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Comparative Study on the Dynamics of Rhizosphere and Non Rhizosphere Soil

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A B S T R A C T

A study was carried out in the Department of Soil Science and Agrl Chemitry, College of Agriculture, Vellayani, Kerala Agricultural University to compare the respiratory and microbial activities under integrated plant nutrient system between rhizosphere and non rhizosphere in laterite soil under Integrated Plant Nutrient System. The rhizosphere and non rhizopshere samples of the test crop Okra were collected and analysed for microbial parameters and respiratory activity. The fertility index (Enzyme activity numbe) was also worked out.Microbial count was calculated using serial dilution technique. For bacteria in the rhizosphere soil, T_8 (P (50 %) as PSB enriched vermicompost + P (50%), N & K) recorded the maximum bacterial count while in the non- rhizosphere soil, highest value of bacterial colonies was recorded by T_{12} (P (75%) as PSB enriched vermicompost + P (25%), N & K). Treatment T_9 (NPK (50 %), PGPR mix-1 enriched vermicompost + N, P & K (50%) recorded maximum number of fungal colonies in rhizosphere soil and actinomycetes in the non rhizosphere soil. In the non rhizosphere soil, maximum number of fungal colonies was observed with the application of T_9 and T_{13}. Treatment T_{13} (N, P, K, (75 %) as PGPR mix-1 enriched vermicompost + N, P & K (25 %)recorded the highest values for actinomycetes in the rhizosphere soil. The enzyme activity number is found to be higher than the rhizosphere soil.It is understood that rhizosphere, the soil adjacent to plant roots is significantly different from bulk soil in chemical, biological and microbiological properties

Introduction

Soil fertility and crop production are affected by biological and chemical processes which are intimately involved in the cycling of nutrients, effect fertilizer use efficiency, reflect the microbiological activity in soil and act as indicators of soil productivity. As soil is a part of terrestrial environment and supports all terrestrial life form, protection of soil is therefore of high priority and thorough understanding of soil physical and biological activities is a critical factor in assuring that the soil remains healthy.

Soil microbial communities in the rhizosphere are the most important functional component of soil biota playing a key role in energy

flows and nutrient reactions (Tate, 2000). Root-colonizing plant beneficial bacteria, commonly referred to as plant growth-promoting rhizobacteria (PGPR), are capable of stimulating plant growth when cultivated in association with a host plant. PGPR are able to increase plant growth, accelerate seed germination, improve seedling emergence responses to external stress factors, protect plants from disease, and promote root growth (Kennedy, 1998).

The balanced fertilization of major elements (NPK) for plant nutrient could be beneficial for the growth of plant above ground parts and roots. However farmers are often forced to make decision about their fertilization strategy that reflects economic rather than agronomic pressure. When economic pressure is lifted, nitrogen and to a lesser extent, phosphorous are the nutrients of choice and the need for potassium is either under estimated or ignored. As a result imbalanced fertilization is still widespread.

Hence the concept of Integrated Plant Nutrient System (IPNS) encompassing adequate and balanced use of nutrients in an integrated manner employing chemical, organic and biofertilizers is the most ideal system of nutrient management. IPNS is a concept and farm management strategy which embraces and transcends from single crop fertilization effects to planning and management of plant nutrients in crop rotation and farming systems on long term basis for enhanced productivity, profitability and sustainability. The primary goal of integrated nutrient management is to combine old and new methods of nutrient management into ecologically sound and economically viable farming systems that utilize available organic and inorganic sources of nutrients in a judicious and efficient way (Acharya *et al.*, 1998). To avoid the side effects of fertilizers and to provide socioeconomic and ecological benefits, biofertilizers are generally recommended. Biofertilizers contains living micro organisms and it is expected that their activities will influence the soil ecosystem and produce supplementary substance for the plants. The region and crop- specific consortia of biofertilizers (combining *Azotobacter*, *Azospirillum*, Phosphate solubilising bacteria, *Rhizobium* and Plant Growth Promoting Rhizobacteria) should be developed. There is a thus dire need to popularize the technology of integrating these bioinoculants with inorganics by the way of substitution which can be achieved through IPNS. Hitherto the present investigation was undertaken to study the effect of integrated plant nutrient system (IPNS) on the dynamics of rhizosphere and non rhizosphere soils.

Materials and Methods

The present study entitled Study on the dynamics of rhizosphere and non rhizophere soil was carried out in the Department of Soil Science and Agrl. Chemistry at College of Agriculture, Vellayani during March- June 2012. The soil of the experimental site was sandy clay loam belonging to the family of Loamy Kaolinitic Isohypothermic Typic Haplustalf. The test crop used for the study is Bhindi variety "Varsha Upahar", a green fruited variety suitable to southern Kerala having duration of 105 days.

Enrichment of vermicompost was carried out using *Azospirillum*, Phosphorus solubilizing bacteria, PGPR mix-1 at the rate of 2 %. Other source of enrichment used was Neemcake @ 5%.

The nutrient content in the enriched composts were analysed and were applied to the crop to meet the nutrient requirement in specific doses. The rest of the crop requirement was supplemented by the addition of inorganic fertilizers. Enriched vermicompost were

analysed for major nutrients using standard analytical procedures and data are presented in Table 1.

Various combinations of enriched vermicompost with inorganics was used for the study. Rhizosphere soils were collected by the method of destructive sampling of the plants. Plants were uprooted and the rhizosphere soils were collected in polythene bags. These soils were stored in deep freezers to ensure the viability of microorganisms.

Non rhizosphere soils were collected from the non-rhizosphere areas and stored as above. Soil for chemical analysis were collected, dried in shade, powdered with a wooden mallet, sieved through a 2 mm sieve and stored in polythene containers. The respiratory activity of the soil samples were estimated using the method outlined by Jenkinson and Powlson (1976), where the CO_2 evolved from a fixed quantity of incubated soil was collected in an alkali and quantified. The initial data on physical, chemical and biological properties of the soil where field experiment was conducted are given below in Table 2.

Microbial count in the soil was enumerated using serial dilution technique proposed by Timonin (1940). Composition of the media was presented in Table 3.

The data generated from these experiments were subjected to the analysis of variance as per the design and their significance was tested by the F test (Snedecor and Cochran, 1975).

Results and Discussion

Soil microbial populations are immersed in a framework of interactions known to affect plant fitness and soil quality. They are involved in fundamental activities that ensure the stability and productivity of both agricultural systems and natural ecosystems. A comparison of respiratory and microbial activities under integrated plant nutrient system between rhizosphere and non rhizosphere was attempted in this study. The differing physical, chemical, and biological properties of the root-associated soil, compared with those of the root-free bulk soil, are responsible for changes in microbial diversity and for increased number and activity of micro-organisms in the rhizosphere micro-environment (Kennedy, 1998).

Microbial count was calculated using serial dilution technique. For bacteria in the rhizosphere soil, T_8 (P (50 %) as PSB enriched vermicompost + P (50%), N & K) recorded the maximum bacterial count (184.67×10^6 CFU g^{-1} of soil) while in the non-rhizosphere soil, highest value of bacterial colonies was recorded by T_{12} (P (75%) as PSB enriched vermicompost + P (25%), N & K). In the rhizosphere soil, the significant effect of treatments on soil bacteria was observed (Fig. 1). It is quite interesting to note that treatment involving the application of 50% of P as Phosphate solubilizing bacteria enriched vermicompost along with inorganics was similar in effect with 50% of NPK as PGPR mix-1 enriched vermicompost in combination with inorganics. This might be due to the positive co-operation between PGPR and PSB thus contributing to higher activity of bacteria. In the non rhizosphere soil, application of bio inoculants has significantly increased the bacterial count.

In the rhizosphere soil, fungi population was higher in bio inoculants treated soils in the rhizosphere zone than the non rhizosphere soil (Fig. 2).From the study it was observed that treatment T_9 (NPK (50 %), PGPR mix-1 enriched vermicompost + N, P & K (50%) recorded maximum number of fungal colonies in rhizosphere soil (13.67×10^4 CFU g^{-1}) and

actinomycetes in the rhizosphere soil (9.33 $x10^4$ CFU g^{-1} of soil). In general the maximum number of funagal colonies was found to be higher in rhizosphere soil than the non rhizosphere soil. In the non rhizosphere soil, maximum number of fungal colonies was observed with the application of T_9 and T_{13} (8.67 $x10^4$ CFU g^{-1}).

It is inferred from the Fig. 3 that the actinomycetes population had varied significantly with treatments in both rhizosphere and non-rhizosphere soils. Application of PGPR mix-1enriched vermicompost had increased the actinomycetes population in both the soils. Treatment T_{13} (N, P, K, (75 %) as PGPR mix-1 enriched vermicompost + N, P & K (25 %) recorded the highest values for actinomycetes in the rhizosphere soil which was higher than the non rhizosphere soil.

The rhizosphere, the zone of soil under the influence of root is characterized by high microbial diversity, activity, number of organisms and complex interactions and root (Oger *et al*., 2004). The population and functions of microorganisms cannot be overlooked while considering soil health because microorganisms provide living environment to the soil and perform various functions. It has been recently postulated that an additional mechanism for plant growth promotion by PGPR could be their altering of microbial rhizosphere communities (Ramos *et al.*, 2003).

The higher activity of microflora as a whole in the rhizosphere soil over the non-rhizosphere soil might be attributed to the microbial colonization in the rhizosphere known as root colonization. Since the rhizosphere is considered as the most intense ecological habitat in soil, it is of interest to study the effects that PGPR may have on total microbial activity and bacterial population where rhizobacteria exerted a direct influence on plants (Jeffries *et al.*, 2003; Aroca and Ruiz-Lozano 2009).

Soil enzymes have been suggested as potential indicators of soil quality because of their essential role in soil biology. Ease of measurement and rapid response to changes in soil management (Dick *et al.*, 1994). Enzyme activity number is an index of biological fertility. Treatment T_9 with the application of NPK 50% as PGPR mix- 1 enriched vermicompost in combination with inorganics reported the highest value for enzyme activity number in the rhizosphere zone indicating the effect of the treatment in sustaining the soil biological health. Similar results were reported by Riffaldi *et al.*, (2002) who reported higher enzyme activity number in untilled management system than the tilled management system.

Table.1 Details of enrichment of vermicompost

Enriched Vermicompost	Rate	N (%)	P_2O_5 (%)	K_2O (%)
Neemcake	@ 5%	4.1	0.7	1.4
Azospirillum	@ 2%	4.7	0.7	0.5
PSB	@ 2%	1.5	1.8	0.5
PGPR mix-1	@ 2%	1.5	1.8	1.9

Table.2 Microbial properties of initial soil sample

1	**Soil respiratory activity (µg of CO_2 evolved g^{-1} of soil hr^{-1})**		**2.8**
2	Micro flora	Bacteria	42 x 10^6 CFU g^{-1} soil
		Fungi	2 x10^4 CFU g^{-1} soil
		Actinomycetes	0

Table.3 Composition of media

Sl No.	Microflora	Medium
1	Actinomycetes	Ken knight's agar medium
2	Fungi	Martins' Rose Bengal agar
3	Bacteria	Nutrient agar

Table.4 Enzyme activity number (Biological Fertility Index) of the Rhizosphere soil

Treatments	Catalase (ml O_2 g^{-1} dry soil)	Phosphate µg of p-nitrophenol released g^{-1} of soil hr^{-1}	Protease(µM of amino N-hydrolysed g^{-1} of soil hr^{-1})	Dehydrogenase (µg of TPF hydrolysed g^{-1} of soil per 24 hrs)	Cellulase (glucose hydrolysed g^{-1} of soil 24 hrs^{-1})	Enzyme activity number
T_1	2.47	47.53	140.75	158.51	29.24	32.64
T_2	3.15	48.83	148.31	162.82	33.08	33.54
T_3	3.47	49.93	154.44	165.46	35.31	34.11
T_4	7.00	63.71	157.74	203.86	38.30	41.88
T_5	7.01	59.46	149.5	185.09	40.35	38.06
T_6	6.14	62.12	163.13	183.01	42.21	37.73
T_7	6.37	62.22	163.73	188.49	43.59	38.79
T_8	6.91	79.67	175.49	188.32	44.13	38.97
T_9	8.27	75.33	181.13	227.79	49.83	46.84
T_{10}	7.21	51.7	160.76	205.32	38.81	42.12
T_{11}	7.12	53.54	170.82	208.83	42.84	42.89
T_{12}	7.30	68.56	173.53	218.63	43.37	44.93
T_{13}	8.13	67.57	176.38	220.38	45.87	45.29
T_{14}	2.47	40.46	141.08	132.44	26.79	27.39
T_{15}	1.57	39.46	101.45	127.18	25.79	26.14

Fig.1 Bacterial population in post harvest soil samples

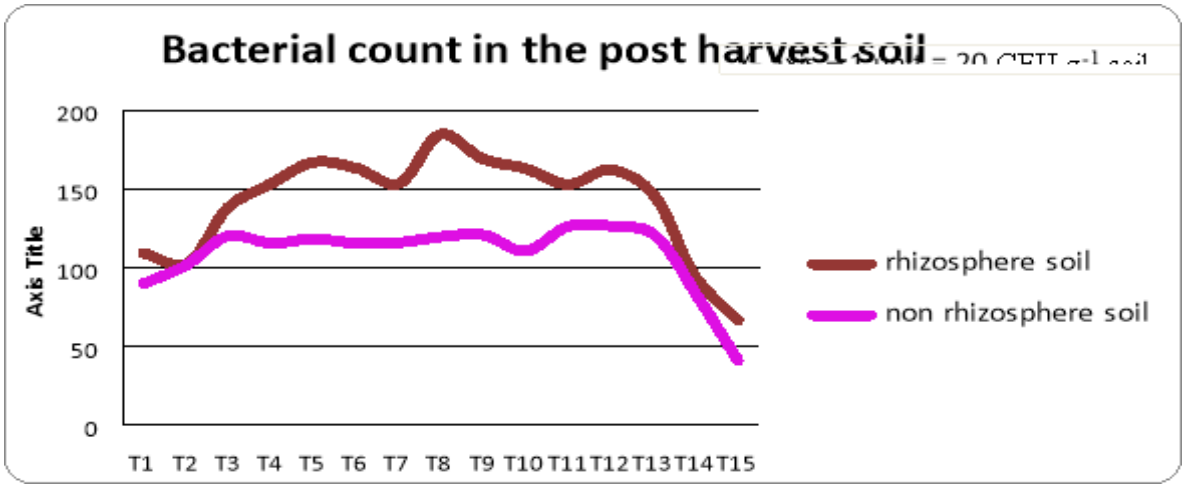


Fig.2 Fungal population in post harvest soil

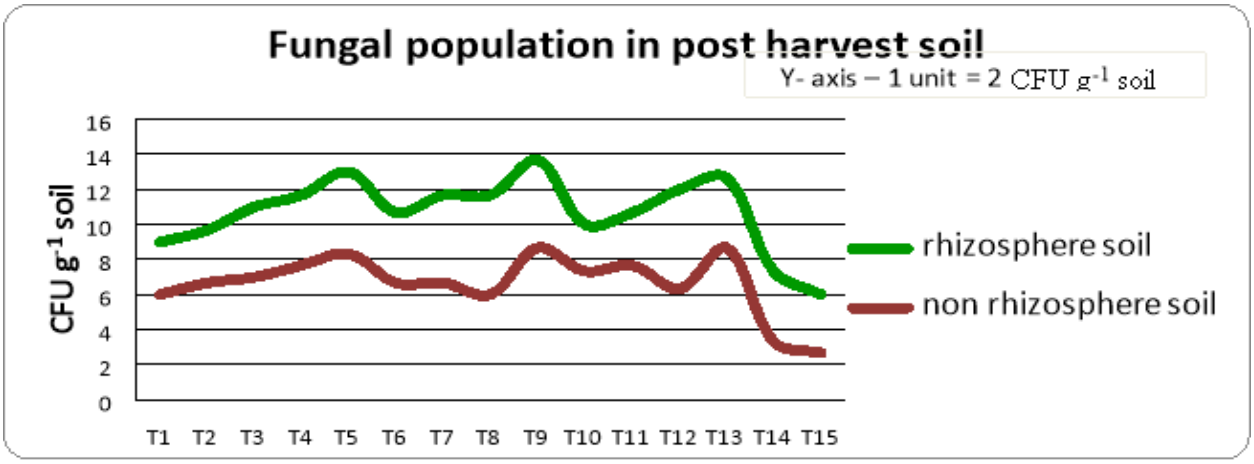


Fig.3 Actinomycetes in post harvest soil

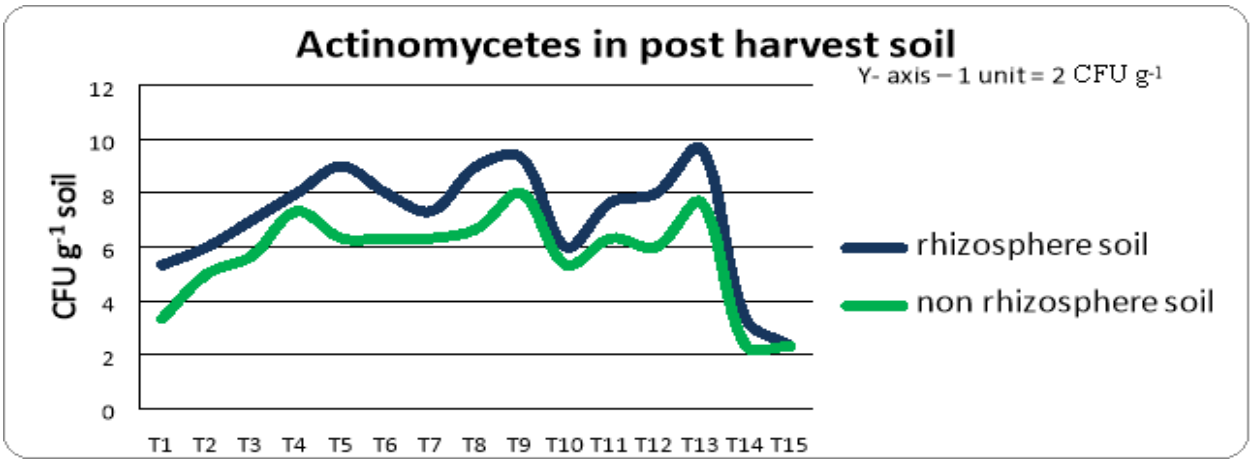


Fig.4 Enzyme activity number of Rhizosphere soil

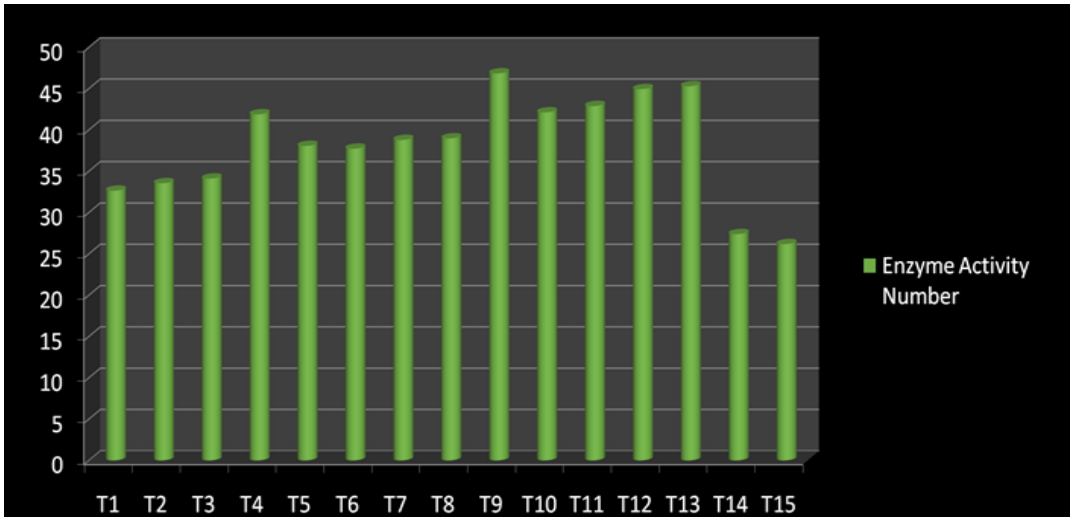
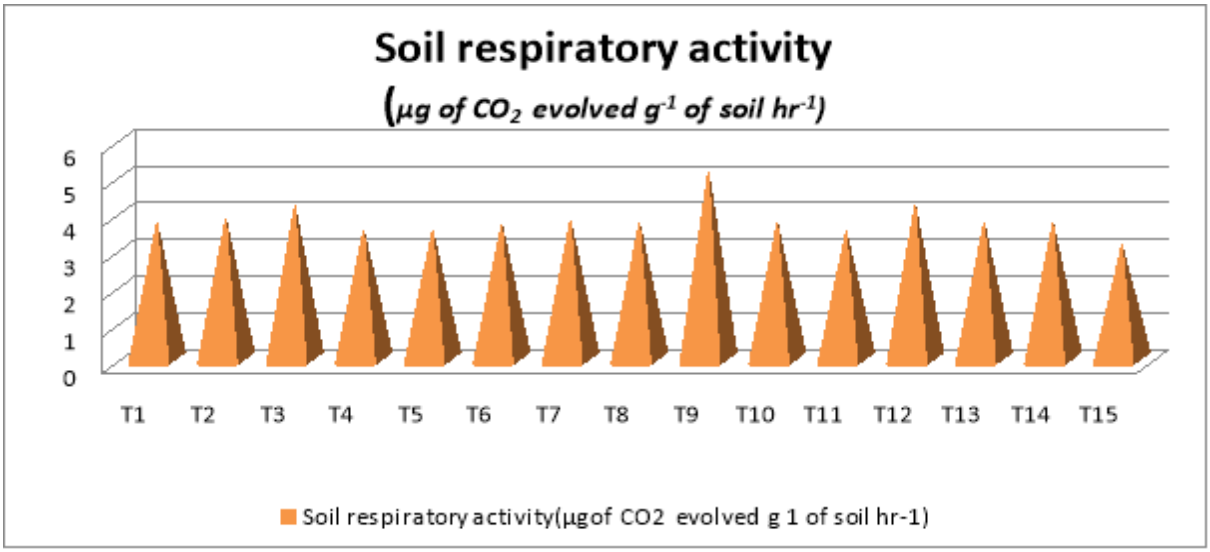


Fig.5 Soil respiratory activity in rhizosphere soil



Respiratory activity of soil belongs among the most important characteristics of the soil biological activity (Iovieno *et al.,* (2009). Usually measured as CO_2 emissions (in laboratory or in situ), it is a strong indicator of the soil metabolism and ecological soil functions (Santruckova, 1993). It is inferred from the Fig. 4., treatments receiving 75% of P as PSB enriched vermicompost in combination with inorganics and 25% of N as *Azospirillum* enriched vermicompost in combination with inorganics had registered highest values for soil respiratory activity. It might be due to the fact that organic fertilisation contributes to the soil organic matter accumulation and turnover (Kubát *et al.,* 1999). Raupp and Lockretz (1997) reported that an increased soil organic matter accumulation and turnover enhanced respiration activity in rhizosphere soils.

It is understood that rhizosphere, the soil adjacent to plant roots is significantly different from bulk soil in chemical, biological and microbiological properties. The

rhizosphere is the zone of soil influenced by roots through the release of substrates that affect microbial diversity and activity.

These microbes are responsible for key environmental processes, such as biogeochemical cycling of nutrients and matter and the maintenance of plant health and soil quality (Barea *et al.*, 2004). In particular, the varied genetic and functional activities of the extensive microbial populations have a critical impact on soil functions, based on the fact that microorganisms are driving forces for fundamental metabolic processes involving specific enzyme activities (Nannipieri *et al.*, 2003). These factors have contributed to the increased microbial activities in rhizosphere.

From the study it is concluded that certain bacteria, fungi and actinomycetes are able to colonize the root soil environment where they carry out a variety of interactive activities known to benefit plant growth and health and soil quality. An increased respiratory activity was also noticed in the rhizoshere zone than the non rhizosphere zone. Under integrated plant nutrient system, it is clearly evident that the microflora was more in rhizosphere than in the non rhizosphere.

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