

APPLICATION OF VETIVER SYSTEM FOR SOIL AND WATER CONSERVATION IN THAILAND

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Abstract

The agricultural sector has progressed in many areas, including management of water resources, land development, agri-business, and agricultural. Thai people have made their living in agriculture for several generations. Degradation of soil resources is very important problem in agricultural sector of Thailand, which soil loss and erosion is the main factor effect to decrease of soil fertility and productivity. Soil and water conservation measure play the important role to prevent such soil loss and erosion in slopping agricultural area. His Majesty the King of Thailand has initiated the use of vetiver grass for soil and water conservation, for environmental rehabilitation. Then application of vetiver grass for soil and water conservation is a measure to solve such problem. In the northern of Thailand, corn plantation along and across slope has different soil loss from 7.81 to 5.19 ton/ha, and plounging and planting corn across slope could decrease soil loss around 33.6%. The vetiver grass strip could decrease soil loss in average to 4.81 ton/ha. And suitable vertical interval (VI) is 1.5 meters in the slopping area. The single line of vetiver plantation was higher development of growth than the double line, especially in number of shooting and size of clumping. Amount of soil sediment was detected the lowest of soil loss in 10 cm. spacing of slip. And in the second year, vetivers planted in double line and develop to dense strip, which play more importance role on reduction of soil erosion. Moreover, vetiver and legume hedge in the second year, should be more effective than the first year. Then in the second year soil loss in such area was reduced 50 to 90%, and corn yield was increased around 15 to 30%. Vetiver grass planted with peanut as hedgerow in corn plantation area of eastern part of Thailand, amount of soil sediment loss in vetiver planted plot was less than in control plot as 4.78 and 24.45 ton/ha, respectively. Moreover, vetiver hedgerow significantly decreases soil loss 82%. In lowland of central region the conventional practice has the highest soil loss 2.25 ton/ha, vetiver grass hedgerow has 1.16 ton/ha and terrace has only 0.91 ton/ha. The highest of corn yield is in terrace plot as 3.56 kg/ha, and slightly decrease to 3.29 kg/ha in vetiver plantation. Within 1 year and 6 months of vetiver development, vetiver system has function as ditch because such soil sediment will accumulate in front of vetiver hedgerow.

1. INTRODUCTION

Agriculture in Thailand is varied and differs in terms of activities in each region or locality, particularly in the way farm cultures and traditions have been handed down through the generations. Each region has clear social and economic differences. The agriculture of the Central region around the Chao Phraya river basin differs from the farm culture of the Northeast, and from that of the North and South of Thailand. Thai agriculture has had a long evolution in Southeast Asia. The development of farming has gone hand in hand with the growth of the Thai nation. Agriculture is important and affects the livelihood of most of the population. Not surprisingly, agricultural activities have been honored and closely observed all through Thai history. Agricultural activities in Thailand are strong and consolidated. The agricultural sector has

progressed in many areas, including management of water resources, land development, horticulture, animal husbandry, fisheries, agri-business, and agricultural industries and cooperatives. Thai people have made their living in agriculture for several generations.

However, degradation of soil resources is very important problem in agricultural sector of Thailand, which soil loss and erosion is the main factor effect to decrease of soil fertility and productivity. Soil and water conservation measure play the important role to prevent such soil loss and erosion in slopping agricultural area. Then application of vetiver grass for soil and water conservation is a measure to solve such problem. On patterns for application of vetiver grass, His Majesty King Bhumibol Adulyadej, accompanied by Princess Mahachakri Sirindhorn, on July 25, 1997 went to present the academic degrees to graduates at Kasetsart University, Bangkok, Thailand. A royal speech on that day is as follows;

“Things that are useful have to be used according to the principles and suitability to the circumstances. Then the usefulness will be shown. For example, planting of vetiver grass must be done in the way that the grass tillers are planted continually and in harmony with the existing terrains. On the highland the rows need to be put across the slope and the waterway. On the plain, the grass should be planted around the crop plots or as a grass strip among crop rows. For water resources, the grass should be planted in rows above the water surface, thus helping in keeping the soil intact, keep the soil moist, and prevent sediment and poisonous materials from polluting the water. Doing like this will be very useful for soil and water conservation, and improvement of soil and forests.”

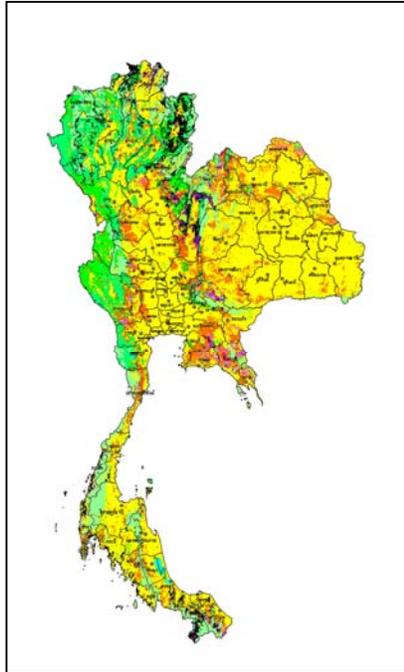
His Majesty has initiated the use of vetiver grass for soil and water conservation, for environmental rehabilitation. He has give speeches to several government agencies related to development. Land Development Department has fully accepted his initiative and has done research about the use of vetiver grass so that this technology can be transferred to farmers and others who are responsible for such works (Land Development Department, 1998).

2. ASSESSMENT OF SOIL EROSION IN THAILAND

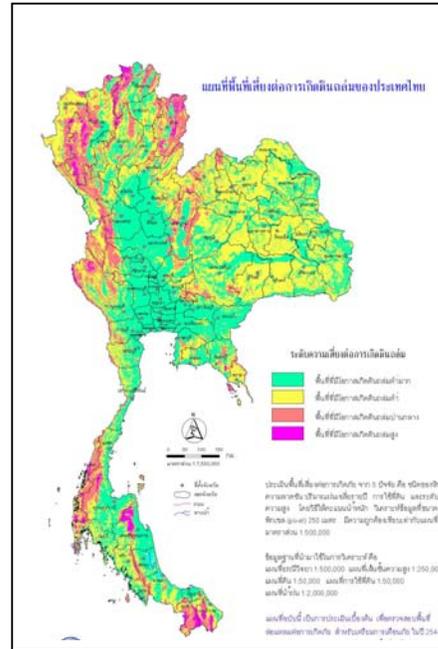
Soil and water conservation measures are extremely important for arable area in the country of which main occupation of the people is agriculture such as Thailand. This is due to losses of soil surface and nutrients mainly by erosion process on the bared and agricultural area with no soil conservation measure applied. Consequently, less soil nutrients left for plant growth as erosion process go on continuously for a long period of time, which will result in poor soil fertility and productivity. The implementation of soil conservation on upland and highland is being done by regional service centers throughout the country as demonstration plot for other government agencies and farmers. The soil conservation practices have been implemented both mechanical and vegetative measures where depend on topography and slope types of such area. The most common of soil conservation measures are terrace and hillside ditch which has been widely used in slopping area. Moreover, hillside ditches seem to be more potential to absorb and drain excesses water to waterway. At present, various types of mechanical combined with vegetative measures are implemented in many areas of northern highland.

Depletion of fertility in cropland is brought by the combined action of many factors such as the removal of large amount of nutrients by annual cropping, losses of soluble components through leaching processes, and the rapid rate of organic matter decomposition as a result of microbial activity in cultivated soils. Moreover, the land used in agriculture is moderately or severely affected by soil degradation resulting in significant cost of inputs, lost of productivity. In addition, the process of erosion is now recognized as one of the most serious forces in the rapid depletion of fertility and productivity of cultivated land. Moreover, the pattern of crop cultivation

in upland and highland, such as the inter-tilled crops afford little protection to the soil so that erosion has proceeded. Row-crops production especially on highly eroded land year after year without proper soil conservation, therefore cause serious erosion then the land will become unproductive.



Soil erosion map (LDD, 2004)



Land slide risk map (LDD, 2004)

Land use problems arise out of utilization and ownership. Unsuitable land utilization has led to problems of soil erosion and degradation. Soil becomes leached out and infertile when soil surface was not covered by plant or residue, and some area faced the problem about saline soil, acid and acid sulfate soil, or has a low buffer capacity. In mountainous and sloping areas the soil is sandy or loamy and should not be used for agriculture without regard for conservation practices.

Soil conservation projects have been implemented for nearly 40 years. At their inception in the early 1960, soil and water conservation stations and units were set up throughout the country, especially in the north and northeast where erosion was very serious. Initially, terracing was introduced as a free service to farmers, linked with ploughing their fields without charge. Farmers were willing to accept the new methodology due to the free ploughing service. Later they removed the terraces because of the reduced cultivation area. Today, however, some farmers have come to realize the long term benefits and accept some soil and water conservation measures and adopt them in their lands (especially in the north). The obstacles to accomplish such activities may be due to the lack of basic data and information needed for establishing appropriate soil conservation measures, local extension staffs do not allow for sufficient contact with farmers, approaches to farmers has been inappropriate measures, and the lack of adoption of soil and water conservation.

3. VETIVER GRASS APPLICATION FOR SOIL AND WATER CONSERVATION

Agricultural production on highland or sloping land is normally followed with soil erosion, which will affect soil resources and environment, usually in the aspects of the loss of topsoil, decrease of soil fertility and sedimentation in water bodies. Erosion control measures cost money and farmers are not inclined to do it-with the main reason that the increased yields may not worth the investment. It is therefore preferable to the farmers to carry out simple soil and water conservation measures that can do by themselves and can assist maintaining or increasing yields. Those practices include planting crops/hedgerows as boundary or on the contour to function in stopping sediments from going downhill, the prominent plant to grow being vetiver grass, a Gramineae. It can be seen that planting crops/hedgerows in that way is basic for using vetiver grass in soil and water conservation and erosion control. The important point is how vetiver grass should be planted in various categories of land. For soil and water conservation purpose, plantation of vetiver grass is done in a single line. With the vetiver plants put close to each other to form a living wall for lowering the speed of runoff and collect sediments (Land Development Department, 2004).

In the highland area of northern and southern part of Thailand, farmers grow trees and fruit trees on the slope area. And in the early stage of tree plantation they usually face the problem on water runoff and soil erosion. However, soil conservation measure is to prevent water runoff and soil erosion and to preserve water into soil and extend soil moisture content. Then soil and water conservation measure should easy to adapt and implement for farmers in agricultural land. Application of vetiver grass with bench terrace and hillside ditch will be useful for strip slope, where runoff and erosion is not serious condition it can plant vetiver grass as hedge along the contour line across the slope.

The important point to consider is plantation of vetiver grass in agricultural area whether to use lowland or upland ecotypes of vetiver. The most important criteria is the kind of main crops are being plant in the area. In plots of field crops it is logical to use upland vetiver, and in those plots that need more care, such as vegetables, the lowland vetiver should be planted. It is known that the efficiency of both upland and lowland vetiver is still depending on soil properties and climate in the designated areas. However, several research activities in each part of Thailand are as follow;

3.1. Case study in northern part

The north is characterized by mountain ranges, where all of these ranges comprise the origins of various rivers which flowing down through valleys, forests, hills, plateaus, and foothill plains feed the main Mekong and Chao Phraya River. However the corn experimental plots of vetiver grass for soil and water conservation measure in 6% slope, where bared soil is control plot in northern part of Thailand. Corn is planted along across slope, compare with strip of tamarind and pigeon pea, strip of vetiver grass (with vertical interval of planting is 1.0, 2.0 and 3.0 meters) as showed in table 1. Inthapan et al. (1994) reported that the highest soil sediment loss is 24.63 ton/ha in control plot, and clearly significant different with both vegetative strip as conservation measure. In the case of corn plantation along and across slope is also different from 7.81 to 5.19 ton/ha, where it is indicated that plounging and planting corn across slope could decrease soil loss around 33.6%. In vetiver grass strip plot with the vertical interval of planting is 1.0, 2.0 and 3.0 meters, is not significantly different. However, the vetiver grass strip could decrease soil loss in average to 4.81 ton/ha. The result of this experiment indicated that strip of vetiver grass is very useful to prevent soil loss in corn plantation area, which it can reduce water runoff and soil erosion in agricultural land. Several experiments are indicated that the suitable vertical interval (VI) is 1.5 meters in the slopping area, where this distance of vertical interval is effective to collect soil sediment in front of the vetiver contour line.

Table 1: Amount of soil loss in each treatment (ton/ha) in corn plantation area

Treatment	soil loss (ton/hectare)			
	1 st year	2 nd year	3 rd year	average
1. control	20.38 a	28.75 a	29.06 a	26.25
2. planting along slope	12.88 ab	2.63 b	0.94 b	5.56
3. planting along contour	6.36 b	1.06 b	0.50 b	3.75
4. strip cropping (VI=3.0 m)	8.06 b	0.69 b	0.50 b	3.06
5. vetiver strip (VI=1.0 m)	8.56 b	0.75 b	0.69 b	3.31
6. vetiver strip (VI=2.0 m)	9.06 b	1.19 b	0.75 b	3.69
7. vetiver strip (VI=3.0 m)	8.06 b	1.13 b	0.75 b	3.44

(Inthapan et al., 1994)

3.2. Case study in northeastern part

The northeastern region is mostly a high plateau which sloped downward from the west and the south toward the east. These areas hold the main watersheds which flow east toward the Mekong River. The experimental plot was setup in northeastern part of Thailand on spacing and lining of vetiver plantation for soil conservation in upland. Including single and double line (30 cm. between hedge) of vetiver plantation and spacing between vetiver slip as 10, 15 and 20 cm. was carried out by Boonap et al. (1995). The result showed that the single line of vetiver plantation was higher development of growth than the double line, especially in number of shooting and size of clumping. The average number of shooting in single line is 18.89 slip/clump and reduced to 15.82 slip/clump in double line of vetiver plantation. It is the same trend as average size of vetiver clump in single line is 15.90 to 13.50 slip/clump in double line. Moreover, the more distance of lining and spacing of vetiver plantation will be better growth as showed in table 2. In contrast, the highest of soil loss was found in control plot (as bared soil). Amount of soil sediment was detected in this experiment and the lowest of soil loss was found in 10 cm. spacing of slip on both of single and double line as 2.13 and 2.00 ton/ha, respectively. In case of 15 and 20 cm. spacing of vetiver slip had soil loss in single line as 4.81 and 5.19 ton/ha, and the amount of soil loss was reduced to 4.06 and 4.69 ton/ha, respectively. And in the second year of this experiment, vetivers planted in double line and develop to dense strip, which play more importance role on reduction of soil erosion. Amount of soil loss in every treatment where planted with vetiver system is in range 1.94-2.69 ton/ha, and control plot is 11.50 ton/ha. It is clearly indicated the effective of vetiver system in soil sediment accumulation as soil and water conservation measure.

Table 2: Amount of soil loss in each treatment (kg/hectare)

Treatment	soil loss (ton/ha)	
	1 st year	2 nd year
1. control	10.81	11.50
2. single line + slip space 10 cm.	2.13	2.25

3. single line + slip space 15 cm.	4.81	2.56
4. single line + slip space 20 cm.	5.19	2.69
5. double line + slip space 10 cm.	2.00	1.94
6. double line + slip space 15 cm.	4.06	2.13
7. double line + slip space 20 cm.	4.69	2.00

(Boonnap et al., 1995)

Application of vetiver grass for soil conservation measures with several legume crops in upland corn plantation of northeastern part of Thailand, where soil texture is silty loam and 6-8% slope. No measure of soil conservation (as control plot) was compared with 1 and 2 lines of vetiver grass, and 1 line of legume crop across the slope in corn plantation area. Anusontpornperm et al. (1996) indicated that amount of soil loss in control plot was 7.25 ton/ha in the first year, and increased to 16.75 ton/ha in the second year. Moreover, vegetative measure for conservation such as vetiver (2 lines) and legume (1 line) should be more effective on prevention of soil loss in the second year, as showed in table 3. This result was confirmed by Phien and Tam (2000), which indicated that vetiver and legume hedge in the second year, should be more effective than the first year because of the growth and development of shoot and root system of vetiver and legume crop. Then in the second year of vetiver system development, soil loss in such area was reduced 50 to 90%, and corn yield was increased around 15 to 30% (compared to control plot).

Table 3: Amount of soil loss in each treatment (ton/hectare) in corn plantation area

Treatment	soil loss (ton/hectare)	
	1 st year	2 nd year
Control (no measure)	7.25	16.75
Vetiver hedge 1 line	4.50	5.19
Vetiver hedge 2 lines	4.81	6.63
Bean strip 1 line	6.88	5.81

(Anusontpornperm et al., 1996)

3.3. Case study in eastern part

The eastern region is characterized by low mountains and rolling plains. The plains are interspersed with low hills which are the watershed of short rivers flowing from north to south toward the Gulf of Thailand. Vetiver grass planted with peanut as hedgerow in corn plantation area of eastern part of Thailand, where it is loamy sand soil and 5% slope. Vetiver was planted in single and double line (30 cm. between line) and space between slip was 10, 15 and 20 cm., compare with non vegetative measure (vetiver with peanut). Peanut was planted in space between vetiver lines. And interval between hedgerows of vetiver grass is 15 meters along slope. Chaovanakit et al. (1995) reported that amount of soil sediment loss in vetiver planted plot was less than in control plot as 4.78 and 24.45 ton/ha, respectively. Moreover, vetiver hedgerow

significantly decreases soil loss 82%. Double line of vetiver was higher efficient in soil loss control than single line. Moreover, spacing of vetiver grass plantation at 10 cm. is better than 15 and 20 cm (as showed in table 4).

Table 4: Amount of soil loss in each treatment (ton/hectare)

Treatment	1 st year	2 nd year	3 rd year	total	average
1. control	34.04	36.72	4.09	74.85	24.95
2. single line + space 10 cm.	7.91	2.31	0.50	10.73	3.58
3. single line + space 15 cm.	11.59	4.30	0.99	16.88	5.63
4. single line + space 20 cm.	14.19	2.89	0.91	17.98	5.99
5. double line + space 10 cm.	5.73	2.09	0.36	8.18	2.73
6. double line + space 15 cm.	11.43	2.39	0.53	14.34	4.78
7. double line + space 20 cm.	8.18	2.65	0.30	11.13	3.71

(Chaovanakit et al., 1995)

Phopan and Vatthanathum (1994) compare efficiency of vetiver grass system and terrace on water runoff and soil erosion in loamy sand soil of eastern part of Thailand with gentle slope of 5-7%. Two types of ploughing as along the slope and along the contour combined with 2 lines of terrace and 2 and 3 lines of vetiver hedge were compared in this experiment. The result was indicated that application of 2 lines of vetiver grass on ploughing along the contour reduced water runoff 6-17% compared with non vetiver plantation. However, 3 lines of vetiver was higher efficiency in runoff and erosion control than 2 lines of vetiver, especially in the first year of application. However, the 2 lines of vetiver can prevent soil loss lower than 3 lines of vetiver around 10% as showed in table 5. On this matter, the high efficiency of 2 lines of terrace nearly the same as vetiver plantation in both 2 and 3 lines of such hedge. When vetiver grass grows in the third year, the soil erosion control efficiency of 2 and 3 lines of vetiver were nearly the same. This indicated that the line of matured vetiver grass would have full function to control runoff and erosion in such slope area.

Table 5: Amount of water runoff (cubic meter/hectare) in each treatment in cassava plantation

Treatment	1 st year		2 nd year		3 rd year	
	runoff	R.E.	runoff	R.E.	runoff	R.E.
1. plough along slope	2605.69 b	-	1408.56 c	-	2419.05 c	-
2. plough along contour	2175.00 b	16.53	1240.00 bc	11.97	2150.38 a	11.82
3. plough along contour + terrace 2 lines	1620.00 a	37.83	937.13 a	33.47	1527.88 a	37.35
4. plough along contour + vetiver hedge 2 lines	2010.00 ab	22.86	1111.44 ab	21.09	1739.31 ab	28.67

5. plough along contour + vetiver hedge 3 lines	1941.44 ab	25.49	1031.44 ab	26.77	1787.88 ab	26.68
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(Phopan and Vatthanathum, 1994)

3.4. Case study in central plain

The central region is largely composed of a vast and fertile floodplain. The Chao Phraya river is the major waterway. In the west, the mountains are a continuation of mountain ranges from the north to south. In corn cultivation area of central plain of Thailand, where is 10% slope and shallow soil with problem of soil erosion. Chareonrungrueng et al (1994) reported that conventional practice has the highest soil loss 2.25 ton/ha, vetiver grass hedgerow has 1.16 ton/ha and terrace has only 0.91 ton/ha. The highest of corn yield is in terrace plot as 3.56 kg/ha, and slightly decrease to 3.29 kg/ha in vetiver plantation, where it is significantly decrease to 2.74 kg/ha in conventional practice as showed in table 6. Within 1 year and 6 months of vetiver development, vetiver system has function as ditch.

Table 6: Amount of soil loss in each treatment (ton/hectare)

Treatment	soil loss	soil sediment	collection efficiency
control	2.25	0.00	0.00
terrace	0.91	1.34	6.25
vetiver	1.16	1.09	5.06

(Chareonrungrueng et al., 1994)

However, several scientific reports contributed cultivation of vetiver grass across slope is efficient nearly the same as terrace and clearly different from non conservation measure as most of farmer done in corn cultivation area. Application of vetiver system for soil and water conservation as hedgerow on slope area will develop to ditch, because such soil sediment will accumulate in front of vetiver hedgerow. Moreover, root system of vetiver penetrate deeply in soil has effect in water absorption and moisture accumulation in such layer of soil. As the research result of Babolola et al. (2005) clearly indicated that strip of vetiver grass can prevent water runoff and soil erosion in Oxic Paleustaff, Ultisol. Amount of soil loss in control plot (without vetiver) is 70.00 kg/ha, where vetiver planted plot is only 1.75 kg/ha. In upland agricultural area, Nakalevu et al. (2000) reported that vetiver strip reduced soil loss in upland agriculture area, where soil sediment loss in control plot 3.31-312.63 ton/ha in ginger cultivation, soil loss in pineapple strip plot was reduced to 0.25-120.13 ton/ha. In case of vetiver strip plot, soil loss was clearly reduced to 0.19-5.00 ton/ha as showed in table 7.

Table 7: Amount of soil loss (ton/ha) with vetiver grass and pineapple hedge in ginger plantation

Treatment	amount of soil loss (ton/hectare)					
	1 st year	2 nd year	3 rd year	4 th year	5 th year	6 th year
control	3.31	141.25	312.63	161.38	10.81	26.81
pineapple hedge	0.69	4.00	2.06	120.13	5.56	0.25
vetiver hedge	1.69	2.63	1.31	5.00	0.25	0.19

(Nakalevu et al, 2000)

Moreover, the distance or interval between vetiver lines depend on strip of slope and length of the area but it can adjust to some extent to suit the landscape. In general, it has been established that the slope of the land for agriculture should less than 35%, more than that the land should be left as watershed and forest. On this matter, vetiver grass is suitable to be planted in agricultural areas as follows:

- ***Highland area***

These highland areas with 31-35 percent slope. Single lines of vetiver should be planted on the contour at an interval of 8 m between the two lines. The area between the lines can be use to cultivate vegetables, crops, fruit trees, etc. For vegetables and field crops they should be planted along the contour as well. For fruit trees, it is advised that a single half-circle line of vetiver should be planted around the tree trunk to intercept water from the upper area. The planted line around 30 cm outside the canopy line. In case of lower hill slope areas between 21 and 30 percent slope, the interval between the two contour lines of planted vetiver grass can be lengthened to 10 m. Moreover, the waterways and drainage way is usually setup in highland to lowland of agricultural areas. And vetiver grass can be planted as row with 30 cm from the rim of waterway on both sides. In case of broad waterways, vetiver grass can be planted in inverted V shape, with the upper corner making an angle of 90-120 degree and right on the middle of the waterway, while the two hands of the vetiver line extend to rim of the waterway.

- ***Upland area***

In rolling areas between 11 and 20 percent slope, the interval between the two contour line of vetiver grass can be lengthened to 12 m. If the landscape of that area is between 6 and 10 percent slope as undulating areas, the interval of vetiver grass along the contour line can extend to 20 m. In gently sloping areas around 3-5 percent slope, the interval between the two contour line of vetiver grass can be lengthened to 30 m. In case of farm pond, it is usually setup in upland areas as water storage for agricultural activities. The bank of farm ponds is almost prone to erosion. It is therefore to plant vetiver as lines to sieve sediment and some residue as well as to stabilize the bank. In general, two lines should be planted, where the first line being around 50 cm from the rim and the second one at the level of the spillway. In case of depth slope bank, three rows of vetiver grass should be planted, where the first row at the maximum storage level of such pond and the second row should be planted 20 cm above the first row. And the third row should be planted about 20 cm. above the second row.

- ***Lowland area***

In the plain areas may be flat or has slope up 2 percent, with low erosion rate. However, there is still some runoff from the upper terrain. There should be one vetiver line growing for every 40 m. Generally such land is used for paddy rice cultivation, so it is beneficial to grow vetiver on the bund or as boundary of the land. And line of vetiver should be grown about 30 cm from the rim and around each plot to avoid soil erosion. In lowland where there is waterlogging, it is useful to plant vetiver to absorb water both of aboveground and underground. In this case vetiver grass should be planted as half-circle around the fruit tree with a distance of 30 cm outside of the canopy or planted in spacing of 50x50 cm in the whole area.

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