Study on soil microbial biodiversity in rhizosphere of vetiver grass in degradating soil

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Abstract

The experiment was carried out at Kao-Changum Royal Project, Rachaburi Province, Nakhornayok Province and Kalasin Province which the ecotypes of vetiver grass had grown in Tha Yang, Ongkharak and Roi-Et saline variant series respectively, comparing to non-planting vetiver grass area. One year of planted vetiver grass, the results were indicated significantly increase soil fertility which included soil microbial activities, chemical and physical properties change in 0-30 and 30-60 cm of soil depth. For suitable growing vetiver ecotypes Phrarachatan, Sri Lanka, Surat Thani and Songkhla3 in the normal soil as Tha Yang series, the dense root system produced some organic substances to stimulate non-symbiotic nitrogen fixing bacteria in rhizospheres which increased from 1.00 and 1.06 to 3.16-4.17 and 2.81-4.59 log no./gm of soil. Phosphate solubilizing microorganisms also changed from 1.04 and 1.47 to 2.17-3.84 and 3.00-3.63 log no./gm of soil, and phosphatase activity in soil increased from 10.75 and 11.75 to 17.79-20.58 and 18.16-21.40 milli unit/gm of soil. Nevertheless chlamydospore number of endo-mycorrhizal fungi were increased from 1.1 and 4 to 5-11 and 18-39 spore/100 gm soil and also appeared the dense arbuscule inside the fibrous root cells of vetiver which absorb and accumulate of plant nutrients, especially phosphorus indicated from 2.07 and 2.39 to 4.29-5.02 and 3.18-6.11 ppm. Furthermore decomposed leaves residue and dead cells of vetiver fibrous root had effect on soil organic matter content from 0.58 and 0.42 to 1.01-1.03 and 0.92-0.93 percent. In acid sulfate soil as Ongkharak series, vetiver growth 6 ecotypes: Phrarachathan, Surat Thani, South India, Sri Lanka, Ratchaburi and Fiji had specially effected to decrease quantitive iron from 91 and 107 to 56-75 and 70-89 ppm including reduced aluminum from 1.317 and 1.346 to 1.184-1.221 and 1.235-1.292 meq/100 gm soil. Planting vetiver as Sri Lanka and Songkhla3 ecotypes in saline soil, salinity (EC_e) decreased from 13-16 to 7-9 dS/m.

Keywords: microbial biodiversity, vetiver grass, rhizosphere, degradating soil

Introduction

Vetiver is known as a miracle plant with a deep and dense root system which can penetrate vertically in a wall-like from into the soil. Therefore, the benificial characteristics of vetiver are especially in soil and water conservation and erosion control. Furthermore, vetiver planting has effect decreased salted level in saline soil by absorbing water and hence help holding soil moisture for preventing salt volatization in soil. Vetiver is considered as a tolerant plant under adversed condition, the Sri Lanka ecotype in particular, grows well in saline and acid sulfate soils (Yoon, 1991; Sunantapongsuk, 2001; Pongwichian, 1999).

There are two species of vetiver in Thailand*: Vetiveria zizanioides Nash and V. nemoralis A. Canus.* They are growing naturally in the uplands and lowlands in various soil conditions at the altitudes from sea level to about 800 m (Office of the Royal Development Projects Board, 1996). Land Development Department has collected vetiver grasses from various localities throughtout the country and selected 27 ecotypes and suggested that 10 ecotypes have appropriate characteristies for multiplication and use for soil and water conservation as the following ecotypes: Sri Lanka, Loei, Nakhon Sawan, Kamphaengphet1, Kamphaengphet 2, Surat Thani, Songkhla 3, Ratchaburi, Prachuab Khiri Khan and Roi Et.

The research of soil miccroorganismes in rhizosphere of vetiver ahould be studied because of luxuriant growth of vetiver roots on the top soil layer. The plants are growing or have lately died, the substrates they provide can deanse the microbial population of the soil to increase greatly (Russell, 1982; Lynch, 1990). Root exudates such as soluble carbohydrates, organic acids, amino acids and growth organic substanced are considered to promote the growth of rhizosphere microoganisms. Benificial microorganisms in vetiver rhizosphere should be studied for proposing this research.

Materials and Methods

Soil characteristics

Soil series	Soil familly	pH	OM (%)	P (ppm)	K (ppm)	Ec_e (ds/m)
Tha Yang	Oxic Haplustults, Clayey-skeletal, kaolinitic	5.0	0.52	2.2	98	0.9
Roi-Et saline variant	Aeric Halaquept, fine-loamy, mixed	5.5	0.26	1.6	30	14.5
Ongkharak	Sulfic Tropaquepts, Very fine, mixed, acid	4.0	1.80	4.5	148	1.1

Experimental plan

This experiment was randomized complete block design. There were 7, 11 and 3 treatmtnts in each 3 replications which the vetiver ecotypes had growh in Tha Yang, Ongkharak and Roi-Et saline variant soil series respectively, comparing to non-planting vetiver area. Spacing between plants and rows of vetiver were 50x50 cm. Vetiver ecotypes in 7 treatments consisted of Phrarachathan, Surat Thani, Sri Lanka, Songkhla3, Prachuab Khiri Khan and Ratchaburi. For growing vetiver ecotypes in 11 treatments were South India, Fiji, Phrarachathan, Monto, Surat Thani, Prachuab Khiri Khan, Roi Et, Kamphaengphet, Ratchaburi and Nakhon Sawan. In 3 treatments of growing vetiver ecotypes were Sri Langka and Songkhla 3.

Data collection

After one year of planted vetiver, soil samples were taken from the vetiver rhizosphere at the soil depth of 0-30 and 30-60 cm were analyzed soil benificial microorganisms, some chemical properties, enzyme activities and soil moisture content and also comparing analysis of soil biochemical properties in non-planted vetiver areas.

Results and Discussion

Change of soil biological properties in vetiver rhizosphere:

The soils the plots with vetiver showed significantly more microbes than those without vetiver both at the depth of 0-30 and 30-60 cm. Vetiver fibrous root produced some organic substances such as soluble carbohydrates, organic acids, amino acids and growth hormones served as nutrient and energy sources for the growth of rhizosphere microbes (Russell, 1982; Lynch, 1990). The number of cellulolytic microbes in vetiver rhizosphere: *Bacillus* sp. increased in the soils at the depth of 0-30 and 30-60 cm in normal, saline and acid sulfate soils from 5.74-5.44, 5.10-5.14 and 5.58-5.45 to 8.89-8.58, 7.80-7.59 and 7.48-7.11 log no./gm of soil respectively. Where as *Streptomyces* sp. changed from 5.70-5.02, 5.16-5.40 and 5.41-4.86 to 8.64-8.14, 7.48-6.39 and 6.97-6.49 log no./gm of soil and *Aspergillus* sp. also changed from 3.65-3.23, 2.59-2.24 and 2.16-2.65 to 4.94-4.80, 3.63-3.24 and 4.11-3.57 log no./gm of soil respectively (Figure 1; Tables 1 and 2). These microorganisms produced cellulase from 5.38-4.95, 3.15-3.59 and 2.93-1.89 in soil without vetiver to 8.40-7.11, 6.72-5.87 and 7.53-5.83 milli unit/gm of soil with vetiver (Figure 2 and Table 3).

Table 1 Change of cellulolytic microorganisms in vetiver rhizosphere and non-planted vetiver at the soil depth of 0-30 cm under some problem soils.

Soil types	Cellulolytic microbes (log no./gm soil)					
	Without vetiver at 0-30 cm			With vetiver at 0-30 cm		
	Bacillus sp.	*Streptomyces* sp.	*Aspergillus* sp.	*Bacillus sp.*	*Streptomyces sp.*	*Aspergillus sp.*
Normal soil	5.74	5.7	3.65	8.89	8.64	4.94
Saline soil	5.1	5.16	2.59	7.80	7.48	3.63
Acid sulfate soil	5.58	5.41	2.16	7.48	6.97	4.11

Table 2 Change of cellulolytic microorganisms in vetiver rhizosphere and non-planted vetiver at the soil depth of 30-60 cm under some problem soils.

Soil types	Cellulolytic microbes (log no./gm soil)					
	Without vetiver at 30-60 cm			With vetiver at 30-60 cm		
	Bacillus sp.	*Streptomyces sp.*	*Aspergillus sp.*	*Bacillus sp.*	*Streptomyces sp.*	*Aspergillus sp.*
Normal soil	5.44	5.02	3.23	8.58	8.14	4.8
Saline soil	5.14	5.04	2.24	7.59	6.39	3.24
Acid sulfate soil	5.45	4.86	2.65	7.11	6.49	3.57

Table 3 Change of cellulase and phosphatase activities in vetiver rhizosphere and non-planted vetiver under some problem soils.

Soil types	Cellulase (milli unit/gm soil)				Phosphatase (milli unit/gm soil)			
	Without vetiver		With vetiver		Without vetiver		With vetiver	
	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
Normal soil	5.38	4.95	8.40	7.11	10.75	11.75	19.18	19.78
Saline soil	3.15	3.59	6.72	5.87	7.52	7.01	16.54	14.23
Acid sulfate soil	2.93	1.89	7.53	3.83	14.03	7.43	25.43	15.03

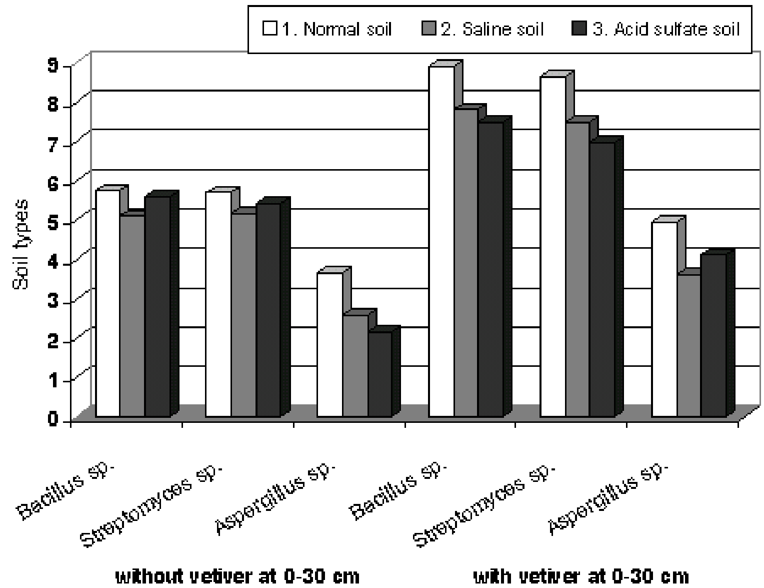

Figure 1 Change of cellulolytic microorganisms in vetiver rhizosphere and non-planted vetiver at soil depth of 0-30 cm under some problem soils.

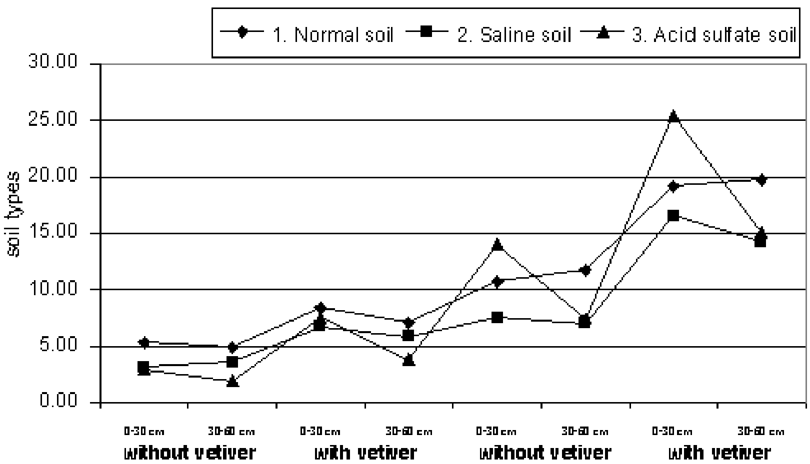

Figure 2 Change of cellulase and phosphatase activity in vetiver rhizosphere and non-planted vetiver under some problem soils.

For non-symbiotic nitrogen fixing bacteria, the number of *Azotobacter* sp. increased in soils at the depth of 0-30 and 30-60 cm in normal, saline and acid sulfate soils from 1.00-1.06, 1.51-1.67 and 1.56-1.03 to 4.17-3.61, 3.38-2.98 and 2.85-2.30 log no./gm of soil respectively (Figure 3; Tables 4 and 5). The phosphate solubilizing microbes as *Aspergillus niger* changed from 1.04-1.47, 1.51-1.71 and 1.39-1.08 to 3.84-3.63, 3.11-3.30 and 2.78-2.69 log no./gm of soil. The phosphatase produced in soil increased from 10.75-11.75, 7.52-7.01 and 14.03-7.43 to 19.18-19.78, 16.54-14.23 and 25.43-15.03 milli unit/gm of soil (Figure 2 and Table 3). Furthermore, the number of chlamydospores of endomycorrhiza increased from 1-4, 3-3 and 2-1 to 8.28, 41-48 and 6-2 spores/100gm soil. (Table 6) The hyphae germinated from the spore and then penetrated in to the root cells which formed numerous vesicles or arbuscules as the structure for accumulating nutrient sources especially phosphorus (Ogawa, 1994).

Table 4 Change of microorganisms in vetiver rhizosphere and non-planted vetiver at the soil depth of 0-30 cm under some problem soils.

Soil types	Soil microbes (log no./gm soil)			
	Without vetiver at 0-30 cm		With vetiver at 0-30 cm	
	Azotobacter sp.	*Aspergillus niger*	*Azotobacter sp.*	*Aspergillus niger*
Normal soil	1.00	1.04	4.17	3.84
Saline soil	1.51	1.51	3.38	3.11
Acid sulfate soil	1.56	1.39	2.85	2.74

Table 5 Change of microorganisms in vetiver rhizosphere and non-planted vetiver at the soil depth of 30-60 cm under some problem soils soil microbes (lot no./gm soil).

Soil types	Without vetiver at 30-60 cm		With vetiver at 30-60 cm	
	Azotobacter sp.	*Aspergillus niger*	*Azotobacter sp.*	*Aspergillus niger*
Normal soil	1.06	1.47	3.61	3.63
Saline soil	1.67	1.71	2.98	3.30
Acid sulfate soil	1.03	1.08	2.30	2.69

Table 6 Change of chlamydospore of endomycorrhiza in vetiver rhizosphere and non-planted vetiver under some problem soils.

Soil types	Chlamydospore (spore)			
	Without vetiver		With vetiver	
	0-30 cm	30-60 cm	0-30 cm	30-60 cm
Normal soil	1.1	4.0	8.0	28.5
Saline soil	3.0	3.0	41.0	48.5
Acid sulfate soil	2.0	1.0	6.5	2.5

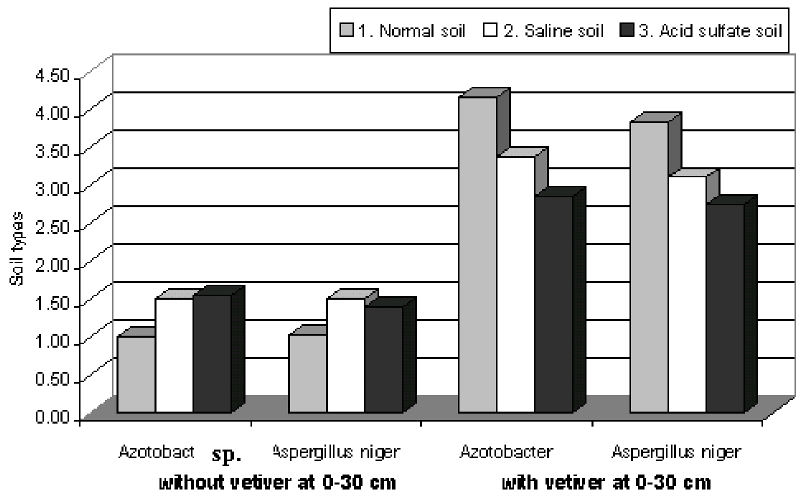

Figure 3 Change of microorganisms in vetiver rhizosphere and non-planted vetiver at soil depth of 0-30 cm under some problem soils.

Change of soil chemical and physical properties in vetiver rhizosphere

Chemical properties of soils changed after one year of planting vetiver. Increasing microbial activities in rhizosphere raised available nutrients content in soil and played an especially important role by decomposing organic substances or transforming inorganic substance to available nutrients for the plant growth and the pH of all soils were raised as shown in Tables 7 and 8 (Tate, 1995). The phosphorus in normal, saline and acid sulfate soils increased from 2.07-2.39, 1.75-1.49 and 5.03-4.08 without vetiver to 4.49-4.66, 3.28-2.29 and 5.28-6.67 ppm with vetiver respectively. Soil organic matter in vetiver rhizosphere also raised from 0.58-0.42, 0.31-0.23 and 2.34-1.16 to 0.94-0.93, 0.56-0.28 and 2.43-1.29 percent. In Tables 9 and 10 showed the salinity decreased in salt affected and Fe^{++} and Al^{+++} in acid sulfate soil decreased (Arunin, 1996). In addition, soil moisture in vetiver rhizosphere changed from 5.8-5.0, 7.2-7.0 and 26.0-28.9 to 9.2-8.0, 10.1-10.5 and 23.5-24.9 percent because the dense fibrous root system help holding soil moisture.

Table 7 Change of chemical and physical properties in vetiver rhizosphere and non-planted vetiver at 0-30 cm of soil depth under some problem soils.

Soil types	without vetiver at 0-30 cm				with vetiver at 0-30 cm			
	OM (%)	P_2O_5 (ppm)	pH	soil moisture (%)	OM (%)	P_2O_5 (ppm)	pH	soil moisture (%)
normal soil	0.58	2.07	5.0	5.8	0.94	4.49	6.3	9.2
saline soil	0.31	1.75	5.5	7.2	0.56	3.28	5.9	10.1
acid sulfate soil	2.34	5.03	4.3	26.0	2.43	5.28	4.6	23.5

Table 8 Change of chemical and physical properties in vetiver rhizosphere and non-planted vetiver at 30-60 cm of soil depth under some problem soils.

Soil types	without vetiver at 30-60 cm				with vetiver at 30-60 cm			
	OM (%)	P_2O_5 (ppm)	pH	soil moisture (%)	OM (%)	P_2O_5 (ppm)	pH	soil moisture (%)
normal soil	0.42	2.39	5.0	5.0	0.93	4.66	6.1	8.0
saline soil	0.23	1.49	5.4	7.0	0.28	2.29	5.7	10.5
acid sulfate soil	1.16	4.08	3.9	28.9	1.29	6.77	4.2	24.9

Table 9 Change of salinity (electrical conductivity) in vetiver rhizosphere and non-planted vetiver under some problem soils.

Soil type	Ec_e (dS/m)			
	0-30 cm of soil depth		30-60 cm of soil depth	
	without vetiver	with vetiver	Without vetiver	with vetiver
Saline soil	13.00	**7.00**	16.00	**9.00**

Table 10 Change of iron and aluminum content in vetiver rhizosphere and non-planted vetiver under acid sulfate soil.

Soil type	Fe^{++} (ppm)				Al^{+++} (meq/100 gm soil)			
	without vetiver		with vetiver		without vetiver		with vetiver	
	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
acid sulfate soil	91	107	56	71	1.31	1.34	1.20	1.26

Conclusions

1. The number of soil microorganisms and microbial activities in vetiver hizosphere in the upper soil depth at 0-30 cm were higher than those of the lower soil depth at 30-60 cm.

2. Microbial activities in vetiver rhizosphere were higher than those of non-planted areas.

3. Cellulolytic microbes and cellulase activity in rhizosphere were higher in normal soil than in saline and acid sulfate soils respectively. Highest phosphatase activity in rhizosphere were produced in acid sulfate soil. The numerous chlamydospore of endomycorrhiza had been found in saline and normal soils.

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