Study on relationship between soil microorganisms and nutrient elements of *Vetiveria zizanioides* and *Vetiveria nemoralis* in some problemed soils of Thailand

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Abstract

The relationship between soil microorganisms and nutrient elements of *Vetiveria zizanioides* and *Vetiveria nemoralis* was studied when planted various kinds of vetiver grass in problem soils namely acid sulfate soils area at Nakhon Nayok province, shallow soils area at Ratchaburi province and saline soils area at Kalasin province, compare to non-planted vetiver grass. The result showed that population of effective microorganisms adjacent vetiver rhizosphere were increased both of *vetiveria zizanioides* and *Vetiveria nemoralis* in three site planted area that is cellulolytic bacteria, cellulolytic fungi and cellulolytic actinomycetes increased from 5.58-6.70, 2.59-3.16 and 5.41-5.70 in soil without vetiver grass to 6.00-8.89, 3.18-4.98 and 5.60-8.64 log no./g. of soil with vetiver grass respectively. Free-living nitrogen-fixing microbes increased from 1.00-2.56 to 2.60-4.36 log no./g. of soil. Phosphate solubilizing microorganisms changed from 1.04-2.39 to 2.17-3.87 log no./g. of soil including found endomycorrhizal fungi ranged of 26-143 cell/5 mm. length of root in 5 pieces of vetiver root. The chemical properties of soil; organic matter, macronutrient, micronutrient and moisture content changed after one year of planting vetiver grass such as organic matter and nitrogen raised from 0.31-2.34 and 0.008-0.140 to 0.49-2.62 and 0.016-0.239%. Phosphorus and potassium content increased from, 1.75-5.03 and 32-163 to 3.27-6.96 and 51-247 ppm respectively when compared to non-planted area. To analyze the correlation coefficient indicated that the concerned microorganism on changing nutrient elements of *vetiveria zizanioides* was arbuscular mycorrhizal fungi and related significantly to phosphorus increment by multiple linear regression (R^2 = 0.698). Furthermore, organic matter showed positive correlation with plant nutrient elements and highly influenced on changing of nitrogen, phosphorus and magnesium by R^2 were 0.933, 0.899 and 0.944 respectively. For consideration *Vetiveria nemoralis* found that phosphate solubilizing bacteria significantly correlated with increasing of nutrient element in soil especially positive effect on releasing available phosphorus and could be predicted phosphorus changing (R^2 = 0.868). Additionally, total amount of organic matter closely positive correlated to nitrogen, phosphorus and moisture content by R^2 were 0.899, 0.788 and 0.951 respectively.

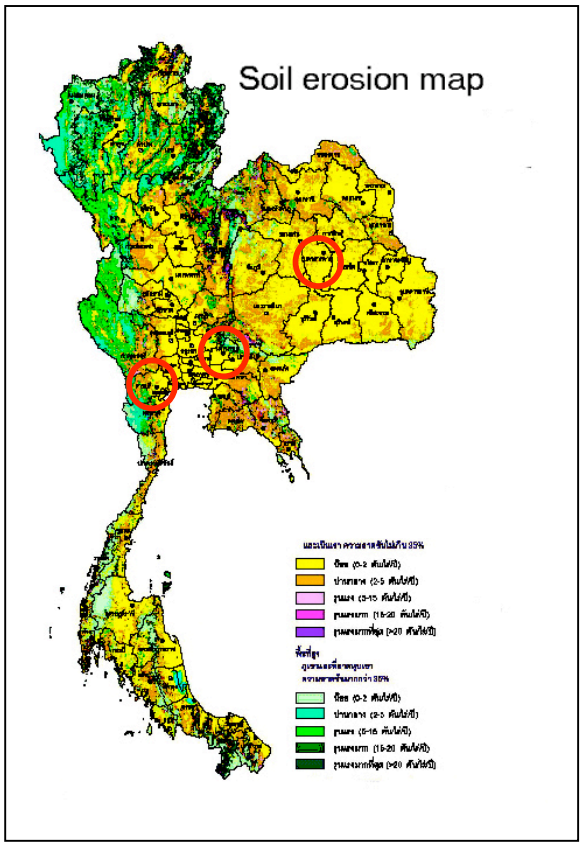
Introduction

The main problem of agriculture in Thailand is infertile and deteriorated soil from inappropriate utilization of soil resources and soil erosion from deforestation where it result in decreasing of crop yields and poverty of farmers. Vetiver grass is known as a miracle plant with a deep and dense root system which can penetrate vertically in a wall-like form into the soil and also considered as a tolerant plant under adversed condition such as infertile soil lateritic soil or flooding areas. The Sri Lanka ecotype in particular,

grows well in saline and acid sulfate soils (Yoon, 1991; Sunantapongsuk, 2001; Pongwichian, 1999). The potential value of vetiver grass for soil and water conservation is extensive root systems penetrating and adhering soil particles tightly to prevent soil erosion and maintain soil moisture content. On this reason, the King of Thailand stimulates the government agencies study and research on the beneficial matter of vetiver grass especially in soil and water conservation, reclamation of infertile soil and environment prevention. Moreover, soil microorganisms and their activities have the importance role in transformation on plant nutrients to available form and also have many metabolisms related to soil fertility improvement. Microbial population and activities is higher detected in rhizosphere of vetiver grass than out side of rhizosphere. So the changes of chemical, physical and biological of soil properties are studied and microbial activities in rhizosphere drives many functions promoted to increase fertility of soil. Several kinds of microorganism in that area carry out decomposition of organic matter and release several plant nutrients, accelerate in absorption of phosphorus and biological control of some plant pathogen. However, the objectives of this research are emphasized on the changes and relationships between biological and chemical soil properties in rhizosphere of vetiver grass under various problem soil conditions.

Materials and Methods

Experimental site*: Vetiveria zezanioides* such as South India, Fiji, Prarachathan, Monto, Sri Lanka, Surathani and Songkhra ecotypes; *Vetiveria nemoralis* such as Prachuabkhiri Khan, Khampangphet, Rachaburi and Nakhonsawan ecotypes were planted in problem soil of Thailand.



And 3 locations of problem soils were selected, namely acid sulfate soil in central plain at Nakhon Nayok province (Ongkharak soil series), shallow soil in lower part of central plain at Ratchaburi province (Tha Yang soil series) and saline soil in north eastern part Kalasin province (Roi-Et saline variant soil series) as showed in figure 1.

Experimental design: Randomized complete block design was planned, where spacing between plants and rows of vetiver was 50x50 cm. The plots without vetiver grass were treated as control.

Data collection: Soil samples were taken in April, August and December from the experimental plots with and without vetivers grass after one year of planting at 0-30 cm of the soil depth for some biological and chemical soil properties analyses.

Figure 1: Soil erosion map of Thailand and location of 3 experimental sites of problem soil.

Results and Discussion

Soil characteristics

Soil characteristics of 3 soil series were determined and some chemical properties were showed in table 1. Moreover acid sulfate soil (Ongkharak soil series) is in the central plain and pH is very low, where it used for rice cultivation and organic matter content is very high as 1.8 %. Shallow soil (Tha Yang soil series) is in the lower part of central plain, where it used for pine apple and upland crops. pH is around 5.0 and organic matter content is a bit low as 0.52%. Saline soil (Roi-Et soil series saline variant) is in the north eastern part of the country, where covered with infertile soil and sandy in texture. It used for rice cultivation in lowland and corn, cassava or other crops in upland, even organic matter and main plant nutrient content in this soil is very low.

Table 1: Soil characteristics of Ongkharak, Tha Yang and Roi-Et (saline variant) soil series.

soil series	soil family	pH	OM (%)	P_2O_5 (ppm)	K_2O (ppm)	ECe (ds/m)
Ongkharak	Sulfic Tropaquepts, Very fine, mixed, acid	4.0	1.80	4.5	148	1.1
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	3.0	14.5

Change of soil biological properties

The soil of three sites in the plots with vetiver grass showed more microbial population than without vetiver grass planted area. Because of the exudates substances from vetiver fibrous root secrete into rhizosphere where it consist of some organic substances such as soluble carbohydrates, organic acids, amino acids and growth hormones. That vetiver root exudated substances served as nutrient and energy sources for the growth of microorganisms in the rhizosphere (Russell, 1982 and Lynch, 1990). However, the population of bacteria and actinomycetes in soil is usually higher than fungi in 3 types of soil; acid sulfate soil, shallow soil and saline soil as showed in figure 1. In case of some specific group of microorganisms, the population of cellulolytic microorganisms especially bacteria and non-symbiotic nitrogen fixing bacteria in vetiver rhizosphere both of *Vetiveria zezanioides* and *Vetiveria nemoralis* was increased when compared to unplanted vetiver grass from 5.58 to 6.32 and 6.84; from 2.56 to 2.88 and 3.37 log no./gm of soil in acid sulfate soil, shallow soil increased from 5.74 to 8.31 and 7.32; 1.00 to 3.90 and 3.49 log no./gm of soil, in saline soil from 6.7 to 7.67 and 1.51 to 3.31 log no./gm of soil respectively as showed in figure 2.

The population of phosphate solubilizing microorganisms (PSM) in rhizosphere was increased, which compared to non planted vetiver, in case of PSM population in acid sulfate soil was increased from 2.28-2.39 to 2.98-3.46 log no./gm of soil, in shallow soil from 1.04-1.60 to 2.24-3.55 log no./gm of soil and in saline soil from 1.51-1.68 to 3.01-3.06 log no./gm of soil. Moreover population of chlamydospore of endomycorrhiza in acid sulfate soil was increased from 2 to 6-7 spores/100gm of soil, in shallow soil from 1 to 5-8 spores/100gm of soil and in saline soil from 3 to 29 spores/100gm soil as showed in figure 2.

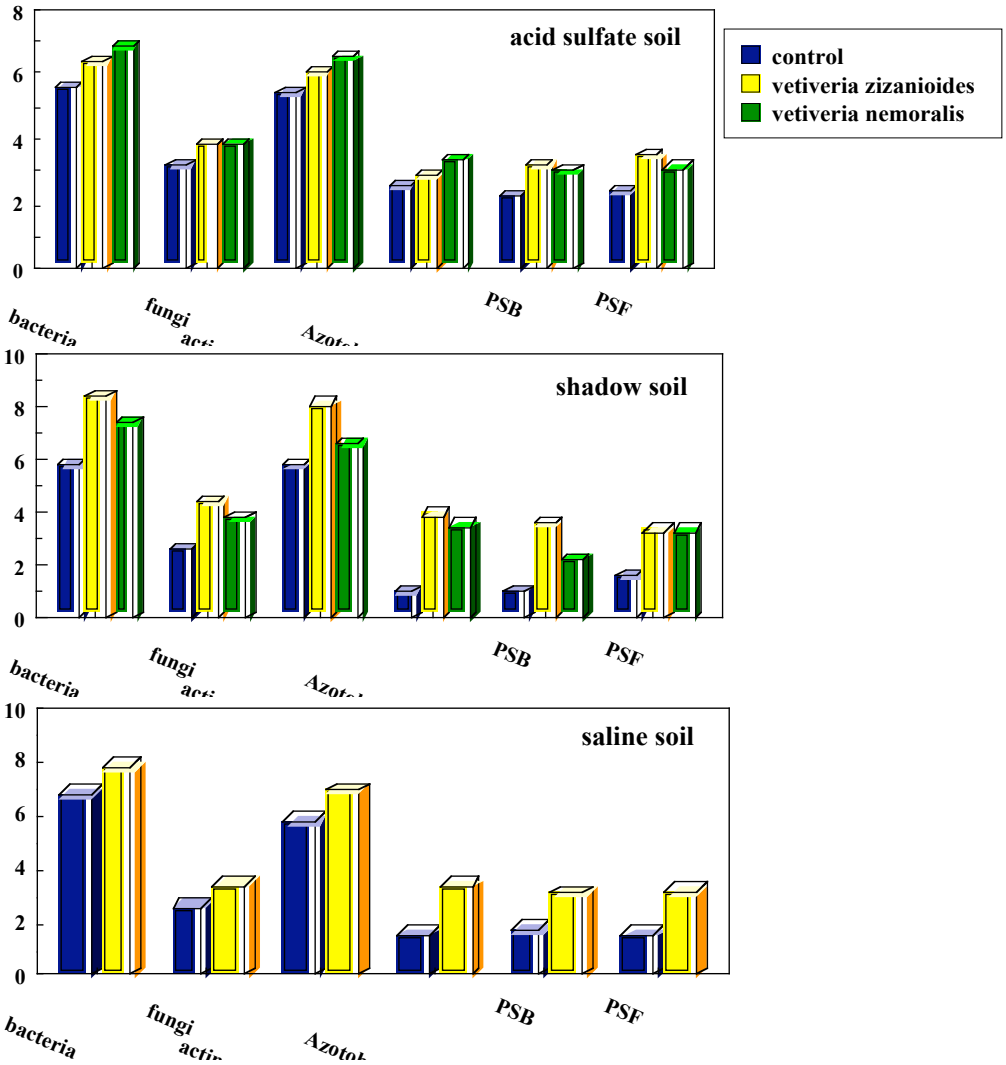


Figure 2: change of microorganisms population in vetiver rhizosphere of some problem soils

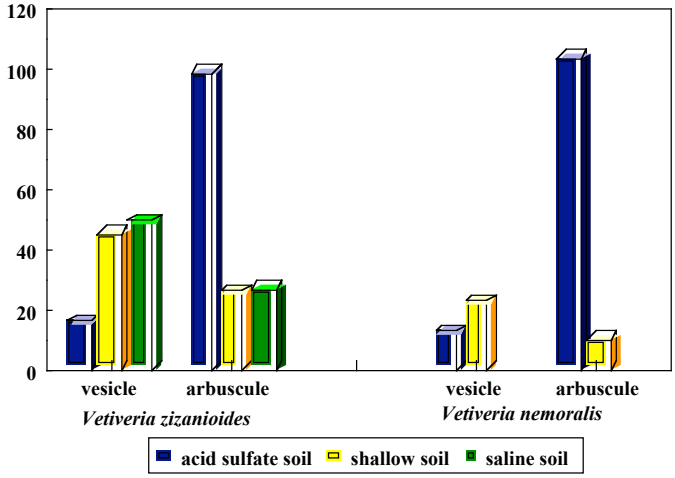


Figure 3: change of vesicle and arbuscule mycorrhiza population in vetiver root of some problem soil

However, vesicle and arbuscule endomycorrhizal fungi (VAM) were found in range of 13-16 and 113-117 cells in acid sulfate soil, 23-45 and 10-26 cells in shallow soil, 49 and 27 cells in saline soil as showed in figure 3, when examined from 5 mm. length of vetiver root amount 5 pieces, due to the hyphae germinated from the spore and then penetrated in the root cells which formed numerous vesicle and arbuscule as the structure for accumulation nutrient sources especially phosphorus (Ogawa, 1994)

Change of soil chemical properties

The average content of soil organic matter in acid sulfate soil was 2.34 % and it was increased to 2.49 % in soil planted with *Vetiveria zezanioides* and the average content of organic matter was increased to 2.47 % in soil planted with *Vetiveria nemoralis.* In case of average organic matter content in shallow soil was 0.58 % and it was increased to 1.00 % and 0.97 % in soil planted with *Vetiveria zezanioides* and *Vetiveria nemorali,* respectively.

The average content of nitrogen, phosphorus and potassium in soil, where planted with two species of vetiver grass was not difference but increased when compared to non planted area and the average content of such nutrients in acid sulfate soil was increased in nitrogen content from 0.14 to 0.19-0.21 %, in phosphorus content from 5.03 to 6.24-6.36 ppm and in potassium content from 163 to 188-214 ppm in. And in shallow soil was increased in nitrogen content from 0.01 to 0.02 %, in phosphorus content from 2.07 to 4.59-4.82 ppm and in potassium content from 103 to 154 ppm. Moreover, in saline soil nitrogen content from 0.01 to 0.02 %, in phosphorus content from 1.75 to 3.28 ppm, and in potassium content from 32 to 52 ppm, respectively as showed in table 2.

Table 2: change of organic matter and macro-nutrient content in vetiver rhizosphere

soil type	without vetiver grass				*Vetiveria zezanioides*				*Vetiveria nemoralis*			
	OM (%)	N (%)	P_2O_5 (ppm)	K_2O (ppm)	OM (%)	N (%)	P_2O_5 (ppm)	K_2O (ppm)	OM (%)	N (%)	P_2O_5 (ppm)	K_2O (ppm)
acid sulfate	2.34	0.14	5.03	163	2.49	0.21	6.36	214	2.47	0.19	6.24	188
shallow	0.58	0.01	2.07	103	1.00	0.02	4.82	154	0.97	0.02	4.59	154
saline	0.49	0.01	1.75	32	0.44	0.02	3.28	52	--	--	--	--

Most micronutrients content in soil of 3 sites of problem soil were increased, whereas sulfur content in acid sulfate soil was decreased, namely calcium content was increased average from 782 to 887-951 ppm, magnesium content increased from 1,121 to 1,134-1,460 ppm, while sulfur content decreased from 102 to 78-80 ppm. For shallow and saline soil found that calcium content was increased from 271 to 513-523 and 92 to 125 ppm, magnesium content was increased from 345 to 556-570 and 132 to 171 ppm, and sulfur content was increased from 0.83 to 1.68-1.84 and 1.21 to 2.34 ppm, respectively as showed in table 3. Soil chemical properties were changed after one year of planting vetiver grass because of increasing microbial population in rhizosphere effect on transforming inorganic substances to available nutrients or decomposing organic substances from root residue to raise humus content in soil (Tate, 1995)

Table 3: change of micro-nutrient and soil moisture content in vetiver rhizosphere

soil type	Without vetiver grass				*Vetiveria zezanioides*				*Vetiveria nemoralis*			
	Ca (ppm)	Mg (ppm)	S (ppm)	MC (%)	Ca (ppm)	Mg (ppm)	S (ppm)	MC (%)	Ca (ppm)	Mg (ppm)	S (ppm)	MC (%)
acid sulfate	782	1121	102	26.1	951	1460	78	22.8	887	1134	80	23.0
shallow	271	345	0.83	5.83	513	570	1.84	8.63	523	556	1.68	7.15
saline	92	132	1.21	7.17	125	171	2.34	9.76	--	--	--	--

Moreover, soil moisture in vetiver rhizosphere of shallow and saline soil was raised from 5.83 to 7.15-8.63 and 7.17 to 9.76 % because the dense fibrous root system assist to conserve water in soil, where moisture content was increased in both of problem soil, but moisture content in acid sulfate soil was decreased from 26.1 to 22.8-23.0 % as showed in table 3, due to increasing of soil aggregate and soil aeration.

Correlation analysis

The relationship between population of some specific microorganisms and some plant nutrients in vetiver rhizosphere were analyzed in term of correlation coefficient. And analyze the correlation coefficient between several kinds of microorganisms and plant nutrients in grouping of *Vetiveria zezanioides* indicated that the concerned microorganism on changing nutrient elements was arbuscular mycorrhizal fungi and related significantly to phosphorus increment by multiple linear regression R^2 was 0.698. The others such as cellulolytic microorganisms, non symbiotic nitrogen fixing microbes and phosphate solubilizing microorganisms was not correlated to macro and micro nutrient changing. Furthermore, organic matter showed positive correlation with plant nutrient elements and highly influenced on changing of nitrogen, phosphorus and magnesium by R^2 were 0.933, 0.899 and 0.944, respectively as showed in figure 3.

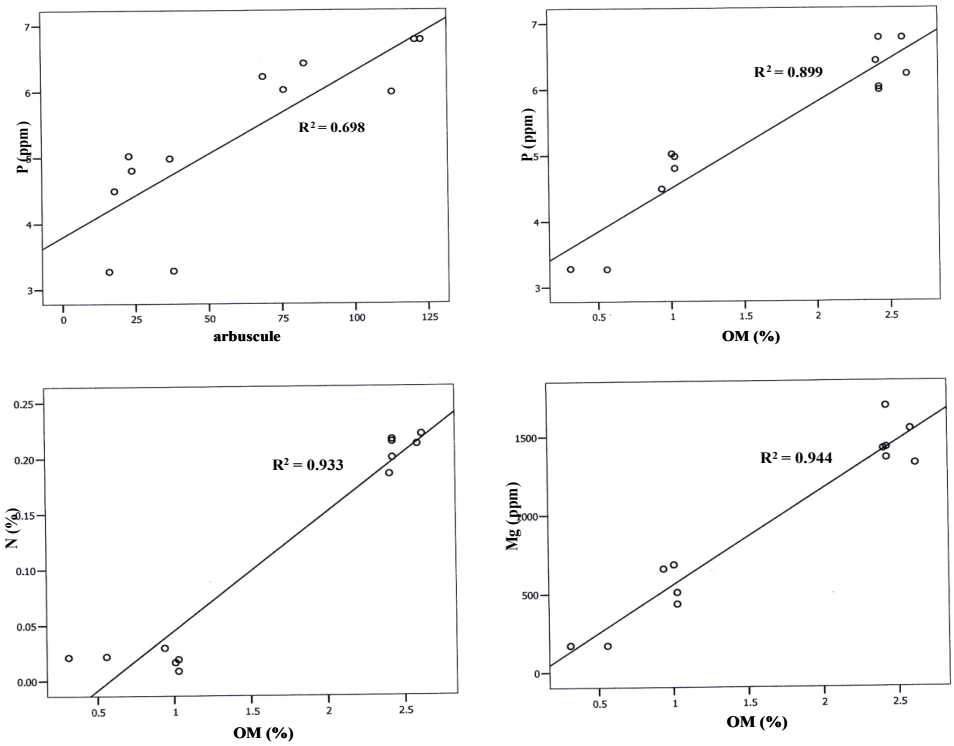


Figure 3: correlation between arbuscular mycorrhiza on changing phosphorus in soil and organic matter correlate with plant nutrient of *Vetiveria zezanioides*

For consideration correlation coefficient between planted several kinds of *Vetiveria nemoralis* and non planted vetiver grass found that phosphate solubilizing bacteria population significantly correlated with increasing of nutrient element in soil especially positive effect on releasing available phosphorus and could be predicted phosphorus changing by multiple linear regression R^2 was 0.868. Additionally, total content of organic matter closely positive correlated to nitrogen, phosphorus and moisture content by R^2 were 0.899, 0.788 and 0.951, respectively as showed in figure 4. The other nutrients increment was not correlated to increasing of organic matter.

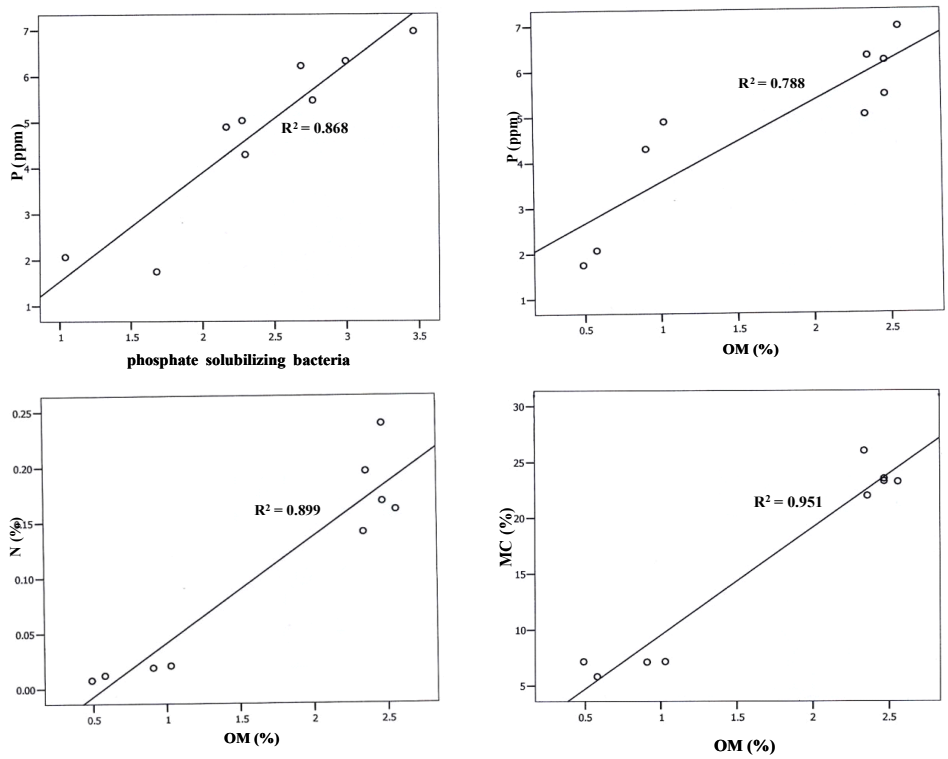


Figure 4: correlation between phosphate solubilizing bacteria population on changing phosphorus in soil and organic matter correlate with macronutrient and soil moisture content of *Vetiveria nemoralis*

Conclusion

The population of soil microorganisms in vetiver rhizosphere both of *Vetiveria zezanioides* and *Vetiveria nemoralis* in acid sulfate, soil shallow soil and saline soil was higher than those of non planted area. Microbial population adjacent vetiver root of *Vetiveria zezanioides* and *Vetiveria nemoralis* soil was not difference in acid sulfate but microorganisms in rhizosphere of *Vetiveria zezanioides* were higher than *Vetiveria nemoralis* in shallow soil. Total macronutrient, micronutrient, organic matter and moisture content in three problem soils were higher with two ecotype vetiver plantation than without vetiver plantation. However, the concerned microorganism on changing nutrient elements of *Vetiveria zizanioides* was arbuscular mycorrhizal fungi population but *Vetiveria nemoralis* was phosphate solubilizing bacteria population which related significantly to phosphorus increment. Moreover, organic matter content in rhizosphere of

Vetiveria zizanioides was highly influenced on changing of nitrogen, phosphorus and magnesium content but in case of *Vetiveria nemoralis*, organic matter was closely positive correlated to nitrogen, phosphorus and moisture content

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