.e. ( ± ) | 0.714 | 0.596 | 0.928 |
| LSD (P<0.05) | 2.33 | 1.94 | 3.03 |



Photo 22. Tops above 40 cm height are cut to measure dry matter production

(Ref: 23/1990)

| | | **Dry weight of tops (gm)** | | | |
|---|---|---|---|---|---|
| Bag sizes (inches) | 1 st month | 2 nd month | 3 rd month | 4 th month | 5 th month |
| 6 x 13 | 6.51a | 15.7 | 23.5 | 16.0 | 17.1 |
| 6 x 9 | 4.09 bc | 12.7 | 22.6 | 16.3 | 18.4 |
| 5 x 7 | 5.25 ab | 14.2 | 21.2 | 16.6 | 17.8 |
| 4 x 7 | 5.27 ab | 12.5 | 19.7 | 15.0 | 18.3 |
| 4 x 6 | 2.61 c | 10.4 | 22.4 | 18.5 | 17.4 |
| s.e ( ± ) | 0.592 | 1.314 | 2.10 | 1.37 | 1.64 |
| LSD (P<0.05) | 1.82 | - | - | - | - |

| | | **Inter-clump gap measurements (cm)** | | | |
|---|---|---|---|---|---|
| Bag sizes (inches) | 1 st month | 2 nd month | 3 rd month | 4 th month | 5 th month |
| 6 x 13 | 8.2 b | 6.7 b | 5.8 bc | 5.3 b | 4.9 b |
| 6 x 9 | 8.5 b | 6.7 b | 5.6 c | 5.1 b | 4.8 b |
| 5 x 7 | 8.4 b | 7.0 b | 6.0 bc | 5.4 b | 5.0 ab |
| 4 x 7 | 9.7 a | 7.9 a | 6.6 a | 6.0 a | 5.4 a |
| 4 x 6 | 9.3 a | 7.6 a | 6.2 ab | 5.4 b | 5.1 ab |
| s.e. ( ± ) | 0.20 | 0.17 | 0.15 | 0.14 | 0.15 |
| LSD (P<0.05) | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |

FIGURE 7 EFFECT OF BAG SIZES ON DRY MATTER PRODUCTION

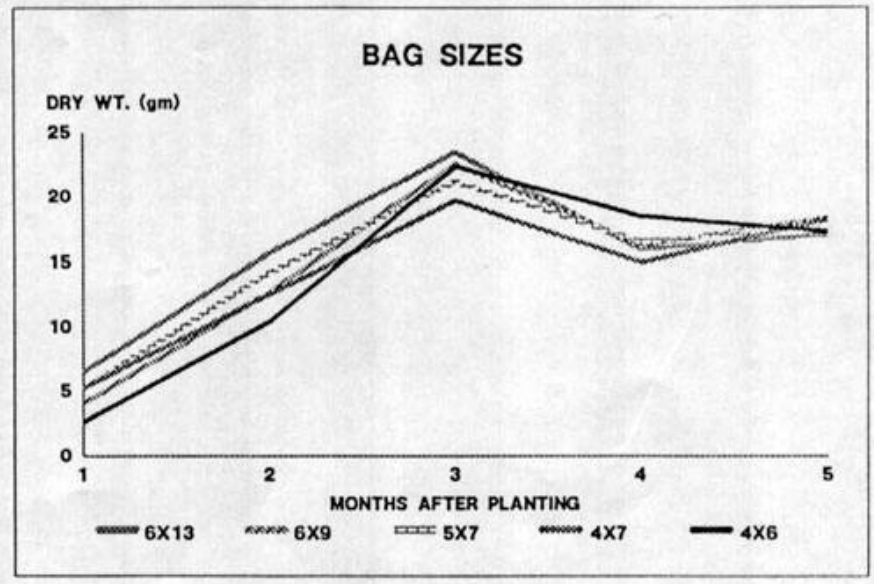
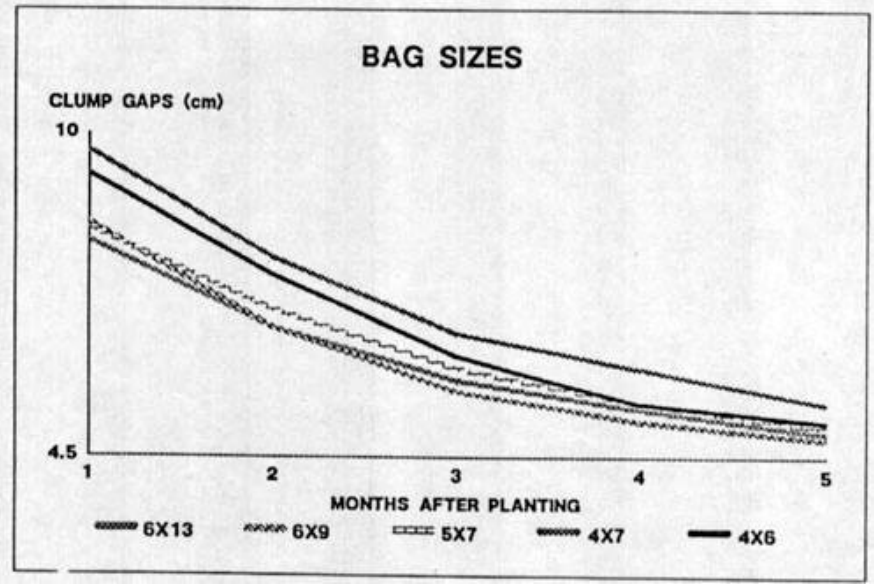



FIGURE 8 EFFECT OF BAG SIZES ON GAPS BETWEEN VETIVER CLUMPS




## 3.3 Bag sizes for hedgerow establishment – later results

*Source: Second Progress Report, 2.1*

The total cost of establishing hedgerows using polybag plants will be affected by cost of:

Bags Filling the bags Digging the trench Planting the polybag plants

A trial was therefore started to assess the practicality and cost-effective reduction in possible bag sizes, without compromising the quality and speed of hedgerow formation.

Five bag sizes holding different weights of soil were used. The details of trial are given in Photo 1 .

The planting distance was kept at a constant 15cm between clumps ( Photo 1 ). Fertilizer application was 1 Kokei (6 gm) per point at the time of planting and then

2 Kokei (6gm) nuggets at 5 months 2 Kokei (6gm) nuggets at 8 months 2 Kokei (6gm) + 2 Field King (15gm) nuggets at 11 months.

RESULTS

In the First Progress Report, the results on timing of planting were given. Also the dry weights of tips and inter-clump gaps at monthly intervals were given for the first 5 months. Additional data are now available. In this Report, the first 5 months data are reproduced to allow continuity of reporting.

(a) Photographic Records

Photo 1 Shows the good hedgerow already formed after only 8 weeks growth.

Photo 2 Shows how topping was done at 40 cm and the severed tops were used to measure the growth rates. The inter-clump gaps, clearly seen in the photo, wee measured at each topping.

Photo 3 Shows the hedgerow after 16 weeks, with one treatment already topped to measure dry matter production.

(b) Inter-clump Gaps

The gaps in the hedgerow were measured at monthly intervals. It is interesting to note that the plot coefficient of variance (c.v.) increases with the months after planting ( Table 1 ). This should be expected, as the error of measurement will increase, as the absolute value becomes smaller. C.V.s of the first 6 months are readily acceptable while those of 7 – 9 months are tolerable.

However, the data from 10 and 12 months are too variable. Thus the validity of the mean as an indicator is questionable and gap measurement for planting distance of 15 cm should not be considered after 9 months.

At the beginning, the inter-clump gap size was determined by the different bag sizes since the planting distance was constant. Later, any change would be due to the different growth rates of plants from different polybag sizes. These measurements are given in Table 2 .

As expected, the larger bag-size plants have lower inter-clump gap sizes than the smaller ones ( Table 2 and Figure 1 ). The 4" x 6" bag size clumps started with gaps larger than the 3 bigger bags (5" x 7", 6" x 9" and 6" x 13"), but from the fourth month, the different gap sizes are generally not polybag size – dependent.

It is rather surprising that the 4" x 7" bag size plants produce consistently highter inter-clump gaps than those plants raised in 4" x 6" bag size (although the difference was not significant) and was significantly worse thant 5" x 7", 6" x 9" and 6" x 13" for the first eight months.

Table2 also summarises the gap reductions between measurements. Other than the period of 2-3 months after planting they are not influenced by the original bag sizes used. This suggests that the clumps were growing (expanding) at the same rate, though they may have originated from different bag sizes.

Growth Rates

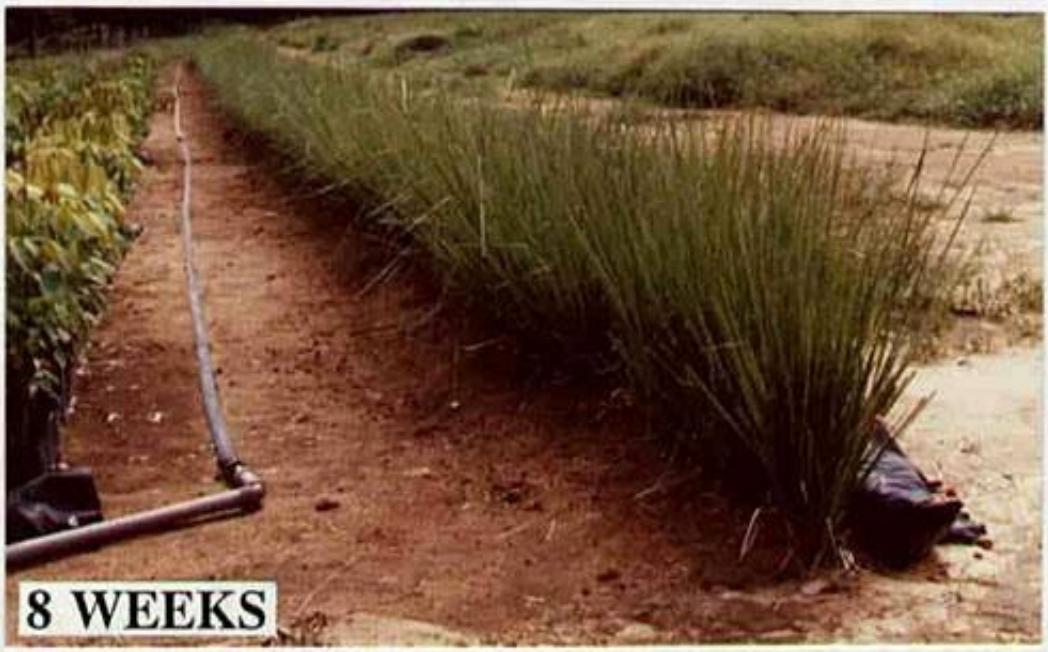
The tops above 40 cm were cut and the dry weight determined. For the first10 months this was done monthly, thereafter, it was carried out at 2 monthly intervals till the trial stopped at 16 months. The results are given int Table 3 and Figure 2 . Other than the first month's measurements, the top dry weights from all bag sizes were not significantly different.

DISCUSSION AND CONCLUSION

In using quality polybag plants, the transplanting success was 100%. However, the trial did not include a treatment of using slips of newly cut tillers. Another weakness in the trial is the absence of measurement of the dry weights of tops and roots of plants raised in different bag sizes before transplanting to the ground. These two points should be included in subsequent trials involving different cultivars.

Despite the limitations in the trial, the results showed that plant growth is the smallest bag size treatment of 4" x 6" produced similar inter-clump gap size from the fourth month and similar dry matter production from the second month after planting. Thus, the conclusion is that the small bag size of 4" x 6" could be the most economical size for fast and good establishment of Vetiver hedgerows.

My earliest work uses 6" x 9" bags holding 1486 gm of soil per bag. This was later changed to 5" x 7", thus reducing the weight to 837 gm. Now the weight could be further reduced to 401 gm per bag. This weight decrease is substantial especially when plants have to be transported from central nurseries to field sites over long distances.




| Treatment | Bag Size | Weight (gm) |
|---|---|---|
| T-1 | 4" x 7" | 498 |
| T-2 | 4" x 6" | 401 |
| T-3 | 6" x 9" | 1486 |
| T-4 | 5" x 7" | 837 |
| T-5 | 6" x 13" | 2492 |

Design: Randomized block
5 bag sizes x 4 reps x 20 plants/treatment

*Photo 1.* General view of trial to study effect of bag sizes on production of quality hedgerow.




*Photo 2.* *Vetiver* clumps, planted at constant 15 cm apart, were topped at 40 cm. The severed tops were used to measure growth rates.




*Photo 3.* General view of *Vetiver* hedgerow at 16 weeks after planting, showing the topping of the treatment to measure dry matter production.

TABLE 1 EFFECT OF BAG SIZES ON CV (%) OF GAPS IN VETIVER HEDGEROW

| **Months after planting** | **Ranges of plot CV of each treatment Bag sizes (inches)** | | | | |
|---|---|---|---|---|---|
| 4 x 6 | 4 x 7 | 5 x 7 | 6 x 9 | 6 x 13 | |
| 1 | 12-24 | 10-22 | 12-20 | 17-28 | 10-32 |

| | | | | | |
|---|---|---|---|---|---|
| 2 | 17-24 | 12-32 | 12-26 | 24-30 | 12-32 |
| 3 | 19-28 | 12-37 | 14-32 | 29-36 | 14-35 |
| 4 | 21-35 | 18-41 | 18-36 | 31-43 | 16-37 |
| 5 | 22-37 | 24-42 | 17-41 | 30-42 | 17-40 |
| 6 | 29-37 | 29-54 | 18-47 | 34-51 | 25-59 |
| 7 | 31-47 | 35-63 | 23-51 | 43-60 | 30-69 |
| 8 | 30-52 | 39-71 | 43-55 | 46-83 | 50-72 |
| 9 | 31-67 | 47-89 | 43-101 | 54-95 | 55-83 |
| 10 | 44-168 | 70-224 | 84-166 | 87-200 | 81-174 |
| 12 | 98-412 | 98-412 | 129-412 | 0-412 | 91-412 |

TABLE 2 EFFECT OF BAG SIZES ON INTER-CLUMP GAPS AND GAP REDUCTIONS (CM) IN VETIVER HEDGEROW

| | **Gaps at months after planting** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bag sizes (inches) | 1 | 2 | 3 | 4 | 4 | 6 | 7 | 8 | 9 | 10 | 12 |
| 6 x 13 | 8.2b | 6.7b | 5.8bc | 5.3b | 4.9b | 4.0c | 3.3b | 3.0b | 2.6a | 1.3a | 1.0a |
| 6 x 9 | 8.5b | 6.7b | 5.6c | 5.1b | 4.8b | 4.0c | 3.3b | 2.9b | 2.5a | 1.1a | 0.3a |
| 5 x 7 | 8.4b | 7.0b | 6.0bc | 5.4b | 5.0ab | 4.3bc | 3.7b | 3.1b | 2.5a | 1.2a | 0.5a |
| 4 x 7 | 9.7a | 7.9a | 6.6a | 6.0a | 5.4a | 4.8a | 4.2a | 3.8a | 3.0a | 1.8a | 1.3a |
| 4 x 6 | 9.3a | 7.6a | 6.2ab | 5.4b | 5.1ab | 4.4ab | 3.7ab | 3.4ab | 2.9a | 1.5a | 0.9a |
| s.e. ( ± ) | 0.20 | 0.17 | 0.15 | 0.14 | 0.15 | 0.14 | 0.15 | 0.17 | 0.23 | 0.25 | 0.21 |
| LSD (P<0.05) | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | - | - | - |
| | Gap reductions at months after planting | | | | | | | | | | |
| Bag sizes (inches) | 1 – 2 | 2 – 3 | 3 – 4 | 4 – 5 | 5 – 6 | 6 – 7 | 7 – 8 | 8 – 9 | 9 – 10 | 10 - 12 | |
| 6 x 13 | 1.5a | 0.9c | 0.6a | 0.4a | 0.8a | 0.7a | 0.3a | 0.3a | 1.3a | 0.4a | |
| 6 x 9 | 1.7a | 1.2ab | 0.5a | 0.3a | 0.7a | 0.7a | 0.5a | 0.4a | 1.4a | 0.7a | |
| 5 x 7 | 1.4a | 1.0bc | 0.6a | 0.4a | 0.6a | 0.6a | 0.6a | 0.6a | 1.2a | 0.7a | |
| 4 x 7 | 1.8a | 1.3a | 0.6a | 0.6a | 0.7a | 0.6a | 0.4a | 0.7a | 1.2a | 0.6a | |
| 4 x 6 | 1.8a | 1.3a | 0.8a | 0.3a | 0.6a | 0.7a | 0.4a | 0.5a | 1.4a | 0.6a | |
| s.e. ( ± ) | 0.15 | 0.07 | 0.08 | 0.06 | 0.08 | 0.07 | 0.10 | 0.09 | 0.30 | 0.12 | |
| LSD (P<0.05) | - | 0.2 | - | - | - | - | - | - | - | - | |

Note 1: Means with the same subscript alphabets are not significantly different at P<0.05

Note 2: Data on 10 and 12 months are too variable and should not be used. It is presented here just for records.

TABLE 3 EFFECT OF BAG SIZES ON DRY WEIGHTS (G) OF TOPS IN VETIVER HEDGEROW

| | **Month** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | **s after plantin g** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bag sizes (inches ) | 1 | 2 | 3 | 4 | 4 | 6 | 7 | 8 | 9 | 10 | 12 | 14 | 16 |
| 6 x 13 | 6.5a | 15.7a | 23.5a | 16.0a | 17.1a | 25.1a | 26.8a | 33.8a | 31.7a | 39.7a | 91.3a | 79.7a | 51.6a |
| 6 x 9 | 4.1bc | 12.7a | 22.6a | 16.3a | 18.4a | 26.5a | 28.1a | 38.9a | 34.4a | 44.5a | 112.7a | 89.5a | 55.0a |
| 5 x 7 | 5.3ab | 14.2a | 21.2a | 16.6a | 17.8a | 28.0a | 31.0a | 41.6a | 38.7a | 46.7a | 127.8a | 101.9a | 64.5a |
| 4 x 7 | 5.3ab | 12.5a | 19.7a | 15.0a | 18.3a | 24.0a | 25.1a | 35.0a | 32.1a | 42.4a | 99.9a | 87.0a | 54.2a |
| 4 x 6 | 2.6c | 10.4a | 22.4a | 18.5a | 17.4a | 27.5a | 27.9a | 35.6a | 34.4a | 44.7a | 107.6a | 86.0a | 60.2a |
| s.e. ( ± ) | 0.59 | 1.31 | 2.10 | 1.37 | 1.64 | 1.93 | 1.92 | 3.35 | 3.32 | 3.51 | 14.82 | 7.55 | 4.86 |
| LSD (P<0.0 5) | 1.8 | - | - | - | - | - | - | - | - | - | - | - | - |

Cutback at 40 cm height Means with the same subscript alphabets are not significantly different at P<0.05

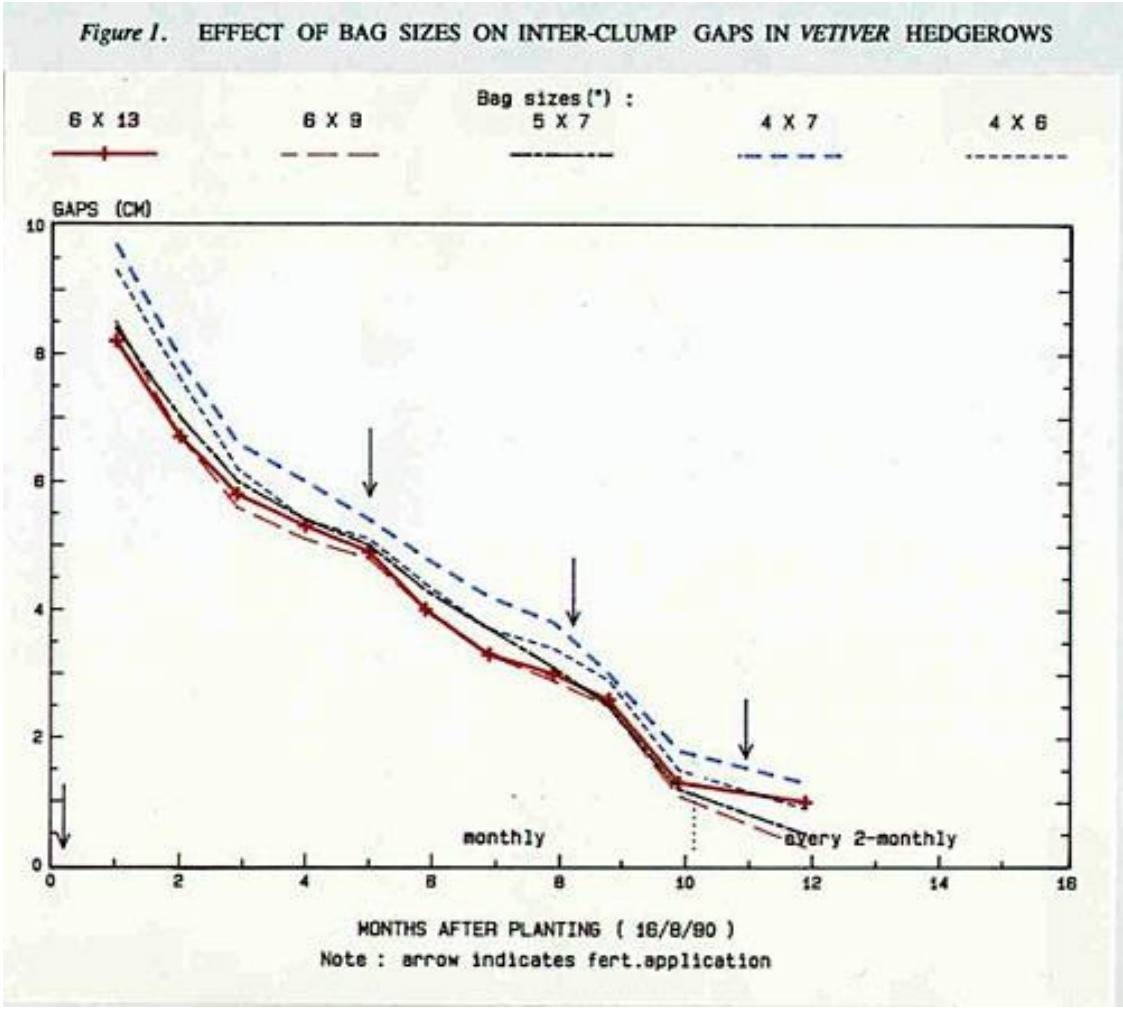
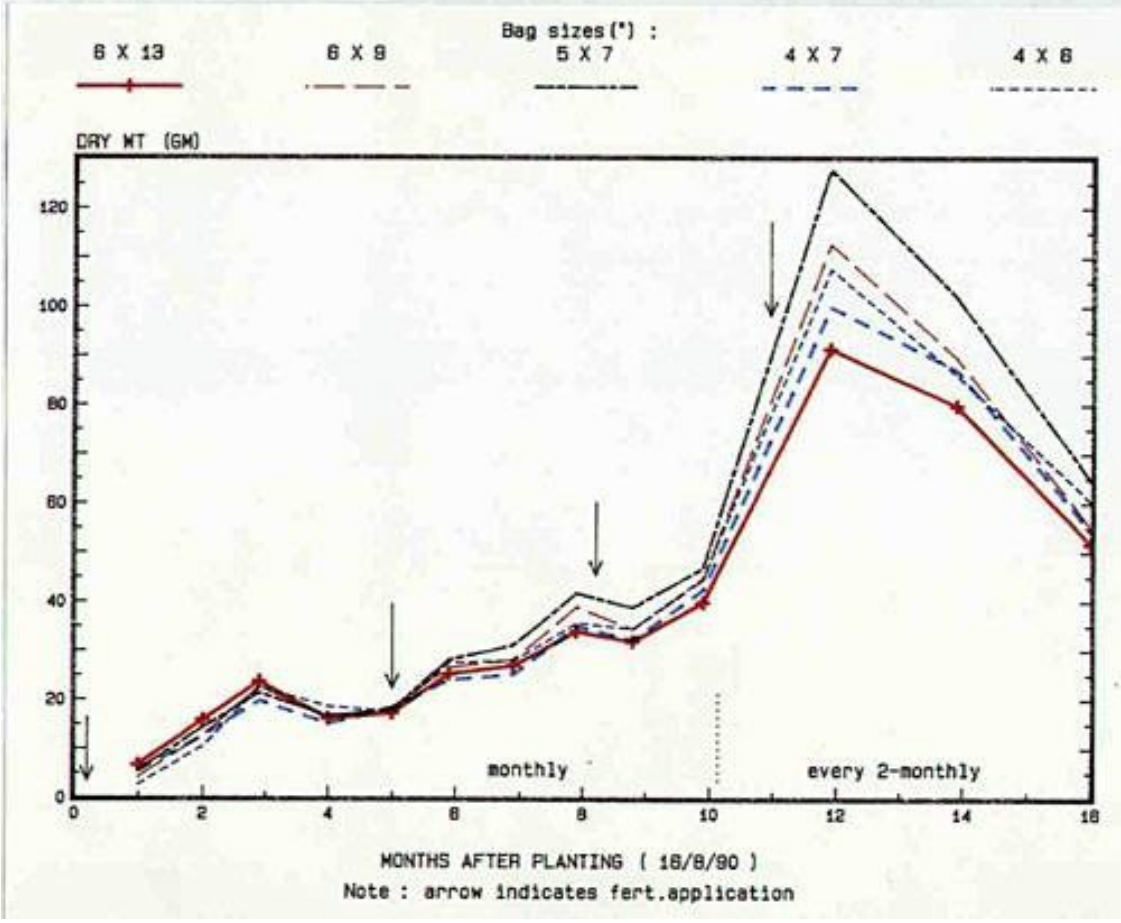


*FIGURE 2.* EFFECT OF BAG SIZES ON DRY MATTER PRODUCTION OF TOPS OF *VETIVER* HEDGEROWS




## 3.4 Spacing and fertilizer – first results

*Source: First Progress Report, C-V*

On any terrain and soil condition, producing a good hedgerow is dependent on three factors:

the quality of plant material used The distances of planting between clumps The amount of fertilizer used.

A trial was set up to test this using three spacing distances and three rates of fertilizer applications. Photo 27 shows the hedgerows. Three month old polybag plants, selected for uniformity were used for all treatments.

### Results

Assessments are based on production of dry matter from tops above 40 cm. The results to date are given in Table 12 and Figure 14 . In summary:

The dry weights of tops per clump show no significant difference in the first month and no difference in the second month either. However, there was significant effect of fertilizer with the higher fertilizer application producing higher dry matter in the second month. The dry matter production per running distance would naturally be more controlled by the planting density. Thus, in the first and second month, the closer plantings produce higher dry matter. Fertilizer effect was not noticed in the first month but demonstrated in the second month.

CONCLUSION

Preliminary data suggests:

Dry matter production per clump is not significant because between clump competition has not arisen. Fertiliser plays a bigger part in field planting than previously experienced in polybag planting.

The experiment continues.

PHOTO 27. EFFECT OF SPACING AND FERTILIZER ON GROWTH OF VETIVER HEDGEROWS



Row 1 Row 2

(Ref: 23/1990)

Design: Complete factorial experiment (S3 x F2 x R4)
Arranged in Randomized complete blocks

| Treatments | Spacing (cm) | Fertilizer nuggets |
|---|---|---|
| T-1 | 15 | $K_1$ |
| T-2 | 15 | $K_3$ |
| T-3 | 30 | $K_1$ |
| T-4 | 30 | $K_3$ |
| T-5 | 60 | $K_1$ |
| T-6 | 60 | $K_3$ |

Field Arrangement

| Rep 1 | Rep 2 | Rep 3 | Rep 4 |
|---|---|---|---|
| T-3 | T-4 | T-5 | T-1 |
| T-6 | T-3 | T-2 | T-6 |
| T-2 | T-1 | T-6 | T-5 |
| T-5 | T-6 | T-1 | T-3 |
| T-1 | T-2 | T-4 | T-4 |
| T-4 | T-5 | T-3 | T-2 |

Row 1 Row 2

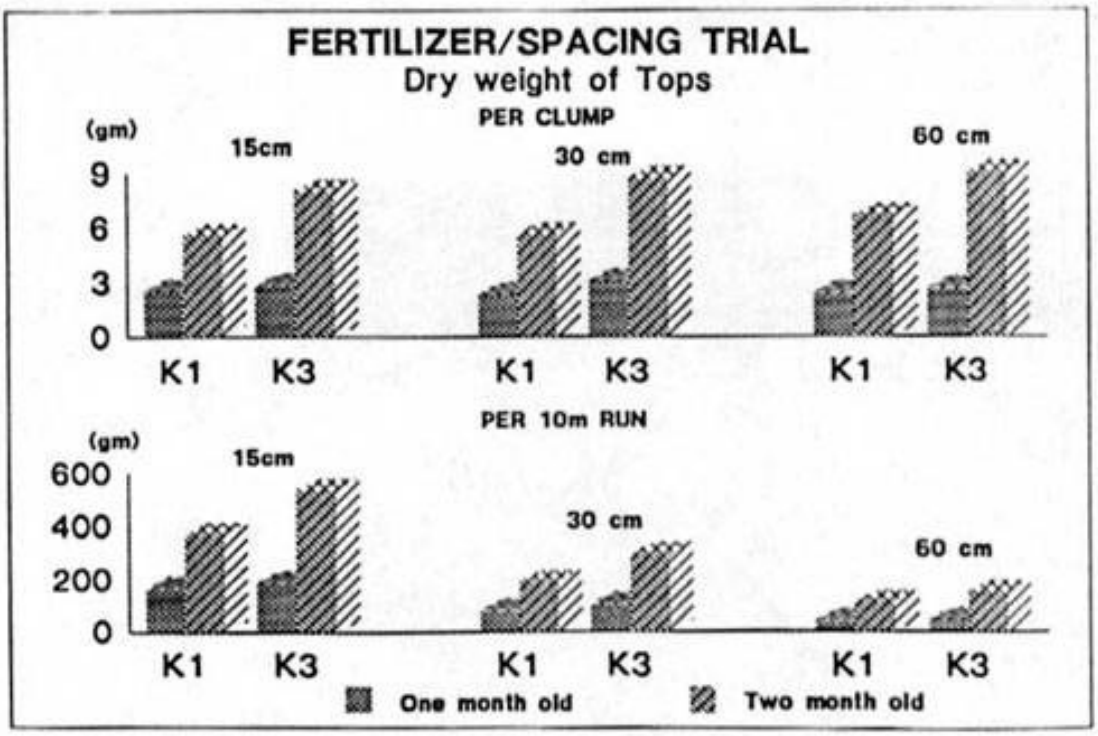
| | | | **Dry weight (gm) of tops** | | | |
|---|---|---|---|---|---|---|
| Treatment | Spacing | Fertilizer | 1 month | 2 months | | |
| | (cm) | | Per clump | Per 10m run | Per clump | Per 10m run |
| 1 | 15 | K1 | 2.48 | 165.6 a | 5.5 c | 366 b |
| 2 | 15 | K3 | 2.81 | 187.2 a | 8.0 ab | 533 a |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 30 | K1 | 2.33 | 77.7 b | 5.6 c | 186 d |
| 4 | 30 | K3 | 3.06 | 102.0 b | 8.7 a | 289 c |
| 5 | 60 | K1 | 2.39 | 39.8 c | 6.6 bc | 110 e |
| 6 | 60 | K3 | 2.60 | 43.3 c | 9.0 a | 49 de |
| s.e ( ± ) | | | 0.252 | 9.80 | 0.63 | 24.8 |
| LSD (P<0.05) | | | - | 29.5 | 1.9 | 75 |

K1 = 1 kokei (6 gm) nugget

K3 = 3 kokei (6 gm) nugget

FIGURE 14 EFFECT OF SPACING AND FERTILIZER ON DRY MATTER PRODUCTION OF VETIVER HEDGEROW




## 3.5 Spacing and fertilizer – later results (gap closure)

*Source: Second Progress Report, 2.2*

In any terrain and soil condition, production of good quality hedgerows is mainly dependent on 3 factors:

The quality of planting materials used The planting distance between clumps The amount of fertilizer used

A trial was set up to test these using 3 spacing distances and 2 rates of fertilizer applications. Good quality 3-month-old polybag plants, selected for uniformity, were used for all treatments. The details of the trial are given in Photo 4.

The fertilizer treatments are:

| Months | Level F- 1 | Level F-2 |
|---|---|---|
| 0 | Kokei 6 gm - 1 nugget | Kokei 6 gm - 3 nuggets |
| 4 | Kokei 6 gm - 1 nugget | Kokei 6 gm - 3 nuggets |
| 8 | Kokei 6 gm - 1 nugget | Kokei 6 gm - 3 nuggets |
| | Field | Field |
| | King 15 gm - 1 nugget | King 15 gm - 3 nugget |
| | Kokei 15 gm - 1 nugget | Kokei 15 gm - 3 nuggets |
| 16 | Kokei 6 gm - 1 nugget | Kokei 6 gm - 3 nuggets |
| | Field | Field |
| | King 15 gm - 1 nugget | King 15 gm - 3 nugget |
| 22 | Kokei 6 gm - 1 nugget | Kokei 6 gm - 3 nuggets |
| | Field | Field |
| | King 15 gm - 1 nugget | King 15 gm - 3 nuggets |
| 24 | Kokei 6 gm - 1 nugget | |

Assessments were based on determination of dry matter production from tops cut above 40 cm. Because of staff constraint, gap measurement was not started fill ten months later, at which time, it was not possible to measure the gaps between the 15 cm planting as the error would be too great (see previous discussion page 4).

RESULTS

In the First Progress Report the results of the first and second months were given. For easy reference and discussion, they are reproduced here.

(a) Photographic Record

Photo 5 Show the influence of planting distance on inter-clump gaps at 4 months after planting. Note that while there were still small gaps in the 15 cm, planting, the hedgerow would already be functional enough to slow down the speed of water rushing through the hedgerow. Also, the trapped twigs, leaves and other debris would help to retain the soil-wash.

Photo 6 Shows the good hedgerow formed by the 15 cm planting after 18 months. Note the neat dense and compact hedgerow with uniform good growth.

Photo 7 Shows the hedgerows of 3 planting densities at 19 months after planting. Note the big inter-clump gaps at the 60 cm planting.

Photos 8 , 9 & 10 Show 2 different views of the hedgerows at 24 months after planting. Large inter-clump gaps are evident in the 60 cm planting; this hedgerow is still not functional to protect soil erosion. Small gaps still exist in the 30 cm planting and the individual clumps are still observable. The 15 cm planting has become a defined and integrated hedgerow. There was no inter-clump gap and the individual clumps cannot be observed.

Photo 11a & 11b Show the good quality of Vetiver clumps with active evenly distributed growth.

Photo 12a & 12b Show conditions where the "centre" has died.

Photo 13a & 13b Show the result of layering the older culms in the 60 cm planted hedgerow. Only 10.3% of inter-clump gaps were filled with new plants.

(b) Inter-clump Gaps

Inter-clump gap measurements were only started when the trial was 10 months old and only involved the wider spacings of 30 cm and 60 cm plantings. It was not possible to measure the 15 cm planting as the gaps would be too small for accurate measurement (see page 4).

Table 4 and Figure 3 summarise the results from 10 to 25 months. Improvement from higher fertilizer rates was marginal and was generally not significant. Spacing has highly significant (P< 0. 001) effect with the 60 cm planting having consistently higher gaps than the 30 cm planting. Table 5 . summaries the

variations in the plot cv. CV of 60 cm plantings is consistently lower than that of 30 cm plantings. This is largely because of the bigger interclump gap measurements. There appears to be a slight increase in cv for the 30 cm plantings from 19 months onwards. This could be due to certain dying out of the clumps and will be discussed later.

Table 4 also summaries the gap reduction which quantifies the rate of closure of the inter-clump gaps. The 2 rates of fertilizer application did not have any effect. However, spacing effect was highly significant in the earlier periods of 10-12, 12-13 and 13-15 months with the 60 cm plantings closing at a much faster rate than the 30 cm plantings.

From 19 months onwards, we noted certain die-back in the centre of the clumps. This situation became worse by the 24th month. Photos 11a & 11b show the good clumps while Photos 12a & 12b show the "centre" has died. This is mainly in the replications, which became more shaded as the neighbouring Hevea trees canopy develops. In addition, it was also observed that these weaken plants subsequently succumbed to termites attack. All these will have very adverse effects on the measurements and therefore the trial was terminated at 25 months.

(c) Top Dry Matter Production Per Clump

The results are given in Table 6a & 6b and Figure 4. Generally the fertilizer effect was marginal and significant only up to the 7th month. The higher level of fertilizer produced higher top dry matter. The significant difference in the 25th month was surprising and may have been confounded by the dying off of centre of certain clumps.

Spacing did not have any effect in the first 2 months. Thereafter the lower spacing treatment produce consistently higher dry matter than those planted closer.

(d) Top Dry Matter Production per 10 m Run

The results are summarised in Tables 7a & 7b and Figure 5 . The fertilizer effect is similar to the results for dry matter per clump given above; the higher level of fertilizer application produced significantly more dry matter than the lower level for the first 7 months. The dry matter production per 10m run is influenced by the production per clump and the spacing, which determined the number of clumps per experimental plot. The effect of spacing was observed from the first month. The closest planting distances of 15cm have the highest gramme per 10m run up to 7 months largely because of the higher number of plants. The 30 cm planted hedgerow catches up with the 15 cm, from the 8th 10, 13, 15, 18, 19 and 23rd months; it even surpasses the production by the higher density planting at 22nd and 23rd month. The 60cm planting produces significantly lower dry matter per unit length (gramme per 10 m) over the entire 25 months period suggesting a much poorer hedgerow.

(e) Layering

After recognising that the inter-clump gaps will close very slowly for wider spacing planting, attempts were carried out to fill the resultant gaps with new plants by layering the older culms from adjoining clumps along the hedgerow. Observation on 68 gaps showed that the success was poor at 10. 3 % only ( Photo 13). This differs from other results (85.9% success) of layering the culms perpendicularly away from the hedgerow. The most likely reason is self-shading by the clumps in the hedgerow itself. Therefore this approach will not be satisfactory. Closer planting should be used from the start to produce good hedgerows.

DISCUSSION AND CONCLUSION

Since this was only an observation trial for practical application the conclusions are tentative. More fertilizer treatments and wider range of spacing would be preferred. Additional fertilizer seemed to have an effect on dry matter production in the early months, but the higher level did not produce any increase later. Spacing plays a big role in dry matter production; the wider spacing produces significantly higher dry matter per clump. The reverse was noted in dry matter production per linear distance, reflecting the interaction of individual plant growth and the planting density. There is an apparent time x density interaction and 30cm spacing seem to have caught up with the 15cm spacing after 8 months. However, 60cm spacing stayed consistently lower. The dry matter studies, the measurement of inter-clump gaps and gap reduction strongly indicate that close planting of 15 cm is preferred for quick establishment of a functional hedgerow. Use of layering of culms to fill the gaps between wider spacing is of little value.







| Treatment | Spacing (cm) | Fertilizer (nuggets) |
|---|---|---|
| 1 | 15 | F1 |
| 2 | 15 | F2 |
| 3 | 30 | F1 |
| 4 | 30 | F2 |
| 5 | 60 | F1 |
| 6 | 60 | F2 |

Design: Complete factorial experiment (S3 x F2 x R4)
Arranged in Randomized complete blocks

*Photo 4.* Shows the treatments on effect of spacing/fertilizer on production of hedgerow.










*Photo 5.* Effect of planting distances on inter-clump gaps at 4 months after planting. All photos were taken on the same scale.




*Photo 6.* A good neat and compact hedgerow formed by 15 cm planting after 18 months.

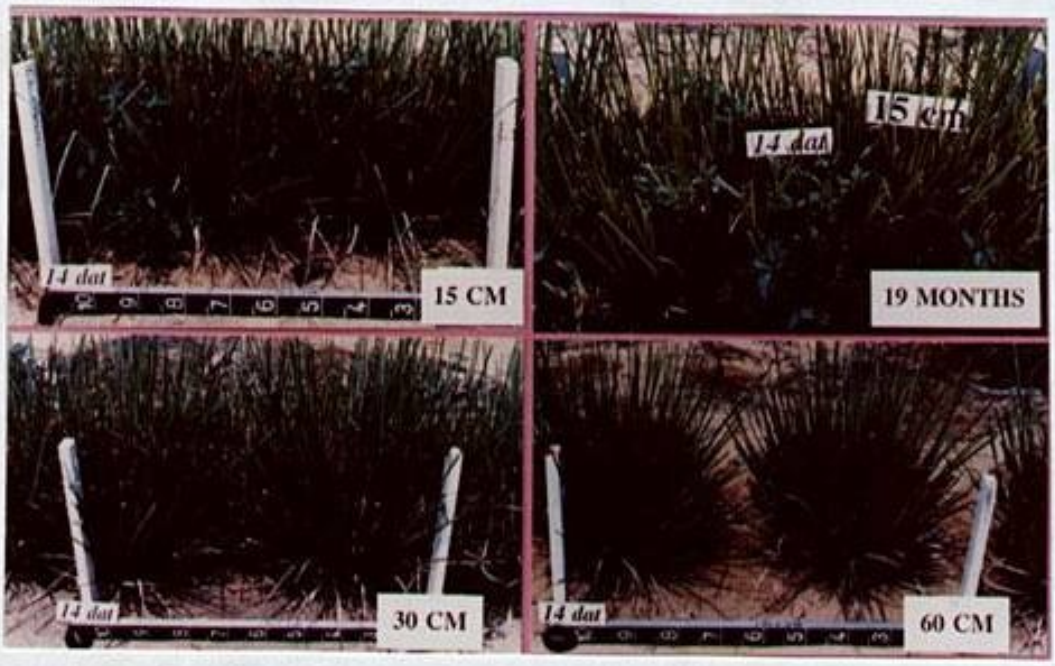



*Photo 7.* *Vetiver* hedgerows after 19 months. Note the gaps between the clumps planted at 60 cm apart have still not closed.




*Photo 8a & 8b.* Show general view of experimental site with topping of 60 cm width plantings. Note the large inter-clump gaps in the 60 cm planting while the gaps in the neighbouring hedgerows of 15 cm and 30 cm planting have largely closed over.




*Photo 9.* After 24 months, there are large gaps in the 60 cm planting. Smaller gaps still exist in the 30 cm planting.

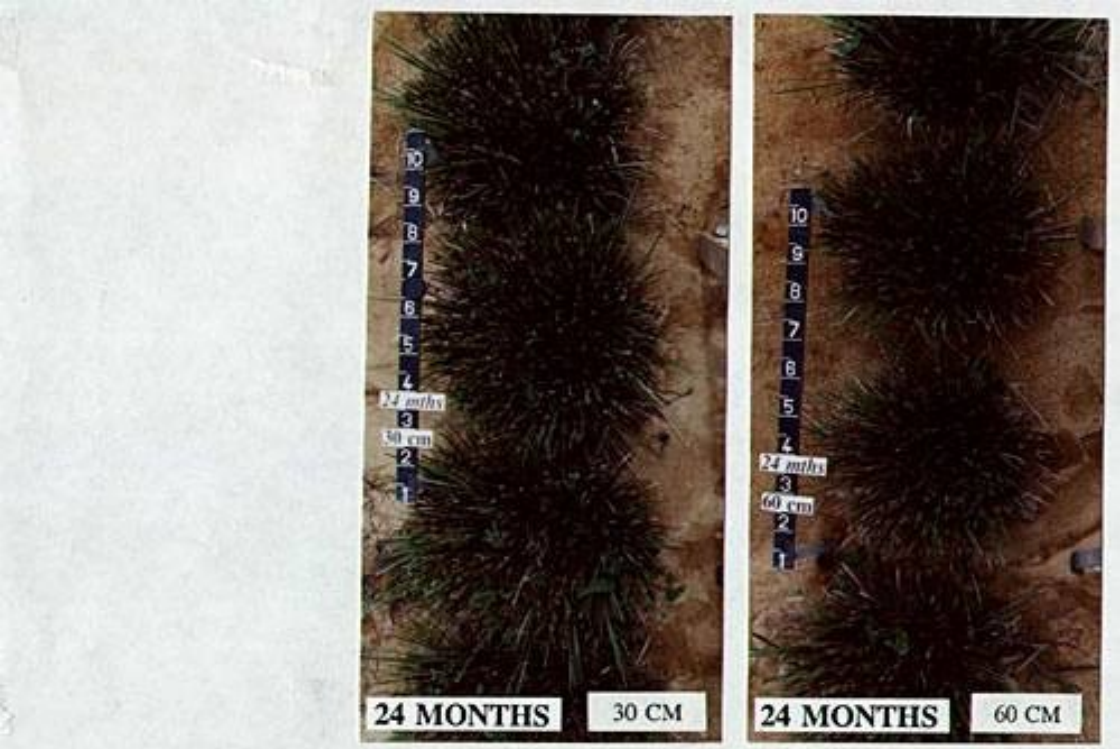



*Photo 10.* After 24 months, large gaps are clearly evident in the 60 cm planting. Smaller gaps occurred in the 30 cm planting where distinct individual clumps still exits. The 15 cm planting has formed a defined, intergrated compact hedgerow.




*Photo 11a.* Shows good quality clumps with live tillers evenly distributed right to the centre.




*Photo 11b.* Good production of new tillers evenly distributed within the clump at 1 week after topping. This is the unique characteristic of *Vetiver*; the "centre" does not die.





*Photo 12a & 12b.* The "centre" of the clumps have died. These clumps were weakened by shading and also by termite attack.



*Photo 13a.* Shows layering along the 60 cm hedgerow. A new plant is produced in 1 inter-clump gap. The other 2 gaps are still vacant.



*Photo 13b.* New plants have sprouted in inter-clump gaps after layering.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **TABLE 4: EFFECT OF SPACING / FERTILIZER ON GAPS AND GAPS REDUCTION (CM) IN VETIVER** | | | | | | | | | |

| **HEDGEROW** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Gaps at months after planting | | | | | | | | |
| Treatment | 10 | 12 | 13 | 15 | 18 | 19 | 22 | 23 | 25 |
| 30 cm F1 | 16.8 b | 16.2 b | 15.3 b | 14.5 b | 13.6 b | 13.2 b | 12.8 b | 12.5 b | 12.3 b |
| 30 cm F2 | 15.7 b | 15.1 b | 14.3 b | 13.4 b | 12.2 c | 12.0 b | 11.6 b | 11.4 b | 11.1 b |
| 60 cm F1 | 44.3a | 42.8a | 41.3a | 39.7a | 38.1 a | 37.3a | 36.9a | 36.3a | 35.6a |
| 60 cm F2 | 43.6a | 42.2a | 40.7a | 38.9a | 37.4a | 36.5a | 36.1 a | 35.8a | 35.1 a |
| s.e. (±) | 0.5 | 0.44 | 0.39 | 0.36 | 0.41 | 0.39 | 0.39 | 0.44 | 0.42 |
| LSD (P<0.05) | 1.6 | 1.4 | 1.2 | 1.2 | 1.3 | 1.2 | 1.3 | 1.4 | 1.3 |
| | Gap reductions at months after planting | | | | | | | | |
| Treatment | 10-Dec | Dec-13 | 13-15 | 15-18 | 18-19 | 19-22 | 22-23 | 23-25 | |
| 30 cm F1 | 0.6 b | 0.9 b | 0.8 b | 0.8a | 0.5 bc | 0.3a | 0.3a | 0.2a | |
| 30 cm F2 | 0.7 b | 0.8 b | 0.9 b | 1.2a | 0.2 c | 0.4a | 0.3a | 0.3a | |
| 60 cm F1 | 1.5a | 1.5a | 1.6a | 1.6a | 0.8ab | 0.5a | 0.6a | 0.7a | |
| 60 cm F2 | 1.4a | 1.5a | 1.8a | 1.5a | 0.9a | 0.4a | 0.3a | 0.7a | |
| s.e. (±) | 0.12 | 0.15 | 0.12 | 0.20 | 0.13 | 0.15 | 0.10 | 0.14 | |
| LSD (P<0.05) | 0.40 | 0.50 | 0.40 | - | 0.40 | - | - | - | |
| Means with the same subscript alphabets are not significantly different at P<0.05 | | | | | | | | | |

TABLE 5 EFFECT OF SPACING / FERTILIZER ON CV OF GAPS IN VETIVER HEDGEROW

| | **Months after planting** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment | 1 | 2 | 3 | 5 | 6 | 7 | 8 | 10 |
| 15 cm F1 | 2.5 a | 5.5 c | 5.7 d | 4.8 d | 9.3 d | 11.0 d | 9.1 c | 24.3 b |
| 15 cm F2 | 2.8 a | 8.0 ab | 8.6 bc | 6.3 cd | 13.0 cd | 14.7 cd | 10.8 c | 22.7 b |
| 30 cm F1 | 2.3 a | 5.6 c | 7.2 cd | 8.3 bc | 16.4 bc | 20.8 bc | 19.9 b | 44.1 a |
| 30 cm F2 | 3.1 a | 8.7a | 9.7 b | 10.4 ab | 19.5 b | 23.7 b | 19.9 b | 44.7 a |
| 60 cm F1 | 2.4 a | 6.6 bc | 9.2 b | 10.0 b | 19.5 b | 26.4 ab | 24.8 ab | 51.7 a |
| 60 cm F2 | 2.6 a | 9.0 a | 12.5 a | 13.0 a | 27.1 a | 30.3 a | 27.8 a | 57.6 a |
| s.e. ( ± ) | 0.25 | 0.63 | 0.63 | 0.94 | 1.83 | 2.06 | 2.24 | 5.85 |
| LSD (P<0.05) | - | 1.9 | 1.9 | 2.6 | 5.5 | 6.2 | 6.7 | 17.6 |

TABLE 6a EFFECT OF SPACING / FERTILIZER ON DRY WEIGHT (GM) PER CLUMP OF TOPS OF VETIVER HEDGEROW

| | **Months after planting** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment | 12 | 13 | 15 | 18 | 19 | 22 | 23 | 25 |
| 15 cm F1 | 33.4 c | 28.4 de | 30.8 cd | 52.9 d | 39.1 c | 28.1 c | 25.7 d | 25.7 c |
| 15 cm F2 | 35.1 c | 24.9 e | 29.8 d | 59.7 d | 37.6 c | 30.6 c | 29.9 cd | 25.4 c |
| 30 cm F1 | 50.7 bc | 44.0 cd | 55.5 bc | 97.5 c | 86.4 b | 72.0 b | 47.9 bcd | 52.3 b |
| 30 cm F2 | 62.6 ab | 51.7 bc | 62.5 b | 125.2 bc | 101.6 ab | 81.6 b | 56.9 bc | 67.8 b |
| 60 cm F1 | 77.0 a | 62.0 ab | 80.1 ab | 151.6 ab | 109.5 ab | 98.6 ab | 65.8 ab | 67.7 b |
| 60 cm F2 | 74.2 a | 74.4 a | 92.4 a | 159.9 a | 139.8 a | 130.2 a | 85.0 a | 88.9 a |
| s.e. ( ± ) | 7.30 | 5.88 | 8.21 | 11.02 | 13.21 | 13.06 | 9.16 | 6.00 |
| LSD (P<0.05) | 22.0 | 17.7 | 24.7 | 33.2 | 39.8 | 39.4 | 27.8 | 18.1 |

Cutback at 40 cm height

Means with the same subscript alphabets are not significantly different at P<0.05

TABLE 6b EFFECT OF SPACING / FERTILIZER ON VETIVER - TOPS DRY WEIGHT (GM) PER CLUMP

| | **Month after treatment** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Spacing (cm) | 1 | 2 | 3 | 5 | 6 | 7 | 8 | 10 | 12 | 13 | 15 | 18 | 19 | 22 | 23 | 25 |
| 15 | 2.7 a | 6.7 a | 7.1 b | 5.6 c | 11.2 c | 12.8 c | 10.0 c | 23.5 b | 34.3 c | 26.7 c | 30.3 c | 56.3 c | 38.3 c | 29.4 c | 27.8 c | 25.5 c |
| 30 | 2.7 a | 7.1 a | 8.5 b | 9.4 b | 17.9 b | 22.3 b | 19.9 b | 44.4 a | 56.7 b | 47.8 b | 59.0 b | 111.3 b | 94.0 b | 76.8 b | 52.4 b | 60.1 b |
| 60 | 2.5 a | 7.8 a | 10.8a | 11.5a | 23.3 a | 28.4 a | 26.3 a | 54.7 a | 75.6 a | 68.2 a | 86.3 a | 155.7 a | 124.7 a | 114.4 a | 75.4 a | 78.3 a |
| s.e. ( ± ) | 0.18 | 0.45 | 0.45 | 0.67 | 1.29 | 1.46 | 1.58 | 4.14 | 5.16 | 4.16 | 5.80 | 7.79 | 9.34 | 92.4 | 6.48 | 4.24 |
| LSD (P<0.05) | - | - | 1.3 | 2.0 | 3.9 | 4.4 | 4.8 | 12.5 | 15.6 | 12.5 | 17.5 | 23.5 | 28.2 | 27.8 | 19.6 | 12.8 |

| | **Month after treatment** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fertilizer | 1 | 2 | 3 | 5 | 6 | 7 | 8 | 10 | 12 | 13 | 15 | 18 | 19 | 22 | 23 | 25 |
| F1 | 2.4 a | 5.9 b | 7.4 b | 7.7 b | 15.1 b | 19.4 a | 17.9 a | 40.1 a | 53.7 a | 44.8 a | 55.5 a | 100.7 a | 78.3 a | 66.2 a | 46.5 a | 48.6 b |
| F2 | 2.8 a | 8.5 a | 10.3 a | 9.9 a | 19.9 a | 22.9 a | 19.5 a | 41.7 a | 57.3 a | 50.3 a | 61.6 a | 114.9 a | 93.0 a | 80.8 a | 57.3 a | 60.7 a |
| s. e. (±) | 0.15 | 0.37 | 0.36 | 0.55 | 1.06 | 1.19 | 1.29 | 3.38 | 4.22 | 3.39 | 4.74 | 6.36 | 7.63 | 7.54 | 5.29 | 3.46 |
| LSD (P<0.05) | - | 1.1 | 1.1 | 1.6 | 3.2 | - | - | - | - | - | - | - | - | - | - | 10.4 |

Means with the same subscript alphabets are not significantly different at P<0.05

TABLE 7a EFFECT OF SPACING / FERTILIZER ON DRY WEIGHT (GM) PER 10 M RUN OF TOPS OF VETIVER HEDGEROW

| | **Months after planting** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment | 1 | 2 | 3 | 5 | 6 | 7 | 8 | 10 |
| 15 cm F1 | 166 a | 366 b | 378 b | 322 ab | 623 bc | 732 b | 609 ab | 1622 a |
| 15 cm F2 | 187 a | 533 a | 572 a | 418 a | 867 a | 978 a | 723 a | 1515 a |
| 30 cm F1 | 78 b | 186 d | 240 cd | 276 bc | 547 bc | 694 b | 662 a | 1471 a |
| 30 cm F2 | 102 b | 289 c | 324 bc | 347 ab | 649 b | 790 b | 663 a | 1492 a |
| 60 cm F1 | 40 c | 110 e | 153 d | 166 d | 324 d | 439 c | 413 c | 862 b |
| 60 cm F2 | 43 c | 149 de | 208 d | 216 cd | 451 cd | 506 c | 463 bc | 960 b |
| s.e. (±) | 9.8 | 24.8 | 30.7 | 33.3 | 58.9 | 52.8 | 51.9 | 115.9 |
| LSD (P<0.05) | 30 | 75 | 92 | 100 | 178 | 159 | 156 | 349 |

| | **Months after planting** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment | 12 | 13 | 15 | 18 | 19 | 22 | 23 | 25 |
| 15 cm F1 | 2229 a | 1895 a | 2056 a | 3529 ab | 2604 abc | 1874 bc | 1716 ab | 1712 b |
| 15 cm F2 | 2342 a | 1659 ab | 1987 ab | 3978 a | 2503 abc | 2043 bc | 1995 a | 1693 b |
| 30 cm F1 | 1691 bc | 1466 abc | 1851 ab | 3250 ab | 2880 ab | 2400 ab | 1597 abc | 1744 b |
| 30 cm F2 | 2088 ab | 1722 a | 2083 a | 4173 a | 3388 a | 2719 a | 1896 ab | 2261 a |
| 60 cm F1 | 1284 cd | 1033 c | 1335 c | 2526 b | 1825 c | 1643 c | 1096 c | 1128 c |
| 60 cm F2 | 1237 d | 1239 bc: | 1540 bc | 2665 b | 2330 bc | 2170 abc | 1416 bc | 1482 b |
| s.e. (±) | 142.2 | 149.8 | 165.1 | 334.6 | 307.8 | 206.2 | 190.7 | 111.3 |
| LSD (P<0.05) | 429 | 451 | 498 | 1008 | 927 | 621 | 578 | 335 |

Cutback at 40 cm height Means with the same subscript alphabets are not significantly different at P<0.05

TABLE 7b EFFECT OF SPACING / FERTILIZER ON VETIVER - TOPS DRY WEIGHT (GM) PER 10 M RUN

| | **Month after treatment** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Spacing (cm) | 1 | 2 | 3 | 5 | 6 | 7 | 8 | 10 | 12 | 13 | 15 | 18 | 19 | 22 | 23 | 25 |
| 15 | 176 a | 449 a | 475 a | 370 a | 745 a | 855 a | 666 a | 1568 a | 2285 a | 1777 a | 2021 a | 3753 a | 2554 ab | 1958 b | 1855 a | 1703 b |
| 30 | 90 b | 238 b | 282 b | 312 a | 598 b | 742 b | 663 a | 1481 a | 1889 b | 1594 a | 1967 a | 3711 a | 3134 a | 2559 a | 1747 a | 2003 a |
| 60 | 42 c | 130 c | 180 c | 191 b | 388 c | 472 c | 438 b | 911 b | 1261 c | 1136 b | 1438 b | 2595 b | 2078 b | 1906 b | 1256 b | 1305 c |
| s.e. (±) | 6.93 | 17.5 | 21.7 | 23.5 | 41.7 | 37.3 | 36.7 | 82.0 | 100.6 | 105.9 | 116.8 | 236.6 | 217.6 | 145.8 | 134.8 | 78.7 |
| LSD (P<0.05) | 21 | 53 | 65 | 71 | 126 | 112 | 111 | 247 | 303 | 319 | 352 | 713 | 656 | 439 | 409 | 23.7 |

| **Month after treatment** | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fertilizer | 1 | 2 | 3 | 5 | 6 | 7 | 8 | 10 | 12 | 13 | 15 | 18 | 19 | 22 | 23 | 25 |
| Fl | 94 a | 221 b | 257 b | 254 b | 498 b | 622 b | 561 a | 1318 a | 1735 a | 1465 a | 1747 a | 3101 a | 2436 a | 1972 a | 1470 a | 1528 b |
| F2 | 111 a | 324 a | 368 a | 327 a | 656 a | 758 a | 616 a | 1322 a | 1889 a | 1540 a | 1870 a | 3605 a | 2741 a | 2311 a | 1769 a | 1812 a |
| s.e. (±) | 5.7 | 14.3 | 17.7 | 19.2 | 34.0 | 30.5 | 29.9 | 66.9 | 82.1 | 86.5 | 95.3 | 193.2 | 177.7 | 119.0 | 110.1 | 64.3 |
| LSD (P<0.05) | - | 4.3 | 53 | 58 | 103 | 92 | - | - | - | - | - | - | - | - | - | 194 |

Means with the same subscript alphabets are not significantly different at P<0.0

*FIGURE 3.* EFFECT OF SPACING CUM FERTILIZER ON INTER-CLUMP GAPS IN *VETIVER* HEDGEROWS

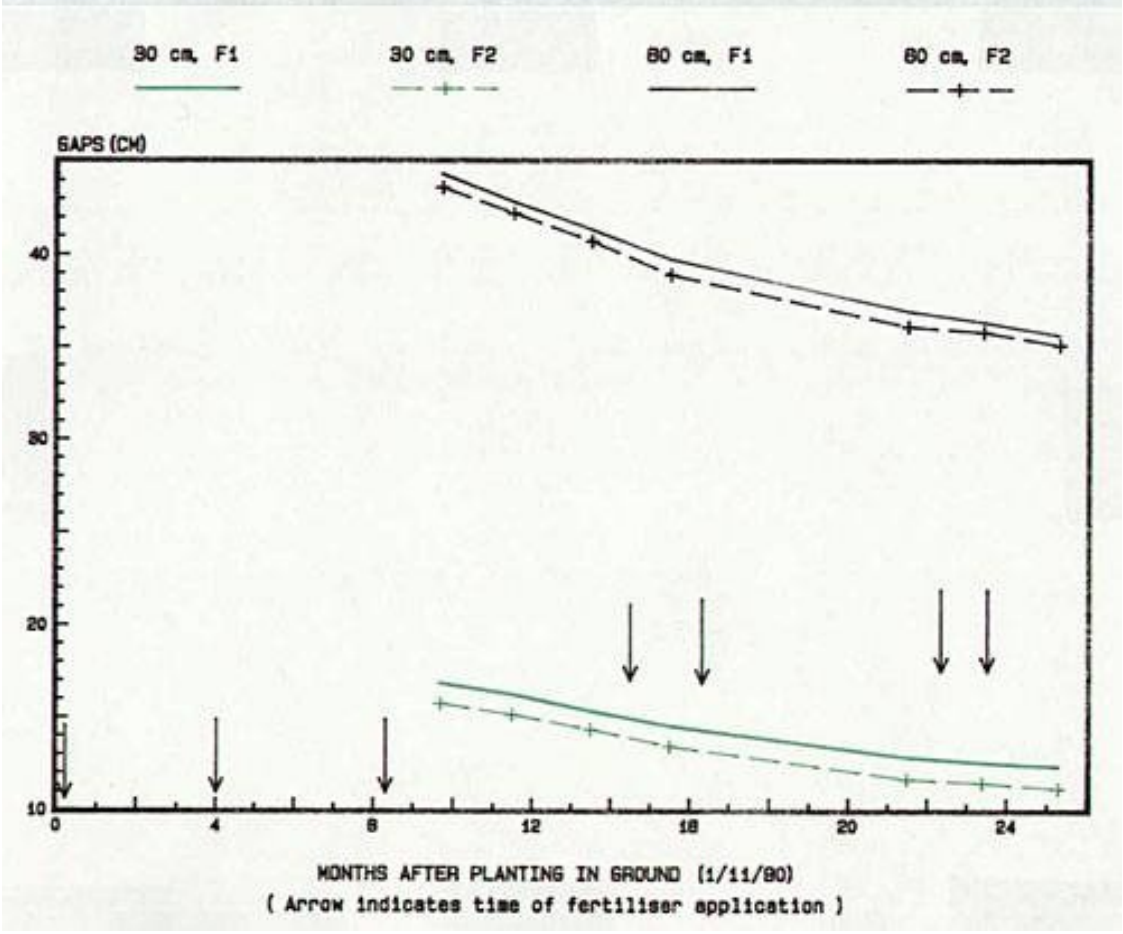


*FIGURE 4.* EFFECT OF SPACING CUM FERTILIZER ON DRY MATTER PRODUCTION OF TOPS OF *VETIVER* CLUMPS

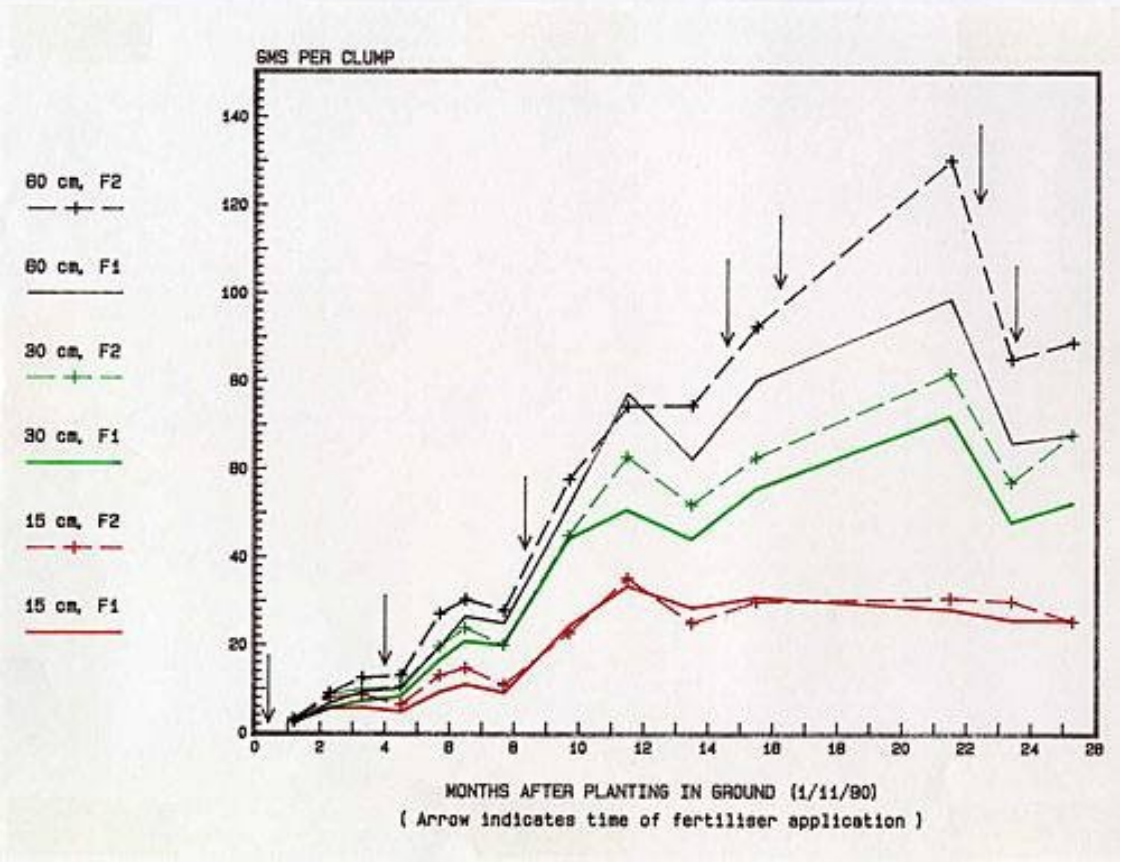
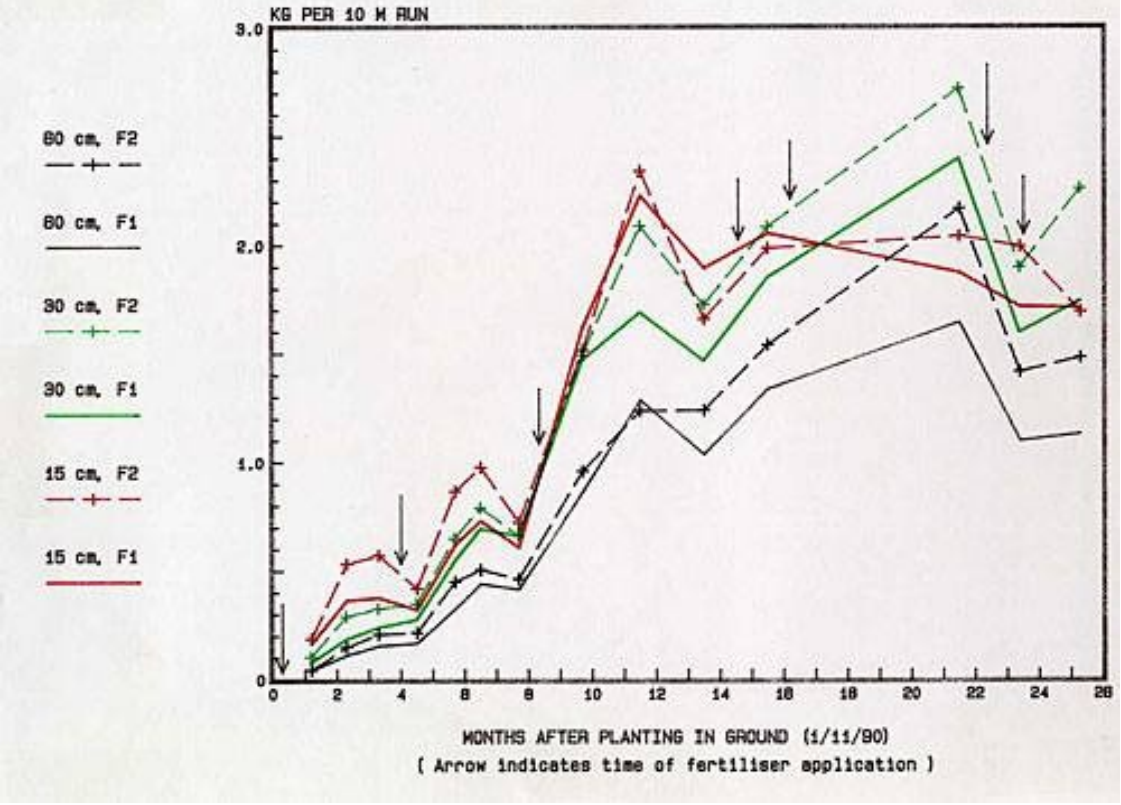


*FIGURE 5.* EFFECT OF SPACING CUM FERTILIZER ON DRY MATTER PRODUCTION PER 10 M OF *VETIVER* HEDGEROWS




## 3.6 Weed control with selective herbicides

*Source: Second Progress Report, 2.3*

Weed management is an important aspect in the maintenance of quality Vetiver hedgerows. In Malaysia, weeds grow luxuriantly under high rainfall (2100 – 2500mm/year), humidity (52-96%) and temperature (21-35 o C). These weeds compete with the Vetiver directly for nutrients, water and light. The last factor is most important, as Vetiver is not shade tolerant. As a result of strong competition caused by swarming over and shading by these weeds, the growth of Vetiver hedgerow is retarded and suppressed. In a severe weed-infested situation, even an established Vetiver hedgerow will be weakened and less effective for its intended purpose.

Weed is a plant growing where it is not desired. In Vetiver hedgerow establishment and maintenance, the weeds are mainly grasses and broad-leaves. The grasses are less important. The more damaging weeds are broadleaf such as Asystasia intrusa, Chromolaena odorata (Siam weed), and Mikania micrantha ( photos 14 to 17 ). Included also are the leguminous creepers normally grown as covers in agricultural plantations ( Photos 18 and 19 ). These are the most noxious weeds because they swarm over, strangle and shade out the Vetiver hedgerows.

a) Control of Noxious Weeds in Vetiver Hedgerows

An evaluation of selective herbicides in the control of A. intrusa was conducted at the Rubber Research Institute Experiment Station, Sungai Buloh * . The herbicides tested were Starane 200 0.1 and 0.3 1/ha and 2,4-D amine 0.5 and 1.5 1/ha. The volume of spray was 450 1/ha (Photo 20). Examples of plots marked for testing and treatment arrangements are shown in Photos 21 and 22 . Photos 23a to 23d traced the schedule of observations at 0, 1, 2, 4 weeks and its response to the 2,4-D amine 1.51/ha treatment.

At 7 days after spraying, the leaves of A. intrusa were scorched by Starane 200 (0.31/ha) and 2,4-D amine (0.5 and 1.51/ha) while light scorching was found in Starane 200 0. 11/ha plots. At 14 days, 60%

control was recorded for Starane 200 (0.31/ha) and 2,4-D amine (0.5 and 1.51/ha) while in Starane 200 (0.11/ha) plots, only the leaves were scorched but not the stems. The same trend was recorded at 28 days after treatment. At 45 days after treatment, the % control for Starane 200 (0.31/ha), 2,4-D amine (0.5 and 1.51/ha) was 93%, 92% and 98% respectively ( Table 8 ). Poor control of 50% was recorded in Starane 200 0. 11/ha plots and there was regeneration from the stems. Photos 24 and 25 records the other 2 effective herbicides of 2,4-D amine 0.51/ha and Starane 200 0.31/ha at 4 weeks. Therefore, for control of A. intrusa the recommended herbicides spraying are 2,4-D amine at rates of 0.5 and 1.51/ha or Starane 200 at 0.3 1/ha.

Based on other ad hoc experiments in the establishment of Vetiver hedgerows, the various herbicides and rates recommended to control other weeds are as follows:

| **Chromolaena odorata (Siam Weed)** | **Ally 20 DF** | **150 g** |
|---|---|---|
| 2,4-D amine | 1.5 l | |
| | Starane 200 | 1.25 l |
| Mikania micrantha | 2,4-D amine | 1.0 l |
| | Starane 200 | 0.5 l |
| Pueraria phaseoloides (Legume) | Ally 20 DF | 100 g |
| Starane 200 | 0.375 l | |



*Photo 14.* *Vetiver* hedgerow swarmed over by *Mikania micrantha*.



*Photo 15.* The *Vetiver* hedgerow is severely weakened by *Mikania micrantha*.



*Photo 16.* The invasion of *Mikania micrantha* has swarmed over the *Vetiver* hedgerows in this oil palm estate.



*Photo 17.* The survival of *Vetiver* hedgerows protecting this embankment are being threatened by *Mikania micrantha*.





*Photo 18a & 18b.* Two views of *Vetiver* hedgerows protecting the shoulder of roads being swarmed over by leguminous creeper, *Pueraria phaseoloides.*



*Photo 19a.* Shows the *Vetiver* hedgerows being swarmed over by leguminous creepers.



*Photo 19b.* The leguminous creepers were removed manually to expose the *Vetiver* hedgerow.



| Treatment | Herbicide | Rates (l/ha) |
|---|---|---|
| 1 | $Starane_{200}$ | 0.1 |
| 2 | $Starane_{200}$ | 0.3 |
| 3 | 2,4-D amine | 0.5 |
| 4 | 2,4-D amine | 1.5 |
| | Control (no spraying) | |

Design: Paired comparison;
Control vs treated for each of
4 treatments x 3 replications

*Photo 20.* Shows half the experimental plot being sprayed with herbicide treatment while the control half is protected from contamination by a piece of plywood.




STARANE$_{200}$ 0.1 L/HA 0 DAY CONTROL




STARANE$_{200}$ 0.3 L/HA 0 DAY CONTROL

*Photo 21a & 21b.* Show experimental plots to test Starane$_{200}$ against *Asystasia intrusa*. The centre pole marks the boundary between the half plots.




2,4-D AMINE 0.5 L/HA 0 DAY CONTROL




2,4-D AMINE 1.5 L/HA 0 DAY CONTROL

*Photo 22a & 22b.* Show experimental plots to test 2,4-D amine against *Asystasia intrusa*.




2,4-D AMINE 1.5 L/HA 0 DAY CONTROL

*Photo 23a.* Condition of plot 8 before treatment with 2,4-D amine at 1.5 l/ha.




2,4-D AMINE 1.5 L/HA 1 WEEK CONTROL

*Photo 23b.* Plot 8 at 1 week after treatment, the *Asystasia intrusa* was scorched, but even the youngest *Vetiver* tiller was not affected.




*Photo 23c.* At 2 weeks, 60% control of weeds were achieved.




*Photo 23d.* At 4 weeks the *Asystasia intrusa* had completely died but new tillers of *Vetiver* are being produced.




*Photo 24.* 2,4-D amine 0.5 l/ha has destroyed the *Asystasia intrusa* but new tillers of *Vetiver* are being produced.




*Photo 25.* Starane$_{200}$ 0.3 l/ha produces good control of *Asystasia intrusa*. The *Vetiver* plants have rejuvenated and new tillers are observed.

TABLE 8 EFFECT OF HERBICIDES ON THE CONTROL OF ASYSTASIA INTRUSA IN VETIVER HEDGEROWS

| Herbicides | Rates 1/ha | % control* (45 days after treatment) |
|---|---|---|
| Starane 200 | 0.1 | 50 |
| Starane 200 | 0.3 | 93 |
| 2,4-D amine | 0.5 | 92 |
| 2,4-D amine | 1.5 | 98 |

*Mean of 3 replicates

(Courtesy: Chee Yan Kuan)

## 3.7 Competition with weeds

*Source: First Progress Report, G-VIII*

In a commercial ground nursery, no weeding was carried out. The Vetiver plants in rows grows well in competition with the weed Borreria sp . and some sedges. However, it should be noted that Borreria sp . is normally regarded as a weak weed ( Photo 60 ).

The ability of Vetiver to compete with weeds is important because any need for weeding will increase the cost of multiplication, establishment and maintenance of Vetiver nurseries and hedgerows.

PHOTO 60. COMPETITION OF VETIVER WITH OTHER WEEDS



(a) No weeding had been undertaken in this nursery.



(b) The main weeds is *Borreria sp.* with some sedges.

(Ref: 22/1990)

## 3.8 Tolerance to contact weedicide spray drift

*Source: First Progress Report, G-VI*

Weedicide spray drift is, at times, unavoidable. An incident occurred in one Vetiver multiplication nursery next to a rubber seedling nursery. The weedicide used was Paracol; a contact weedicide, ( Photo 58a ) shows the damage. Only the tops of the plants were affected. Photo 58b shows the good recovery after 2 ½ months.

PHOTO 58 – TOLERANCE TO CONTACT WEEDICIDE SPRAY DRIFT




(a) Plants accidentally damaged by Paracol spray drift.

Photo taken: 3/3/1990 (Ref: 4/1990)




(b) Recovery after 2 1/2 months.

Photo taken: 16/5/1990 (Ref: 4/1990)

## 3.9 Diseases

*Source: First Progress Report, Chapter E*

For any introduction and expanded planting of a new plant species or even a new cultivar, it is important that the introduction is not an alternative host for any disease of economic importance to major crops in the country. We, therefore pay special attention to any pest and disease affecting Vetiver.

## Results

In the period under observation, fungal attack was observed and identified as:

Nigrospora sp. Curvularia sp. Helminthosporium sp. (Photo 49)

With the help of a mycologist, we isolated the inoculum involved. We then tried to inoculate new emergent leaves (Photo 50 ). Our first two attempts failed to produce similar symptoms despite using all known information available to us for such actions. It was only recently (February 1991) at the third attempt using cut leaves in inoculation chamber that we were able to inoculate and develop symptoms using Helminthosporium sp. spores. Nigrospora sp . and Curvularia sp. were only pathogenic on detached leaves that had been subjected to wounding.

PHOTO 49. DISEASES OF VETIVER (1)



(a) Vetiver plants attacked by fungal diseases.



(b) *Helminthosporium sp.* and *Curvularia sp.* were isolated from these leaves.

(Ref: 17/1990)

PHOTO 50. DISEASES OF VETIVER (ii)



(a) Healthy polybag plants of Vetiver were placed under dense shade of rubber nursery. The fungal spores of *Helminthosporium sp.* and *Curvularia sp.* were sprayed onto cut-leaves.



(b) The plants were covered with polybags. The plants were kept cool and moist with a continuous mist produced by irrigation tubes.

(Ref: 17/1990)

## CONCLUSION

Of the many areas planted only two sites experienced such fungal attacks and these are in the crowded nurseries of RRIM Experiment Station, Sungei Buloh. The plants in the affected plots were topped at 40 cm. Thereafter, growth continued as normal. There are difficulties to inoculate with the isolated inoculum. All the above points suggest the fungal attacks to be non-virulent. However, on examining the checklist of hosts and pests in Malaysia, we spot certain potential hosts of economic importance. These are summarised below:

| Pest | Disease | Host |
|---|---|---|
| Curvularia lunata (Wakker) & Boedijn | (leaf spot) | Elaeis guineensis Jacq (oil palm) |
| Curvularia maculans (Bancroft) Boedijn | (leaf spot) | Elaeis guineensis Jacq (oil palm) |

| | | |
|---|---|---|
| Helminthosporium halodes Petch. | (leaf spot) | Elaeis guineensis Jacq. (oil palm) |
| Helminthosporium incurvatum Bernard | (leaf spot) | Cocos nucifera L. (coconut) |
| Helminthosporium maydis Nelson | | Zea mays L. (maize) |
| Helminthosporium rostratum Petch. | (leaf spot) | Elaeis guineensis Jacq. (oil palm) |
| Helminthosporium (Drechslera) sacchari Link. | (sugar cane eye spot) | Saccharum officinarum L. (sugar cane) |
| Helminthosporium sp. | (leaf disease) | Elaeis guineensis Jacq. (oil palm) |
| Helminthosporium stenospilum (Drechsler) Subram & Jain | (brown stripe) | Saccharum officinarum L. (sugar cane) |
| Helminthosporium turcicum Pass . | (leaf blight) | Zea mays L. (maize) |

It is therefore important to identify the correct species and cultivar of the various fungi attacking Vetiver albeit on a small scale. Such knowledge in not available in Malaysia and we therefore plan to send our inoculum to the British Mycology Institute for identification.

## 3.10 Labour

*Source: First Progress Report, G-II*

Labour cost in the agricultural sector in Malaysia is relatively higher compared with other developing countries. Therefore, cost of multiplication and establishment must be looked into. Consequently, we use slow release fertilizer and irrigation systems. These are all established and proven practices introduced to the Industry by my co-workers and me. Use of polybags is an accepted practice and may be more cost-effective.

Mechanised topping is obviously more cost effective. A worker can cut a 50m bed of six rows of plants at 6" square planting, in 5 minutes, i.e. topping of 1,800 clumps. All of the above have been discussed in Chapter A.

## 3.11 Weather conditions

*Source: First Progress Report, G-III*

The high intensity rainfall in Malaysia dictates that the hedgerows must be established fast in order to be effective. For highway construction, the contract of establishment of cover on embankment to control erosion runs into $100 millions and therefore cost of establishment is not prohibitive. What is expensive is the following "repair" work, if there were any failure. Therefore, the main target is to establish the good uniformed hedgerows fast. The same also applies to landfills in ponding, irrigation canals, housing estates, etc.

# 4. Erosion control and special characteristics of hedgerows

## 4.1 Introduction and demonstration against topsoil loss

*Source: First Progress Report, Chapter D and D-I*

Soil erosion is a massive problem, especially so in Malaysia with its high density rainfall. Vetiver purportedly, could minimise topsoil loss, increase soil stability and aids in moisture conservation. This chapter reports various attempts to study such effects.

A simple demonstration site was set up in a nursery land. The terrain was gently undulating (4 – 5 o slope). Planting was across a small gully already existing, taking care not to introduce any extraneous earth.

Photo 36a shows the Vetiver hedgerows (A) at the lower end of the slope. They had trapped the topsoil and the gully had disappeared; in fact the slope has become platforms between the hedgerows. Photo 37a and 37b are close-ups of a hedgerow (B) at mid-level and shows the effectiveness of the hedgerow to trap topsoil.

This demonstration site continues to exist for showing to interested parties. Invariably all visitors, to date, were impressed enough to want to use Vetiver on their land.

PHOTO 36. PREVENTION OF SHEET EROSION BY VETIVER (1)




(a) General view of site with gentle (4–5°) slope. The gully was already formed before planting the Vetiver hedgerows.




(b) The lowest hedgerows after 3 months. The gully is filled with top soil and the gentle slope has become platforms between hedgerows.

Planted: 1/6/1990
Photo taken: 3/9/1990 (Ref: 16/1990)

PHOTO 37. PREVENTION OF SHEET EROSION BY VETIVER (ii)



(a) Close-up of Hedgerow B.



(b) The amount of top soil trapped by the hedgerow is most demonstrative.

Planted: 1/6/1990
Photo taken: 3/9/1990 (Ref: 16/1990)

## 4.2 Filled earth (effluent pond bunds)

*Source: First Progress Report, D-II*

It is a statutory requirement of the Department of Environment that all latex concentrate factories must discharge their effluent in a designed effluent pond system. The construction of a new factory in a co-operating estate necessitates the ponding to be done with bunds of filled earth. This gave us a good opportunity to test the value of Vetiver to control soil erosion.

Three attempts were made:

Demonstration plot set up on 24/7/1990. Trial 1 set up on 31/7/1990. Trial 2 set up on 3/9/1990.

### Observations and results

The plants established very well rapidly, but heavy rainfall on the following days:

9/10/1990 – 26.0 mm

10/10/1990 – 96.6mm

11/10/1990 – 89.6 mm

12/10/1990 – 42.0 mm

caused the bunds to collapse on the evening of 11/10/1990 and the morning of 12/10/1990.

### (a) Demonstration Plot

This was set up with no intention of any measurement. Photo 38 shows the position at planting. Photo 39a and 39b show collapse, but notice the row alignments of planting were barely out. The whole collapse was due to sub-soil collapse as shown in Photo 40 .

### Trial 1

This trial was initiated to have more detailed measurements of surface water run off, soil wash, etc. The details are given below Photo 41 , which shows the condition at planting.

The experimental plots were demarcated by zinc-sheet boundaries to measure surface water run off and soil wash into the drums (Photo 42a). At each level, there were three marked wooden pegs to measure topsoil loss. Measurements were conducted for a few days but with the heavy rain on 11/10/1990, the drums were washed away and the zinc boundaries collapsed leading to extensive leakage (Photo 42b ). It is not possible to repair this and the trial had to be abandoned. However, Photo 42b had demonstrated the better effect of Vetiver to reduce topsoil erosion when compared with estate practice.

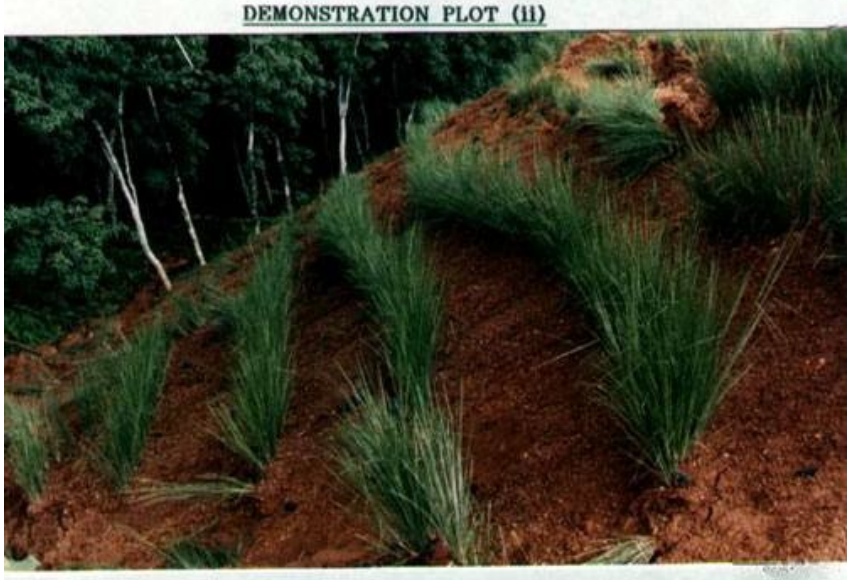
PHOTO 38. GROWTH OF VETIVER ON FILLED EARTH – DEMONSTRATION PLOT (1)





Planted: 24/7/1990
Photo taken: 24/7/1990 (Ref: 11/1990)

PHOTO 39. GROWTH OF VETIVER ON FILLED EARTH – DEMONSTRATION PLOT (ii)



(a) The plant rows are intact despite soil collapse.



(b) The top of the bund has collapsed.

Photo taken: 14/10/1990 (Ref: 20/1990)

PHOTO 40. GROWTH OF VETIVER ON FILLED EARTH –

DEMONSTRATION PLOT (iii)



Photos show the collapse at the top of the bund.

Photo taken: 14/10/1990 (Ref: 20/1990)

**PHOTO 41. GROWTH OF VETIVER ON FILLED EARTH – TRIAL 1 (i)**



Established: 31/7/1990
Photo taken: 3/8/1990 (Ref: 13/1990)

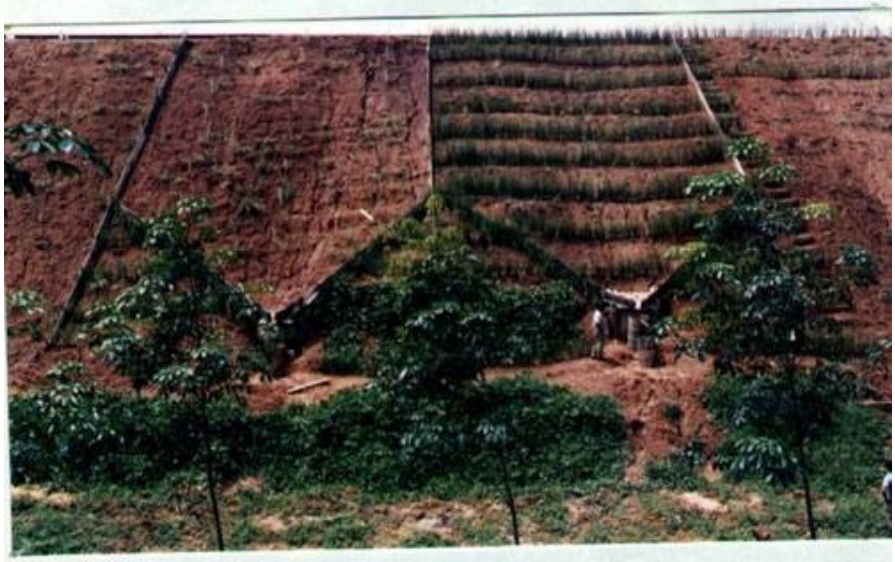
Trial 1

Terrain: Filled earth
Plot size: 10-metre width
Design: Split plot;
2 Treats x 2 Reps

Treatments

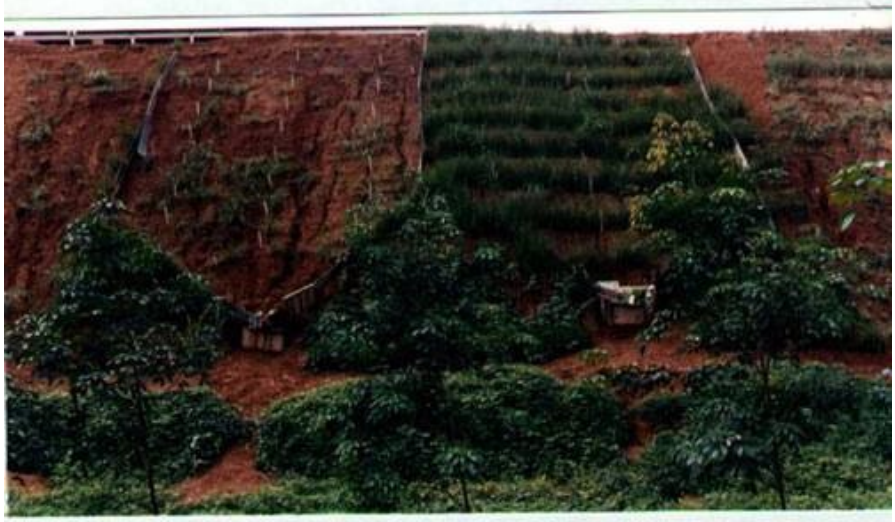
T-1 : Estate practice
T-2 : Vetiver at vertical height of 1 metre
Rep 1 : 9 rows of Vetiver
Rep 2 : 11 rows of Vetiver

PHOTO 42. GROWTH OF VETIVER ON FILLED EARTH – TRIAL 1 (ii)



(a) Note the wooden pegs and the oil drums used for measurements.

Photo taken: 19/9/1990 (Ref: 18/1990)



(b) Due to the heavy rainfall, the drums were washed off. The side-wall of zinc sheets were distorted with extensive leakage.

Photo taken: 14/10/1990 (Ref: 20/1990)

## Trial 2

This trial was on bunds where filled earth which has been established for about a month earlier, to being immediately piled on at time of planting of Vetiver.

The details of the trial is given below Photo 43 , which shows the replicate block on the older filled soil. The well established Vetiver plants as compared with estate treatments are clearly shown. After the collapse on 11-12/10/1990 the interesting phenomenon was that the alignment of Vetiver planting held very well thought he whole top area of soil in the plots had slipped down (Photo 44a ). In the plot with the latest constructed bund, the plants have been dropped more than 4-5 metres (Photo 44b). Closer examination of the various plots showed that the Vetiver planted on the oldest filled soil held well (Photo 45a) and continued to do so (Photo 45b ). Such observations confirm that the root system of Vetiver was established most rapidly and have penetrated and held approximately one foot of soil. This trial was

abandoned but the earliest planted block continues to show the better value of Vetiver to reduce soil erosion, as compared to normal practice of using cow grass and New Guinea grass (Photo 45b).

PHOTO 43. GROWTH OF VETIVER ON FILLED EARTH – TRIAL 2 (I)



Established: 3/9/1990
Photo taken: 19/9/1990 (Ref: 18/1990)

Terrain: Filled earth of 100-metre width
Plot size: 5-metre width
Design: 2 Treats x 10 Reps

Treatments

T-1 : Estate practice
T-2 : Vetiver at vertical height of 1 metre

Field Arrangement

| Rep 1 | Rep 2 | Rep 3 | Rep 4 | Rep 5 | Rep 6 | Rep 7 | Rep 8 | Rep 9 | Rep 10 |
|---|---|---|---|---|---|---|---|---|---|
| T-1 | T-2 | T-1 | T-2 | T-2 | T-1 | T-2 | T-1 | T-1 | T-2 |
| T-2 | T-1 | T-2 | T-1 | T-1 | T-2 | T-1 | T-2 | T-2 | T-1 |

PHOTO 44. GROWTH OF VETIVER ON FILLED EARTH – TRIAL 2 (ii)



(a) The bund has collapsed because of heavy rain. Note the alignment of Vetiver plants held very well.

Photo taken: 14/10/1990 (Ref: 20/1990)




(b) The sub-soil has collapsed. The Vetiver plots had slipped 4–5 metres from the top original level ($L_O$) to the lower new level ($L_N$)

Photo taken: 14/10/1990 (Ref: 20/1990)

PHOTO 45. GROWTH OF VETIVER ON FILLED EARTH – TRIAL 2 (iii)



(a) There is much more soil erosion in the control estate plot.

Photo taken: 14/10/1990 (Ref: 20/1990)



(b) The Vetiver plants continue to grow well in the oldest plots. Compare these with the plot planted with cow grass and New Guinea grass.

Photo taken: 23/12/1990 (Ref: 24/1990)

CONCLUSION

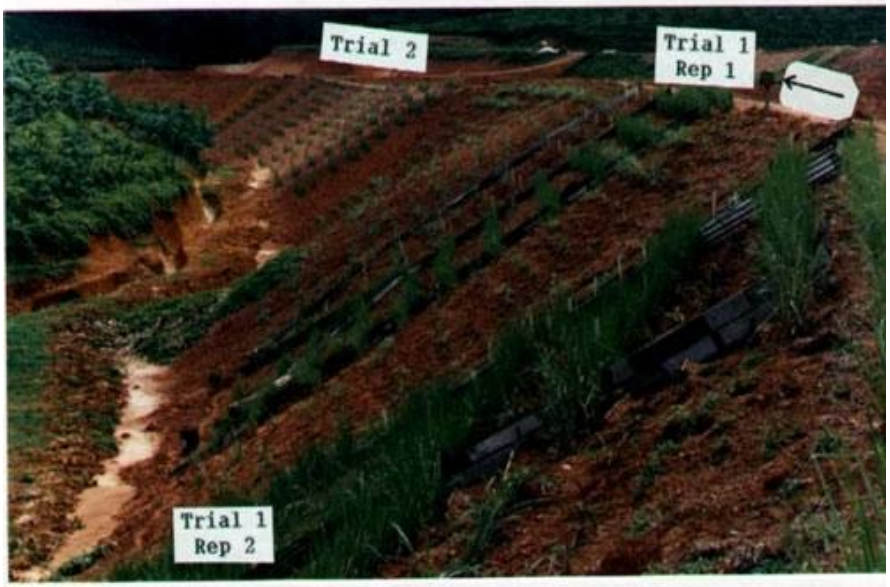
A large effort, in terms of labour and finance, was expanded on the demonstration plot and the two trials. The collapse of the filled-earth bunds was a big disappointment to us. However, rather than showing the failures of the Vetiver system, it tended to show it's intrinsic strength. This is best illustrated in the overall picture. Photo 46a shows the general view of the two trials. The direction of the earthwork and the planting of the Vetiver is indicated by the arrow (® ). This shows the size of the trials and the slope and height of the filled earth bunds; Photo 40b shows the collapse of the bunds. Because of the great height and steep slope, we were too optimistic not to have taken care of the subsoil and the poor physical structure by piling. A combination of some structural work and planting of Vetiver may have overcome the collapse of the bund.

The main conclusions were:

The top 1 foot of soil was held together by Vetiver thought the whole area slid down. Earlier plantings before the onset of heavy rain would have allowed longer time for the Vetiver to establish further and may have helped. Very deep soil fill will still need structural/physical engineering work.

Nevertheless, the results are so encouraging that the owner intends to repeat and expand the use of Vetiver and has offered additional and increased amounts of funding for my future observations.

PHOTO 46. GROWTH OF VETIVER ON FILLED EARTH




(a) General view of experimental site.

Photo taken: 19/9/1990 (Ref: 18/1990)



(b) The filled-earth bunds have collapsed after the heavy rain.

Photo taken: 14/10/1990 (Ref: 20/1990)

## 4.3 Cut earth

*Source: First Progress Report, D-III*

The value of Vetiver on cut-earth of highway embankments, etc are of interest. An experiment was carried out in a co-operating estate using an area of 150 metre width. Photo 47 shows a general view with the details given below. It also tests two densities of planting. The main study will be on:

The growth of Vetiver and formation of hedgerows. Surface soil erosion as measured by wooden pegs.

Early observations suggest that plants grown on the top terrace with some topsoil was much more vigorous when compared to those with only sub-soil. In the later cases, while the plants established "successfully" their growth was slow and stunted (Photo 48a and 48b).

This experiment is continuing.

**PHOTO 47. GROWTH OF VETIVER ON CUT-EARTH (1)**



General view of trial.

Planted: 1/10/1990
Photo taken: 23/12/1990 (Ref: 24/1990)

Terrain: Cut-earth of 120-metre width
Plot size: 10-metre width
Design: Randomized blocks
3 Treats x 4 Reps

| Treatments | Vertical Ht. | Distance Between Plants |
|---|---|---|
| T-1 | 2 m | 15 cm (6") |
| T-2 | 2 m | 30 cm (12") |
| T-3 | Control | |

Field Arrangement

| Rep 1 | Rep 2 | Rep 3 | Rep 4 |
|---|---|---|---|
| T-2 | T-1 | T-3 | T-2 |
| T-1 | T-3 | T-2 | T-3 |
| T-3 | T-2 | T-1 | T-1 |

PHOTO 48. GROWTH OF VETIVER ON CUT-EARTH (ii



(a) General view of trial after 4 months



(b) The growth of plants on the sub-soil is poor
The top-most hedgerow grows much better.

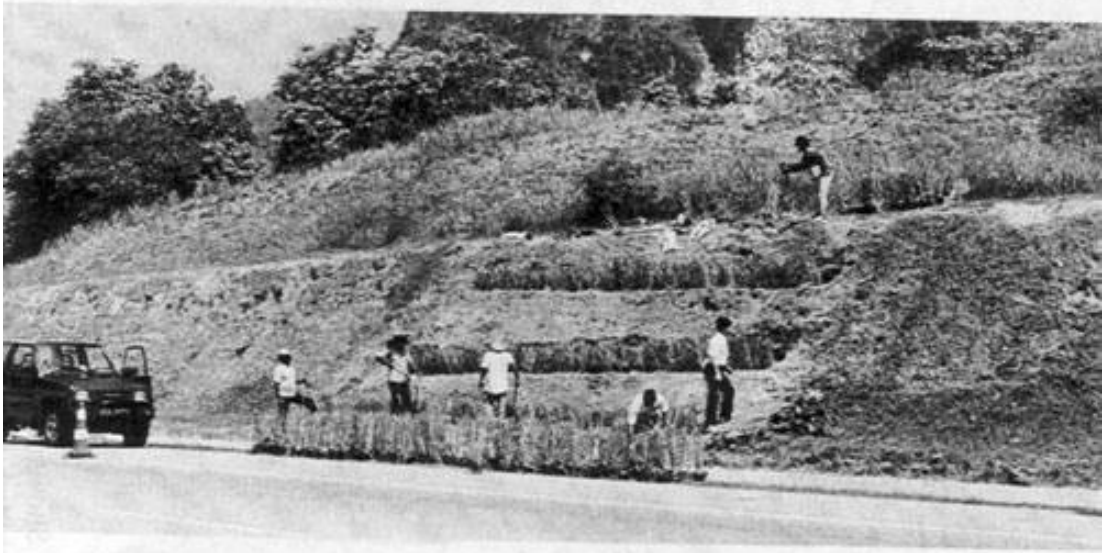
Planted: 1/10/1990
Photo taken: 3/2/1991 (Ref: 4/1991)

## 4.4 Highway embankments on very difficult soils

*Source: Second Progress Report, 5.2*

A small stretch of the North-South Highway near Taiping, Perak Darul Ridzuan, was specially selected because the maintenance engineers had failed to establish any grass covers despite repeated attempts. The following photos highlight the planting of Vetiver hedgerows and the good results. The tops of the Vetiver hedgerows grew well. Excavation of the two difficult soil types in this small area showed that Vetiver roots will seek out any weak spot in the soil. Despite the rather poor root system, highway engineers are most impressed by the performance of these Vetiver hedgerows to trap soil-wash and other debris from polluting the drain. Also by slowing down the run-off, the hedgerows have allowed other grasses to grow where they were not able to earlier.



*Photos 10a & 10b.* Show the planting of the *Vetiver* hedgerows on the highway embankment.

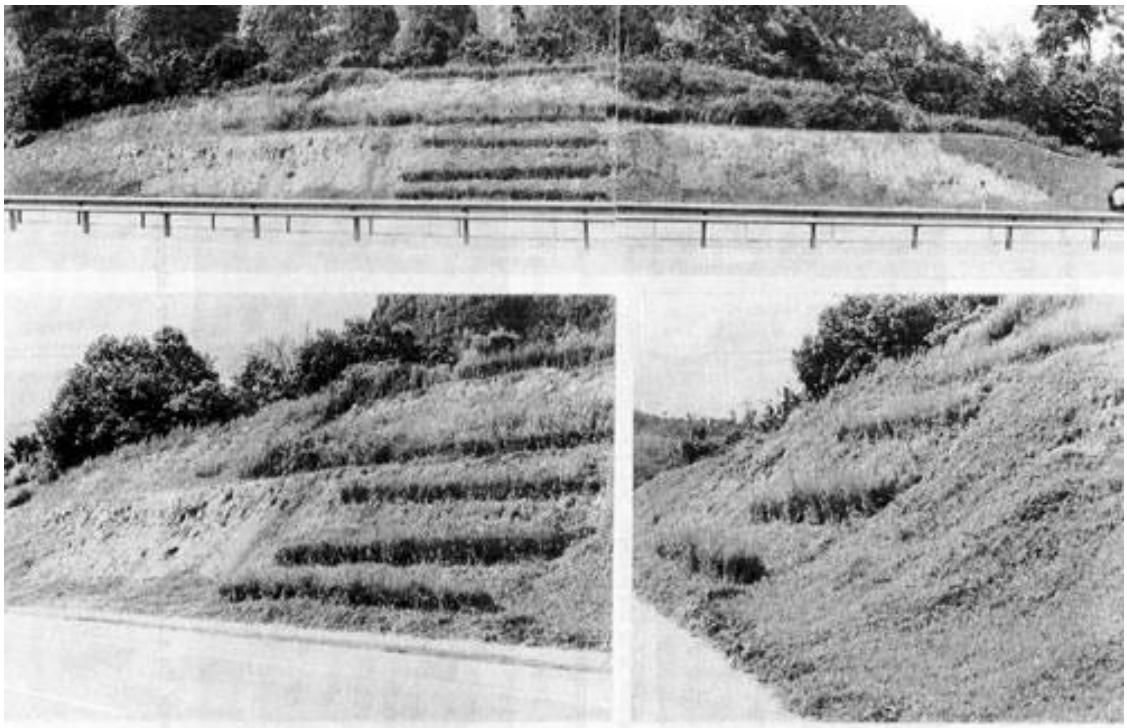


*Photo 11.* Shows the experimental site after 8 months. The parts of the embankment not protected by *Vetiver* hedgerows have eroded further. Note the *Vetiver* hedgerows have encouraged the growth of other vegetation below them.





*Photos 12a & 12b.* Site A: Show excavation of the soil to study the root system of *Vetiver* hedgerows. The soil was so hard that a heavy oil palm harvester had to be used.

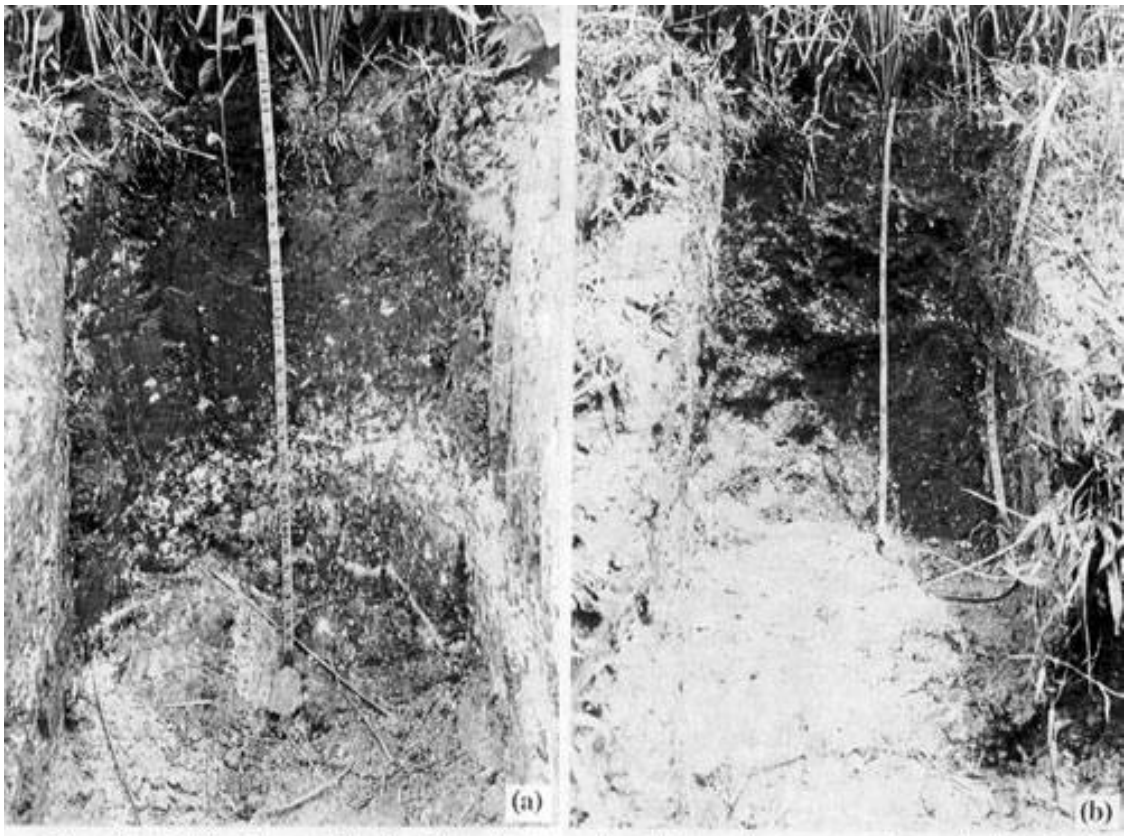
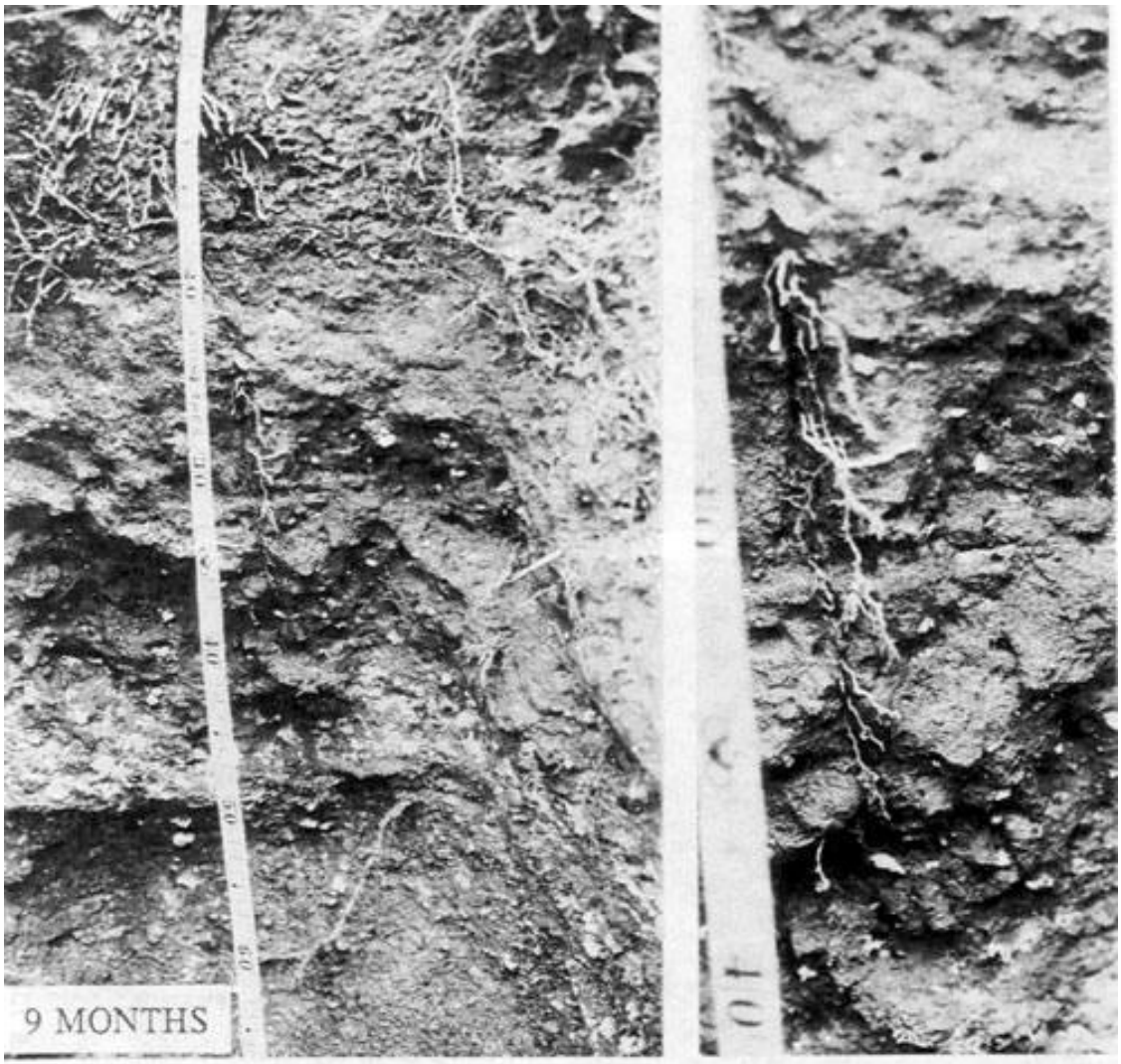



*Photo 13a & 13b.* View of Site A. *Photo 13a* shows the soil exposed after excavation and shaved with a heavy oil palm harvester. The roots shown were those originally in the polybags, virtually no new roots was observed in other places. *Photo 13b* shows the exposed roots after washing.




*Photos 14a & 14b.* Site A: Note the small amount of roots. The soil is so hard that *Vetiver* roots cannot grow; it only seeks its way through the "cracks" in the soil.

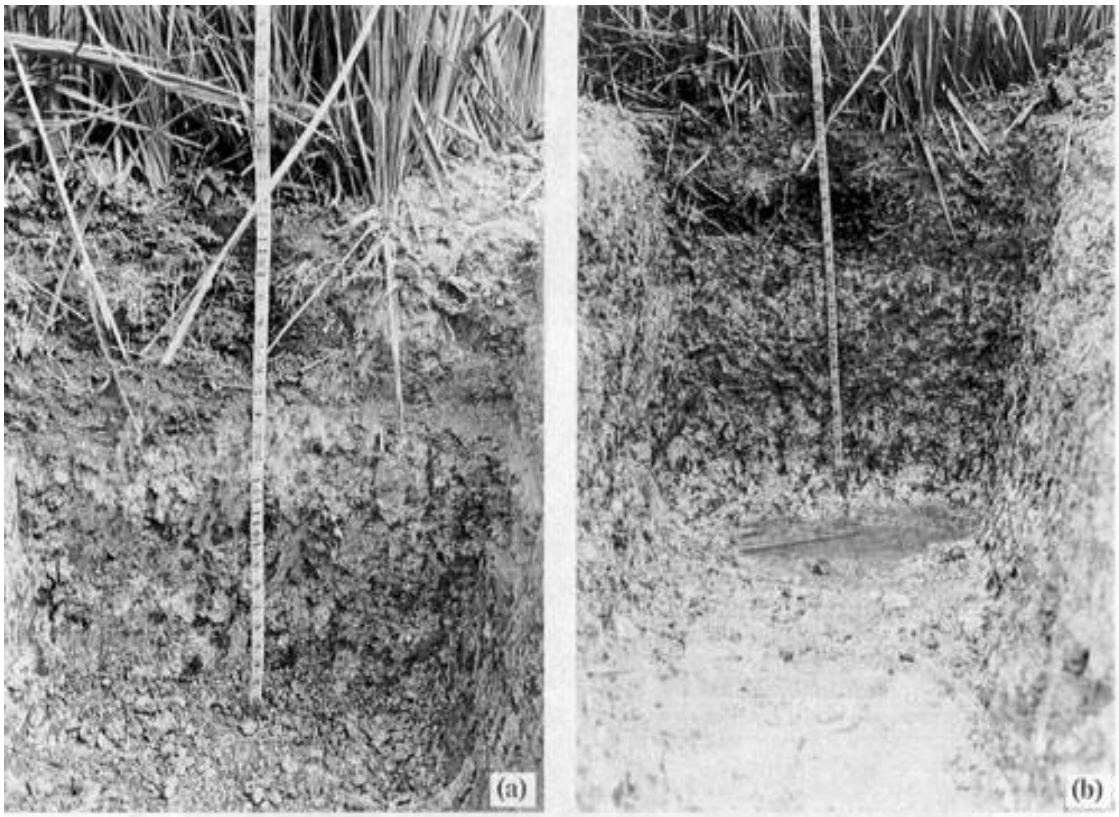
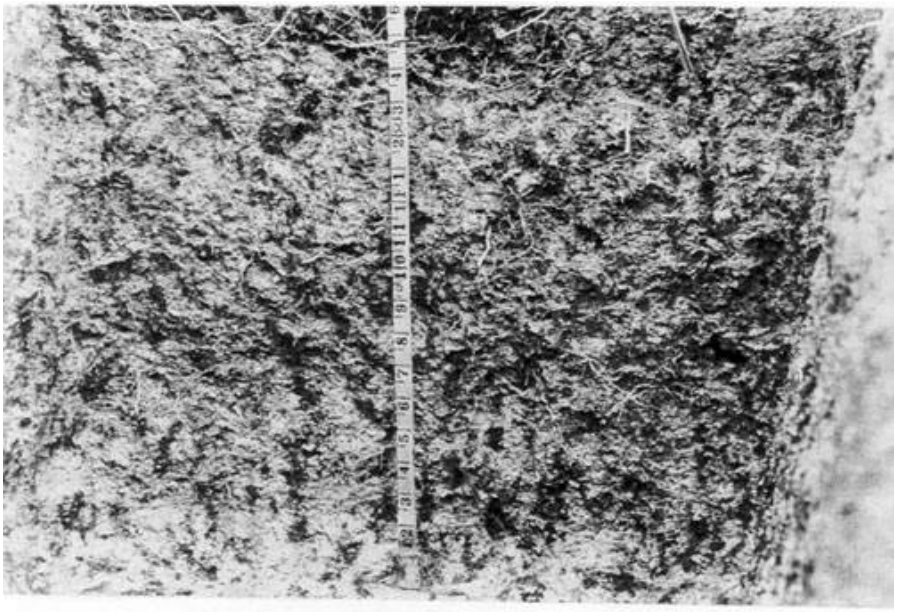



*Photo 15a & 15b.* View of Site B. *Photo 15a* shows very few roots after excavation and shaving with an oil palm harvester. *Photo 15b* shows the soil after washing. More roots are observed.





*Photos 16a & 16b.* Site B: Close-up photos showing the difficult soil type filled with iron oxides. Again, the *Vetiver* roots search their way through the weak spots. Highway engineers are impressed by this characteristic of *Vetiver* roots.




*Photo 17a.* A general view at 13 months after planting. Note the more extensive erosion at the unplanted area of the embankment.




*Photo 17b.* Note the wrong planting at the lowest row; it should have been planted lower, just next to the drain.

## 4.5 Excavation: trapped soil, hedgerow growth and roots

*Source: Second Progress Report, 5.3*

Excavations at various sites were done to study:

The soil trapped by Vetiver hedgerows in cross-sectional soil profiles. The dynamics of the growth of Vetiver hedgerows, and The root system.

A video recording was taken at various stages of the excavation with detailed commentaries. Readers are referred to the following tape:

| Subject | Tape No. | Point of Location (Hrs/mins/Secs) |
|---|---|---|
| Excavation | 2 | 0h.00m.00s. |

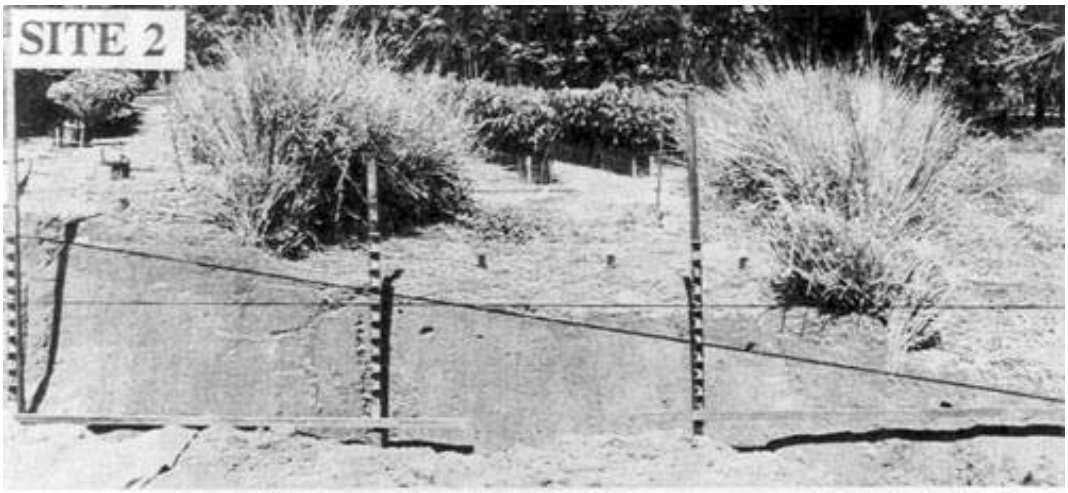
The attached photos serve to highlight certain special features of the Vetiver hedgerows.

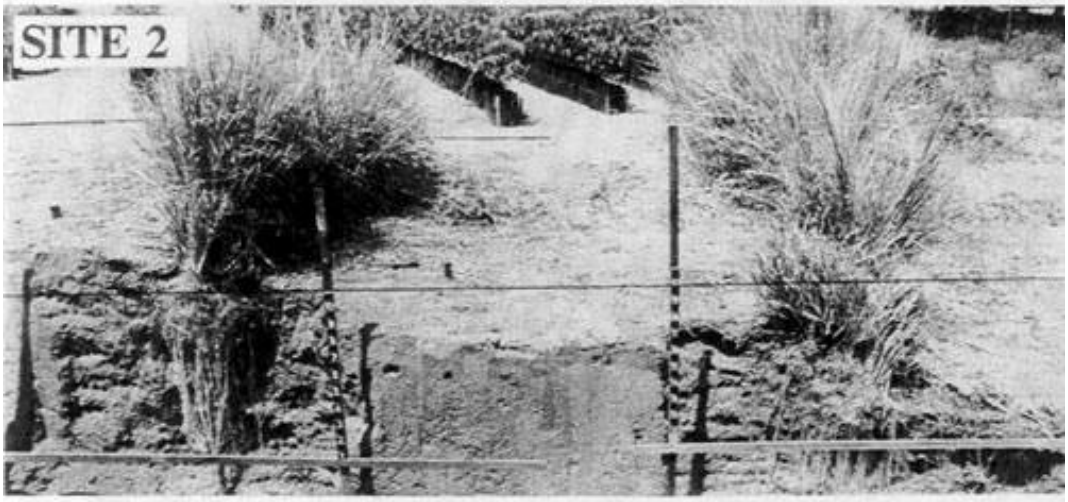






*Photos 18a & 18b.* Site 2: This involves two hedgerows of 23 months. A back-hoe was used to dig a pit (42' x 10' x 4') through the centre of the hedgerows. The gradient of this site is 11%.




*Photos 19a & 19b.* Shows the cross-sectional profile of the soil under the 2 hedgerows which are 23 months old. To expose the different soil textures and colours require careful shaving with oil palm harvester. The different colour tones allow the original slope to be traced. The horizontal poles and the vertical measuring poles are mounted using a carpenter's spirit level for precise placement. Note the soil trapped on the up-slope sides of the 2 hedgerows and the soil erosion on the down-slope of the hedgerows.




*Photo 20a.* Site 2: This shows the upper hedgerow. Note the amount of top-soil trapped on the up-slope. All the top-soil on the down-slope side has been washed away.

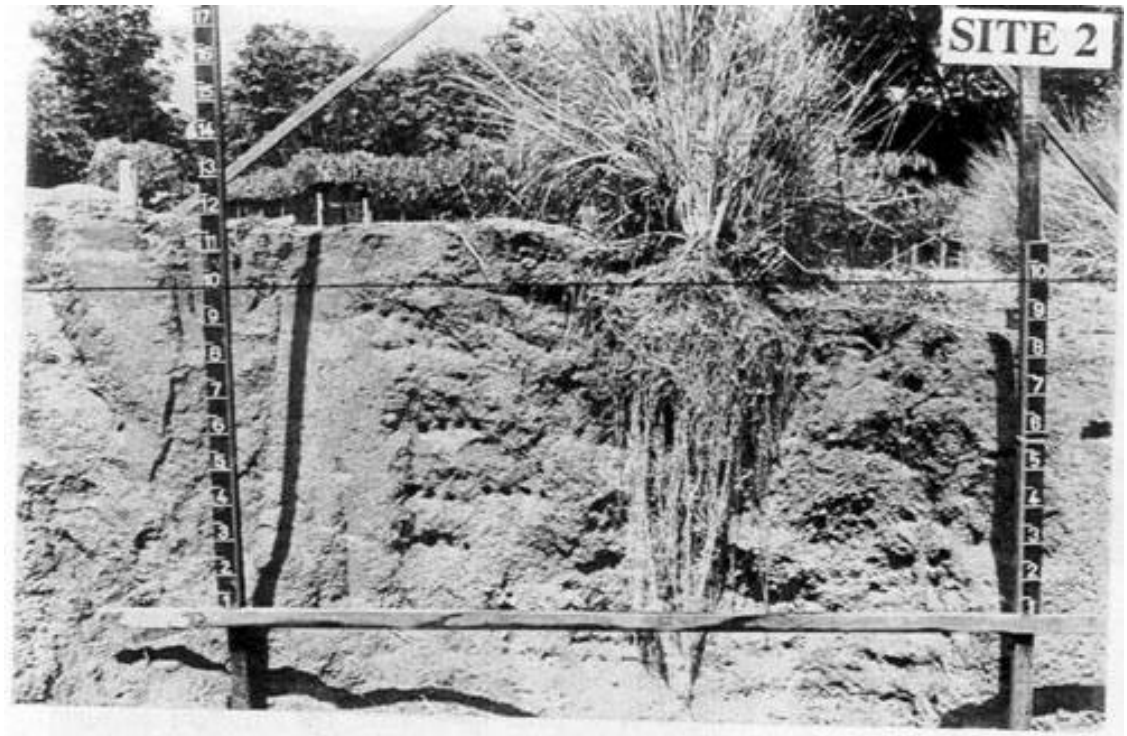



*Photo 20b.* Site 2: This shows the upper hedgerow after the roots are exposed by washing. Note how the roots grow mainly downwards rather than sideways.

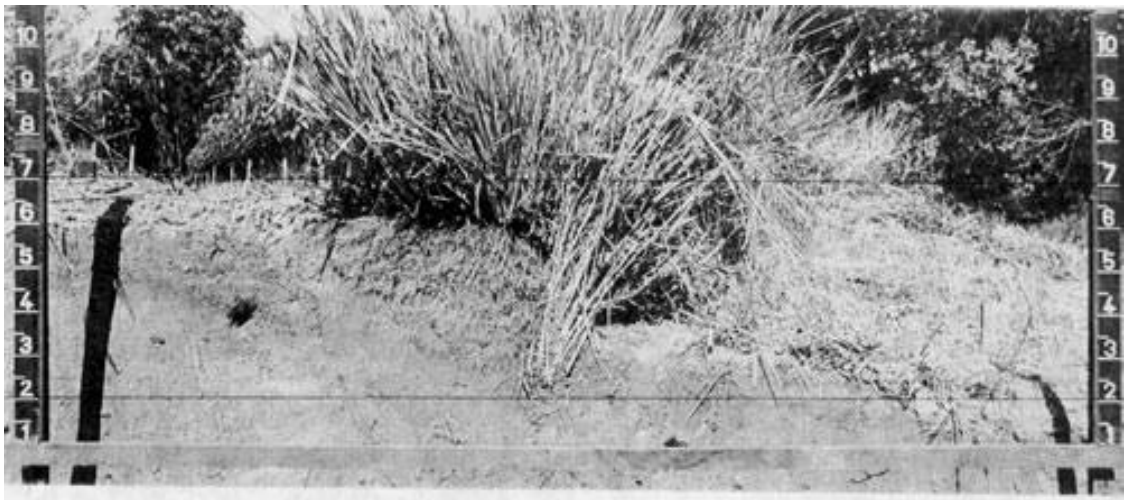


*Photo 21a.* Site 2: Soil built-up on the up-slope side is clearly illustrated in this close-up transverse view of the lower hedgerow. Note how the expanding hedgerow adjusts and climbs with the accumulating soil-wash to match the the level of the new soil surface.

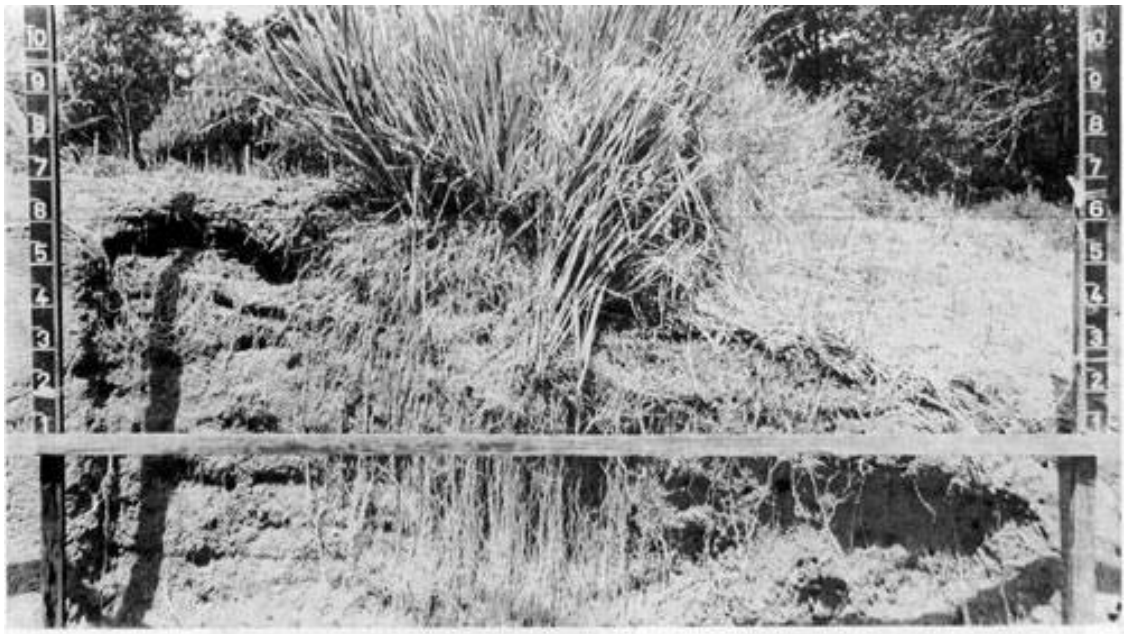


*Photo 21b.* Site 2: The massive root system of this lower hedgerow is exposed after washing. The curtain of fibrous inter-twining roots expands as the hedgerow widens. Note again, the manner in which off-spring tillers, from nodes of culms, are produced progressively higher, riding the crest of the ever-changing soil surface.

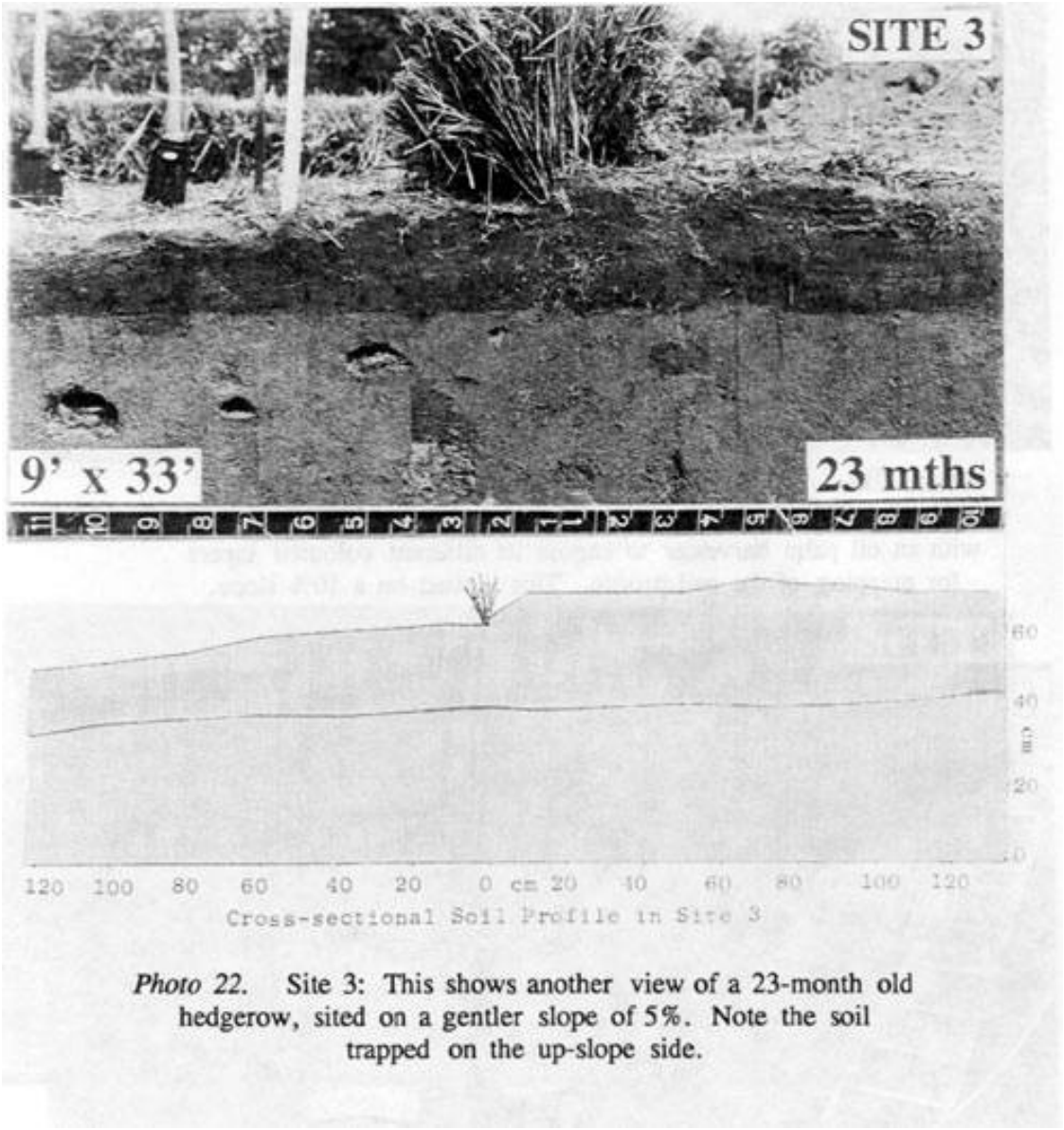


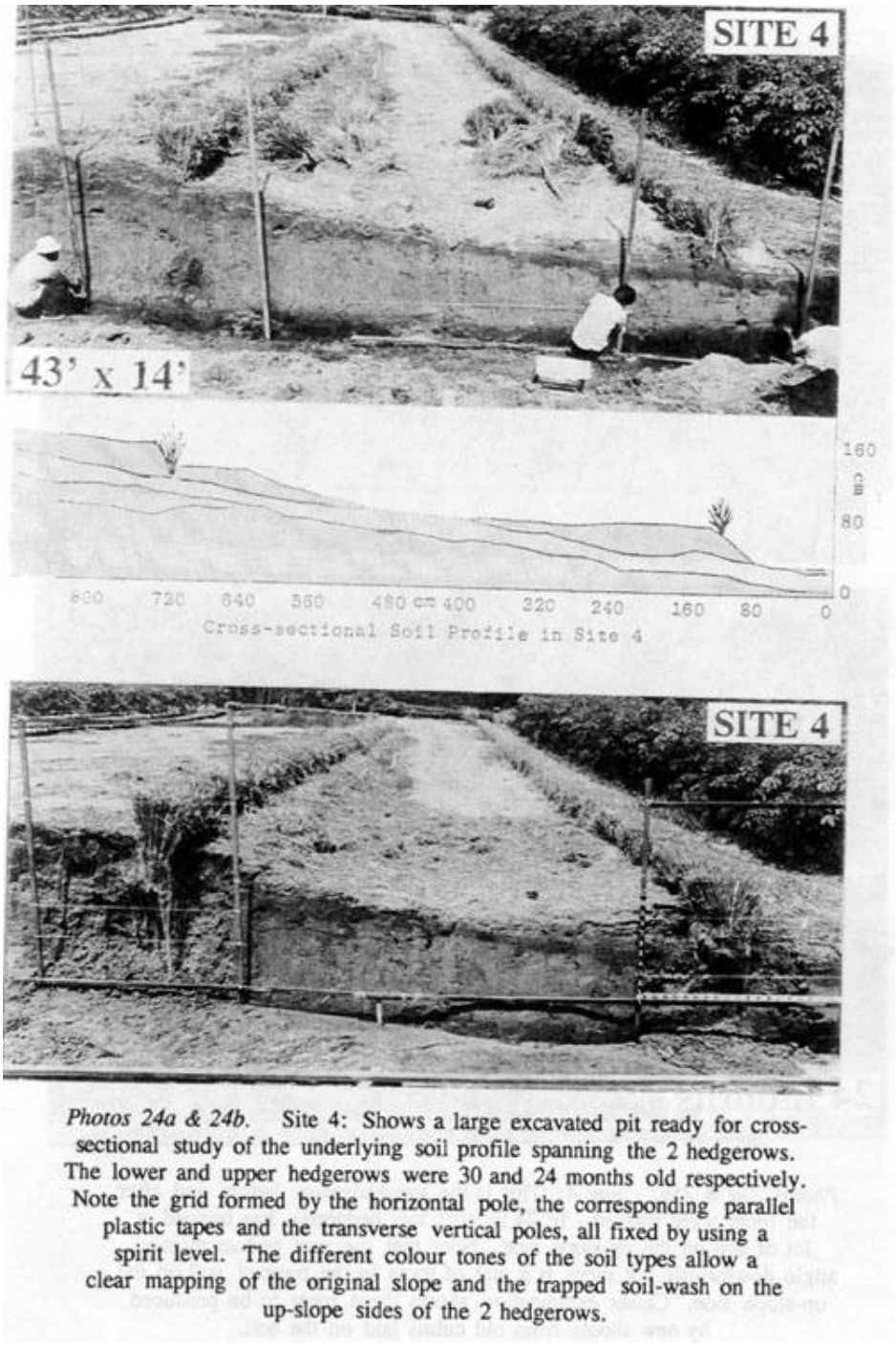

*Photo 22.* Site 3: This shows another view of a 23-month old hedgerow, sited on a gentler slope of 5%. Note the soil trapped on the up-slope side.



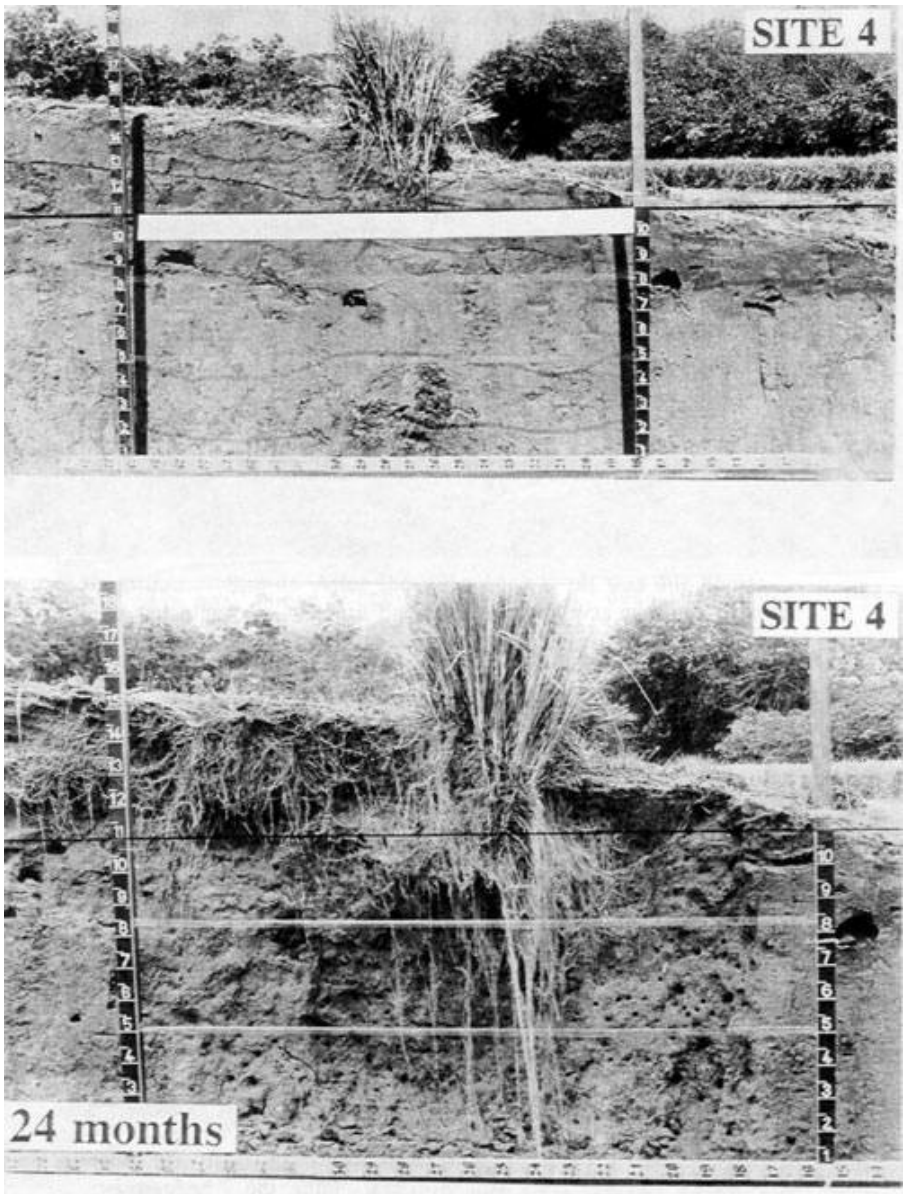
*Photo 23a.* Site 4: After the 43' x 14' x 8' pit was dug across another 2 hedgerows, using a backhoe, the soil was carefully shaved with an oil palm harvester to expose its different coloured layers for mapping of the soil profile. This is sited on a 10% slope.




*Photo 23b.* Site 4: After mapping the soil profile, the roots are carefully exposed by washing.




*Photos 24a & 24b.* Site 4: Shows a large excavated pit ready for cross-sectional study of the underlying soil profile spanning the 2 hedgerows. The lower and upper hedgerows were 30 and 24 months old respectively. Note the grid formed by the horizontal pole, the corresponding parallel plastic tapes and the transverse vertical poles, all fixed by using a spirit level. The different colour tones of the soil types allow a clear mapping of the original slope and the trapped soil-wash on the up-slope sides of the 2 hedgerows.




*Photos 25a & 25b.* Site 4: This is the top hedgerow before and after the roots were washed. In 24 months this hedgerow has trapped a lot of soil on the up-slope side. Note that the root system mainly angle downwards but there is a mat of roots in the trapped soil on the up-slope side. Closer examination shows these roots to be produced by new shoots from old culms laid on the soil.

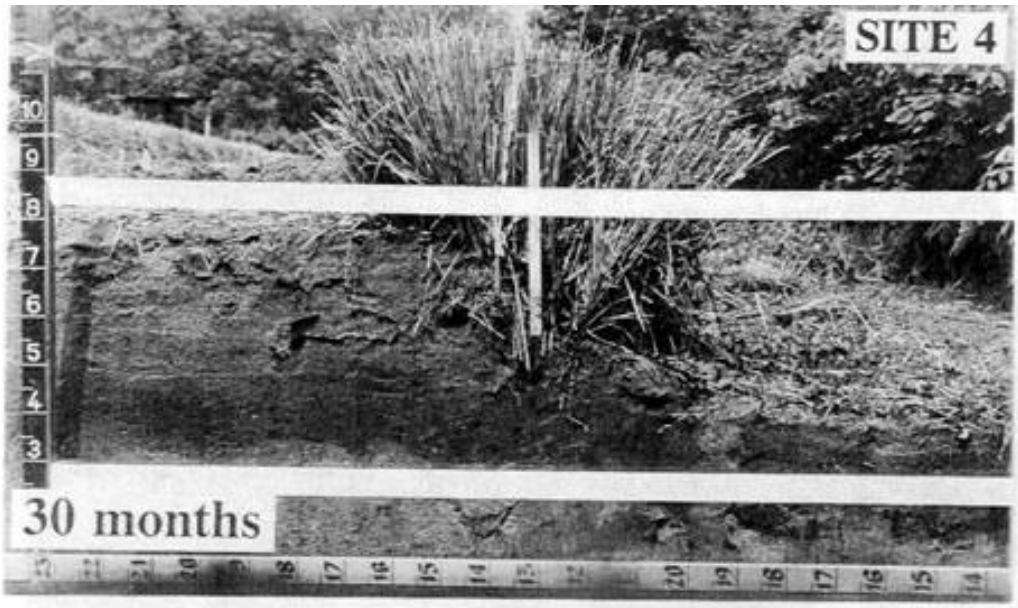



*Photo 26.* Site 4: This shows the lower hedgerow. The wooden peg was buried in the hedgerow at the time of planting, with the painted portion above the ground to measure the soil trapped by the hedgerow. This 30 months old hedgerow is neat and compact with lots of good active culms; there is no dead centre. Note how the crown of the hedgerow climbs with the accumulation of trapped soil; this self-adjustment ensures that the hedgerow is not buried. The hedgerow is alive; it grows taller as the silt builds up. It rises up and then bends to follow the surface soil being formed on the up-slope.




*Photo 27a.* Site 1: To expose the whole root of the *Vetiver* plant, a back-hoe was used to dig the pit (18' x 15' x 10') next to the 32 months old *Vetiver* hedgerow.

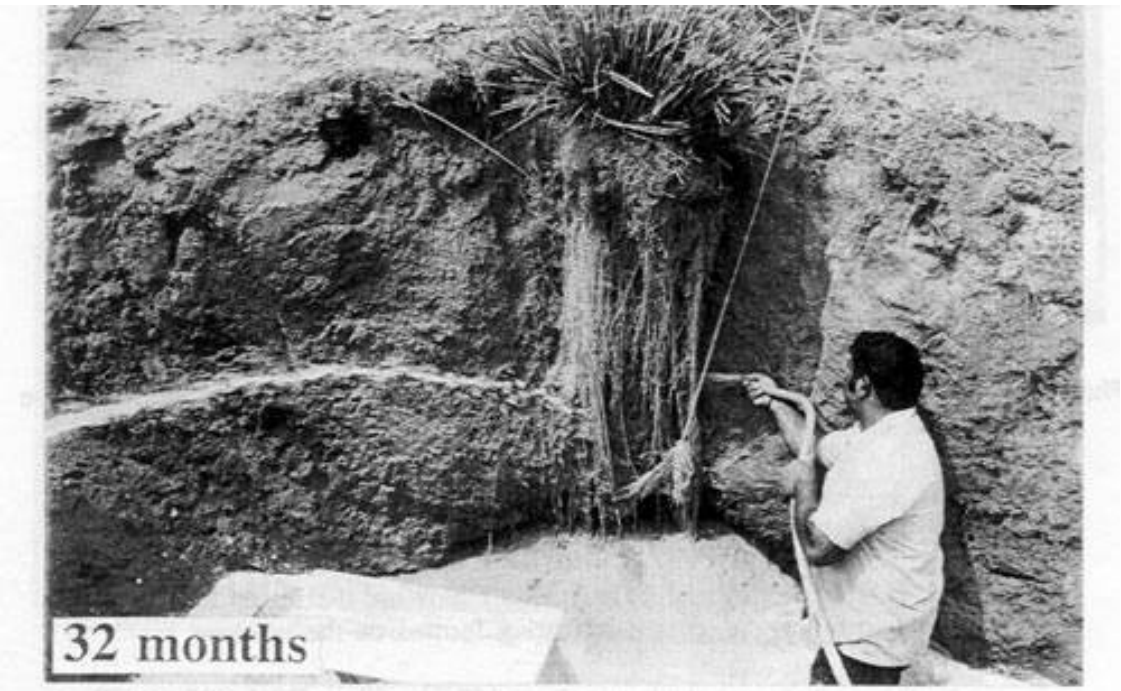



*Photo 27b.* Site 1: This shows the root exposed after careful washing. The root reached 2.6 m depth but thereafter, it was stopped by a hard-pan. Note the massive root system and that it angles downwards with virtually no side way expansion. Our attempt to remove and preserve these roots intact failed when the rope holding up the plant snapped and the roots were damaged. We shall try again!

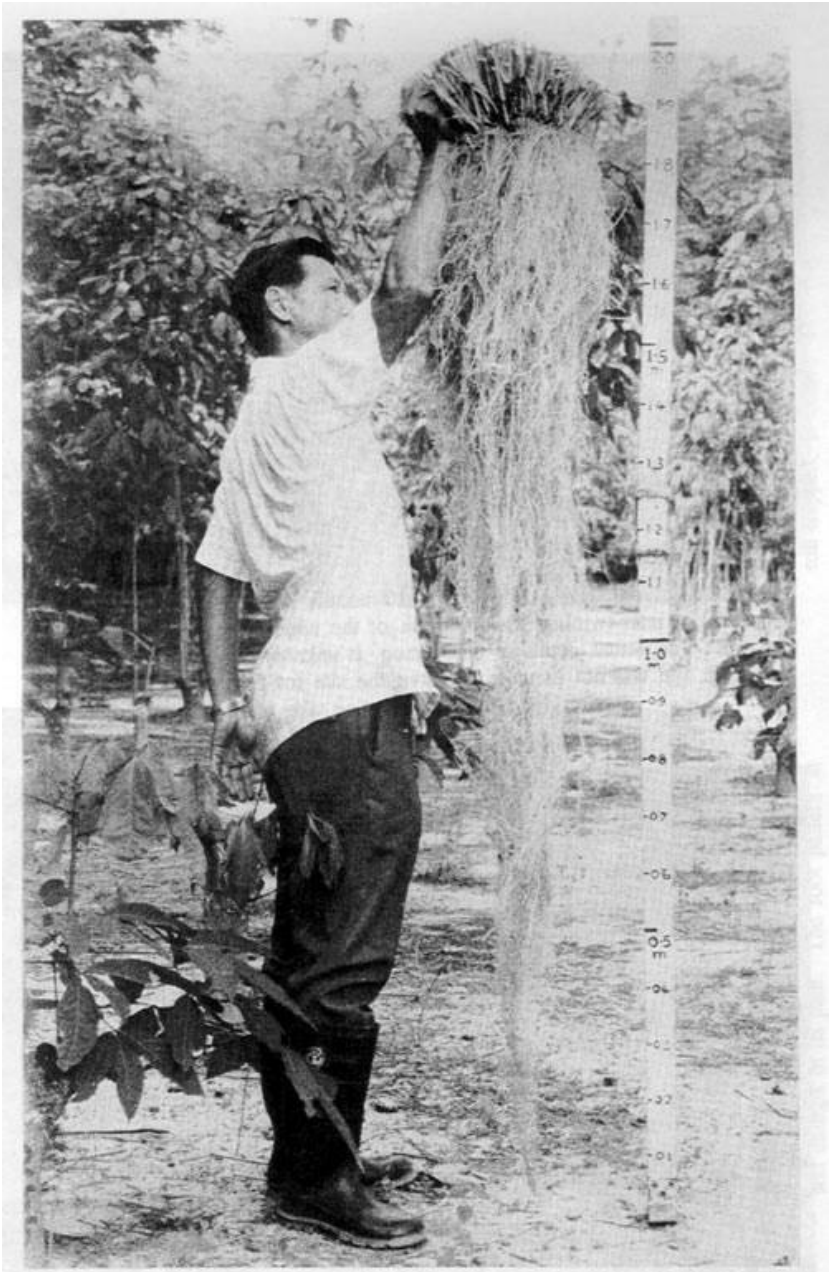


*Photo 28.* This is a 1 year old root system excavated from another site earlier. The root was estimated to reach 2 m. As expected, some roots at the deepest level were damaged during excavation; even so, this shows the massive root system of the *Vetiver* plant.

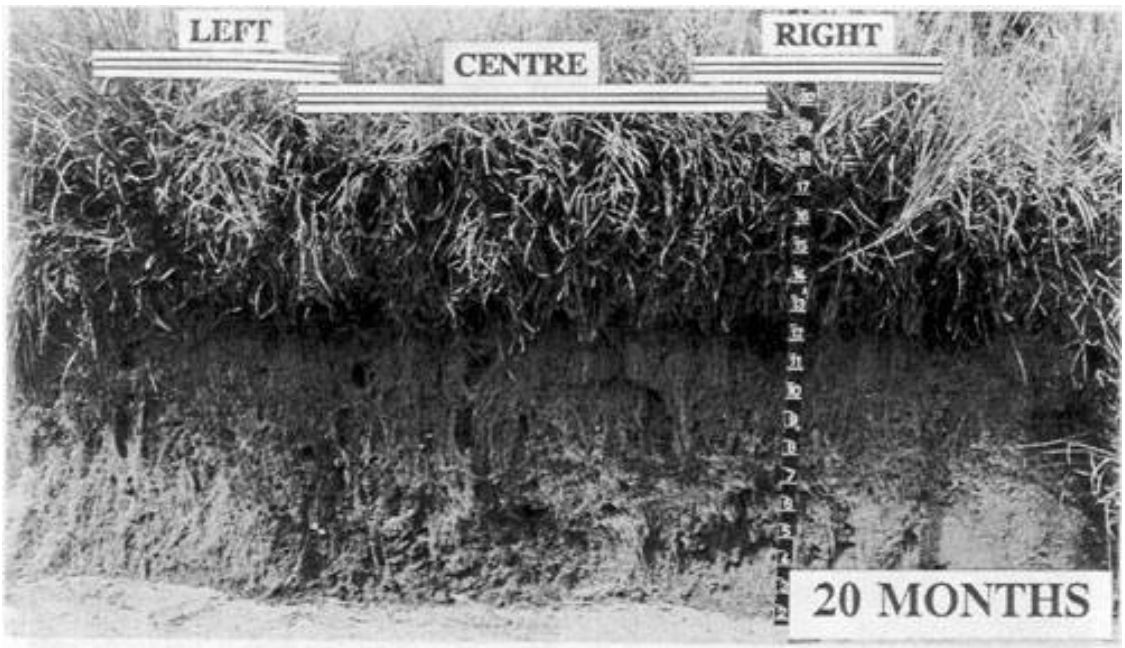



*Photo 29a.* This *Vetiver* hedgerow is 20 months old. Note only about 1 m depth of inter-twining "lace" curtain of the underlying root system is exposed. The actual depth of penetration is unknown as deeper excavation of the site was not done to preserve the site for future observations. Section for closer examination are marked.

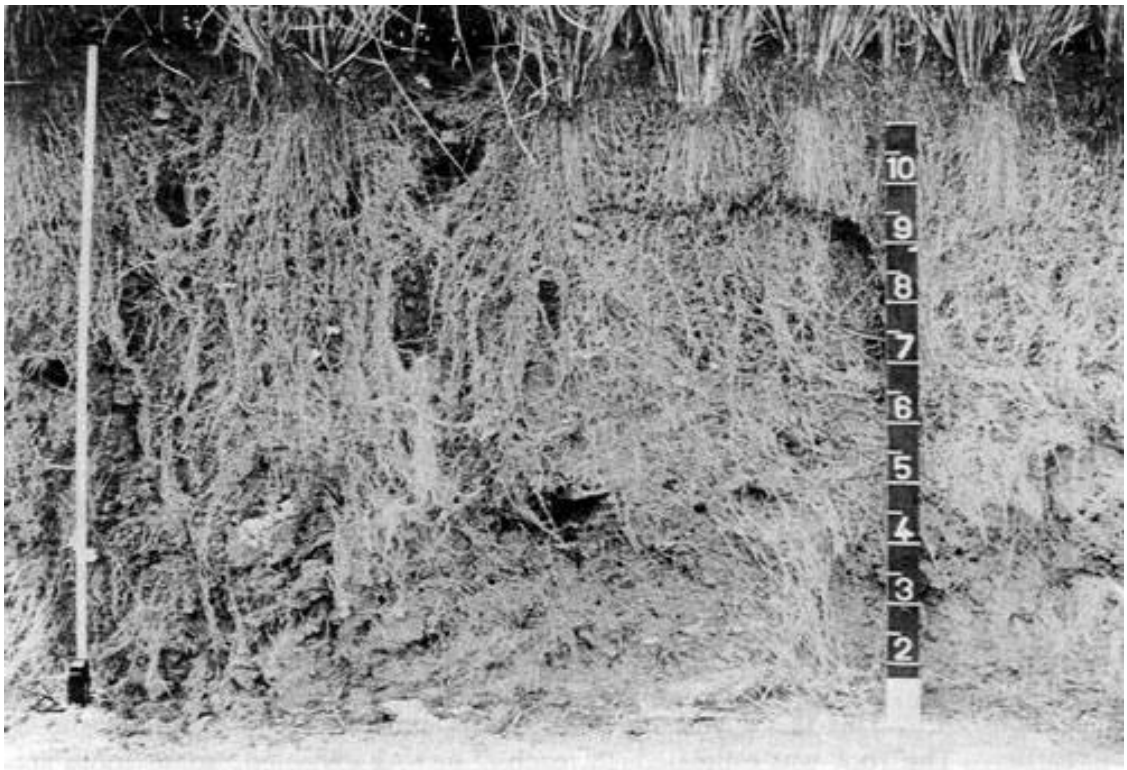



*Photo 29b.* Shows the close-up view of the centre section. Root growth is downward and angles out slightly in a cone formation.

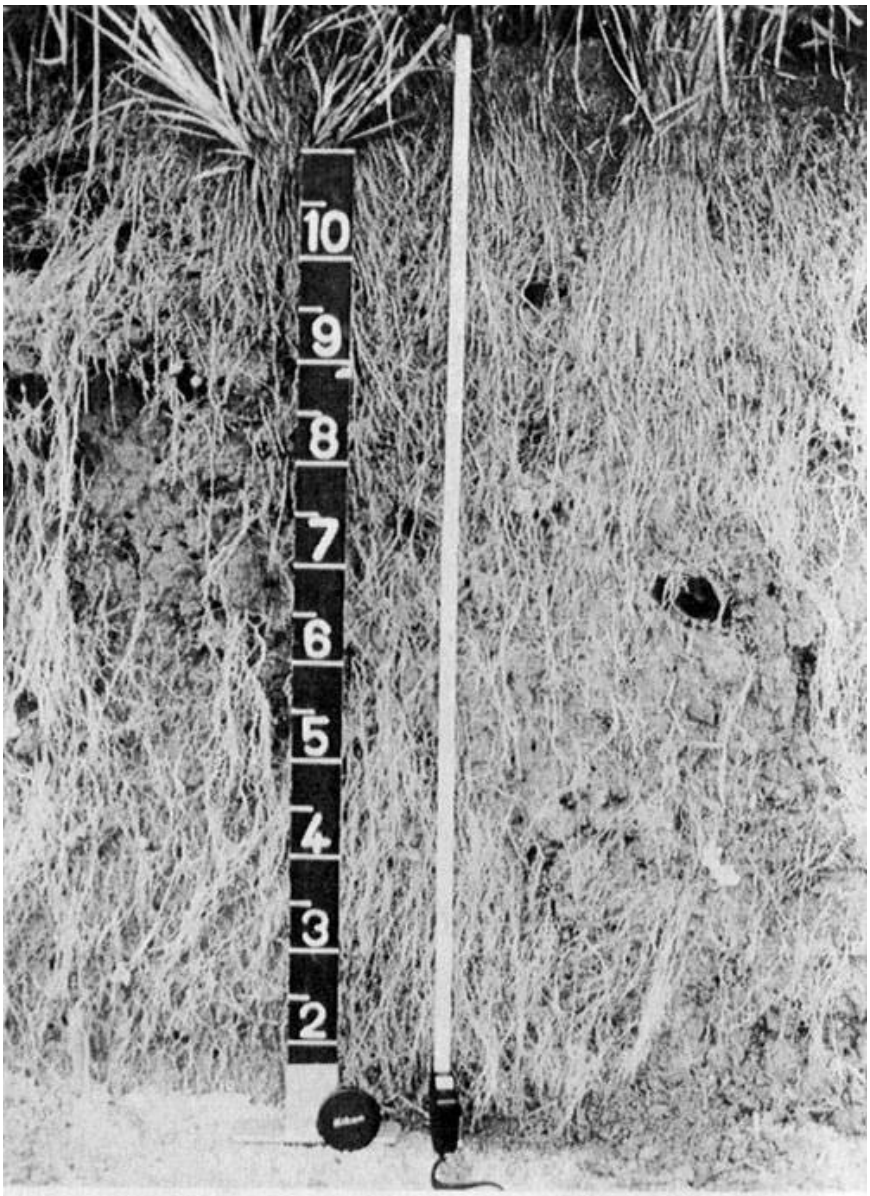



*Photo 29c.* Shows a close-up view of the left section. Root growth is downward, encasing soil clumps in its path. The root pattern at the base suggests penetration is much deeper.

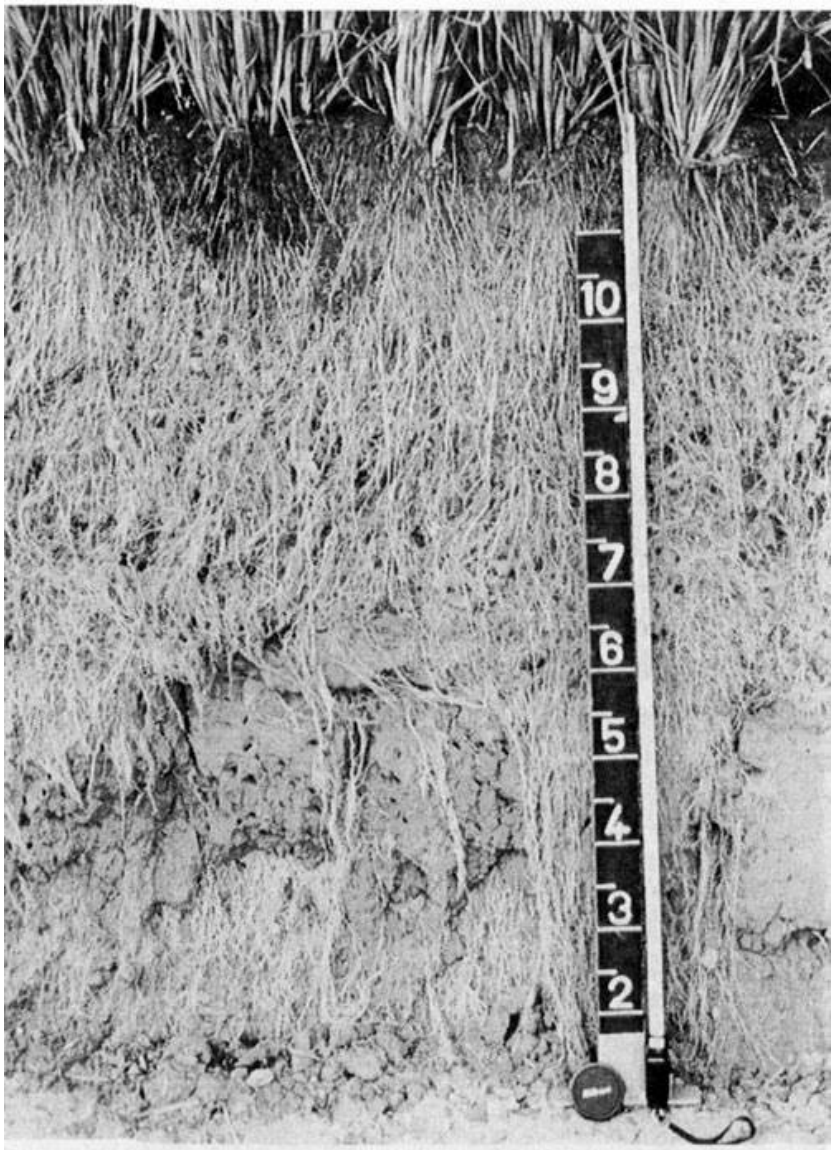



*Photo 29d.* Shows close-up of the right section. The inter-twining massive root system with soil trapped, is clearly seen. Note the inner curtain of roots squeezing out from the soil fizzure near the base.

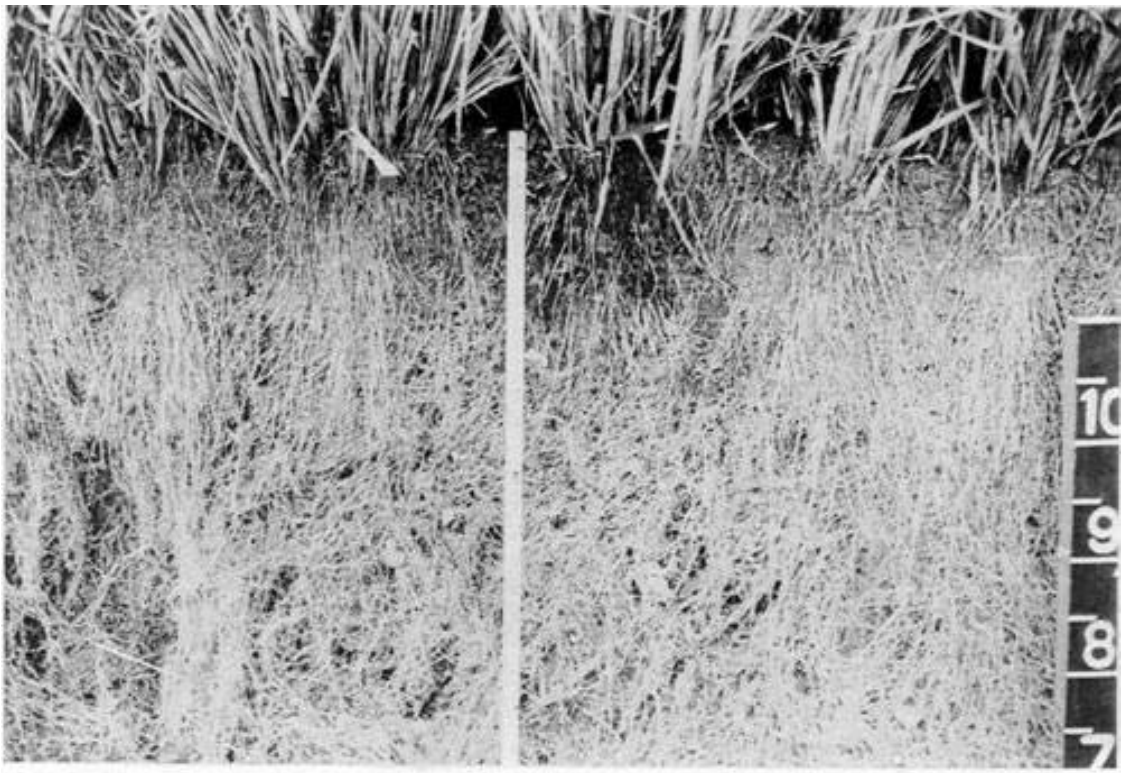



*Photo 29e.* Shows close-up of top portion of the right section. Growth is downwards and then inter-twines in an underground network with roots of neighbouring plants in the hedgerow, trapping soil clumps inside its' dense root system.

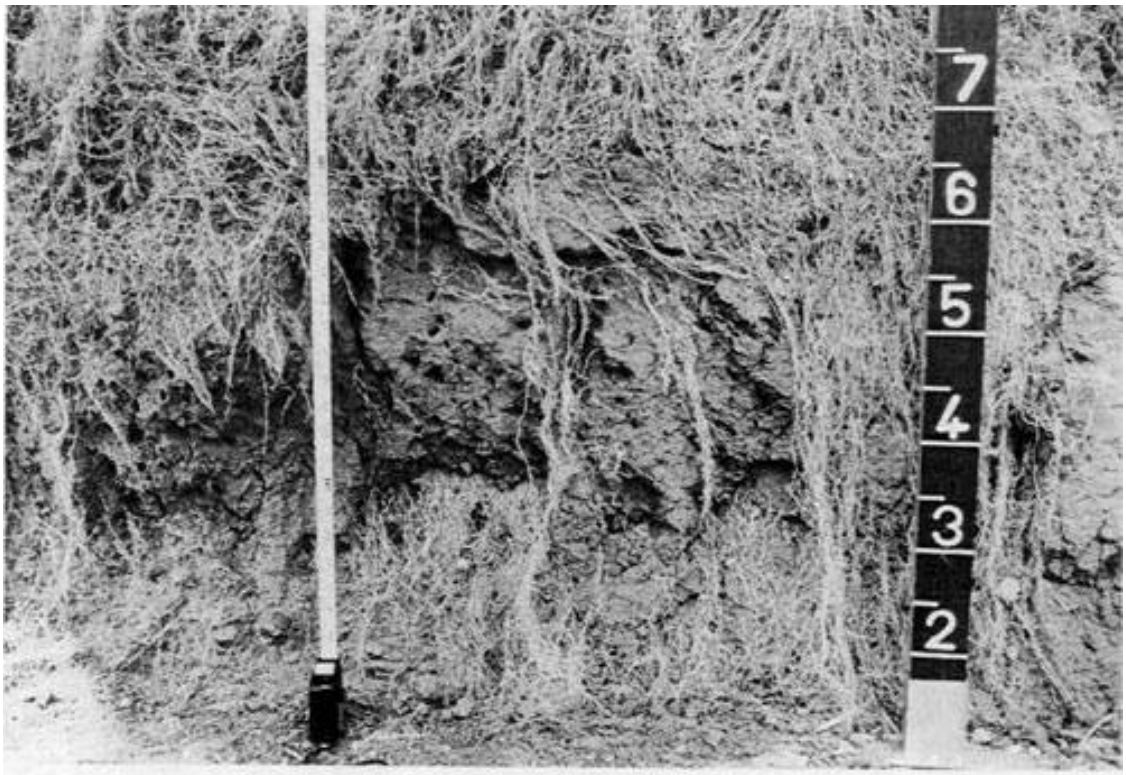



*Photo 29f.* Shows close-up of the lower portion of the right section. The inter-twining dense network of roots is continued. The inner curtain of roots is forming another network.

## 4.6 Resistance to fire damage

*Source: Second Progress Report, Part 5 and 5.1*

This part examines certain special characteristics of Vetiver hedgerows.

Resistance to Fire Damage: A trail in ex-mining land was severely damaged by 'bush' fire. Sequential examinations at weekly intervals show fast and good recovery. The video recording discusses the details of this. In this Report, a number of highlights are given in the following photo–essay. Growth in Highway Embankments with Very Difficult Soil Types: A very difficult area on a highway embankment was used to test this. These trial results are summarised in the following photographs, which clearly show that the Vetiver root system will seek out any weak point in a difficult soil structure. Excavations of Vetiver Hedgerows: Excavations were carried out to show the effect of Vetiver hedgerows on reducing surface soil erosion as well as to examine the root system. The video recording shows the results of these investigations. The photo-essay given from Photos 18 to 27 only highlight certain features. Layering in Vetiver Hedgerows: Vetiver was chosen for hedgerows because of its non-spreading characteristics. It is distinctive and compact and is an effective biological barrier for soil erosion and moisture conservation. However, under certain conditions, it may be desirable to produce blanket cover for the whole area. By layering, new shoots are produced from the culm and we can make Vetiver grass into a runner. This section examines how we can seduce nature to behave in such a way as to suit our needs.

A trial was set up to investigate the possibility of using Vetiver to control soil erosion in ex-mining land and also to rehabilitate such disturbed areas. The early results of this trial was most promising ( Photos 1&2 ). But a 'bush' fire in the site has damaged the trial severely. This attempts to trace the recovery from that fire.

Vetiver hedgerows recovered rapidly from fire damage. The older and dry parts of the Vetiver clumps were burnt, but culms that were green and active were only damaged in the upper portion. The lower parts, near the crown and partly buried in the sand, were not burnt. Similarly, there was little sign of

damage to the massive root system buried in the ground. Within a week, new tillers were produced from the unburned portion of culms. By 4 weeks, all clumps have recovered, with vigorous new growth.

The photographs in the following pages illustrate the various stages of recovery. More details are found in the video recordings.

| Subject | Tape No. | Point of Location (Hrs/Min/Secs) |
|---|---|---|
| Resistance to Fire Damage | 2 | 0h.41m.16s. |

Which feature time sequence photos of more sites of interest. There is also a life-recording of the recovery at six months after the fire.



*Photos 1a & 1b.* Show two views of the trial on ex-mining land to test soil erosion control by *Vetiver* and to attempt to rehabilitate such land.

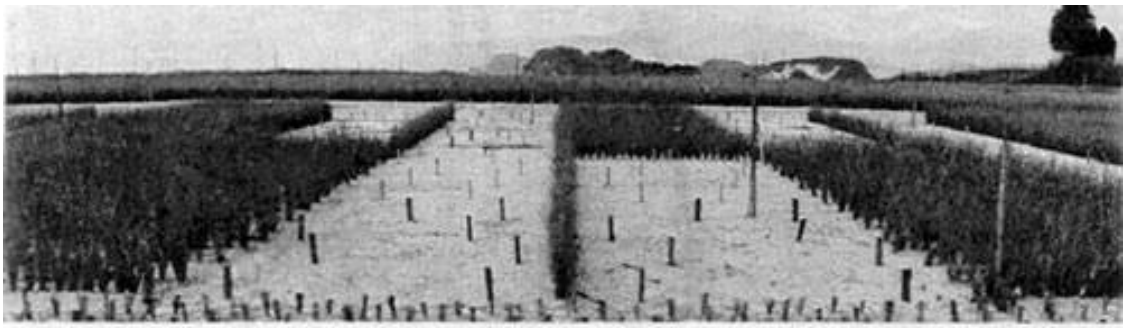


*Photo 2a.* Shows the good growth of *Vetiver* after only 13 weeks.

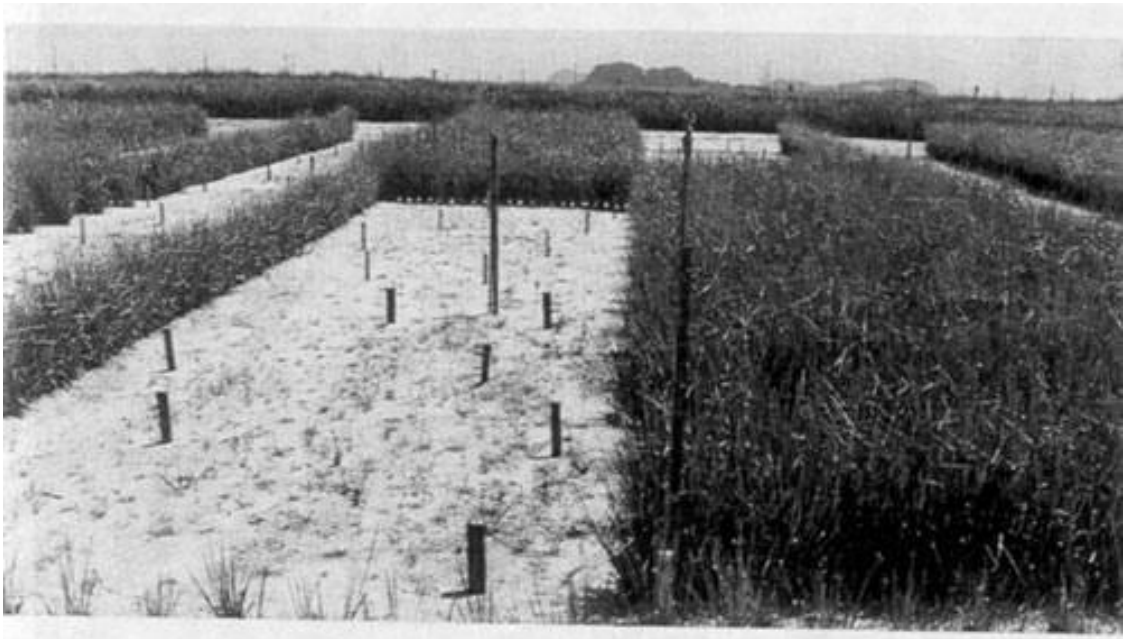


*Photo 2b.* Shows the *Vetiver* hedgerows fully established and trapping soil-wash. In addition, they have slowed down the surface run-off, thus allowing other plants to establish. Note the use of overhead sprinkler and application of slow release fertilizer (Kokei - 6 gm) at 3-monthly intervals.







*Photo 3a & 3b.* Two views of the same trial on ex-mining land showing the extensive fire damage.




*Photo 4.* The tops were cut about one week before the fire and these dried toppings may have contributed to the 'bush' fire.




*Photo 5.* Close-up of one clump showing the extent of the burn.




*Photo 6a.* At 1 week after the burn, new tillers were sprouting.




*Photo 6b.* At 4 weeks there were more fresh green tops than the brown burnt culms.




*Photo 7a.* General view at 2 weeks after the fire. Note the good amount of freshly grown tillers.




*Photo 7b* General view at 4 weeks after the fire. Note that there were more greens of newly produced tillers than the old brown burnt culms.

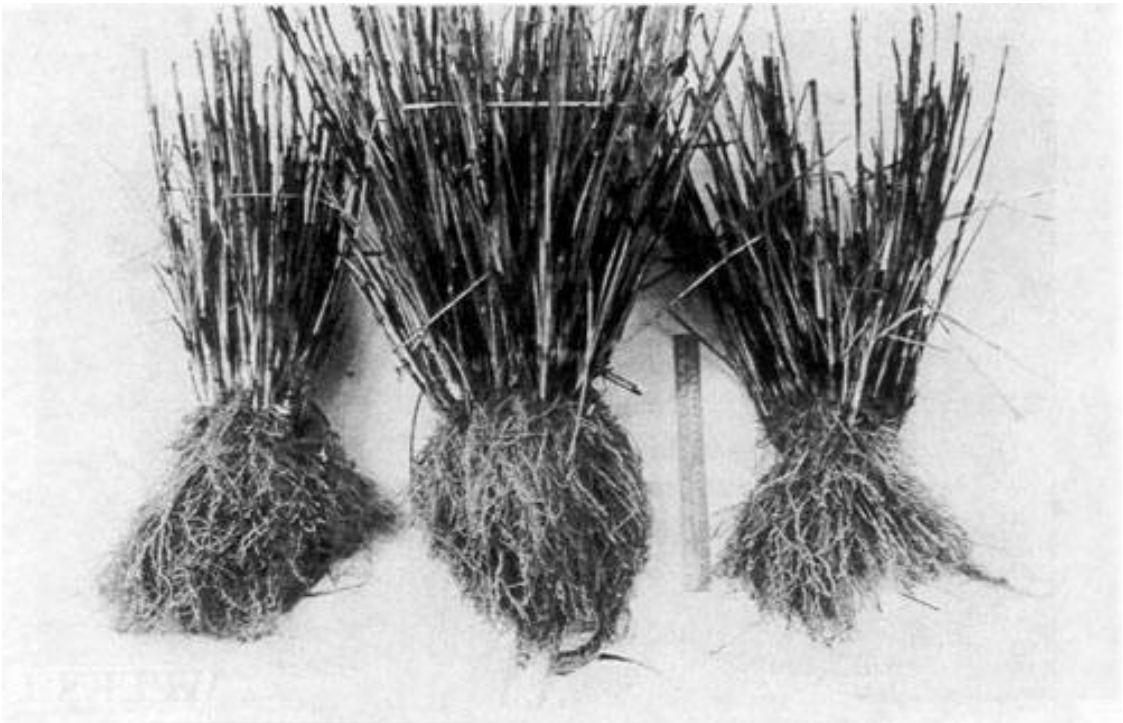


*Photo 8a.* Three clumps at 1 week after the fire. Note the crowns which were buried were not burnt. Similarly, note the good condition of the roots.

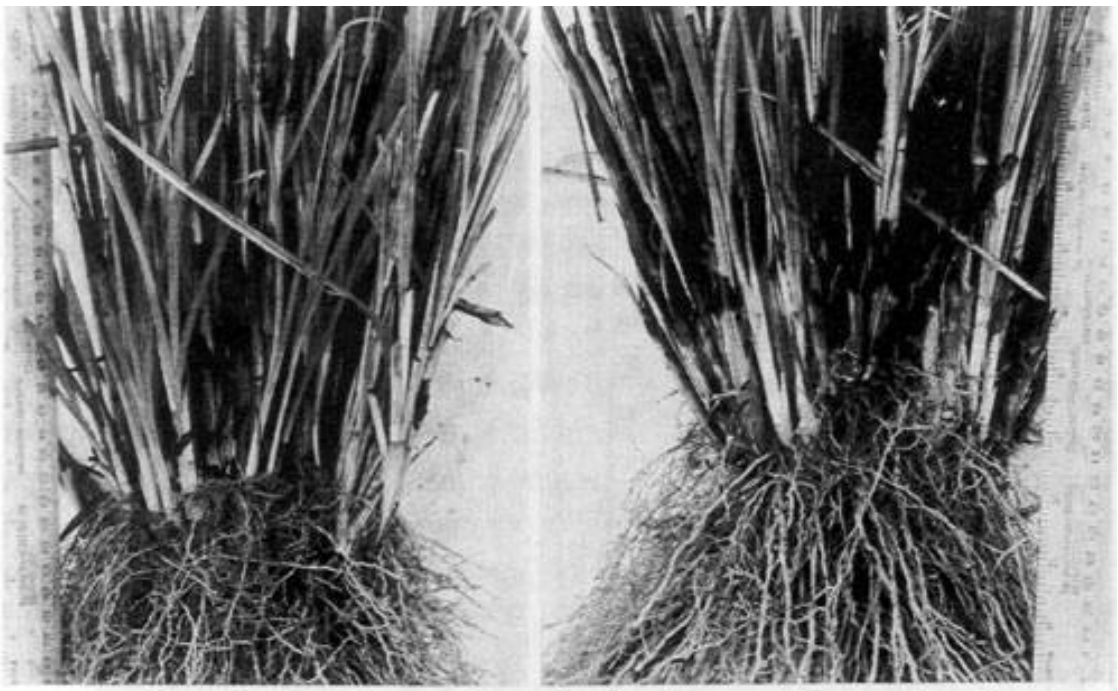


*Photo 8b & 8c.* Close-up photos showing that new tillers are formed. Note the burn does not extend down to the top part near the collar and to the roots as both portions were buried in the ground and kept moist.



*Photo 9a.* Close-up of one clump shown in *Photo 8a* after 6 months. Note the many vigorous tillers produced.



*Photo 9b.* Section through the centre of the clump in *Photo 9a* Note the remains of some old burnt culms and how the new tillers have emerged from those unburnt parts lower down the crown.

# 5. Vetiver with rubber and other uses on the farm

## 5.1 Vetiver as in-situ mulch in rubber plantings

*Source: Second Progress Report, Part 3*

The good growth of Vetiver, under many adverse conditions, suggests it to be highly competitive. In a preliminary trial, Vetiver without regular slashing has been demonstrated to be competitive against Hevea ; the girthing of the young Hevea was depressed. On the other hand, this growth characteristic can be exploited for various used as in situ source for mulch when the tops are regularly slashed. Six experiments were set up to test this in three estates. These trials are sited in three estates as follows:

| Location | Trial |
|---|---|
| Sg. Chinoh Estate, Perak | 1 |
| | 2 |
| | 3 |
| Sg. Gapi Estate, Selangor | 4 |
| | 5 |
| Pinang Tunggal Estate, Kedah | 6 |

The experimental details are:

| | |
|---|---|
| **Trial 1** | **Alternate plots of linear planting of Vetiver hedgerows and legume covers were replicated three times. This is a large-scale observation area comparing the effect of mulching produced by the Vetiver hedgerows with normal estate practice.** |
| Trial 2 | The design is randomised blocks with four treatments and six replications. They are: T1 Control with legume covers T2 Linear planting of Vetiver, 6" apart. T3 Circular planting of Vetiver, 24" radius T4 Circular planting of Vetiver, 18" radius |
| Trial 3 | This is sited on steep slope. Vetiver is linear planted as hedgerows for mulch in a block flanked by commercial practice on either side. |
| Trial 4 | Trial layout is similar to that of Trial 1 but replicated five times instead of three. |
| Trial 5 | Double grouping of treatments in a 5x5 Latin square is adopted for this trial sited on hilly terrain. The treatments are: T1 Control – no Vetiver T2 Circular planting radius 24", 13 plants. T3 Circular planting radius 18", 20 plants T4 Circular planting radius 18", 10 plants T5 Circular planting radius 24", 26 plants |
| Trial 6 | This is sited in North Peninsular Malaysia with a very pronounced dry spell. The area is on a very steep land with very poor soil (Gajah Mati). The details of the trial is given below:Randomised blocks, seven treatments x nine replications: T1 Circular planting of Vetiver, 24" radius (26 plants) T2 Circular planting of Vetiver, 18" radius (20 plants) T3 Linear planting of Vetiver, 6" apart T4 Linear planting of Vetiver, 12" apart T5 Circular planting of Vetiver, 24" radius(10 Plants) T6 Circular planting of Vetiver, 24" radius (13 plants) T7 Control with legume covers. |

### RESULTS

The results are now discussed below:

### Trial 1

The starting of this trial was reported in the First Progress Report. Photos 1-4 show the Vetiver clumps at field planting and the luxuriant hedgerows formed at 9, 15 and 44 weeks after planting. The Vetiver hedgerows establish very rapidly. Note the sparse legume covers in the Vetiver plots, but the Pueraria

phaseoloides grows very well in the control plots. However later, the leguminous covers were shaded out by the Hevea canopy. Periodic measurements of Hevea plant girths and the increment derived are used as growth indicators. These are given in Table 1 . Analysis using t-test suggests the effect of Vetiver mulches on Hevea growth to be non-significant at four months after treatment. At ten months, mulching has shown positive effect in one block out of three. Both in relation to girth and girth increment over six (4-10) months. Measurements at 17 months show Vetiver planting to be beneficial in the same block but detrimental to Hevea growth in the other two blocks. The girth increment between 10-17 months shows Vetiver planting to suppress the growth rate of Hevea in these tow blocks also.

At 24 months, the Vetiver planting depresses the growth of Hevea ; this is also shown in the girth increment between 17-14 months.

The rounds of slashing of the Vetiver tips are as follows:

| Round | Interval (months) between slashing |
|---|---|
| 1 | 5 |
| 2 | 3 |
| 3 | 3 |
| 4 | 6 |
| 5 | 2 |
| 6 | 4 |

Because of labour constraint we were not able to carry out the schedule slashing at 2 – 2 ½ months intervals.

### Trial 2

The field conditions in this trial are illustrated in Photos 5 to 8 . Photos 5 and 6 show the Vetiver circular planting of 18 inches and 24 inches radius at time of establishment. Photo 7 shows the Vetiver plot of 18 inches circular planting at 12 weeks with the plot of linear planted Vetiver in the lower terrace. Photo 8 was at 14 weeks after planting the Vetiver and two weeks after slashing of tops. The plot shown is circular planting of 24 inches, while linear planting is visible at the lower terrace.

The girth measurements taken are summarised in Table 2 . Vetiver planted at 18 inches round the Hevea plant depressed the girth of Hevea from the seventh month after planting. With the bigger radius of 24 inches, the depression only starts after 14 months.

With growth rates measured by girth increment, linear planting of Vetiver was beneficial to Hevea growth between one to seven months while circular planting at 18 inches depressed the Hevea growth rates. The growth of Hevea between seven to fourteen and fourteen to twenty two months were similar for all treatments. The rounds of slashing the Vetiver tops are as follows:

| Round | Interval (months) between slashing |
|---|---|
| 1 | 2 |
| 2 | 3 |
| 3 | 3 |
| 4 | 6 |
| 5 | 2 |
| 6 | 4 |

Since Trials 1 & 2 are sited in the same estate, topping was done in the same month by the estate. The interval between the topping rounds are similar to Trial 1, except for Round 1 with a shorter duration of two months compared with five months in the earlier trial.

### Trial 3

This is on a very step hill. The Vetiver was established six months earlier than the Hevea . Photos 9 and 10 show the general view of the linear Vetiver hedgerows at various weeks after planting. Photos 11 and 12 show the condition when Hevea was just planted; the mulch is from Vetiver hedgerows already established. Photo 13 shows the partially decomposed state of the Vetiver mulch after an interval of three

months. Even when we examined the plants at midday, the soil around the collar of the Hevea plant was still moist ( Photo 14 ). The trial is too early for girth measurements. The trial continues.

### Trial 4

Photos 15 & 16 show the trial at planting of the Vetiver hedgerows. The demarcation between plots can be seen by the raffia string ( ® ) and extends down the slope of the hill. The plot size varies, depending on the number of planting rows.

Girth measurements at 6, 14, and 18 months show that there is no difference between hevea plants in the Vetiver plots and the control plots Table 3 . Also the girth increments at six to fourteen months and fourteen months and eighteen months are similar for both treatments.

### Trial 5

Photo 17 shows the experimental site. Photo 18 shows the Vetiver circular planting of 18 inches. Notice the rapid establishment of Vetiver plants at only four weeks after planting; this is a result of using good quality polybag plants prepared in the nursery. Table 4 summarises the girth measurements of the Hevea plants at three, 19 and 12 months and girth increments for the specific periods. There is no difference between the girth of the treated and control. Although control was superior at three to ten months, there is no difference of growth rates at ten to twelve months.

### Trial 6

Trial 6 sited on a steep hill of a different soil type. Photos 19 and 20 show the general view. Photos 21, 22, 23 and 24 show the various treatments at planting. Photos 25 and 26 show treatment (24 inches – 26 plants) at 19 and 28 weeks after planting. Notice the good growth of the Vetiver. Photos 27 and 28 show the general view of various treatments after five and 32 weeks respectively. Photos 29 and 30 show the stages of Vetiver growth at 28 and 44 weeks after planting; the Vetiver plants were growing well. However, there was a deliberate spraying of herbicides on the Vetiver plants at 58 weeks ( Photo 31 ) , mainly due to an unresolved industrial dispute. Fortunately, the Vetiver plant recovered remarkably well as shown in Photo 32 , taken four weeks later. However the effect of this spraying may affect the outcome of the trial.

The trial continues and growth of the Hevea plants will be closely monitored till the trees are opened for tapping (normally 5 years).

The girth measurements and girth increments are summarised in Table 5 . The close circular planting of 18 inches with 20 plants of Vetiver was suppressing the Hevea seedling growth from the seventh week and also the growth rates from seven to twelve and twelve to fourteen months. 18 inches circular planting with ten plants was just as suppressive except that the seedling girth at seven months was still similar to the control. Circular planting with 24 inches was slightly less suppressive to Hevea growth but still adversely affected the seedling girth at twelve and fourteen months and the girth increment at seven to twelve months. Linear planting of Vetiver hedgerow have the least suppressive effect on Hevea growth. The surprising result was that linear planting with polybag plants at twelve inches apart were more suppressed than the linear plants at six inches apart.

Scion girth was only measurable at twelve and fourteen months and generally the circular planting of Vetiver was depressing the Hevea girthing.

The period of twelve to fourteen months went through a dry spell. In this period, Vetiver as less suppressive and only the close circular and higher density planting of Vetiver suppressed the Hevea growth. Even so, this is disappointing and we were expecting the Vetiver mulches to contribute to Hevea growth over this adverse weather condition. Perhaps the period of observation is too short.

## DISCUSSION AND CONCLUSION

The effects of Vetiver as in situ mulches on the early Hevea growth over one to two years are rather disappointing. In two trials no effect was detected, while in another three trials, Vetiver growing round a Hevea plant seems to be competitive and suppressing the growth and growth rate of Hevea . Linear planting of Vetiver was beneficial for Hevea growth in two trials in the earliest girth measurements but thereafter is depressive though not as severe as circular plants. All the above suggest that Vetiver is competitive; this could be due to excessive number of Vetiver plants used and the vigorous growth of Vetiver. However, it should be noted that normally, in Hevea research the girth rates of the first two years are rarely used to assess the overall effect on the immaturity period of four to five years. We shall

continue to monitor the results. Special attention will be paid to the effect of shading on the growth and competition of Vetiver as the Hevea canopy close over.




*Photo 1.* *Vetiver* hedgerows being established.




*Photo 2.* *Vetiver* hedgerows well established after 9 weeks. The raffia string demarcated the *Vetiver* plot from the adjacent control plot. Note the good growth of *Pueraria phaseoloides* in the control plot.

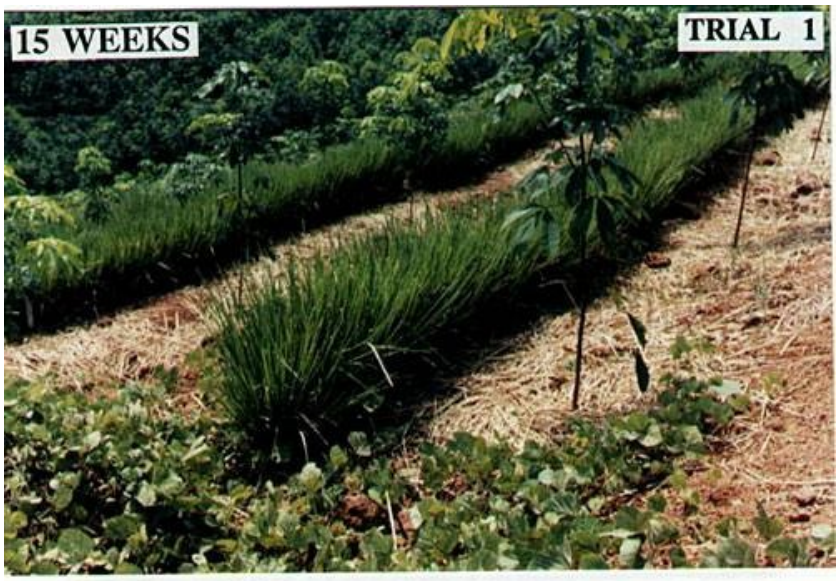



*Photo 3.* Note the good growth of the *Vetiver* hedgerows after 15 weeks. The tops cut 2 weeks earlier, were scattered on the ground.

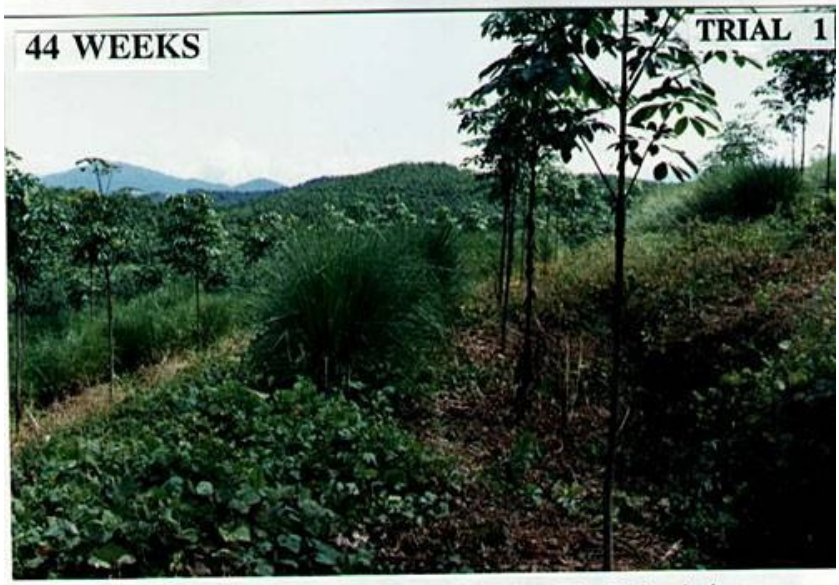



*Photo 4.* The field condition after 44 weeks. The *Vetiver* hedgerows are very vigorous. The legume cover, in the control plot is also growing well.




*Photo 5.* Planting of *Vetiver* in a circle with radius of 18".

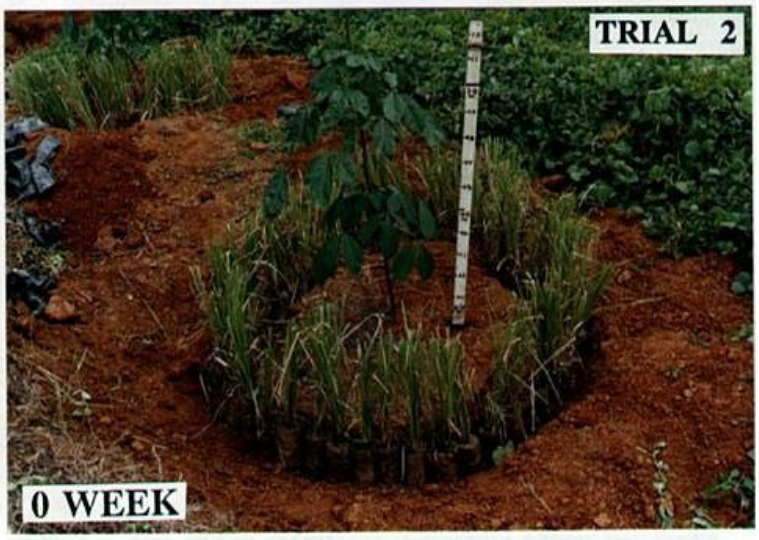



*Photo 6.* Planting of *Vetiver* in a circle of 18".
Note the close planting of the *Vetiver* polybags.




*Photo 7.* Shows growth of *Vetiver* at 12 weeks after planting. The plot in front uses circular 18" planting with linear planting at the lower slope.




*Photo 8.* This plot of 24" circular planting of *Vetiver* was topped 2 weeks earlier. Note that there was no attempt to arrange the toppings.




*Photo 9.* General view of site. The *Vetiver* hedgerows at the top of the hill are just being planted; those at the lower part of the hill were planted 7 weeks earlier.




*Photo 10.* General view of the hill with the distinctive *Vetiver* hedgerows.

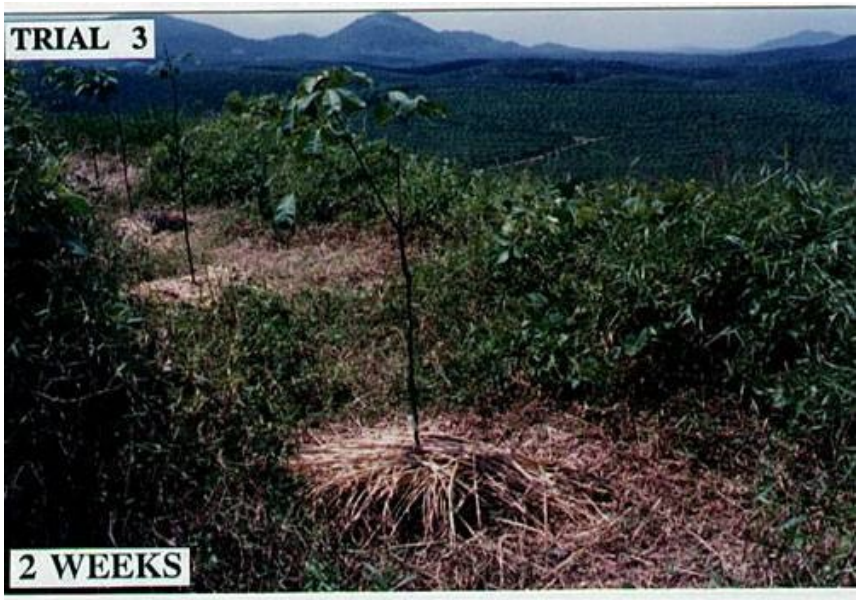



*Photo 11.* The *Vetiver* mulch was topped from the *Vetiver* hedgerows and placed around the *Hevea* plant.

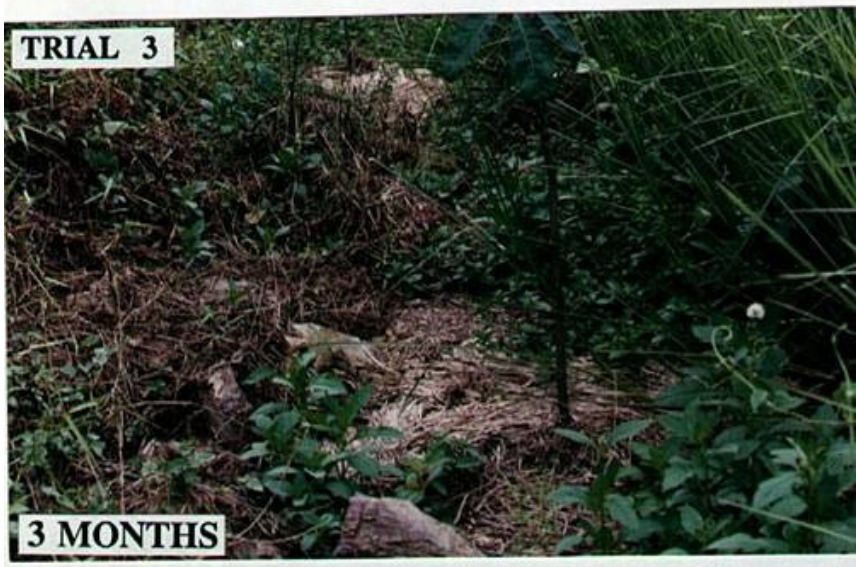



*Photo 12.* The condition of the *Vetiver* mulch at 3 months after placement.




*Photo 13.* Close-up view of the *Vetiver* mulch at 3 months after placement. The *Vetiver* leaves have started to break down.




*Photo 14.* Examination carried out at midday showed the soil to be still moist round the *Hevea* plant collar.




*Photo 15.* General view of the experiment site. Note the raffia string (arrowed) separating the plots.




*Photo 16.* This shows the *Vetiver* hedgerows just after planting. The raffia string separates the *Vetiver* plot from the adjacent control plot.




*Photo 17.* General view of experimental site for Trial 5.




*Photo 18.* Circular planting of *Vetiver* plants at 18" radius. This is at 4 weeks after planting.




*Photo 19.* General view of land preparation in experimental site.

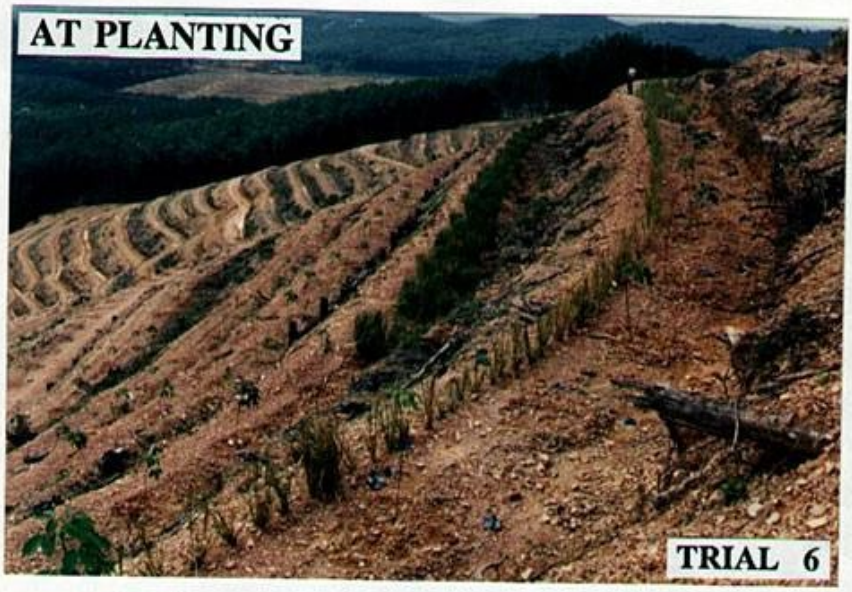



*Photo 20.* General view of *Vetiver* plants just planted.




*Photo 21.* This shows the control plot and the difficult soil type.

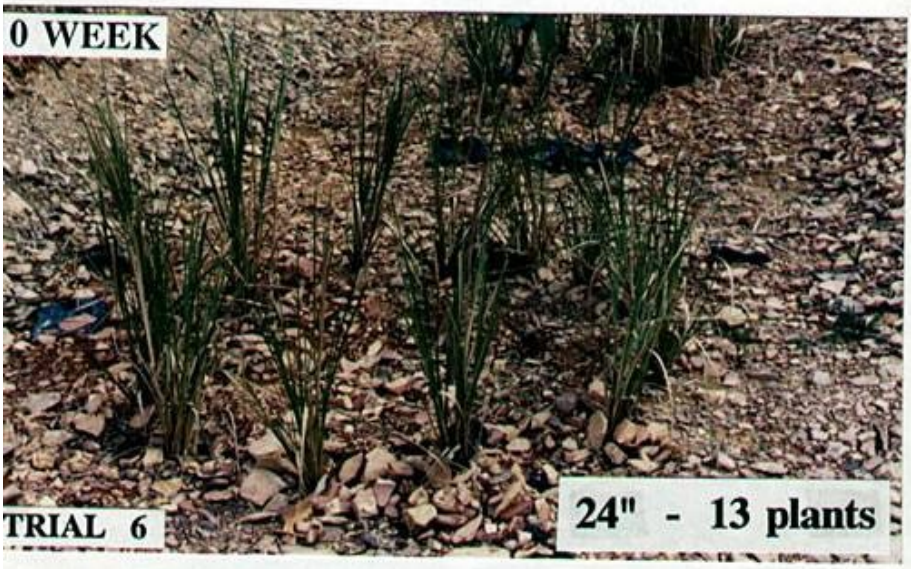



*Photo 22.* The *Vetiver* was planted in a circle with a radius of 24". 13 polybag plants were used.

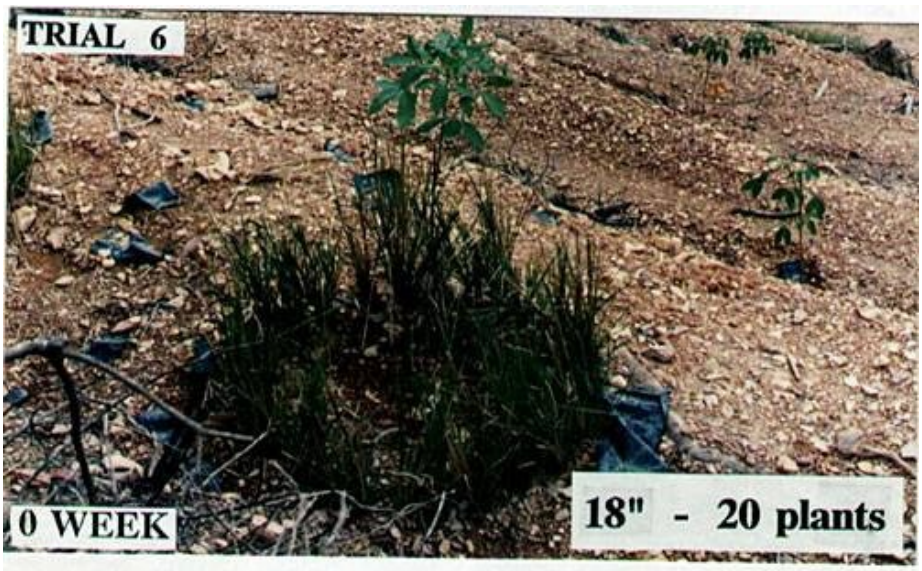



*Photo 23.* 20 *Vetiver* polybag plants were planted in a circle with 18" radius.




*Photo 24.* 26 *Vetiver* polybags plants were planted in a circle with 24" radius.

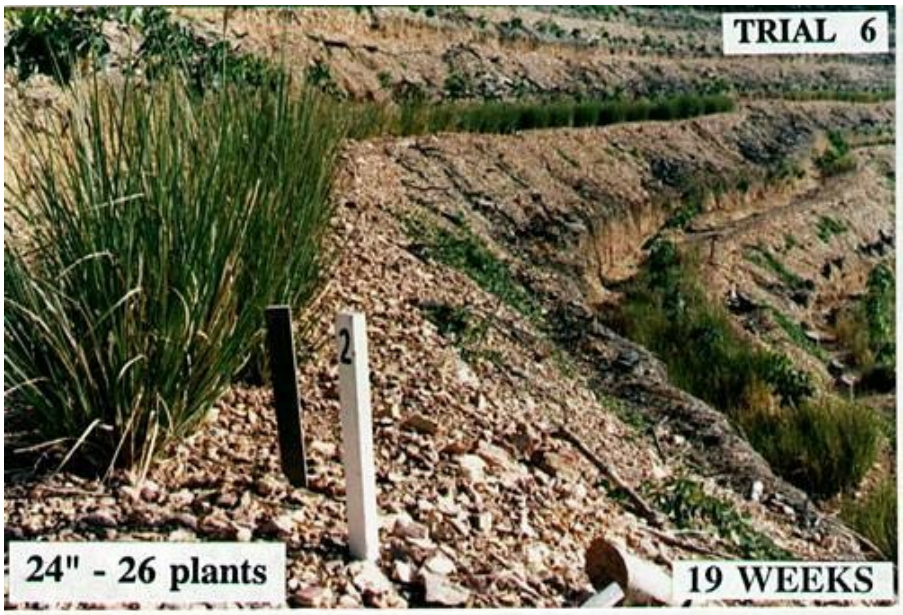



*Photo 25.* Shows plot with *Vetiver* planted at circular 24" using 26 bags. The *Vetiver* plants were 19 weeks old.

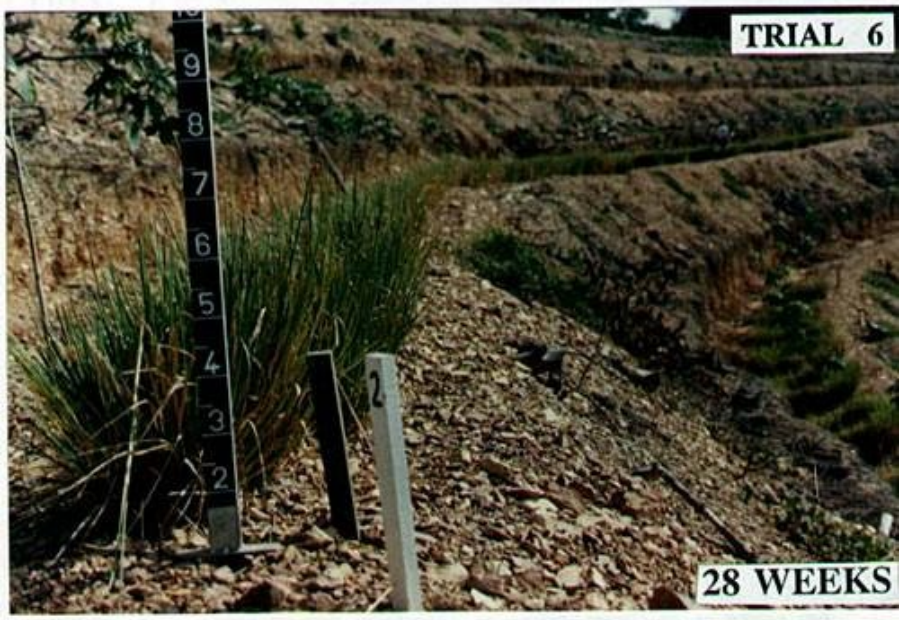



*Photo 26.* The *Vetiver* plants are growing well at 28 weeks.




*Photo 27.* General view showing various treatments at 5 weeks after planting the *Vetiver*.

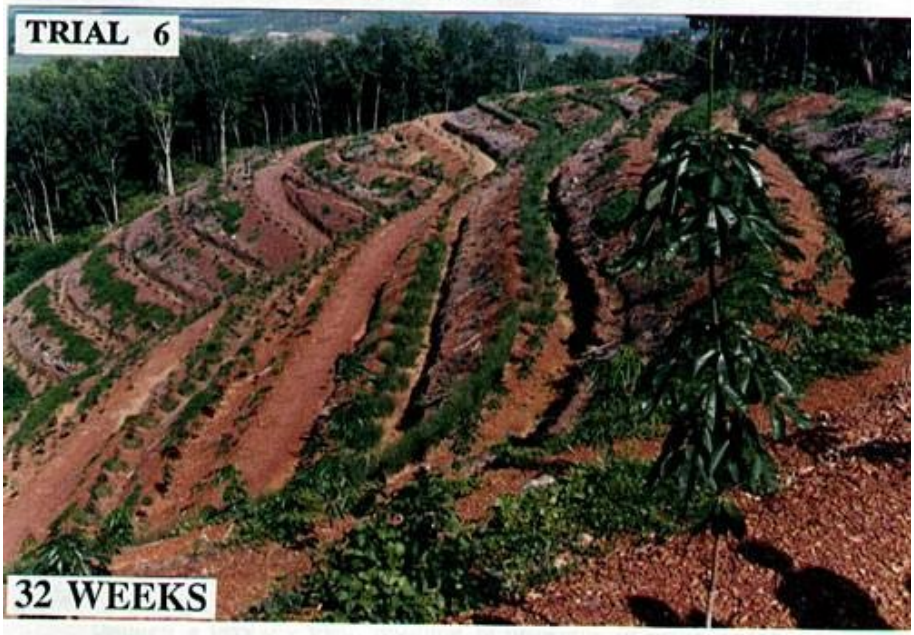



*Photo 28.* Shows various treatments of *Vetiver* plants at 32 weeks old.

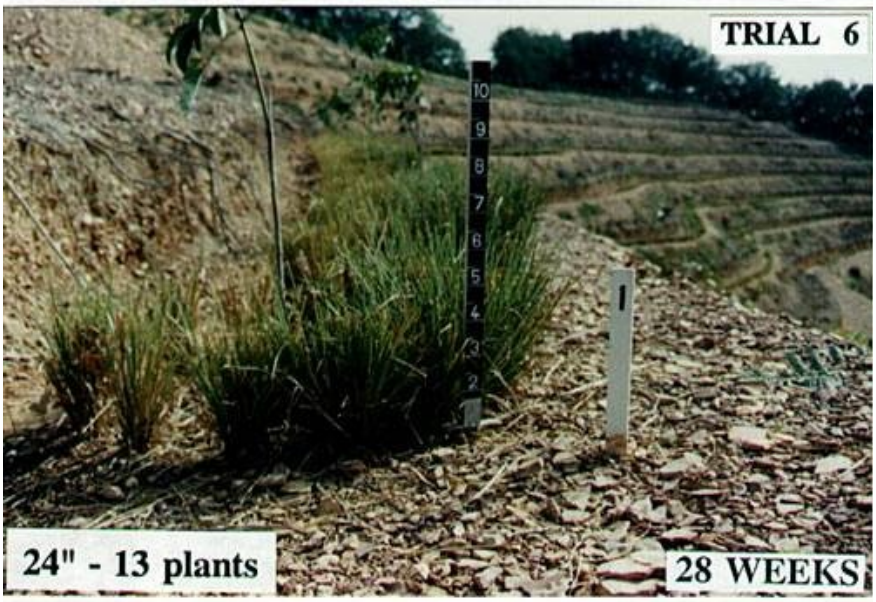



*Photo 29.* Shows the *Vetiver* plants growing well.




*Photo 30.* The *Vetiver* plants are 44 weeks old. Despite having gone through a very dry spell, resulting in browning of many leaves, the overall condition of the plants is satisfactory.




*Photo 31.* The *Vetiver* plants were deliberately sprayed with weedicide.




*Photo 32.* Good recovery of *Vetiver* plants to weedicide damage. The plants have recovered fairly well after 62 weeks.

## TABLE 1 EFFECT OF VETIVER PLANTING ON HEVEA GROWTH AT VARIOUS MONTHS AFTER TREATMENT

| **Block** | **Mean Girth (cm)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 10 | 17 | 24 | | | | | | | | | |
| Control | Vetiver | Sig. of t | Control | Vetiver | Sig. of t | Control | Vetiver | Sig. of t | Control | Vetiver | Sig. of t | |
| 1 | 6.9 ± 0.10 | 6.9 ± 0.11 | ns | 11.3 ± 0.17 | 12.3 ± 0.15 | *** | 17.5 ± 0.28 | 18.8 ± 0.24 | ** | 24.9 ± 0.37 | 25.3 ± 0.37 | ns |
| 2 | 6.6 ± | 6.7 ± | ns | 11.3 ± | 11.3 ± | ns | 18.1 ± | 15.6 ± | *** | 25.3 ± | 22.1 ± | *** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.10 | 0.08 | | 0.14 | 0.14 | | 0.23 | 0.22 | | 0.33 | 0.31 | |
| 3 | 6.4 ± 0.07 | 6.4 ± 0.07 | ns | 10.7 ± 0.12 | 10.6 ± 0.13 | ns | 16.4 ± 0.23 | 15.6 ± 0.22 | * | 22.4 ± 0.36 | 20.2 ± 0.34 | *** |
| Pooled | 6.6 ± 0.05 | 6.7 ± 0.05 | ns | 11.1 ± 0.08 | 11.3 ± 0.10 | * | 17.2 ± 0.15 | 16.8 ± 0.16 | P<0.1 | 24.0 ± 0.23 | 22.2 ± 0.25 | *** |

| **Block** | **Girth Increment (cm)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 4 to 10 | 10 to 17 | 17 to 24 | | | | | | | |
| | Control | Vetiver | Sig. of t | Control | Vetiver | Sig. of t | Control | Vetiver | Sig. of t |
| 1 | 4.4 ± 0.10 | 5.4 ± 0.13 | *** | 6.2 ± 0.14 | 6.5 ± 0.20 | ns | 7.4 ± 0.14 | 6.5 ± 0.26 | ** |
| 2 | 4.7 ± 0.10 | 4.7 ± 0.10 | ns | 6.7 ± 0.16 | 5.2 ± 0.13 | *** | 7.2 ± 0.15 | 5.5 ± 0.18 | *** |
| 3 | 4.3 ± 0.09 | 4.2 ± 0.10 | ns | 5.7 ± 0.15 | 5.0 ± 0.15 | ** | 6.1 ± 0.20 | 4.6 ± 0.19 | *** |
| Pooled | 4.4 ± 0.06 | 4.7 ± 0.07 | * | 6.2 ± 0.09 | 5.5 ± 0.10 | *** | 6.8 ± 0.11 | 5.4 ± 0.13 | *** |

## TABLE 2 EFFECT OF VETIVER PLANTING ON HEVEA GROWTHAT VARIOUS MONTHS AFTER TREATMENT

| **Treatment** | **Mean girth (cm)** | **Girth Increment(cm)** | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 7 | 14 | 22 | 1-7 | 7-14 | 14-22 | |
| Estate practice | 5.4a | 10.3b | 15.2a | 21.3a | 4.9b | 4.9a | 6.1a |
| Linear planting | 5.4a | 10.9a | 15.7a | 22.0a | 5.6a | 4.8a | 6.3a |
| Circle 24" radius | 5.3a | 9.9bc | 14.1b | 19.5b | 4.5bc | 4.3a | 5.4a |
| Circle 16" radius | 5.2a | 9.5c | 13.6b | 19.0b | 4.3c | 4.1a | 5.4a |
| s.e. ( ± ) | 0.09 | 0.15 | 0.31 | 0.42 | 0.14 | 0.30 | 0.33 |
| LSD (P<0.05) | - | 0.4 | 0.9 | 1.3 | 0.4 | - | - |

Means with the same subscript alphabets are not significantly different at P<0.05

## TABLE 3 EFFECT OF VETIVER PLANTING ON HEVEA GROWTH AT VARIOUS MONTHS AFTER TREATMENT

| **Treatments** | **Mean Girth (cm)** | **Girth increment (cm)** | | | |
|---|---|---|---|---|---|
| 6 | 14 | 18 | 6-14 | 14-18 | |
| Control | 8.0a | 13.4a | 17.6a | 5.3a | 4.3a |
| Linear planting | 8.1a | 13.9a | 18.0a | 5.7a | 4.2a |
| s.e. ( ± ) | 0.08 | 0.24 | 0.31 | 0.17 | 0.10 |
| LSD (P<0.05) | | - | - | - | - |

Means with the same subscript alphabets are not significantly different at P<0.05

TABLE 4 EFFECT OF VETIVER PLANTING ON HEVEA GROWTH AT VARIOUS MONTHS AFTER TREATMENT

| **Vetiver treatment** | **Mean girth (cm)** | **Girth increment (cm)** | | | |
|---|---|---|---|---|---|
| 3 | 10 | 12 | 3-10 | 10-12 | |

| | | | | | |
|---|---|---|---|---|---|
| Control | 4.5a | 8.5a | 12.0a | 3.9a | 3.5a |
| Circle 24" radius, 13 plants | 4.2a | 7.3a | 11.0a | 3.0b | 3.7a |
| Circle 24" radius, 26 plants | 4.3a | 7.2a | 10.9a | 2.9b | 3.7a |
| Circle 18" radius, 10 plant | 4.6a | 7.8a | 11.7a | 3.2b | 3.9a |
| Circle 18" radius, 20 plants | 4.2a | 7.1a | 10.6a | 2.9b | 3.4a |
| s.e. (±) | 0.21 | 0.38 | 0.53 | 0.22 | 0.22 |
| LSD (P<0.05) | - | - | - | 0.7 | - |

Means with the same subscript alphabets are not significantly different at P<0.05

### TABLE 5 EFFECT OF VETIVER PLANTING ON HEVEA GROWTH AT VARIOUS MONTHS AFTER TREATMENT

| **Vetiver Treatments** | **Mean Girth (cm)** | **Girth increment (cm)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Seedling | Scion | Seedling | Scion | | | | | | | |
| 3 | 7 | 12 | 14 | 12 | 14 | 3-7 | 7-12 | 12-14 | 12-14 | |
| Control | 5.4a | 7.5a | 13.5a | 15.5a | 11.2a | 12.9a | 2.1abc | 6.0a | 2.0a | 1.7ab |
| Linear 6" apart | 5.2a | 7.4a | 13.1a | 15.3a | 11.0ab | 12.8a | 2.2ab | 5.7ab | 2.2a | 1.8a |
| Linear 12"apart | 5.1a | 7.5a | 12.9bc | 15.0ab | 11.0ab | 12.5ab | 2.3a | 5.4bc | 2.1a | 1.6bc |
| Circle 24" radius, 13 plants | 5.2a | 7.3ab | 12.5cd | 14.3c | 10.6bc | 12.1bcd | 2.0abc | 5.2cd | 1.9abc | 1.5bc |
| Circle 24" radius, 26 plants | 5.4a | 7.2ab | 12.6bc | 14.5bc | 10.8ab | 12.2bc | 1.8bc | 5.4bc | 1.9abc | 1.4c |
| Circle 18" radius, 10 plants | 5.5a | 7.2ab | 12.4cd | 14.0cd | 10.5bc | 12.0cd | 1.8c | 5.2cd | 1.6c | 1.4bc |
| Circle 18" radius, 20 plants | 5.3a | 7.0b | 11.9d | 13.6d | 10.1c | 11.6d | 1.7c | 5.0d | 1.7bc | 1.4c |
| s.e ( ± ) | 0.10 | 0.12 | 0.19 | 0.22 | 0.17 | 0.19 | 0.15 | 0.11 | 0.11 | 0.08 |
| LSD (P<0.05) | - | 0.3 | 0.6 | 0.6 | 0.5 | 0.5 | 0.4 | 0.3 | 0.3 | 0.2 |

Average over 3 scions Means with the same subscript alphabets are not significantly different at P<0.05

## 5.2 Effect of vetiver on growth of rubber (Hevea)

*Source: First Progress Report, G-VII*

A colleague is looking into possible competitive effect of Vetiver on growth of Hevea . This compares with effect of other common weed species. Briefly, there are four trials:

In pots ( Photo 59a ). In large polybags buried in the ground ( Photo 59b ). Next to newly planted rubber buddings ( Photo 59c ). Next to 9-month-old rubber buddings ( Photo 59d ).

The effect on rubber as measured by height and girth will be studied.

**PHOTO 59. EFFECT OF VETIVER ON GROWTH OF *HEVEA* (i)**




(a) Trial 1. Plants grown in pots.

(Ref: 17/1990)

(b) Trial 2. Plants grown in large polybags buried in the ground.



(Ref: 24/1990)

PHOTO 59. EFFECT OF VETIVER ON GROWTH OF *HEVEA* (11)



(c) Vetiver established together with young buddings of rubber.



(d) Vetiver established 9 months after rubber planting.

(Ref: 4/1991)

## 5.3 Vetiver as a mulch

*Source: First Progress Report, G-V*

The effect of mulches on establishment and growth of crops, soil erosion and soil water conservation is well documented. In Malaysia, use of lalang as mulch is an accepted practice, though in recent years it has been superseded by oil palm empty fruit branches where available.

A preliminary observation comparing Vetiver cut tops with lalang has shown that it was longer lasting and without the adverse effect of seeding. Analysis also shows considerable available nutrient (N, P, K, Mg). Therefore, in addition to usage as erosion and soil moisture control, Vetiver planting in agricultural crops would also contribute in terms of a ready and repeated supply of quality mulch.

## 5.4 Fodder production

*Source: First Progress Report, G-IV*

Vetiver hedgerows purposely grown in the normal path that sheep travel, from their pen to young rubber grazing fields, were not eaten by them. It seems that sheep do not prefer this grass if they have other food. The farmer-selected variety from India will be tried as soon as sufficient materials have been multiplied. Meanwhile it was noted that the tops of Vetiver, cut at monthly intervals at 40 cm height, were found to be readily consumed by sheep and Chinese grass carp. Therefore, the rate of dry matter production was studied under the following conditions in the ad hoc experiments:

Fertilizer effect Spacing Soil types

The fodder value of Vetiver as reported in Vetiver Newsletter No. 4 is most welcome. Those smallholders who use Vetiver for protection or erosion in fish ponds will be most encouraged to top the Vetiver and feed the fish. Likewise, those using Vetiver for soil erosion would be encouraged to cut the tops for fodder. Such repeated topping would make the hedgerows dense and neat.

# 6. Uses on estates: case studies

## 6.1 Adaptive use by an end user (a 700-acre estate)

*Source: First Progress Report, Chapter F*

Vetiver plants have been given to many end users. For illustration, this Chapter discusses the uses of the grass by one recipient.

This is a privately owned estate of about 700 acres planted with rubber and oil palm. As returns from these two crops are low, the owner wanted to convert to growing fruit trees. However, the estate is sited in an area with a distinct dry spell. A good water source is therefore essential. In addition, because the land is fairly steep, soil erosion and moisture control becomes critical.

The main targeted uses for Vetiver in this estate are:

Centre for production and distribution of materials for interested smallholders around the area. Ponding. Erosion control in irrigation piping. Modify nursery land topography. Erosion control and moisture conservation.

I. PRODUCTION OF PLANTING MATERIALS

Based on early experience gained, two methods were used:

Polybag nursery . Photo 51a illustrates a nursery producing about 30,000 bags of 6" x 9" polybag plants. A Sumisansui irrigation system was set up and fertilizer applied was 1 Kokei (6 gm) per bag. With such good maintenance, the polybag plants were ready for use in 2-3 months (Photo 51b ).

Ground nursery. Raised beds were prepared mechanically. Each bed was 3 ½ feet x 50 metres with three-foot spacing in between. Planting distance of the tillers were 6" x 6" with each bed producing 1,800 clumps ( Photo 52a ). At the initial phase, six beds were planted to produce 10,800 clumps. With good mechanical Sumisansui irrigation system and liberal use of dried chicken dung, the plants were ready for use in the field after two months (Photo 52b ). However, for multiplication, the plants were left to grow longer. It was estimated that these beds produced more than 150,000 tillers after the first three months. Currently (October 1990), the estate has 12 such beds. My arrangement with the estate (as with all estates) is:

Production of materials are for their own use. All supplies to any third party must be with my clearance and should be given " free of charge".

I believe that the above conditions are honoured and also this nursery has helped to supply to neighbouring smallholders.

PHOTO 51. ADAPTIVE USES OF VETIVER BY END-USERS (i)



(a) 30,000 polybag plants are being produced in this nursery.



(b) Plants ready for use after 2-3 months.

(Ref: 16/1990)

PHOTO 52. ADAPTIVE USES OF VETIVER BY END-USERS (ii)



(a) The density of planting is 6" x 6". Each bed is 50 metres long producing 1,800 clumps.

Planted: 30/5/1990
Photo taken: 24/6/1990 (Ref: 10/1990)



(b) The plants are 6 weeks old. Note the Sumisansui irrigation system.

Photo taken: 15/7/1990 (Ref: 10/1990)

II. PONDING

For conversion into any orchard, abundant water is essential. Because there is no river in or near the estate, ponds have to be dug. A series of ponds occupying a total of 50 feet width x 1,750 feet length was excavated and the embankments of filled earth and cut-earth were planted with Vetiver (Photo 53). Slips with about five tillers of Vetiver from ground nursery were used. The Vetiver established very well and the embankments stabilised very fast to hold 10-11 feet of water (Photo 54 ).

An interesting observation was that the Vetiver survived more than a month of being partly or fully submerged under water during the rainy weather (Photo 55). Another side benefit is that Chinese carp loves the cut-leaves and now these ponds are also used to rear fish. The owner is so pleased with this set of ponds produced at such relatively low cost that he is producing more! Also, this attempt has stimulated the neighbouring smallholders who are introducing fish rearing into their farms.

PHOTO 53. ADAPTIVE USES OF VETIVER BY END-USERS (iii)



(a) A series of ponds covering 50 x 1,750 feet were dug.



(b) Vetiver hedgerows planted on the embankments.

Planted: 29/7/1990
Photo taken: 16/9/1990 (Ref: 17/1990)

PHOTO 54. ADAPTIVE USES OF VETIVER BY END-USERS (iv)



(a) The Vetiver hedgerow stabilized the embankment.



(b) The Vetiver hedgerows protect embankments of 10-11 feet pond.

(Ref: 22/1990)

PHOTO 55. ADAPTIVE USES OF VETIVER BY END-USERS (v)



(a) The lower Vetiver hedgerow is partly submerged by water.

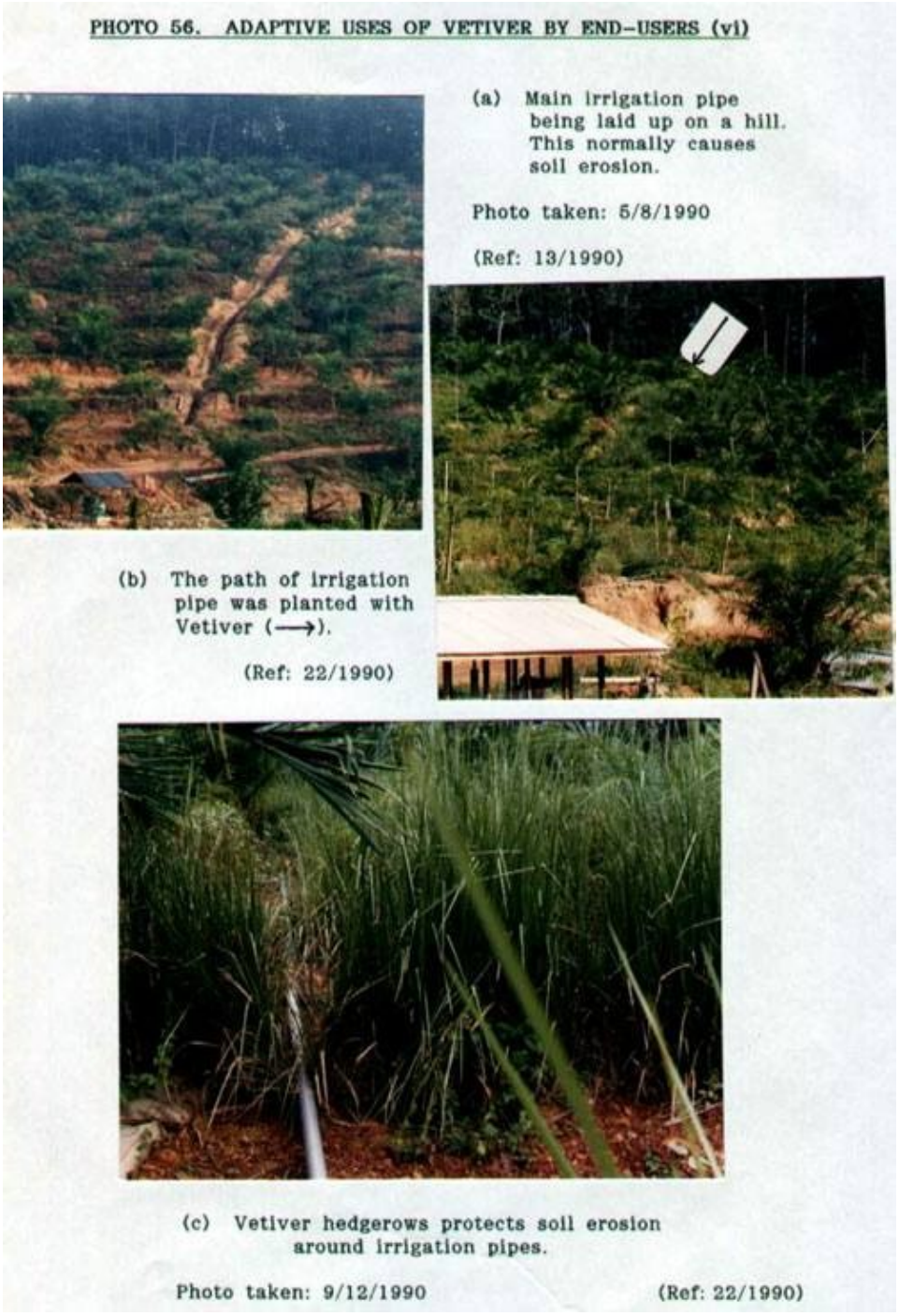


(b) Vetiver continue to grow after being partly or fully submerged for more than a month.

Photo taken: 9/12/1990 (Ref: 22/1990)

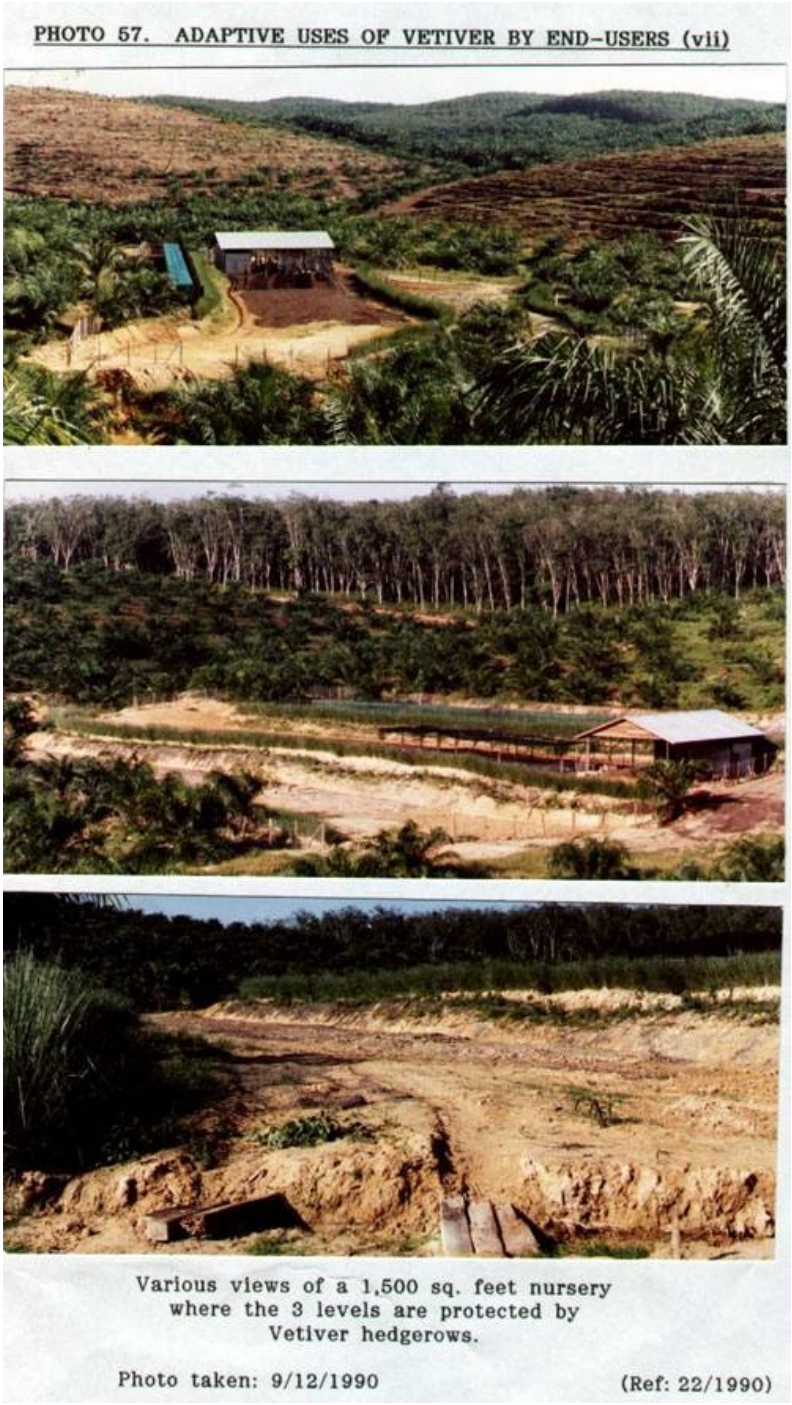
III. EROSION CONTROL IN IRRIGATION PIPING

With the abundance of water available, a complete automatic irrigation system for the whole estate was being attempted. Three hills were already fitted with drip irrigation. To minimise cost, the main supply pipe for each hill must travel from the pond to the tip of the hill in the shortest distance, i.e. at a steep gradient (Photo 56a). Such arrangement normally creates severe erosion. Vetiver planting has effectively eliminated this problem (Photo 56b & 56c ).




IV. TO PROTECT TERRACING

A large nursery is essential for the estate to propagate fruit trees. A level nursery facilitated operation and will reduce costs in the long run. This estate has mainly undulating to rather steep land. To create the 1,500sq. feet nursery, the land was bulldozed and made into three terraces, each with a drop of 1 – 1 ½ metres. The embankments were well protected by Vetiver hedgerows (Photo 57).




V. EROSION CONTROL AND MOISTURE CONSERVATION

Oil palm and rubber field will be cleared for replanting with fruit trees. Vetiver plants are being prepared to be planted on the terraces to reduce soil erosion and to conserve moisture.

## 6.2 Introduction to the estate case studies

*Source: Second Progress Report, Part 4*

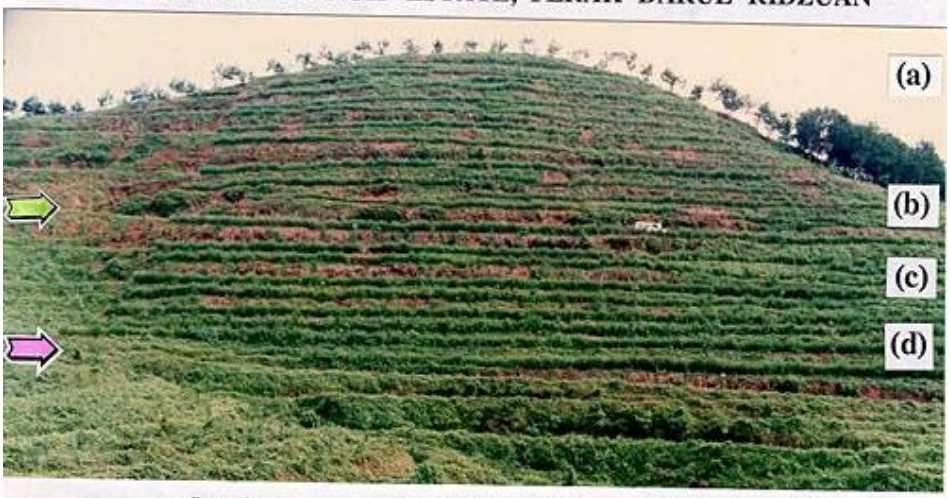
This part of the report summarizes the adaptive uses of Vetiver on three commercial estates. More details are found in the video recordings which features the time sequence photos of specific sites of interest and the current situation existing as at March 1993.

The following photo-essays attempt to highlight only the major points of interest.

## 6.3 Sungei Chinoh Estate, Perak (photo essay)

*Source: Second Progress Report, 4.1*

**4.1. SUNGEI CHINOH ESTATE, PERAK DARUL RIDZUAN**




| Level | Height (m) | Gradient (%) |
|---|---|---|
| (a) | 15.53 | 64 |
| (b) | 15.85 | 65 |
| Middle Road ( ) | | |
| (c) | 10.56 | 61 |
| (d) | 5.44 | 36 |
| Lower Road ( ) | | |
| Total Hedgerow | 1840 metres | |

*Photo 1.* This is a steep hill with gradient mainly above 60%; only the lowest slope is more gentle with gradient of 36%. The total height from the top to the middle road where the 4-WD Vehicle is parked is 31.4 metres, while the height between the middle road and the lower road is 16.0 metres. The main aims of the trial in this area are:

(i) To test potential of using *Vetiver* hedgerows to create planting rows without terracing.
(ii) To assess value of *Vetiver* hedgerows for soil erosion control.
(iii) To investigate the value of *Vetiver* as *in situ* mulch.




*Photo 2.* General view of the trial at the time of land preparation. It was unfortunate that terracing was already done when we visited the site. However, because of the steep gradient the between-terrace areas were large.

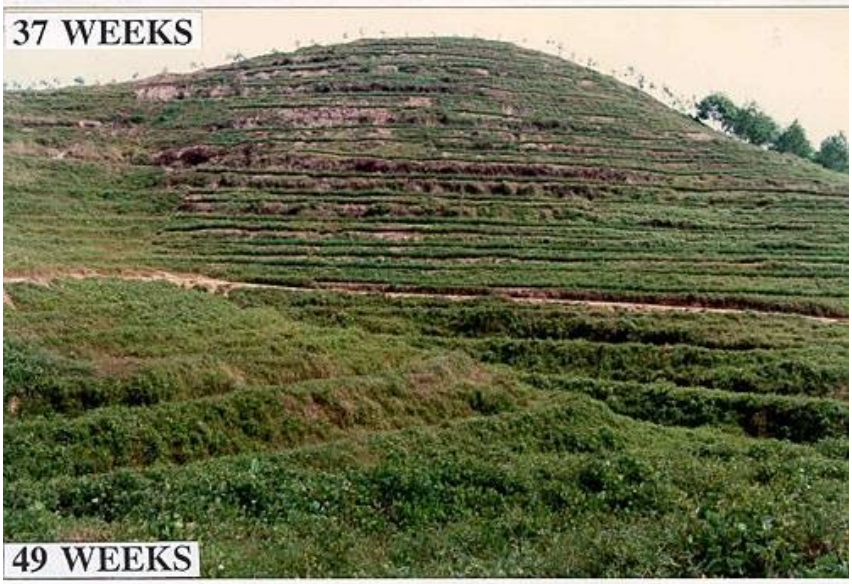



*Photo 3.* General view of the hill after 43 weeks. Note the distinct *Vetiver* hedgerows.




*Photo 4.* The *Vetiver* hedgerows at the lower part of the hill was planted earlier. The size of the planting requires >13,000 polybag plants which were prepared in 2 batches.




*Photo 5.* Shows the good growth of the *Vetiver* hedgerows which have started to trap soil-wash. Note that *Hevea* buddings have not been planted.



*Photo 6.* Shows the well developed *Vetiver* hedgerows at 21 weeks above the middle road and 33 weeks below the middle road. Note particularly those *Vetiver* hedgerows planted between the wide terraces ( ). Rubber buddings will be planted on platform above these hedgerows which should trap soil-wash and with time produce a walking path.

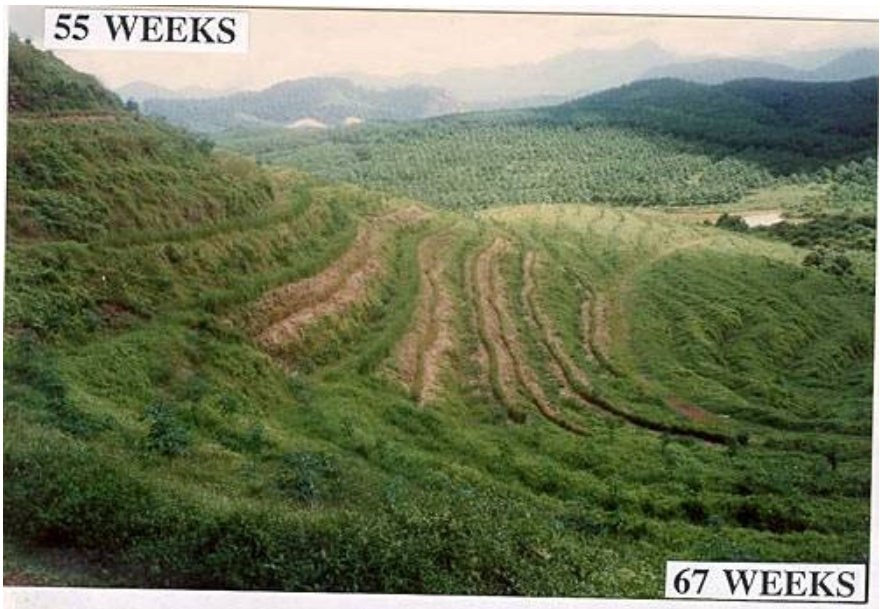



*Photo 7.* The lower hedgerows are 67 weeks old while the top hedgerows are 55 weeks old. The 'brown' colour is the *Vetiver* tops which were cut to provide a mulch for *Hevea* buddings.




*Photo 8.* This was the situation existing in the site when video recording was done in March 1993.

## 6.4 Hwa Li Estate, Pahang (photo essay)

*Source: Second Progress Report, 4.2*

## 4.2. HWA LI ESTATE, PAHANG DARUL MAKMUR

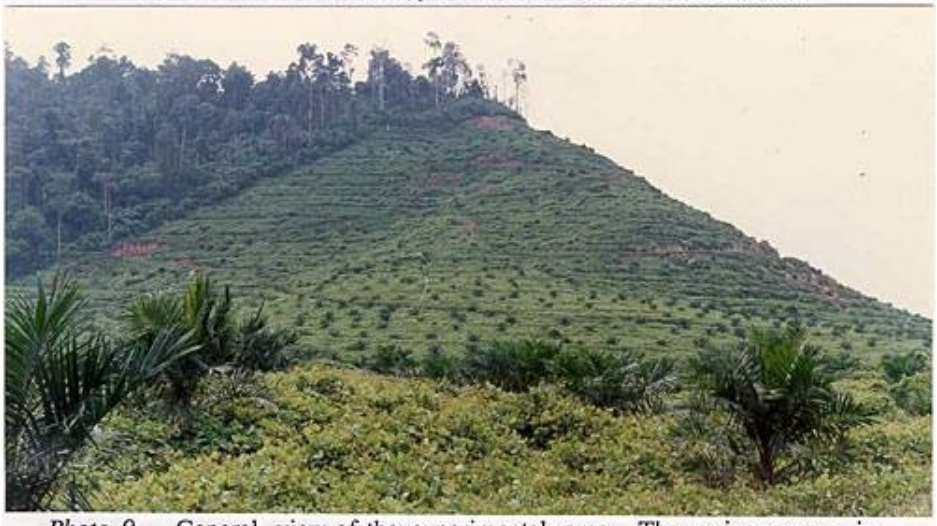


*Photo 9.* General view of the experimental area. The main purpose is to protect the roads and certain steep slopes. The total length of hedgerows planted is 3399 m.




*Photo 10.* The original target was to use *Vetiver* on one hill. However, with the good results obtained, *Vetiver* was also used to protect the second hill as well as introduced to other estates in the group.




*Photo 11a.* Site A: Corner of road junction sloping downhill. Sand bags were used to slow down water-flow to allow *Vetiver* to be established.




*Photo 11b.* Site A: After 34 weeks, the sandbags have disintegrated but the *Vetiver* hedgerows are well established by then to stabilise this weak corner. Note the *Vetiver* plants were topped recently. Usually the *Vetiver* hedgerows are topped every 3-4 months in this estate.




*Photo 12a.* Site B: This is a steep slope at the end of a long steep road. In addition, as the soil is very friable, this area is very susceptible to erosion.

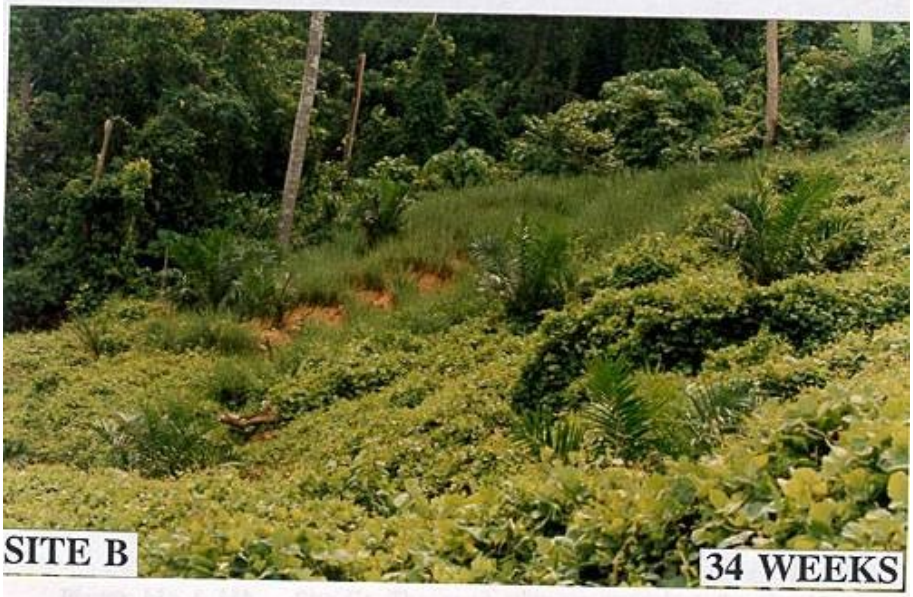
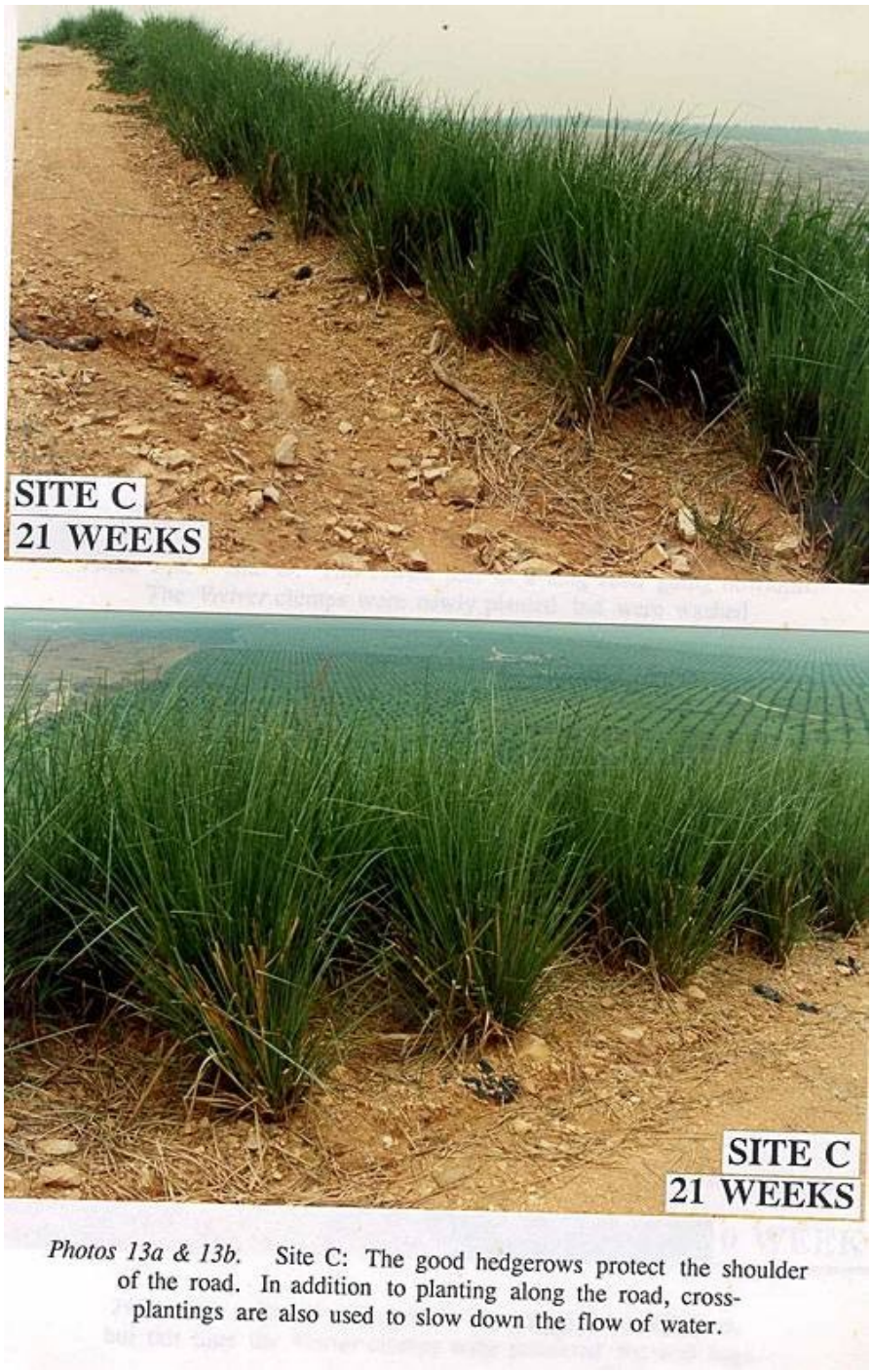



*Photo 12b.* Site B: After 34 weeks the *Vetiver* hedgerows have fully stabilised this weak spot.




*Photos 13a & 13b.* Site C: The good hedgerows protect the shoulder of the road. In addition to planting along the road, cross-plantings are also used to slow down the flow of water.




*Photo 14a.* Site D: The lowest part of a long road going downhill. The *Vetiver* clumps were newly planted but were washed away the next day by a heavy rain-storm.




*Photo 14b.* Site D: The above site (⇨) was replanted, but this time the *Vetiver* clumps were protected by sand bags.

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*Photo 14c.* Site D: Shows *Vetiver* plants newly planted and protected from being washed away by sand bags.

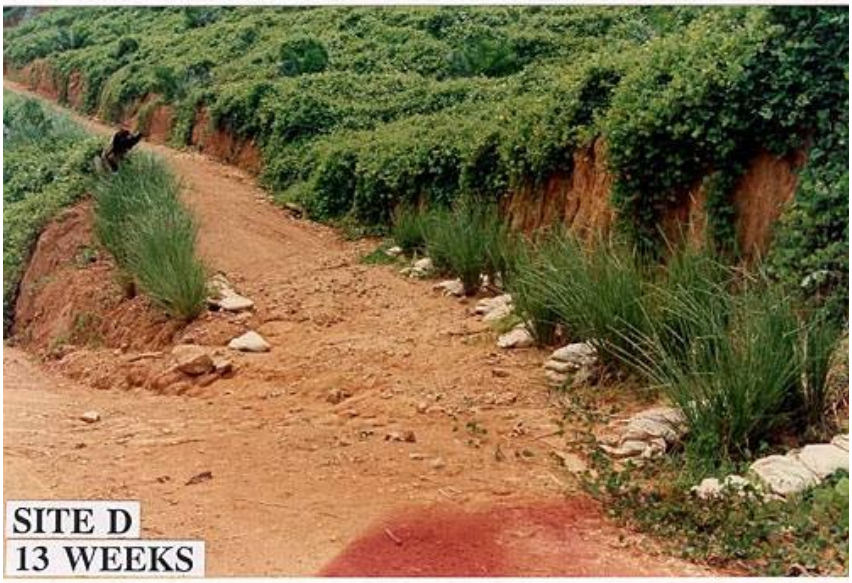



*Photo 14d.* Site D: After 13 weeks, the sand bags have started to disintegrate but the *Vetiver* hedgerows are well established that they could withstand any rain-wash as well as protect the area from erosion.




*Photo 15a.* Site E: The lowest end of a long sloping road which corners into another road also sloping downhill. This is a very weak spot as the soil is highly friable. *Vetiver* hedgerows are already established. Due to the severe erosion, the leguminous creeper cannot be established.




*Photo 15b.* Site E: The *Vetiver* hedgerows are well established after 34 weeks. Note 522 m of *Vetiver* hedgerows are established on the road-shoulders of the hill in the background.

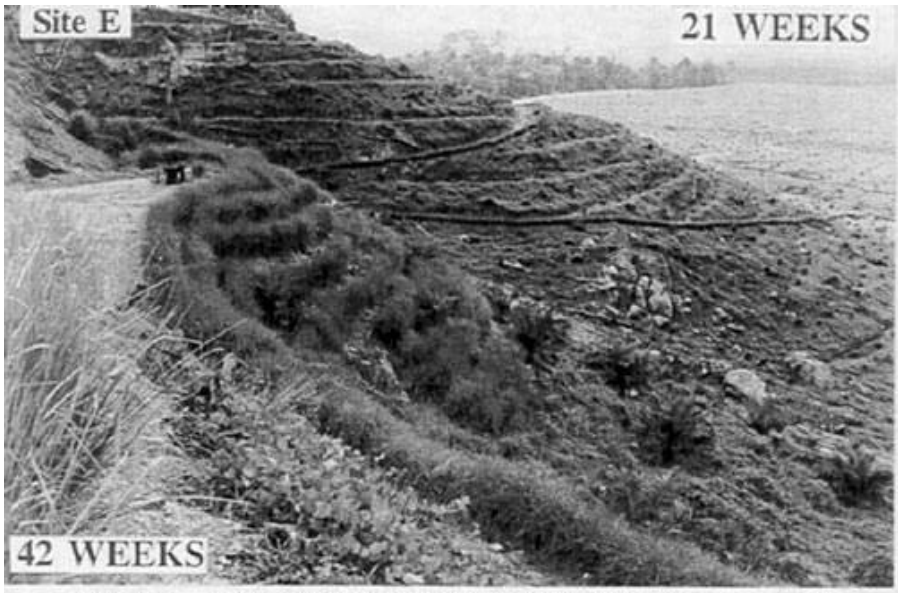



*Photo 15c.* Site E: After 42 weeks, the *Vetiver* hedgerows are so fully established that they have slowed down the flow of water and reduced the soil erosion to such an extent that leguminous creepers manage to take root. Note the good hedgerows produced at the back hill after 21 weeks.




*Photo 15d.* Site E: This weak site is fully protected and the oil palm are growing well.



*Photo 16.* Site F: This shows how *Vetiver* hedgerows have protected the shoulder of the upper road and the slope of the lower road. Note that the *Vetiver* cultivar variety ex-Taiping flowers profusely but concerted attempts have failed to find any fertile seed.





*Photo 17a & 17b.* These 2 photos show that well established *Vetiver* hedgerows are very strong and can stop rock-fall from the upper terraces.

## 6.5 RRIM Smallholders' Laboratory, Bandar Sri Iskandar

*Source: Second Progress Report, 4.3*

In April 1992, I was requested to deal with the severe erosion problem in the Smallholders' Laboratory in Bandar Sri Iskandar. My on-site survey shows the main causes to be:

The steep terrain and rather friable soil in may area; Poor placement of the main water tank on top of the hill at the edge of a slope; Ex-logging trails which should be but were not cut by the terraces. The rather poor planning of the roads resulting in rather steep gradients in many places; The poor alignment of the terraces, which did not follow proper contouring, but sloping, with gradients of > 6% in many places and > 20% in others. Rain and soil-wash from these terraces discharge into the back drains and/or roads, thus compounding the erosion problem; The long back drains along the roads do not have any 'checks' to slow

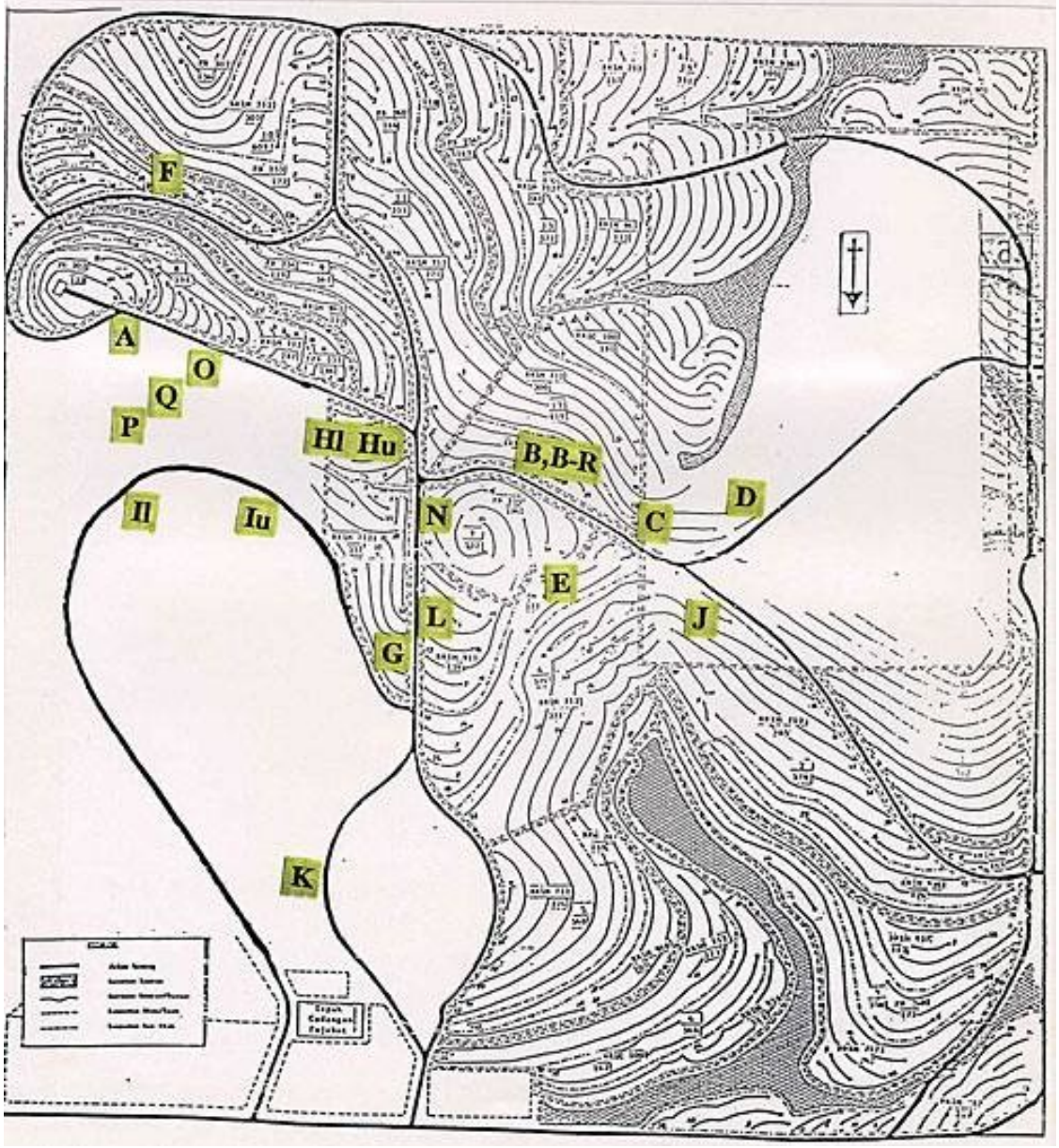
down the rain-wash; Severe erosion occurs at the culvert outlets and the slopes below caused by the concentrated forces of the rain and soil-wash discharged from the long back drains.

To tackle all the above problems poses an exciting challenge and a chance to test the usefulness of Vetiver hedgerows in practical application. The main sites where Vetiver hedgerows were planted are given in Figure 1 . Details of the sites are given in Table 1 . For each site, the number of quality polybag plants and sandbags used are given. The number and the total lengths of hedgerows are recorded. Gradients and vertical drops of each site are measured.

The following photo-essay reports on some sites. More details of these sites are given in the accompanying video recording. The details are as follows:

| **INDEX** | | |
|---|---|---|
| Subject | Tape No. | Point of Location (Hrs/Mins/Secs) |
| Site A | 3 | 0h.00m.00s |
| Site B | 3 | 0h.23m.00s |
| Site B( r ) | 3 | 0h.40m.30s |
| Site C | 3 | 1h.08m.57s |
| Site J | 3 | 1h.23m.0s |
| Site H-I | 3 | 1h.39m.20s |

*FIGURE 1.* RRIM SMALLHOLDERS' LABORATORY
BANDAR SRI ISKANDAR, PERAK DARUL RIDZUAN




| Site | Description | Date Planted | Number of | Hedgerow | Gradient (%) | Vertical Height (m) | | |
|---|---|---|---|---|---|---|---|---|
| | Length | | | | | | | |
| Plants | Sandbag | Nos . | (M) | | | | | |
| A | Storage tank | 21/05/92 | 356 | 95 | 4 | 31.30 | 26.50,36.25 | 2.55, 1.71 |
| | | 02/09/92 | 213 | 15 | 8 | 23.35 | 6.50, 6.75 | 1.31, 3.49 |
| | | | - | - | - | - | | |
| | | | 569 | 110 | 12 | 54.65 | | |
| B | Culvert 1 | 21/05/92 | 423 | 275 | 16 | 20.30 | 5.25, 7.25, 20.50, 43,75 | 1.57, 2.09, 2.87, 2.66 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 03/09/92 | | | | | | |
| B(r) | Culvert IR | 19/11/92 | 570 | 89 | 12 | 41.30 | 5.25, 7.25, 20.50 | 1.57, 2.09, 2.87 |
| | | | | | | | 43.75,69.50 | 2.66, 6.27 |
| C | Slope | 04/09/92 | 283 | 73 | 15 | 105.45 | 4.75, 5.50. 6.50 | 1.15, 1.02, 0.65 |
| | | | | | | | 37.25, 45.25,48.25 | 2.10, 3.14, 6.13 |
| D | Back drain | 20/11/92 | 248 | 72 | 13 | 19.40 | 13.00,13.00, 16.00 | 6.53.6.53,7, 82 |
| | | | | | | | 29.25 | 2.88 |
| E | Steep Slope | 04/09/92 | 712 | 92 | 21 | 122,85 | 62.50, 66.75, 79.50 | 5.14, 6.69, 5.88 |
| F | Road beside | 19/11/92 | 422 | 41 | 11 | 56.85 | 63.25, 70.75 | 6.34, 5.32 |
| | jungle trail | 20/11/92 | 818 | 64 | 23 | 61.60 | 6.50, 6.75. 7.50 | 2.79, 3.49, 1.74 |
| | | | - | - | - | - | | |
| | | | 1240 | 105 | 34 | 118.45 | | |
| G | Culvert lll | 24/09/92 | 351 | 79 | 16 | 55.25 | 19.75, 20.50,39.75 | 3.30, 1.67, 3.11 |
| H(u) | Ex-logging | 24/09/92 | 556 | 146 | 9 | 31.05 | 14.50, 23.50, 25.00 | 1.43, 2.75, 7.26 |
| | trail (upper) | | | | | | 27.00 | 15.53 |
| H(l) | Ex-logging | 29/12/92 | 264 | 38 | 9 | 37.97 | 25.50 | 7.38 |
| | trail (lower) | | - | - | - | - | | |
| | | | 820 | 184 | 18 | 69.02 | | |
| I(u) | Road (upper) | 25/09/92 | 1034 | 207 | 3 | 77.10 | 2.50, 9.00 | 1.10, 1.57 |
| I(l) | Road (lower) | 28/12/92 | 1475 | 72 | 39 | 205.07 | 10.00,10.00, 10.50 | 2.88, 2.88, 5.66 |
| | | | | | | | 13.50,14.00, 14.75 | 3.92, 2.78.8.61 |
| | | | | | | | 14.75 | 4.30 |
| | | 15/01/93 | 178 | 26 | 2 | 17.60 | 9.50 | 1.65 |
| | | | - | - | - | - | | |
| | | | 2687 | 305 | 44 | 299.77 | | |
| J | Ex-logging | 04/09/92 | 473 | 189 | 16 | 30.04 | 5.25,37.50 | 2.07, 8.89 |
| | trail | | | | | | | |
| K | Culvert ll | 24/09/92 | 807 | 75 | 10 | 81.30 | 42.75. 54.50.60.25 | 2.84, 3.70, 3.76 |
| L | Slope | 14/01/93 | 206 | 56 | 15 | 15.70 | 9.75,12.50,12.75 | 3.07, 6.09, 8.83 |
| M | Slope | 29/12/92 | 212 | 36 | 9 | 10.95 | 4.50, 7.00 | 3.45, 3.49 |
| N | Slope | 25/09/92 | 178 | 40 | 8 | 16,75 | 6.00,10.00. 54.50 | 1.32, 1.81, 2.02 |
| 0 | Slope | 22/11/92 | 286 | 27 | 11 | 47.10 | 34.00,34.50 | 5.21,11.87 |
| P | Slope | 20/02/93 | 204 | 47 | 16 | 48.52 | 31.00, 43.00,44.00 | 4.39, 3.99,10.58 |
| Q | Slope | 22/ 11/92 | 148 | 18 | 4 | 13.60 | 20.50 | 2.99 |
| | | 18/02/93 | 214 | 4 | 6 | 26.20 | 10.00 | 1.92 |
| | | | - | - | - | - | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 362 | 22 | 10 | 39.80 | | |




*Photo 18.* Site A is a water storage tank next to a slope. (i) Shows planting of *Vetiver* hedgerows to protect the slope of 36% gradient just below the tank. (ii) Shows *Vetiver* hedgerows 14 weeks later. (iii) & (iv) Shows the slope of 26% gradient at side of water tank protected by *Vetiver* hedgerow




*Photo 19.* Site A shows the slope below the water tank protected by *Vetiver* hedgerows. Another source of erosion is the sloping (6.7% gradient) planting row which has to be protected by cross-planting of *Vetiver* hedgerows.

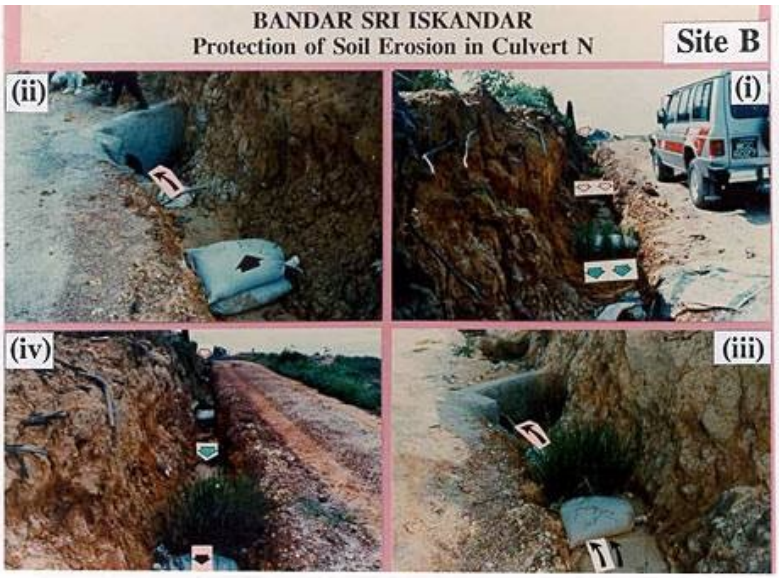



*Photo 20.* Site B: (i) Shows the back drain. (ii) The gradient (5.25% to 7.25% and 20 m length) delivers rain-wash at great velocity to the culvert inlet. (iii) & (iv) The erosive force is progressively reduced by the cross plantings of *Vetiver* hedgerows in the back drain.

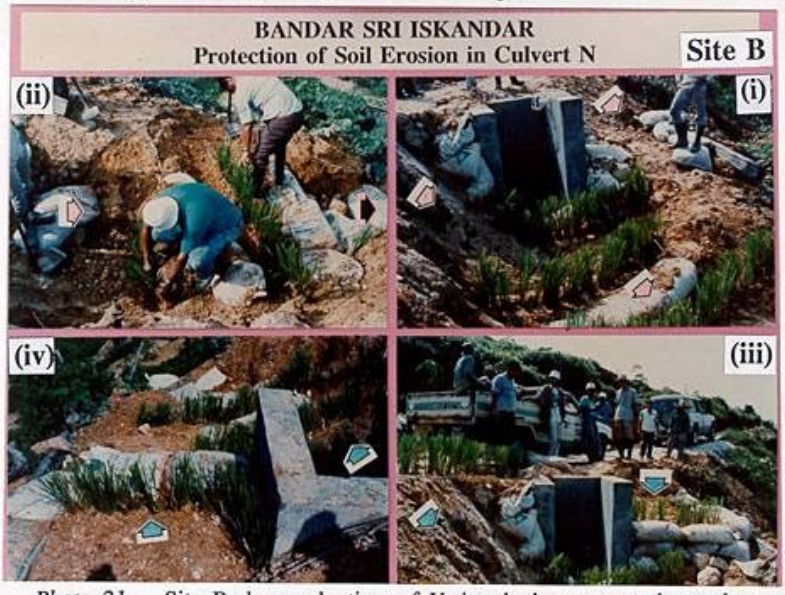



*Photo 21.* Site B shows planting of *Vetiver* hedgerows at the outlet. Note severe erosion had already occurred and 275 sand bags had to be used to fill up the deep gully as well as to protect the *Vetiver* from being washed off. The arrows show the directions of the erosive forces that must be contained.

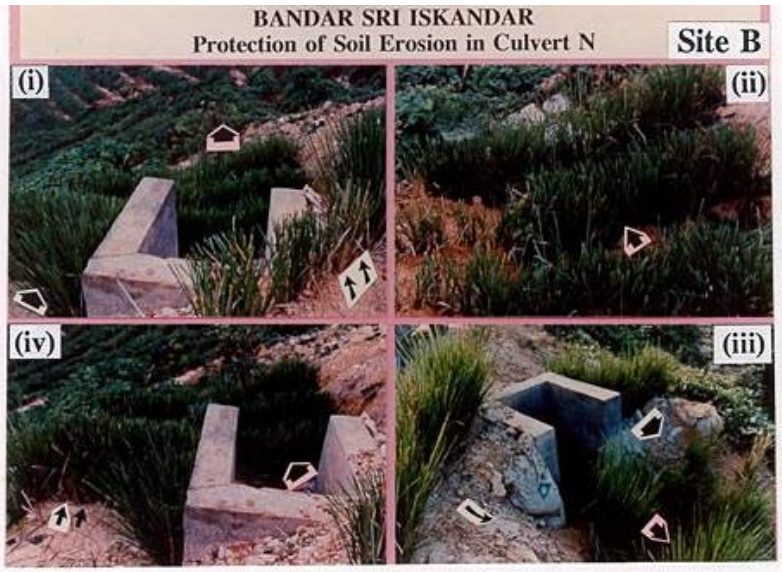



*Photo 22a.* Site B: After 13 weeks the *Vetiver* hedgerows have established firmly and effectively prevent any further erosion at this outlet.




*Photo 22b.* Site B: Note how the cross-planting of the *Vetiver* hedgerows has slowed down the discharge from the outlet, thus reducing the erosive force from this slope of 44% gradient.




*Photo 23.* Site B(r): The *Vetiver* hedgerows protect the culvert and prevent erosion below the culvert outlet. The erosive forces originate from the back drain (length 20 m, 7.25% gradient) and the sloping (20.5% gradient) planting row. These are reduced by cross-planting with *Vetiver* hedgerows. The road-shoulder and the neighbouring area of the culvert were planted with *Vetiver* hedgerows to protect the structure.




*Photo 24a.* Shows the alignment of the *Vetiver* hedgerows at the outlet of the culvert. The gradients are 43.75% at the upper slope and 69.5% further down.




*Photo 24b.* Shows the good growth of the *Vetiver* hedgerows which have started to trap the soil-wash.







*Photos 25a & 25b.* Site C: This was a badly eroded slope with gullies and sink holes already formed. The photos show the site at planting. The arrows (⇨) indicate the direction of the erosion down the slopes with gradients of 37%, 45% and 48%.




*Photo 26a.* Site C: Another view of the slope at the time of planting the *Vetiver* hedgerows. The arrows ( ⇦ ) indicate the direction of the erosion which come from the slope (37% gradient) below the road and the sloping (6.5%) terraced planting row.




*Photo 26b.* Site C: The same view as above, after 10 weeks, showing the established *Vetiver* hedgerows.




*Photo 27a.* Site D: (a) The main problem is the long (19.4 m) back drain with gradient of 13-16% which had already been eroded to 0.5 to 0.6 m deep.




*Photo 27b.* Site D: (b) The subsidiary problem is the badly terraced planting row with 29% gradient. The water from this site discharges into a culvert.







*Photos 28a & 28b.* Site D: These photos show the use of *Vetiver* hedgerows to slow down the force of water gushing down the back drain. The sand bags are essential to prevent the *Vetiver* plants from being washed off and also serve to breakdown the force of the water and trap the soil at the beginning. Note that the soil trapped is already higher than the sand bags showing that *Vetiver* hedgerows are already functioning after 12 weeks. Note the measuring poles are mounted vertically using a spirit level and therefore the horizontal line can be drawn to show that 0.55 m of soil was trapped in 12 weeks.







*Photos 31a & 31b.* Site F: These photos show 2 views of the site. Note how the well established *Vetiver* hedgerows, at 12 weeks after planting, have now stabilised the weak spots with gradients of 63% ( ⇨ ) and 71% ( ⇨ ). This road is now fully protected from erosion at the shoulder.




*Photo 32a.* Site G: This site involves the problem created by discharge from a culvert outlet shown in this photograph.




*Photo 32b.* Site G: This general view shows the great damage caused by the discharge from the culvert outlet ( ). At the time of planting the *Vetiver* hedgerows, erosion had already affected 3 planting rows below the culvert. 351 quality polybag plants had to be used to protect this area.







*Photos 33a & 33b.* Site G: The primary source of the problem is the rain-wash fed by the back drain into this culvert; this is reduced by cross-planting with *Vetiver* hedgerows in the back drain to slow down the discharge coming out of this outlet. At this point, the discharge is further slowed down by the *Vetiver* hedgerows. Notice how the hedgerows are aligned to break down the forces ( ⇨ ) of the rain-wash.




*Photo 34.* Site H is an ex-logging trail with gradients of 25% and 27% and Site I is the major road in the scheme; 300 m of this road with gradients ranging from 10% to 15% were protected with *Vetiver* hedgerows.




*Photo 35.* Site I: Shows a portion of the road which has collapsed. The sand bags are used to re-build the road-shoulder.




*Photo 36a.* Site I: Shows the shoulder of the road planted with *Vetiver* hedgerows. The 2 parts where the road had already collapsed was re-built with sand bags before planting with *Vetiver* hedgerows.




*Photo 36b.* Site I: Showing the good hedgerow formed on the shoulder of the road after only 8 weeks.




*Photo 37a.* Site I: Shows the hedgerow has protected the shoulder of the road.




*Photo 37b.* Site I: Shows the well established hedgerows protecting this weak slope below the road. The sand bags had disintegrated but the *Vetiver* hedgerowsz are well established and fully effective in preventing any further soil erosion.



*Photo 38.* Bird's eye view of Site H at 8 weeks after planting and Site I at 21 weeks after planting the *Vetiver* hedgerows. As the road is very long, planting of *Vetiver* hedgerows at the road-shoulder have to be done in stages because of non-availability of quality planting materials. The *Vetiver* hedgerows at the lower part of the road was only 5 weeks old.




*Photo 39.* Site J: This is an ex-logging trail with a vertical height of 8.9 m and a gradient of 37.5%. In addition, the back drain on the scheme-road at the top discharges the rain-wash into this trail causing severe erosion which has also affected the terraced planting row below.

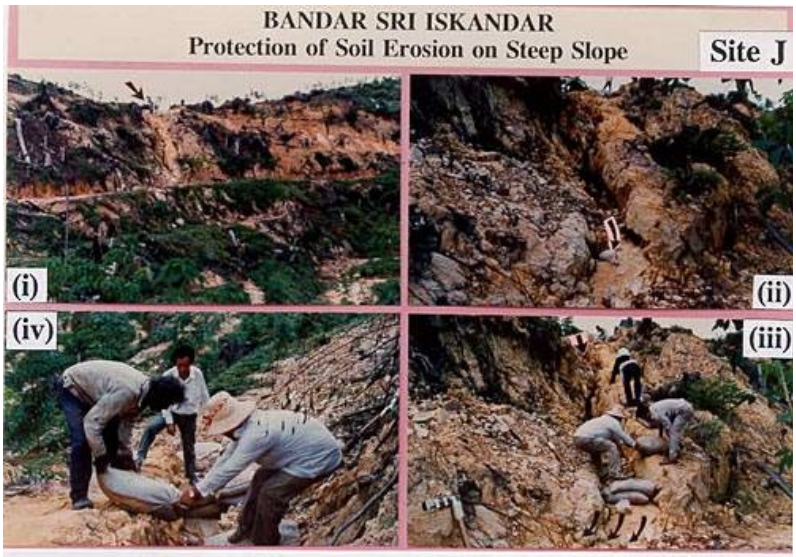



*Photo 40.* Site J: This shows the situation at planting. (i) A general view. (ii) Shows the severe erosion which has already reached the bed-rock. (iii) & (iv) Show the placement of sand bags.

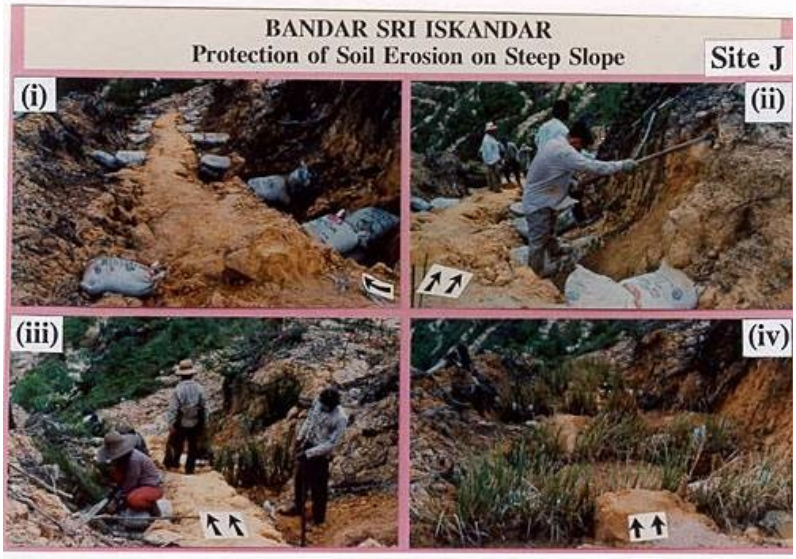



*Photo 41.* (i) Shows the sand bags at 1m vertical interval. (ii) Shows how soil is borrowed to provide a place to plant the *Vetiver*. (iii) Shows *Vetiver* planted just next to the sand bags. (iv) Shows *Vetiver* hedgerows established after 3 weeks.







*Photos 42a & 42b* The major contributing erosive force is the rain-wash from this back drain discharging into the trail. Use of cross-planted *Vetiver* hedgerows have slowed down the discharge and have effectively reduced this erosive force.







*Photos 43a & 43b.* Site J: The *Vetiver* hedgerows established after 10 and 22 weeks. Note the amount of soil trapped. This trail is fully protected from future erosion.



*Photo 44.* Shows the measurement of length of *Vetiver* hedgerow by pedometer.

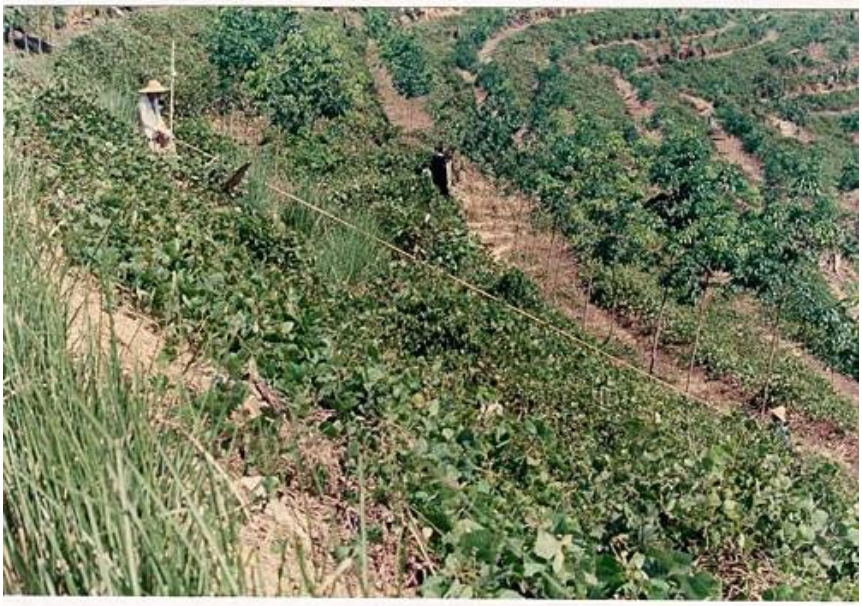


*Photo 45.* Measuring the slope gradient using a clinometer. With the slope length measured by tape, the slope height (or the vertical drop) can be computed.

# 7. Trials initiated in 1991

## 7.1 Cooperative trials being set up

*Source: First Progress Report, Chapter H*

Vetiver plants are being multiplied in many commercial nurseries of end-users. They are to be used in co-operative trials where all funds will be supplied by the interested parties. The following summarises those in advanced stage of being set up.

### Trial 1: To study the effect of Vetiver on growth of rubber.

The trial has just been established ( Photo 61 ). The cost of preparing the polybag Vetiver plants and planting them out cost more than $3,000. This, and the subsequent cost of running the trial, will be borne by the estate.

### Trial 2: To study the effect of Vetiver on growth of rubber.

60,000 polybag plants of Vetiver were being raised ( Photo 62a ) and land has been cleared ( Photo 62b ). Planting of rubber and Vetiver is planned for March 1991.

### Trial 3: To study the effect of Vetiver to prevent soil erosion in very steep terrain.

This is an interesting trial and uses an abnormal approach. The land is very steep and terracing could not be done in many areas. 25,000 polybags of Vetiver are ready ( Photo 63a ). Land clearing had been completed ( Photo 63b ). The Vetiver will be planted out in March but rubber will only be planted out in September 1991. Between the two periods, the amount of soil erosion will be monitored.

### Trial 4: To study the effect of Vetiver growth on the stability of highway embankments.

The site is one where establishment of commonly used grasses had failed and topsoil erosion had occurred ( Photo 64a ). Polybag plants are being prepared ( Photo 64b ). The trial will be established in March 1991.

PHOTO 61. EFFECT OF VETIVER ON GROWTH OF RUBBER (1)



(a) General view of field site. The 2 white dots are workers standing at the plot boundaries. Each plot size is 36 x 36 sq. metre. The terrain is 20° slope.



(b) Looking down from the highest terrace in a Vetiver plot. Each plot has approximately 120 rubber buddings and 2,600 polybag plants of Vetiver.

Established: 21/2/1991
Photo taken: 21/2/1991 (Ref: 6/1991)

PHOTO 62. EFFECT OF VETIVER ON GROWTH OF RUBBER (ii)



(a) 60,000 polybag plants being raised in estate nursery.



(b) The experimental site.

(Ref: 1/1991)

**PHOTO 63. EFFECT OF VETIVER TO PREVENT SOIL EROSION**



(a) 25,000 polybags of Vetiver plants in estate nursery.

(Ref: 24/1990)



(b) The experimental site is too steep for mechanical terracing in many areas. The white dot (→) is a worker.

(Ref: 3/1991)

PHOTO 64. EFFECT OF VETIVER ON HIGH EMBANKMENTS



(a) The experimental site in the North-South Highway.



(b) Polybag plants growing in the end-users' nursery.

(Ref: 4/1991)

# Appendix: index to the video recordings

## Video index

*Source: Second Progress Report*

| | Subject | Tape No. | Point of Location (Hrs/Mins/Secs) |
|---|---|---|---|
| 1. | PRODUCTION OF QUALITY PLANTING MATERIAL | | |
| 1.1 | Root Regeneration | 1 | 0h.00m.00s. |
| 1.2 | Effect of Age of Polybag Plants on Subsequent Growth | 1 | 0h.20m.26s |
| 1.3 | Effect of Tiller Numbers at Planting on Growth | 1 | 0h.33m.51s. |
| 1.4 | Effect of Cultivar and Bag Sizes on Growth | 1 | 1hr.00m.52s. |
| 1.5 | Raising Vetiver Plants in Biodegradable Containers | 1 | 1h.12m.20s. |
| 1.6 | Effects of Unorthodox Rooting – Media on Vetiver Growth | 1 | 1h.15m.24s |
| 4 | USES OF VETIVER – CASE STUDIES | 2 | |
| 4.1 | Sungei Chinoh Estate | 2 | 1h.06m.17s |
| 4.2 | Hwa Li Estate | 2 | 2h.06m.55s. |
| 4.3 | Bandar Sri Iskandar | 3 | |
| | Site A | 3 | 0h.00m.00s. |
| | Site B | 3 | 0h.23m.00s. |
| | Site B ( r ) | 3 | 0h.40m.30s |
| | Site C | 3 | 1h.08m.57s |
| | Site J | 3 | 1hr.23m.00s |
| | Site H-I | 3 | 1h.39m.20s. |
| 5 | OBSERVATIONS TO SHOW SPECIAL CHARACTERISTICS OF VETIVER HEDGEROWS | | |
| 5.1 | Resistance to Fire Damage | 2 | 0h.41m.16s. |
| 5.3 | Excavation | 2 | 0h.00m.00s |