Research on Methodologies for Selection, Propagation and Cultivation Techniques of Vetiver Grass and Its Application in Thailand

by

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ABSTRACT

Soil erosion is a major cause of the land degradation that affects agricultural areas in Thailand. Resolving the soil erosion problem can be achieved only by appropriate technological solutions that are traditionally and economically accepted by the local land users, particularly the farmers. His Majesty's initiative on Vetiver grass as an agronomic measure against soil erosion has been recognized increasingly. Being one of the implementing agencies, the Department of Land Development has been assigned to conduct research to identify appropriate methodologies for cultivation of Vetiver grass in Thailand.

Research stretching over eight years has concerned Vetiver cultivation, large-scale field plantation, quantification of environmental impacts and non-agricultural uses of Vetiver. Illustrations of the interesting research results by statistical means are highlighted. Clearly, Vetiver provides simple, cheap and comprehensive means to control or minimize soil erosion. Hence, Vetiver is increasing in popularity, is being widely adopted by Thai farmers and can be used for many other purposes.

INTRODUCTION

Although Thailand's agricultural growth rate in the past decade has been quite impressive, it has been achieved largely through expansion of cultivated land. However, agricultural development has exacerbated land degradation, especially in ecologically fragile areas. Today, the principal cause of land degradation is misuse of the land and vegetation cover which in turn often results in soil erosion or removal of the topsoil by water. After rainfall, water rushes down slopes, carrying away precious topsoil and plant food. Downslope, ploughing worsens the situation, and often serious gullying develops. It is estimated that the rate of erosion in the region where most field crops (such as cassava) have been cultivated, is about 12.5-62.5 tons/hectare/year. It is most regrettable however, that only a small area of these croplands is protected by erosion control measures.

In recognition of the serious problem of soil erosion, particularly on cultivated land, His Majesty King Bhumibhol Adulyadej initiated in 1991 the idea of using Vetiver grass as a practical tool to reduce soil erosion and improve water conservation in Thailand. After the Royal initiatives, the Department of Land Development (DLD) in particular, was assigned to conduct studies to identify appropriate methodologies for wide-scale cultivation of Vetiver grass, as well as research on appropriate application for different purposes. Meanwhile, His Majesty the King has given most valuable suggestions, at different times, to enhance the effectiveness of the studies and for implementing activities. This paper attempts to highlight the results of the research studies which are applicable to researchers, developers and farmers on the utilization of Vetiver on a wide scale as a technology for soil and water conservation, for solving environmental problems as well as realizing its many uses benefits in non-agricultural production.

ESTABLISHMENT OF VETIVER GRASS CULTIVATION

A. Selection of the planting cultivars

In Thailand, Vetiver can grow naturally throughout the country, on both upland and lowland soils at maximum elevations of approximately 800 masl. Recent studies have indicated that only two species of Vetiver namely *Vetiveria zizanioides* (Linn.) Nash and *Vetiveria nemoralis* (Balansa) A. Camus, have been recognized in Thailand. The main characteristics of these two species are differences in shape of clump, leaves, roots, inflorescence, and seeds. Detailed studies have been made on ecotypes and selection of varieties suitable for various soil types and physiographic regions. Seventy-eight ecotypes were collected from different sites all over Thailand. Afterwards detailed studies on botanical characteristics were conducted. The final study indicated that, in Thailand only 17 different ecotypes of *Vetiveria nemoralis* and 11 ecotypes of *Vetiveria zizanioides* could be differentiated. Then, each ecotype was named after the site name where it was found initially. By using these 28 ecotypes, their adaptability to different soil types, and 12 sites in different physiographic regions (Department of Land Development, 1998) inquiries were made on how to obtain suitable cultivars for use around Thailand. The parameters indicating their adaptability to the sites included number of tillers per clump, diameter of the clump and its height. To date, six ecotypes of *Vetiveria nemoralis* and four ecotypes of *Vetiveria zizanioides* have been recommended to grow in various parts of the country. Tables 1 and 2 summarize the result of the study on growth of different Vetiver ecotypes cultivated on sandy soils, medium-textured soils and skeletal soils (lateritic soils) at the 12 study sites. The data show that cultivation of Vetiver in Thailand is feasible in most areas of the country. Furthermore, it can grow well on some problem soils as illustrated in Table 3.

Fig. 1-2 The Royal Benevolence.

Table 1. Growth of Vetiver on different soil types from 12 experimental plots in different areas of the country

Ecotype	Sandy soils			Medium-textured soils			Skeletal soils		
	A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
1. *Vetiveria nemoralis*									
Loei (V6)	-	-	-	34	14	115	**18**	12	101
Nakornsawan (V7)	**31**	8	79	**39**	15	-	-	-	-
Kampaeng Phet 1 (V8)	30	9	92	38	14	120	-	-	-
Roi Et (V13)	26	7	70	-	-	-	-	-	-
Ratchaburi (V20)	25	8	102	38	16	117	-	-	-
Prachuabkirikhan (V22)	-	-	-	37	17	124	16	12	100
2. *Vetiveria zizanioides*									
Srilangka (V4)	-	-	-	-	-	-	12	10	106
Kampaeng Phet 2 (V9)	26	8	102	-	-	-	14	10	104
Suratthani (V28)	-	-	-	**38**	17	137	15	12	94
Songkhla3 (V28)	**29**	10	106	36	16	141	**16**	14	110

Remarks: A) = no. of plant/tiller
B) = stem diameter (cm)
C) = height (cm)

Source of data: Department of Land Development (1998b)

Table 2. Suitable ecotypes of Vetiver for different soil types and physiographic regions in Thailand

Ecotypes	Suitable for						
	Sandy soils	Medium-textured soils	Skeletal soils	Physiographic regions			
				C & SE	N	NE	S
1. *Vetiveria nemoralis*							
Kampaeng Phet 1	✓	✓		✓	✓		
Loei		✓	✓				
Nakornsawan	✓	✓			✓		
Prachuabkirikhan		✓	✓	✓			
Ratchaburi	✓	✓		✓			
Roi Et	✓					✓	
2. *Vetiveria zizanoides*							
Kampaeng Phet 2	✓		✓	✓			
Songkhla 3	✓	✓	✓	✓		✓	✓
Srilangka			✓		✓		
Suratthani		✓	✓	✓			✓

Remarks:
1. ✓ = suitable
2. C + SE = the Central Plain and the Southeast Coast
N = the North
NE = the Northeast
S = the South
3. Suitable ecotypes on high land (elevation about 1,000 – 1,200 m) are Japanese, DLD; EXT 09 and Maelanoi.

Source of data: Department of Land Development (1998b)

Table 3. Suitable ecotypes of Vetiver for some problem soils

Ecotypes	Feasible to grow on						
	ASS	SLS	PS	SS	HL	HW	GP
Prarajathan	✓				✓	✓	✓
Maelanoi					✓		
Monto					✓	✓	
Nakornsawan						✓	
Songkhla 3		✓	✓	✓			✓
Srilangka	✓	✓		✓			
Suratthani	✓		✓	✓			✓

Remarks:
1. ASS = Acid sulfate soil (with liming)
   SLS = Saline soil
   PS = Peat soil
   SS = Shallow soil
   HL = High land
   HW = Side slope of the highway
   GP = Industrial garbage pit
2. Data obtained from plot experiment in 1998.
3. Fertilizer application is needed.

Source of data: Department of Land Development (1998a)

Fig. 3 Comparative study on different ecotypes of Vetiver: Kampaeng Phet 2, *Vetiveria zizanioides* (Linn.) Nash on the left and Ratchaburi, *Vetiveria nemoralis* on the right.

Fig. 4 Native *Vetiveria nemoralis* growing on a typical dry dipterocarp forest in Kampheng Phet province, the lower North, 1991.

Fig. 5 Experimental plot on selection of suitable ecotypes of Vetiver at Rayong Land Development Station; the Southeast coast, 1992.

Fig. 6 Study on the adaptability of Vetiver grass on a sandy soil at the Klao Hin Son Royal Development Study Center, Chachengsao province; the Central Plain, 1993.

Fig. 7 Study on propagation methods for Vetiver, Nakhonsawan, 1995.

B. Propagation

The production of propagative materials is essentially the first requirement for the establishment of Vetiver cultivation. After selection of the suitable ecotype, a propagation program needs to develop quickly to obtain the hundreds of thousands of seedlings to plant. In general, the most simple way is to propagate Vetiver by root division or slip. However, micropropagation ("**tissue culture**") has introduced to Thailand since 1994, particularly at the sloping land conservation project at Doi Tung in Chiangrai province of the North (Department of Land Development, 1998). The propagative materials from tissue culture are known as plantlets, which are very easy to handle and relatively convenient to transport for transplanting in the field.

The flow chart below illustrates production of the propagative material of Vetiver by **tissue culture**.

Selection of suitable ecotype

↓

Preparation of seedlings by root division and
(kept for 1 month in a nursery)

↓

Operation on tissue culture in the lab; germplasms
(kept in agar and fed with nutrient
formulae 1, 2 and 3 consecutively for 3 months)

↓

Transplant plantlets in plastic chamber,
(kept carefully for 1 month)

↓

Transfer all mini-seedlings to the nursery near
or within the Vetiver growing area

↓

Transplant all plantlets into small vinyl bags
(kept in nursery for 1 month)

↓

Cultivation of Vetiver in the field

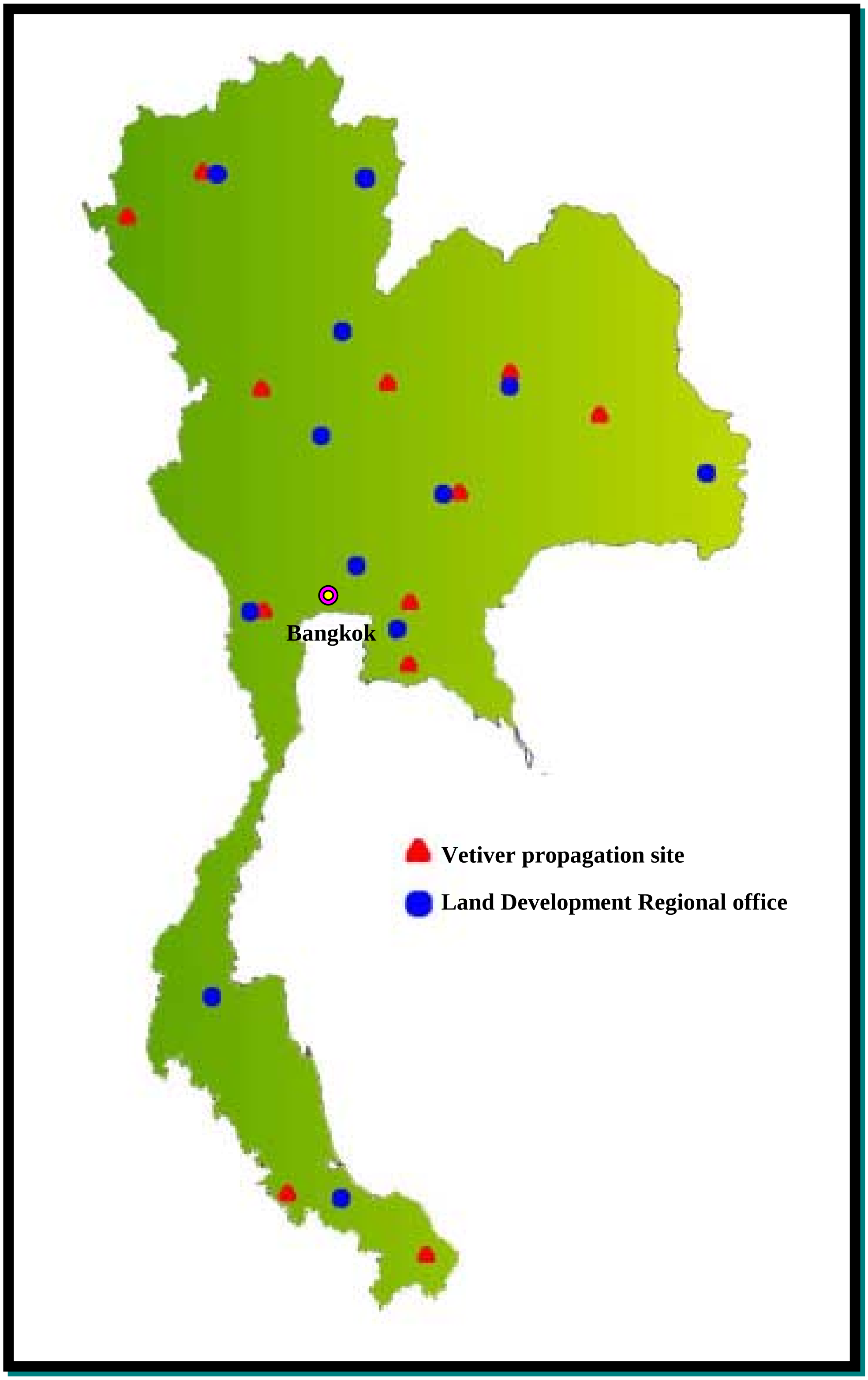

Fig. 8 Location of the Vetiver propagation sites for distribution of the Vetiver cultivars to users thoughout the country; conducted by the Land Development Regional offices.

Fig. 9 Propagation of Vetiver in large quantities from ecotypes recommended for various applications; Chiang Mai, 1999.

Fig. 10 An appropriate Vetiver propagation technique that ensures a uniform growth rate when applied for Vetiver hedgerows in the field; Chiang Mai, 1999.

Although the tissue culture method has several advantages over the conventional method, it is highly technical and a laboratory is required. In most cases the multiplication of Vetiver by root division or slips is easy and many propagative materials can be produced. Vetiver slips, kept in well-prepared light soils in vinyl bags, at the early stage, need to be cared for in a nursery. To enhance good growth of the seedlings or for profuse tillers, fertilizer application and irrigation are necessary.

CULTIVATION OF VETIVER IN THE FIELD

Many studies, not only in Thailand but also in other tropical countries, have assured the usefulness of Vetiver grass in the field to prevent soil erosion and to promote water conservation. After His Majesty the King's initiatives on uses of Vetiver in Thailand, 10 ecotypes were nominated and extensive propagation programs were launched. In 1993, **6,500,000** plants were available and in 1999 the number increased to **99,500,000** plants. The trials have been incorporated in several specific projects dealing with topics discussed next.

A. Research on cultivation of Vetiver on farming areas prone to erosion

In Thailand, it is common for Vetiver to be planted in narrow strip aligned on the contour. The vertical distance between the Vetiver strip depends on the slope gradient of the soil surface. For more effective prevention of soil loss and reduction in the velocity of runoff, ploughing, planting and cultivation on the contour are practiced additionally.

The planting method for Vetiver is simple but needs much labor because the interval for each tiller to be transplanted is about 10 cm. If the soils are very low in fertility, fertilizer application both in chemical and organic forms is needed in the planting holes or planting furrows. However, when planting material is scarce and accessibility in the field is rather poor, slips can be spaced at about 20 cm (Vietmeyer, N.D, 1993) or the planting material can be removed directly from the main clump and planted into the ground (like rice seedlings).

It is important that the planting is done at the beginning of the wet season for enough moisture to enhance the quick establishment of the Vetiver line or hedge. In Thailand, it is generally recommended for Vetiver to be planted from 30 May to 30 July and 15 August to 30 September. After planting and if the survival rate exceeds 90 percent, it takes about 90 days to form a complete hedge or a complete green line. Once the Vetiver grass barriers are complete, they should provide full protection against erosion and last for years.

On experimental plots conducted by the DLD, Vetiver hedges reduced the rate of soil loss and crops could be grown between the Vetiver line.

Table 4 indicates the effectiveness of the Vetiver lines against soil erosion on experimental plots on 20 percent slopes under field crops (maize and black beans). The data show that in the first year, Vetiver hedges reduced annual erosion to less than 0.75 ton/ hectare compared with 12.6 ton/hectare for conventional practices or without Vetiver hedges.

Since degree of slope is one of the factors that can contribute to loss of the topsoil by water erosion, therefore determining the vertical interval (VI) for the layout of each line of Vetiver is necessary.

Fig. 11 Progressive bench terraces for orchards gradually formed by a Vetiver hedge system, Chiang Mai 1998.

Fig. 12 Integrated Vetiver hedgerows and terraces on sloping farmland, Chiang Mai, 1998.

Table 5 presents the results of these studies. It indicates that the vertical interval at 1.0, 2.0 and 3.0 m makes no difference in soil loss. Therefore, the vertical interval can vary from 1.0 to 3.0 m depending upon the crop to be grown. However, the higher the value of the vertical interval (VI), the wider the horizontal interval (HI) of the Vetiver line will be when using this formula

$$HI = \frac{VI}{\%Slope} \times 100$$

It is interesting to note that soil loss was significantly decreased from the first year to the third year which can be attributed to the quick establishment of the Vetiver hedge after a year of planting. Research on maximizing and increasing the efficiency of Vetiver grass continues.

Table 4. Measurement of the annual soil loss from different treatments of the Vetiver trial

Treatments	Annual soil loss (ton/hectare)
1) Single line of Vetiver	
Tr.1.1) Spacing between tiller 10 cm	**0.21** b
Tr.1.2) Spacing between tiller 15 cm	0.32 b
Tr.1.3) Spacing between tiller 20 cm	0.70 b
2) Double lines of Vetiver, interval distance between lines 30 cm	
Tr.2.1) Spacing between tiller 10 cm	0.75 b
Tr.2.2) Spacing between tiller 15 cm	0.67 b
Tr.2.3) Spacing between tiller 20 cm	0.64 b
3) No Vetiver (control)	12.57 a
LSD. (0.05)	

Source of data: Inthaphun, P. et al (Chiang Mai, 1999)

Table 5. Measurement of annual soil loss from different VI of the Vetiver lines

Treatments	Annual soil loss (ton/hectare)		
	1 st yr.	2 nd yr.	3 rd yr.
Tr. 1. Control (Fallow)	20.39 a	28.72 a	29.05 a
Tr. 2. Single line of Vetiver (V.I.=1.0 m)	8.57 b	0.74 b	**0.66** b
Tr. 3. Single line of Vetiver (V.I.=2.0 m)	9.06 b	1.17 b	0.77 b
Tr. 4. Single line of Vetiver (V.I.=3.0 m)	8.37 b	1.10 b	0.76 b
DMRT at 5 %			

Source of data: Inthaphun, P. et al (Chiang Mai, 1999)

B. Research on the cultivation of Vetiver on waterways

The purpose of waterways in a conservation system is to convey runoff at a non-erosive velocity to a suitable disposal point. Within a complete system, there are three types of waterway that can be incorporated i.e. diversion channels, terrace channels and grass waterway. Diversions are commonly placed upslope to intercept runoff water and divert the water across the slope to a grass waterway. Terrace channels collect runoff from the inter-terrace areas and also divert it across the slope to a grass waterway. Grass waterways are designed to drain (downslope) the runoff from these sources to natural streams or natural waterways, farm ponds and reservoirs.

To prevent grass waterway from deterioration by gully or rill erosion, a straddling green line of Vetiver can help a great deal. Row of grass are planted like an inverted ‘V’ across the channel or grass waterway with the apex pointing upstream. Determination for the number of Vetiver lines depends on the gradient of the waterway. In general, a vertical interval (VI) of about 50 cm is recommended. Three months after planting, cutting the top of the plant to about 40 cm above the ground surface is practiced for denser tillering or hedges. Cultivation of Vetiver on the waterway is relatively practical on a wide scale because construction is easy; only a minimal amount of equipment is needed and simple techniques are used (see Fig. 13).

C. Research on the cultivation of Vetiver along the edges of farm ponds, reservoirs, canals, dikes or small check dams

It has been reported that rows of Vetiver grass planted on the edges of excavated ponds, irrigation canals, and dikes on dams prevent scouring to form rills and gullies.

For this purpose, two lines of Vetiver are planted on the edges of the farm ponds, three lines on the edges of a reservoir and only one line along irrigation canals and natural waterways.

On the edges of a reservoir, the first line is located at the top of the spillway or the outlet where the maximum water level is reached. The other two lines will be above and below the first line, with a vertical interval (VI) of 20 cm. For a farm pond, the first line is at the top of the inlet and the second line is below the top of the edge (50 cm). For an irrigation canal or a natural waterway, a line of Vetiver is planted on the dike or levee away from edge (50 cm).

Because the soil at the edge of the excavated pond is generally not fertile, chemical fertilizer (15-15-15) mixed with compost is usually applied in the planting furrow. Three months after planting, it is recommended to cut the tops of the plants to produce more tillers. Sometimes, two fertilizer application may be needed (see Fig. 14).

D. Research on the cultivation of Vetiver on the side slopes of highways or roads

The conventional method to control soil erosion along the side slopes of highways or roads is to build concrete structures along it. However, the construction cost is relatively high. Therefore, to a certain extent, the Vetiver hedge can protect roads from washouts or landslides. If the slope length does not exceed 10 m, rows of Vetiver with a vertical interval of 20 to 50 cm can prevent erosion satisfactorily. If the slope length is longer and the gradient is very steep, planting of Vetiver hedges with an engineering system (such as terraces, berms, bunds or contour drains) can protect soil erosion. For example, Vetiver grass can be planted at the edge of each terrace in one line or two lines. To enhance the effectiveness of the Vetiver hedges, the exposed soil surface should be cultivated with cover crops like Bermuda grass or legumes. However, it is worth mentioning here that utilization of Vetiver for side slope protection of highways or roads in Thailand still needs further study to obtain an appropriate and less expensive technology (see Figs. 15, 16).

Fig. 13 Vetiver grass along a waterway, note the apex of the Vetiver line pointing up stream, Ratchaburi, 1994.

Fig. 14 Vetiver hedge around a farm pond, Ratchaburi, 1997.

Fig. 15 Combination of Vetiver and mechanical measures in road bank stabilization; Chiang Mai, 1999.

Fig. 16 Various cover crops between Vetiver hedgerows on a road bank Chiang Mai, 1999.

E. Research on integrated vegetation management

In general, once the Vetiver hedge is completely established, little management is needed except for cutting of the tops of the plants to produce denser tillers. Furthermore, Vetiver is a great survivor as it is difficult to destroy by fire, grazing, drought or flooding. However, it has been reported that Vetiver can be damaged by diseases and pests in Thailand. For example, the Chiangmai ecotype can be attacked easily by leaf blight caused by *Curvularia trifolli*. Root rotting, perhaps caused by *Fusarium spp*. attacks *Vetiveria zizanioides* ecotypes, particularly the Srilangka ecotype during the rainy season.

Pests such as termites, rats and insects attack Vetiver. Perhaps the most serious pests are aphids and mealy bugs. Stem borers also damage young seedlings in nurseries.

Cutting and thinning, of course, are necessary for vegetation management. Cutting the tops of the plants and taking out the old tillers after flowering (from the clump) can increase the number of young shoots and tillers, to make a denser hedge. However, time of cutting and thinning should be suitable otherwise it will retard the growth of Vetiver. Studies recommend that cutting and thinning of Vetiver should be done only once or twice a year. If the farmers want the Vetiver leaves as raw material for making roofs or handicrafts, cutting the leaves at 180 days can obtain more leaf biomass. If leaves are needed for mulching, the time of cutting should be around 90-120 days. If used for feeding livestock, cutting at 30-60 days is appropriate because leaf analysis shows a narrow C/N ratio. However, the young shoots or tillers can be removed to feed the livestock at any time.

Fig. 17   Cutting is needed for proper management of Vetiver hedgerows, Chiang Mai, 1998.

Table 6. Biomass obtained from different times of leaf cutting of one-year-old Vetiver (Srilangka ecotype)

Treatment	No. of cuttings	Fresh leaves (kg.)	Dry leaves (kg.)	C/N ratio
T1	12	69.34	22.99	**39**
T2	6	98.05	32.99	53
T3	4	**111.58**	**42.94**	63
T4	3	107.97	37.32	67
T5	3	106.45	32.85	67
T6	2	98.25	39.38	67
T7	1	92.27	30.61	71

Remarks:
T1 = cutting the top of the plant at 30 cm every 30 days
T2 = cutting the top of the plant at 30 cm every 60 days
T3 = cutting the top of the plant at 30 cm every 90 days
T4 = cutting the top of the plant at 30 cm every 120 days
T5 = cutting the top of the plant at 30 cm every 150 days
T6 = cutting the top of the plant at 30 cm every 180 days
T7 = cutting the top of the plant at 30 cm every 360 days

Source of data: Suwannakert, V. et al. (1998)

F. By-products and benefits of Vetiver cultivation

As mentioned previously, the cultivation of Vetiver helps to prevent soil erosion as well as to conserve the soil moisture. Moreover, Vetiver has a deep root system that can make soil more porous and the numerous fibrous roots can increase soil organic matter after decomposition. Therefore, it is worth knowing whether such a deep root system can benefit soils in terms of increasing microorganisms and nutrients. Tables 7, 8, 9 and 10 illustrate the results of recent studies. The data indicate clearly that the cultivation of Vetiver increases the population of microorganisms and soil nutrients. These are by-products of Vetiver that can benefit the soil and the environment at no additional cost.

Table 7. Total population of microorganisms at a soil depth of 0-30 cm and 30-60 cm in various plots of different Vetiver ecotypes.

Treatment (Vetiver ecotype)	Soil depth 0-30 cm No. of cell/gm soil			Soil depth 30- 60 cm No. of cell/gm soil		
	Bacteria	Actinomycetes	Fungi	Bacteria	Actinomycetes	Fungi
Check (no Vetiver)	3.8×10^6	6.4×10^5	9.9×10^2	1.1×10^6	3.6×10^5	6.7×10^2
Prarajathan	2.6×10^7	4.8×10^7	7.1×10^3	1.3×10^8	**2.7×10^8**	**8.9×10^3**
Prachuabkirikhan	**9.0×10^7**	3.6×10^6	4.3×10^3	6.1×10^8	3.3×10^7	7.0×10^3
Ratchaburi	5.8×10^6	**7.4×10^6**	**9.1×10^3**	7.2×10^7	2.6×10^7	4.3×10^3
Songkhla3	1.7×10^7	3.5×10^6	8.3×10^3	1.5×10^8	**6.7×10^7**	3.1×10^3
Suratthani	1.7×10^7	2.2×10^6	5.6×10^3	**6.7×10^8**	2.6×10^7	4.0×10^3
Srilangka	1.3×10^7	4.8×10^6	5.8×10^3	8.0×10^7	7.2×10^6	8.8×10^3

Source of data: Sunanthapongsak, W. et al. (1999)

Table 8. Population of cellulose digestible microorganisms at a soil depth of 0-30 cm and 30-60 cm in various plots of different Vetiver ecotypes

Treatment (Vetiver ecotype)	Soil depth 0-30 cm			Soil depth 30-60 cm		
	No. of cell/gm. soil			No. of cell/gm. soil		
	Bacteria	Actinomycetes	Fungi	Bacteria	Actinomycetes	Fungi
Check (no Vetiver)	5.1×10^6	1.07×10^6	1.7×10^2	2.0×10^5	5.06×10^5	4.5×10^2
Prarajathan	2.8×10^8	1.4×10^8	**6.4×10^4**	2.4×10^8	3.1×10^8	8.3×10^4
Prachuabkirikhan	8.6×10^7	2.2×10^7	2.3×10^4	1.0×10^7	2.8×10^6	5.3×10^3
Ratchaburi	**3.2×10^8**	**1.8×10^8**	3.9×10^3	2.0×10^8	4.4×10^6	5.8×10^3
Songkhla3	7.7×10^7	1.4×10^7	1.1×10^4	1.0×10^6	4.4×10^7	7.9×10^3
Suratthani	1.2×10^7	1.0×10^7	4.2×10^3	1.0×10^8	**4.4×10^8**	7.0×10^3
Srilongka	3.5×10^7	1.5×10^7	6.4×10^3	**3.1×10^8**	2.1×10^7	**8.8×10^4**

Table 9. Nutrient status at a soil depth of 0-30 cm in various plots of different Vetiver ecotypes

Treatment	Nutrient (ppm)					pH	Organic matter (%)
	P_2O_5	K_2O	Ca	Mg	S		
Check (no Vetiver)	2.07	103	271	345	0.83	5.04	0.58
Prarajathan	4.98	**161**	534	507	**2**	6.03	**1.03**
Prachuabkirikhan	4.89	159	530	494	1.59	5.98	**1.03**
Ratchaburi	4.29	148	516	618	1.775	5.93	0.91
Songkhla3	**5.02**	147	**575**	**682**	1.727	5.78	1.01
Suratthani	4.80	145	378	433	1.952	5.45	**1.03**
Srilongka	4.49	**161**	563	656	1.67	**6.23**	0.94

Table 10. Nutrient status at a depth of 30-60 cm in various plots of different Vetiver ecotypes

Treatment	Nutrient (ppm)					pH	Organic matter (%)
	P_2O_5	K_2O	Ca	Mg	S		
Check (no Vetiver)	2.39	93	280	362	0.82	5.06	0.42
Prarajathan	5.43	156	508	506	**1.62**	5.88	0.92
Prachuabkirikhon	4.22	141	472	**596**	1.45	5.63	0.82
Ratchaburi	**6.11**	136	434	496	1.5	5.53	0.81
Songkhla3	3.18	132	496	506	1.45	**6.15**	0.74
Suratthani	4.79	142	430	423	1.41	5.95	0.85
Srilongka	4.66	**157**	**515**	538	1.45	6.11	**0.93**

Source of data: Sunanthapongsak, W. et al. (1999)

NON-AGRICULTURAL USES OF VETIVER

Strong evidence confirms that Vetiver can be used for environmental conservation of both natural resources and farmland with good care and management. People pay more attention to the technology if they perceive direct-benefit. Vetiver then becomes a high priority for consideration. The DLD and the Royal Project Foundation assist technical collaboration for preliminary testing among institutes of technology and private agencies.

The following projects have been conducted prior to actual experimental designs for further research and more detailed investigation.

A. Vetiver root harvest technique

Fig. 18 Observation on Vetiver root distribution characteristics as affected by different moisture levels and Vetiver population density; Office of Highland Development, DLD, Chiang Mai, 1998.

Fig. 19 Vetiver roots produced in used fertilizer sacks (another agricultural product for the household farmer in the future); Chiang Mai, 1999.

B. Vetiver soil-cement brick

Fig. 20 Vetiver soil-cement brick developed for native clay cottage improvement. The wall bearing load reduces the cost of household construction; Ratchaburi Land Development Station, DLD Region 10, 1999.

Fig. 21 Samples of different amounts of Vetiver mixtures, soil and cement among soil series are prepared for laboratory testing; Ratchaburi Land Development Station, DLD Region 10, 1999.

C. Light-weight panel

Fig. 22 Bending strength test for a Vetiver lightweight panel; TG Advance Center Co, Ltd., Lopburi, 1999.

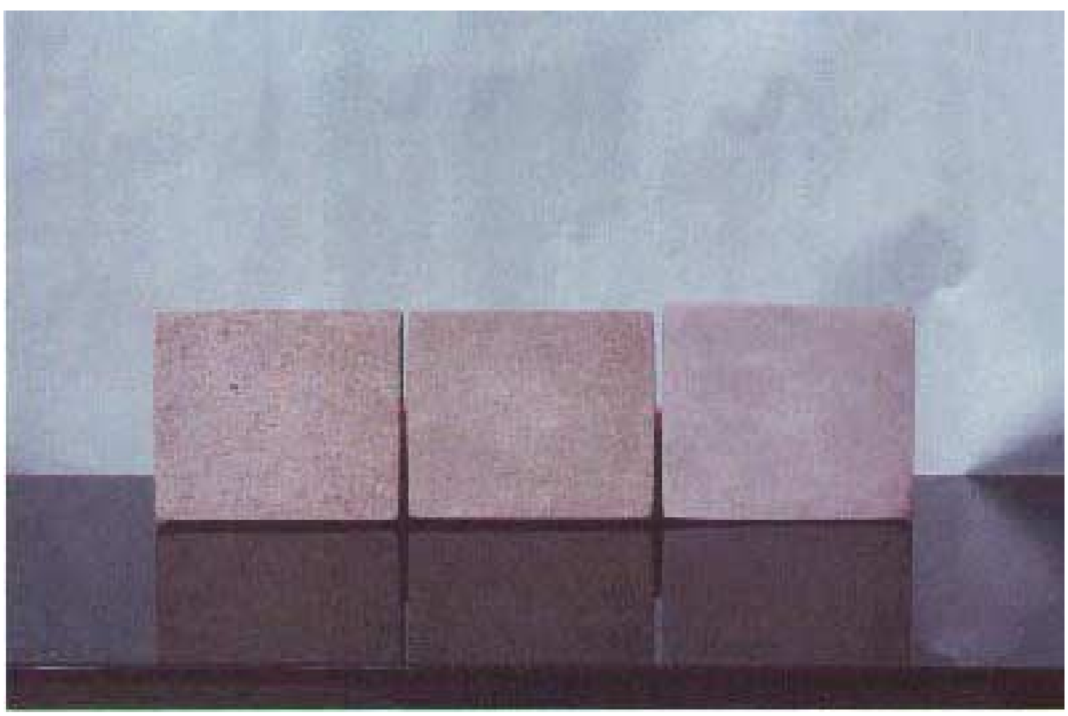

Fig. 23 Samples of cement bonded with leaf particles and stems of Vetiver grass; TG Advance Center Co, Ltd., Lopburi, 1999.

D. Vetiver chip board

Fig. 24 Technical development for a Vetiver board bonded by thermal setting with urea-formaldehyde; OHD and Phra Chom Klao Institute of Technology, Bangkok, 1999.

Fig. 25 Sample of Vetiver particle boards bonded by urea-formaldehyde; OHD and Phra Chom Klao Institute of Technology, Bangkok, 1999.

E. Thermal insulator panel

Fig. 26 Polystylene foam for a thermal insulator panel can be replaced by Vetiver particles. Zinc color-bonded overlay on the top for exposure testing in the field; Great Wall Insulator Co, Ltd., Patumtani, 1999.

Fig. 27 A cabin using Vetiver thermal insulator panels under construction for exposure testing; Great Wall Insulator Co, Ltd., Patumtani, 1999.

F. Natural Organic Fibers as Fiber Reinforcement

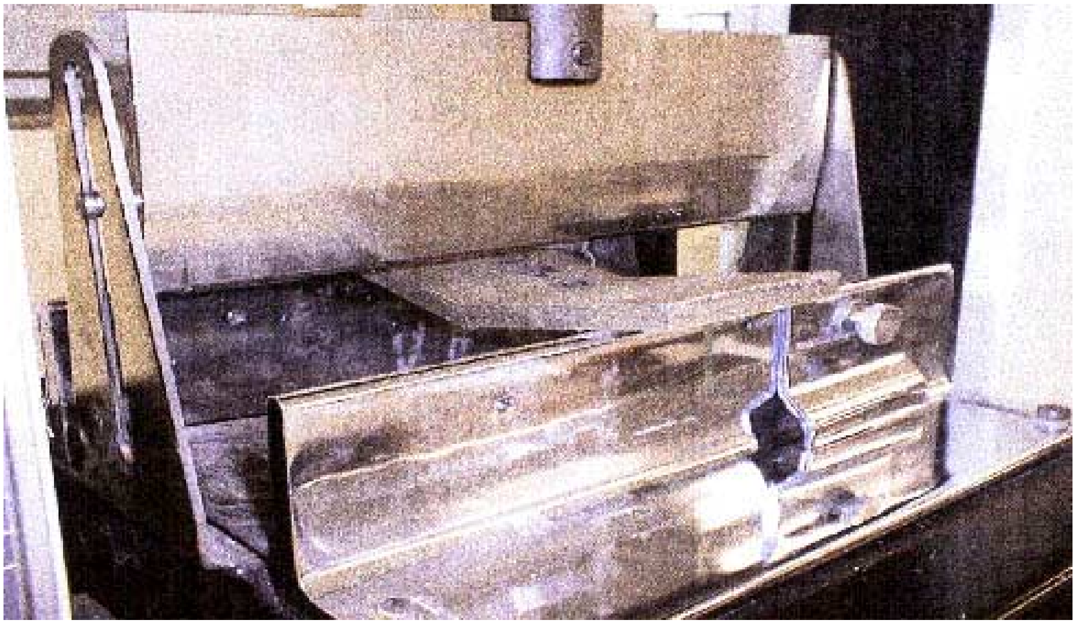

Fig. 28 Bending strength test for a Vetiver grass flake cement sample; Bangkok 1999.

Vetiver grass as a natural organic fiber for fiber reinforcement under preliminary testing (The Siam Research and Development, Bangkok, Co. Ltd., 1999).

G. Essential oil

Fig. 29 Vetiver roots provide quality fragrance after proper processing. The company is now ready for major commercial marketing; Thai-China Flavors and Fragrance Co, Ltd., Ayuttaya, 1999.

H. Vetiver crusher

Fig. 30 A machine is under development for chopping stems, leaves or roots of Vetiver; preparing materials either for preliminary or exposure testing; Phra Chom Klao Institute of Technology, Northern Bangkok, 1999.

I. Cloth sheets and clothes

Fig. 31 Cotton and Vetiver roots produce fragrant cloth for decoration; Royal Project Foundation, Chiang Mai, 1999.

J. Furniture and decor

Fig. 32 Lampshade products from Vetiver roots (lamp stand and shade); Royal Project Foundation, Chiang Mai, 1999.

Fig. 33 Vetiver picture frames, another product from the Royal Project Foundation; Chiang Mai, 1999.

CONCLUSIONS

So far, the DLD's Vetiver research programs have achieved the following:

1. Classification of 78 ecotypes from various locations throughout the country; 28 ecotypes have been accepted as promising ecotypes for further application in sandy, loamy clay and skeletal soils.
2. Various propagation techniques have been tested, for example tissue culture, tiller propagation in polythene bags and tiller propagation on strips. At present, there are approximately 99,500,000 seedlings belonging to the DLD which are available to the public for planting in Thailand.
3. Effective planting techniques such as planting time, spacing and other relevant methods have been developed and are undergoing further investigation.
4. Research programs are focusing on applications of Vetiver for soil and water conservation on arable land, waste land, sloping land; various problem soils such as acid, saline, shallow, and peat soils; on the banks of farm ponds, river, roads, waterways and man-made dikes. Downstream industry, based on Vetiver, is also a component of the programs.
5. Currently, DLD has extensive an knowledge base on Vetiver ecotypes, effective propagation techniques and how to utilize Vetiver to investigate efficiently deterioration and rehabilitation of soil and land resources. Vetiver grass is also easily to obtain.
6. In the near future, Vetiver application should not be limited to arable land. Owing to the aforementioned knowledge base, it can be utilized for various environmental rehabilitation and development programs. The other promising area of use is downstream industry, after preliminary testing, cottage industries .are likely to expand.

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