Vetiver Research for Agricultural Production On Red Soils

Lu Shengluan

Red Soil Research Institute of Jiangxi Province
Jingxian, Jiangxi Province 331717, China

THE KING OF THAILAND AWARDS WINNER

Abstract

More than ten experiments were conducted on the adaptability of vetiver to bare soil, vetiver utilization for agriculture production and reproduction techniques of vetiver seedlings since 1990. Results showed that:

1. Vetiver is an excellent grass for soil and water conservation by its strong adaptability to barren soil.
2. When vetiver pruning was used as green manure, it improved the soil chemical and physical properties and increased the yield of crop.
3. Vetiver growth and its biomass could be promoted by applying proper N and P fertilizer.
4. Planting vetiver in a paddy field in summer is an effective measure for seedling production. A set of techniques for this is advanced.

Key words: Vetiver, Planting, Tillering promotion, Red soil

Vetiver was introduced to Jiangxi Province of China by Mr Richard Grimshaw through World Bank red soil development project in 1988. The Red Soil Research Institute of Jiangxi Province has very actively involved in vetiver research since that time. The results provided basic theory and experiments on vetiver for agricultural production in the red soil region of Jiangxi Province and other provinces of southern China.

1. VETIVER ADAPTABILITY TO BARREN RED SOIL AND EFFECT OF VETIVER ON SOIL AND WATER CONSERVATION

1.1 Design of Experiment

Plots were laid out on a severely eroded low hills of Dafu Hillock, Dong Xian County in where no any plant could grow. The depth of eroded gullies reached to 1 – 2 m deep. The surface soil of the land was completely washed away and then the plinthic horizon exposed to ground surface. Some chemical properties of the soil are: Organic C 1.51 $g \cdot kg^{-1}$, Total N, P, and K 0.45 $g \cdot kg^{-1}$, 0.19$g \cdot kg^{-1}$ and 14.3$g \cdot kg^{-1}$, Available P and K 1.16 $mg \cdot kg^{-}$

^{1} and 49.0 mg·kg^{-1} respectively. All grass experimented including vetiver, *Eremochloa ophiuroides, Imperata cylindrical var, Erigeron acris L* and *Erianthus arundinaceus* were planted in ditches along the contour, spacing 20 cm with two replications. Urea 75 kg and CaMgP fertilizer 150 kg per hectare were applied.

1.2 Experimental Results

1.2.1 Adaptability to barren red soil

The results showed that regarding to the adaptability to barren red soil, vetiver was remarkably better than other grasses experimented even surpassed the local most barren-enduring grass *Erianthus arundinaceus,* compared with which the plant height and tiller of vetiver increased 123.7% and 79.1 % respectively and the biomass of fresh grass increased 3.2 times (Table 1) (Lu, 1994).

Table 1. Growing of vetiver and *Erianthus arundinaceus* in summer in a severely eroded region of low hill of red earth

Kinds of grass	1990		1991		1992		Fresh grass production in 1991
	Height	Tiller	Height	Tiller	Height	Tiller	(kg/ha)
Vetiver	61.4	2.5	85.3	8.3	157.7	16.3	43001.7
Erianthus arundinaceus	34.3	2.3	49.8	7.7	70.5	9.1	10313.0

Note: Height: cm, Tillers/clomps

1.2.2 Strong resistance to drought

In the middle and last ten days period of July, 1991 a high temperature and dry weather lasted 3 weeks (the rainfall only 2.3 mm and mean air temperature 32.2^{o}C among which seven days was more than 38^{o}C). The crop of corn and peanut were hit seriously by this disasters while vetiver still grew well. An investigation on 4th July the period of vigorous growing of grass and on 4th September i.e. after the drought period of hot days of autumn showed that the tiller number of vetiver decreased only 0.2 tillers/per clump, while for *Erianthus arundinaceus* it decreased 3.6 tillers/per clump, i.e. 46.8% of it died by drought. The height of vetiver increased 7.5 cm and only the tip of part of leaves turned to a little yellow while the height of alive plant of *Erianthus arundinaceus* decreased 10.1 cm and many leaves died by withering (Lu, 1997).

Table 2. Effect of hot and dry season on grass growth

Kinds of grass	Before drought		After drought		Effect of drought	
	Height	Tiller	Height	Tiller	Height	Tiller
Vetiver	85.3	8.3	92.8	8.1	+7.5	-0.2

Erianthus arundinaceus	49.8	7.7	39.7	4.1	-10.1	-3.6

Note: Plant height: cm, Tillering: tiller / clump

1.2.3 Remarkable effect on soil and water conservation

An investigation of biennial grass showed that due to a strong adaptability and quick growth the clump wide (length x width of the clump, 10 cm high from its base) of vetiver was 79.8 cm^2 more than that of *Erianthus arundinaceus*. When planted spacing 20 cm between splits, a thick hedge of vetiver can be formed in a year. The extended depth of its roots was 2 times than that of *Erianthus arundinaceus* and *Faber africanum*. The air dry weight of its root was 2.8 times of that of the latter. An observation in a soil profile showed that in the hard plinthic horizon of a severely eroded area bunches of several even tens of vetiver roots were formed and penetrated into the deep layer of soil parent material, the deepest layer even to 2.2 m. The runoff speed on the slop decreased as a continuous hedgerow of vetiver formed. In the meantime the sediment in the runoff were settled on the upper part of the hedge. In a measuring of hedge grow in the second year of planting showed that the runoff amount per year of vetiver hedge plot was 4700 m^3/ha, and the soil loss was 468 t/ha, while in the plot without grass it was 9390 m^3/ha and 1452 t/ha respectively. In other words the vetiver hedge reduced the runoff amount and loss of soil by 50 % and 68% separately (Lu, 1998).

2. EFFECT OF VETIVER PRUNINGS AS GREEN MANURE ON SOIL FERTILITY

2.1 Nutrient Content of Vetiver Plant

The nutrients content in the vetiver of one-year old plant analyzed with an air dried sample and by the standard method was presented in Table 3. These contents would be much higher when the top 1 – 1.5 m of the plant was taken.

2.2 Effect of Vetiver Prunings Applied as Green Manure on Soil Properties

Effect of stem and leaves of vetiver grass cut into pieces, air dried and applied to soil. Experiment consisted of five treatments according to the applied amount of air dried stem and leaves of vetiver.

Table 3. Nutrient contents of dry vetiver ($g.kg^{-1}$)

Kinds	Organic N	Total of contents		
		N	P_2O_5	K_2O
Stems and leaves	422.1	17.0	5.1	75.0
Roots	401.9	21.1	0.6	57.7

(1) 4.45 t/ha air dried vetiver pruning, (2) 2.25 t/ha air dried vetiver pruning, (3) air dried rice straw 2.25 t/ha, (4) chemical fertilizer of N, P_2O_5 and K_2O equivalent to 2.25 t/ha of air dried vetiver pruning, (5) no fertilizer (CK). The plot area was 13.34 m^2 with 3 replications and a randomized block design. And the experiment was arranged on a upland of red soil of weakly mellowing. The grasses used in all treatments were cut into pieces and turned to the soil of 20 cm deep evenly. A succession cropping of 3 seasons of corn was planted.

Results showed that the soil organic matter, total porosity, total and available N and P increased while soil bulk density decreased (Table 4) and the corn yield raised apparently (Table 5) as applying 4.5 t/ha and 2.25 t/ha of stem and leaves of vetiver. In short, the effect of vetiver was about equal to that of rice straw.

Table 4. Effect of vetiver pruning as manure on soil properties

Treatment	contents(g/cm^2)	Total porosity (%)	Organic C (g·kg^{-1})	Total (g·kg^{-1})			Available (mg·kg^{-1})		
				N	P_2O_5	K_2O	N	P_2O_5	K_2O
Vetiver **	-0.03	+1.0	8.24	1.067	0.51	15.13	167.99	16.85	75.00
Vetiver *	-0.04	+1.3	8.26	1.077	0.51	15.12	173.22	15.30	77.50
Straw *	-0.09	+3.0	7.69	1.026	0.48	14.86	119.95	14.10	73.75
Fertilizer	+0.03	-1.3	7.18	1.045	0.46	15.47	158.84	11.80	70.00
Control(CK)	+0.14	-5.0	7.97	1.045	0.50	15.26	163.42	13.50	75.00

Note: ** 4.45 t/ha of dried grass was applied, * 2.25 t/ha was applied, The bulk density was determined
before the corn planting and after it harvested.

Table 5. Effect of vetiver pruning as manure on corn production

Treatment	Dry weight of Straw stalk (t/ha)	Yield increase		
		Production (t/ha)	Increase than control (%)	Increase than equivalent fertilizer (%)
Vetiver (4.5 t/ha)	5.82	2790	34.8	40.9
Vetiver (2.25 t/ha)	5.61	2280	10.1	15.2
Straw (2.25 t/ha)	5.85	2790	34.8	40.9
Equivalent fertilizer	4.95	1980	-4.5	
Control	5.22	2070		4.5

As taking an average of two amount of vetiver applied i.e. 4.5t/ha and 2.25 t/ha in Table 4 the content of organic C, total N and P_2O_5, and available N, P_2O_5 and K_2O per kg of soil increased by 0.28 g, 0.03 g, 0.01 g and 7.2 mg, 2.6 mg and 1.3 mg than that of CK, and increased by 1.07 g, 0.09 g, 0.05 g and 11.8 mg, 4.3 mg and 6.3 mg than that of

equipment chemical applied respectively.

3. TECHNIQUES FOR HIGH SEEDING PROPAGATION

With the promotion by China Vetiver Network and the fact vetiver had lots of beneficial properties, the development of vetiver in the 16 southern provinces of China was rapidly. That resulted in a short supply and high price of vetiver seedling. Therefore, promoting tillering and speeding up the seedling propagation of vetiver was urgent. For this the following experiment was conducted.

3.1 Experiment of Nutrient Solution for Promoting Tillering

3.1.1 Treatment

Five nutrient solutions A, B, C, D and E were prepared with several ratio and concentration of chemical and fertilizers, taking pure water as check. All of which were sprayed on the leaves at the beginning period of tillering of vetiver. The experiment was arranged in a randomized block with 3 replications, plot area 20 m^2, spacing 40 x 20 cm and 3 tiller / clump of vetiver were planted.

3.1.2 Results

1) Effect of promoting tillering. The monthly variation of tiller number of treatments are presented in Table 6. It showed that its effects became apparent one month after sprayed. The average tiller number per clump of treatments A, B, C and D are 6.4, 5.3, 2.9 and 4.1 more than that of CK.

Table 6. Effect of nutrient solutions for promoting tillering on monthly variation and comparison of vetiver tillering

Treatment	7/30		8/30		9/30		10/30		11/30	
	Tillers	Increase (%)	Tillers	Increase (%)	Tillers	Increase (%)	Tillers	Increase (%)	Tillers	Increase (%)
A	24.30	56.46	27.69	73.59	28.82	86.78	32.87	113.03	33.14	114.77
B	23.34	53.18	28.00	83.47	28.25	83.08	32.50	110.63	32.73	112.18
C	20.76	34.30	24.99	61.88	26.23	70.00	30.62	98.44	31.28	102.72
D	22.00	42.55	24.47	58.53	26.50	71.74	29.33	90.08	29.63	92.03
E	18.93	22.67	21.68	40.49	23.06	49.45	26.71	73.04	27.00	74.92
CK	17.91	16.08	19.40	22.77	20.98	35.97	23.86	54.63	24.20	56.84

Note: 1. The % of increase is compared with the number of tillering on the thirtieth of June

2. The average number of tillering per clump on the thirtieth of June was 15.4, but in some plot was this number _+ 2 – 3 realy, All were revised to15.4 in propotin

It also showed that the A, B, C and D solutions once sprayed were effective in whole year and not affected by hot and dry weather. It may well be termed “once sprayed, beneficial to whole year”. The tiller number of A, B and C treatments in the year end were 30 % more than that of CK reached the highest level of significance. For D treatment it reached the level of significance while the increase of it for E only 11.5 % more than Ck, which did not reached significance (Table 7) (Lu, 2002).

Table 7. Effect of nutrient solution for promoting tillering on growing of vetiver and its significant test

Treatment	Tillers/clump at year end	Increase than CK		Significance		Height (cm)	Tillers/clump
		Tillers	%	0.05	0.01		
A	33.14	8.94	36.94	a	A	134.67	0.50
B	32.74	8.54	35.28	a	A	117.33	0.10
C	31.28	7.08	29.26	a	A	137.00	0.40
D	29.63	5.43	22.44	ab	B	152.33	0.57
E	26.70	2.80	11.53	bc	B	143.00	0.53
CK	24.20			c	B	161.67	1.20

Note: Owing to a seriously drought in this year vetiver was short and less head sprouting

2) Effect of nutrient solutions on height and head sprouting of vetiver. The leaves begun thickening and changed to deep green from yellow green especially apparent for the A and B treatments. Thus photosynthesis and nutrient accumulation was enhanced. In the meantime, reproductive development and jointing were delayed, plant shortened, heading sprouting and blooming were restrained after 20 days of the nutrient solutions sprayed. An investigation on 13 November showed that the plant height of B, A and C treatments were 44.3 cm, 27.0 cm and 24.7 cm shorter than that of CK respectively while D and E only 10 cm shorter than that of CK. The heading sprouting of treatments were 34 % - 85 % less than that of CK. It means that the nutrient solutions could restrain sexual reproductive development and concentrating the nutrients for the vegetative development, thus the tillering be enhanced.

3) Effect on cold. Caused by a warm winter, there was no difference of seedlings survival between different treatments, but an investigation at next spring before shooting showed that the overwintering (%) was D > A > E > C > CK > B. It indicated that treatment D, A, E and C could promote the formation of sound seedling, increase cold resistant and benefit it to overwinter. The survive rate for B was 1.5 % less than CK. No significant difference was found between B and CK but the average number of survived seedling per clump of B was 7.6 more (increased 33.12%) than that of CK. The survived number of overwintering seedling of A, B and C were 33 % more than CK. Converted it to a hectare more 0.9 – 1.2 millions of seedling was produced.

Table 8. Effect of nutrient solutions on promoting tillering and overwintering of seedling

Treatment	Tillers before winter	Tillers after winter	Seedling survival rate (%)	Comparison of survival rate (%)
A	33.14	32.63	98.46	142.93
B	32.74	30.39	92.82	133.12
C	31.28	30.53	97.60	133.73
D	29.63	29.27	98.79	128.21
E	26.99	26.49	98.15	116.03
CK	24.20	22.83	94.34	100.00

Note: The number of seedling before and over winter was investigated on Nov.30, 2000 and March 2, 2001 respectively. The survival seedling included the seedling in jointing and heading sprouting stage. The base of its stem was still green and some small tillering seedling of height more than 4 cm

3.2 Effect of N, P and K Elements on the Growing of Vetiver

3.2.1 Treatment

An experiment with N_1 17.5 kg, P_1 18 kg, K_1 22.5 kg and double this amount N_2, P_2, K_2 per hectare consisted of following 7 treatments: (1) N_1, (2) N_2, (3) N_1P_1, (4) N_2P_2, (5) $N_1P_1K_1$, (6) $N_2P_2K_2$, and (7) no fertilizer (CK) and conducted in a upland of red soil. Chemical properties of which are: The soil contained organic C 8.0 $g \cdot kg^{-1}$, available N, P_2O_5, K_2O for 163.4 $mg \cdot kg^{-1}$, 13.5 $mg \cdot kg^{-1}$ and 75.0 $mg \cdot kg^{-1}$respectively with 3 replications, randomized block design, plot area 6.67 m^2, spacig 33 x 25 cm with 3 tiller / clump.

3.2.2 The results

Results showed that (Table 9):

1) Effect of NPK on vetiver was N > P > K. The tiller and fresh grass increased by about 9 % by applying N_1 at a level of significance and 17 % by N_2 very significant.
2) Due to P deficiency in red soil, applying P_1 and P_2 on the base of $N_1$and N_2 application tiller increased 5.5 %, 10.2 % and fresh grass increased 7.7 %, 1.8 % respectively, but the effect is little when increasing the amount of P on a base of further increasing N.
3) No effect could be observed in K for height and tillering, but the fresh grass increased by 5.4 % and 9.3 % by applying K_1 and K_2 respectively. It seems that K made the leave blade thickening.

Table 9. Effect of levels of fertilization on growing and production of vetiver

Treatment l	Height			Tiller			Fresh grass production		
	Cm	Comparison		Tillers/clump	Comparison		Kg/hm^2	Comparison	
		+-	±%		+-	±%		+-	±%
N_1	171.5	16.1	10.4	23.6	2.0	9.3	37225.5	3012.0	8.8
N_2	167.0	11.6	7.5	25.2	3.6	16.7	40000.5	5787.0	16.9
N_1P_1 N_2P_2	170.6	15.2	9.8	24.8	3.2	14.8	39874.5	5661.0	16.5

	175.7	20 .3	13.1	27.4	5.8	26.9	40624.5	6411.0	18.7
$N_1P_1K_1$	166.8	11.4	7.3	24.8	3.2	14.8	41700.0	7486.5	21.9
$N_2P_2K_2$	166.8	11.4	7.3	22.8	1.2	5.6	43800.0	9586.5	28.0
Control	155.4	0	0	21.6	0	0	34213.5	0	0

3.3 Effect of Chemicals and Fertilizers

3.3.1 Treatments

The experiment consisted of 5 treatments:

(1) Solution of powder of rooting stimulator No.3, 60 ppm

(2) Paclobutrazol 750 ppm

(4) Ca Mg P: mud = 1: 10

(3) Paclobutrazol 500 ppm

(5) Pure water CK

Each treatment was conducted by dipping 50 tillers of vetiver in above solution for 2 hours. After the solution on the root dripped, planted them in a ditch on 8th August, spacing 23 x 20 cm with 2 replications. Each split contained one tiller (Lu, 1994).

3.3.2 Results

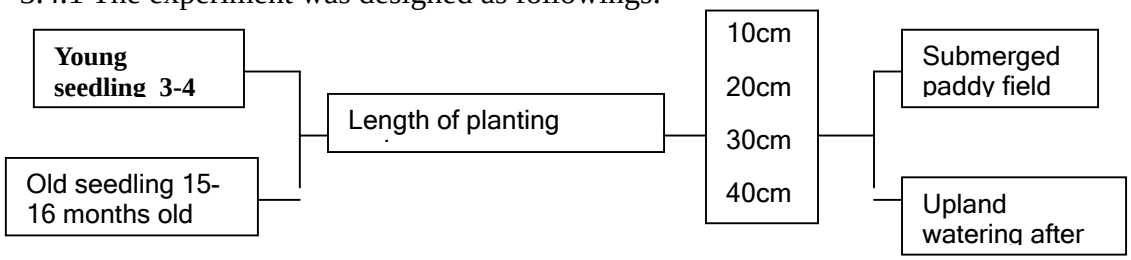
The results showed:

(1) Effect of treatments on the tiller number were treatment (1) 15.2 tiller treatment > (3) 13.8 tillers >(4) 12.9 tillers >CK 12.7 tillers. Compared to the CK the tiller number increased by 19.7 % in treatment (2) (very significant), 8.7 % in treatment (3) (significant) and 1.6 % in treatment (4) (not significant) (Lu, 1999).

(2) Dipping seedling with 750 ppm of paclobutrazol only 80 % of the plant revived from transplanting. It grew slowly with a short and small plant. It should be harmful dipping the seedling with a high concentration solution and a longer time.

3.4 Effect of Young and Aged Seedling, Seedling Length and Different Planting Conditions on the Tillering

3.4.1 The experiment was designed as followings:



The seedlings were planted on 1st July and 7th August 2000 respectively. The young seedlings

was 3 months old when planted in July or 4 months old when planted in August. The old seedling was 15 months old when planted in July or 16 months old when planted in

August.

3.4.2 Results

The result (Table 10) showed that:

Table 10. Tillering of vetiver with different age of seedlings and different planting time in paddy field and upland (tiller / single plant)

Date of planting	Seeding age	Paddy field	Upland	Increase in paddy soil than on upland	
				Tillers	%
7/1	Young	22.9	9.2	13.7	148.9
	Old	22.4	14.0	8.4	60.0
	Average	22.7	11.6	11.1	95.7
	Young	15.0	6.8	8.2	120.6
	Old	13.6	9.6	4.0	41.7
	Average	14.3	8.2	6.1	74.4

1) Whatever planting the aged or young seedling, or planting in different time the tiller number of a single plant of vetiver increased by 41.7 % in the paddy field than that on upland, especially increased several times for the young seedling. It is clear that water is very important for the survival and growing of vetiver in a hot summer. It is suitable and beneficial to propagating seedling in paddy field in the summer.

2) Tiller number of young seedling in the paddy field planted on 1st July was only 2.2 % more than that of the aged, but 10.3 % more than that when planted on 7th August. On the contrary, when planted average tiller number of aged seedling was 3.8 tiller per single plant (increasing 47.5 %) more than that of the younger. It is because the shortage of water in the upland the young seedling lost its water quickly under a intense sunlight of summer. Thus its leaves withered and growing affected.

3) For paddy field, the vetiver number of a seedling planted on 1st July was 8.4 more than planted on 7th August, increased by 58.7%. For upland it was 3.4 tillers more, increased by 41.5%. It means that in summer planting earlier is preferable.

4) The average tiller number with young seedling reached to 15 in paddy field planted on 7th August, 3 millions of planting materials per hectare could be gained. Therefore, propagating following the harvest of early rice in paddy field could produce more vetiver planting materials especially with a shortage of seedling.

5) The survival rate of vetiver increased with the increase of pruning height of seedling (Table11). The average tiller number of a single aged plant was correlated positively with the pruning height of seedling, but for the young the pruning height of 20 – 30 cm is the best especially in the paddy field (Lu, 2000).

3.5 Vetiver Root Pruning

Table 11. Effect of seedling age and its pruning height on the survival and tillering of vetiver

(length: cm; tiller/per clump)

Lengt	Paddy field	Upland

h of seedling	a		b		a		b	
	Survival rate %	Tillers	Survival rate %	Tillers	Survival rate %	Tillers	Survival rate %	Tillers
10	83.3	8.25	94.4	8.23	60.0	2.72	86.7	3.54
20	100.0	12.17	100.0	9.39	66.7	2.26	93.3	4.67
30	94.4	11.46	100.0	10.40	80.0	3.93	100.0	5.60
40	100.0	9.67	100.0	12.26	86.7	3.53	100.0	7.33

Note: “a ”= age of 3 – 4 months, “b”=15 – 16 months. The data was investigated on 20th September

3.5.1 Slips divided from the clumps of vetiver with the roots cut to 5 cm, 10 cm and 15cm long were planted in a upland with middle fertility and another with low fertility, planted on 8th August with 3 replications.

3.5.2 Results (Table 12) showed that the number of tiller with a root of 5 cm long was about 10 % more than the other two length in the upland of red soil with middle fertility. On the contrary, tillering of seedlings with root of 5 cm was 5 % and 10 % less than that 10 cm and 15 cm on the low fertility land. But the difference was disappear in the year end. Therefore, for convenience of transportation and plantation the length of slips might be 5 – 8 cm.

Table 12. Effect of root length pruned on tillering (tillers/per plant)

Length of root	9/27		10/8		11/8	
	a	b	a	b	a	b
5cm	4.6	1.87	6.27	2.28	8.80	3.40
10cm	4.2	1.90	5.93	2.64	7.87	3.44
15cm	4.2	1.99	5.47	2.53	7.80	3.42

3.6 Experiment of Applying Herbicide in the Paddy Field Planted with Vetiver

3.6.1 Two treatments consisted of applying and no herbicide (CK), with plot area 2 m^2, 2 replications and spacing 25 x 20 cm. Each split had one tiller. About 3cm of water layer maintained in the field when vetiver planted. Herbicide was broadcasted after 4 days of planting and the field kept damp as the water in the surface lowered naturally.

3.6.2 Results (Table 13) showed that:

1) Except for the barnyard grass, the effect of herbicide on weeds control was more than

55–60 %.

2) Adverse affect of this herbicide on tillering and growing of vetiver did not observed.

Therefore it may by used on a wide area.

Table 13. Effect of herbicide on weeding and tillering of vetiver

Treatment	Quantity of weed					Tiller number of vetiver				
	Scirpus Yagara Ohwi	*Echinochloa Beauv.*	*Eieocharis Yokoscensis*	Else	Total	8/30	9/30	10/30	12/30	Comparison
CK	118	25	141	298	582	2.68	8.28	10.48	10.56	100%
Herbicide	50	31	58	116	255	3.12	9.24	10.48	10.96	103.8%
Difference	-68	+6	-83	-182	-327					
Effectiveness(%)	57.6		58.9	61.1	56.2					

Note: The number of weeds was plants / m^2 , investigated on 30th Sept, and the tiller number of
vetiver was tiller / single plant

4. SUMMARY

(1) Vetiver has extremely strong resistance to barren soil and drought. It can grow normally on very poor and severely eroded land. Its adaptability and growth are superior to any local species of grass such as *Eremochloa ophiuroides, Faberafricanum, Imperata cylindrical var, Erigeron acris L, etc.* Vetiver is very effective on soil and water conservation with its rapid growing and early hedgerow forming. About 50 % of the amount of runoff and more than 68 % of soil loss may be reduced by a biennial hedgerow.

(2) Soil physical properties can be improved and soil nutrients increased as manuring vetiver pruning to soil. It is effective to improve soil fertility and raise crop yield. When applying air dry stem and leaves 4.5 t/ha and 2.25 t/ha, the yield of corn increased by 34.8 % and 10.1% respectively.

(3) To spray any of a nutrient solution of A, B and C could control jointing and head sprouting, shorten the plant and promote tillering for over 30 %, reaching a very significant level. They are cheap and easy to buy. It is a simple measure to produce more tillers and to form early hedge rows then beneficial to the erosion control.

(4) It is very effective to increase the biomass of vetiver with N, P fertilizer application in the upland of red soil with low fertility. A very significant effect could be obtained as N 34.5 kg / ha and $P_2 O_5$ 36 kg / ha applied together increasing tiller for 27 % and fresh biomass 20 % than that of CK.

(5) It is an effective way to propagate seedling in paddy field in summer before the beginning of autumn. Reproducing at this time, 30 % more seedlings can be gained than other time. According to the research in this paper the effective measures include: selecting the age of 3 – 4 month young seedling, pruning it to 20 – 30 cm and root length 5 – 8 cm, ploughing and rakeing the paddy field and planting vetiver with a water layer for 3cm

thick, broadcasting herbicide after 3 – 4 days of planting, planting with small slips and high densely (150, 000 – 200,000 tillers / ha), applying N, P fertilizer properly, spraying nutrient solution on the leaves for promoting tillering in the tillering period and maintaining the field surface damp.

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