Direct and residual effects of phosphorus from organic manures and single super phosphate on microbial population and biomass carbon content in groundnut- sunflower cropping system

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ABSTRACT

Potculture experiments were conducted using different phosphorus sources at Tamil Nadu Agricultural University, Coimbatore, during 2007 - 2008, to improve organic carbon content and to maintain a better microbial population in groundnut (Arachis hypogaea L) sunflower (Helianthus annuus L) cropping system. Four organic sources (farmyard manure, poultry manure, vermicompost and sewage sludge) evaluated in comparison with the standard inorganic source of single superphosphate, all applied on equal P basis @ 34 kg P_2O_5 ha^{-1}. The six treatments, including a no-P control were replicated four times in a completely randomized design. The main crop of groundnut (VRI 2) was followed by the residual crop of sunflower (Co 4). Post-harvest soil analysis was carried out after groundnut and sunflower. Organic manures increased the organic carbon content, biomass carbon content and microbial population. Poultry manure significantly increased the microbial population and biomass carbon content in main and residual cropping than single supper phosphate. However, the microbial biomass carbon content in the post-residual crop soil was lower than that in the post-harvest soil after first crop.

Keywords: Biomass carbon, microbial population, organic carbon, organic manure, phosphorus source

Introduction

Organic manures play a vital role in maintenance of physical, chemical and biological conditions of soil and supply macro and micronutrients to crops, besides maintaining humic substances in soil (Sharma, 1992). The judicious combination of organic manures and fertilizers should be used for improving crop productivity and maintaining soil fertility (Dikshit and Khatik, 2002).

The soil is crowded with millions of living organisms which make it a living and a dynamic system. These organisms not only help in the development of soils but also carry out a number of transformations and facilitating the availability of nutrients to the plants. In a long term soil management farmyard manure (FYM) increased microbial biomass content in soil Kandeler *et al*. (1999). Organic manures increase soil respiration and levels of soluble organic carbon and microbial biomass carbon by a factor of 2 to 3 compared with the control (Rochette and Gregorich, 1998).

The energy (food) requirements of soil are provided by soil organic matter and reduced substances get continuously added to it. Soil organic carbon changed significantly with the addition of organic manures after a three-year period, but not with inorganic fertilization, in a groundnut-based cropping system (Subrahmaniyan *et al.*, 1999).

Organic manures also have a pronounced residual effect on soil property. Residual effect of long term use of fertilizers alone and in combination with FYM had a significant improvement in soil properties Babhulkar *et al.* (2000). This present study was carried out to study the impact of different organic manures on soil microbial population in post harvest soil after main and residual crop.

Materials and Method

The soil used in the present study was collected from the farm of Regional Research Station, Vriddhachalam, Cuddalore District, Tamil Nadu. The content of organic carbon was 6.3 %. The soil texture was loamy sand.

The processed soil samples were filled in earthen pots at the rate of 8 kg soil per pot. There were four organic sources (farmyard manure, poultry manure, vermicompost and sewage sludge) evaluated in comparison with the standard inorganic source of single superphosphate, all applied on equal P basis at the rate of 34 kg P_2O_5 ha^{-1}. The six treatments, including a no-P (control) were replicated four times in a completely randomized design making a total of 24 pots.

Seeds of groundnut (five per pot) were sown in each pot. To all the pots, common basal applications of urea, muriate of potash and gypsum were given. Routine cultural practices were adopted in raising the crop. After the harvest of main crop groundnut, the soil in the pots were removed, gently powdered and repotted again. Common basal applications of urea and muriate of potash were given; no phosphorus was applied. Seeds of sunflower were then sown in each pot. Routine cultural practices were followed in raising the crop. Post-harvest soil analysis for organic carbon content, biomass carbon content and microbial population viz. bacteria, fungi and actinomycetes were carried out after groundnut and sunflower.

Statistical analysis

The data obtained from the above investigations were subjected to statistical analysis following the methods to find out the effect of various treatments on organic carbon content, biomass carbon content and microbial population in soil after groundnut and sunflower (Panse and Sukhatme, 1967).

Results and Discussion

A. Main effect of phosphorus source

1. Soil organic carbon content in post-harvest soil after groundnut

Phosphorus application significantly increased the soil organic carbon content. Among the phosphorus sources, poultry manure was foremost (7.2%). Superphosphate treated soil recorded the lowest organic carbon content (5.7%) and was significantly higher than control (Figure 1).

Organic carbon contents of soil were significantly improved with different phosphorus sources than control. The increase in organic carbon content might be due to the addition of organic manures which stimulated the growth and activity of microorganisms, and also due to better root growth. These observations are in line with the findings of Varalakshmi *et al.* (2005) in groundnut - finger millet cropping sequence. Organic carbon content was also high in inorganic phosphorus (single superphosphate) treated soil. This might be due to the improvement in root and shoot growth. Higher production of biomass might have increased the organic carbon content (Babhulkar *et al.*, 2000). Poultry manure is rich organic manure since solid and liquid excreta are excreted together resulting in no urine loss (Mohamed Amanullah *et al.*, 2007).

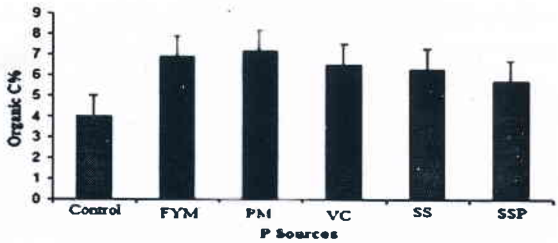

Figure 1. Effect of phosphorus sources on soil organic carbon content after groundnut. (FYM: Farmyard Manure, P: Phosphorus, PM: Poultry manure, SS: Sewage sludge, SSP: Superphosphate, VC: Vermicompost

2. Microbial population and biomass carbon in post-harvest soil after groundnut

a. Microbial population

The data on microbial population in post-harvest soil indicated that the maximum population of bacteria, fungi and actinomycetes (36 cfu x 10^6 g^{-1}, 11 cfu x 10^4 g^{-1} and 28 cfu x 10^3 g^{-1}, respectively) was in the poultry manure treated soil. Among the organic manures, sewage sludge treatment recorded the lowest microbial population, but this was significantly higher than that in chemical fertilizer treatment (Table 1). The high organic carbon content in soil applied with poultry manure might have stimulated the microorganisms by serving as source of carbon, energy and other nutrients essential for their growth and multiplication, and thus increased the soil activities in poultry manure treatment. Similar results of increased enzyme activity due to poultry manure application have been reported by Boomiraj (2003) in Bhendi.

Table 1: Effect of phosphorus sources on microbial population and biomass carbon content

Phosphorus sources	Biomass carbon (mg kg^{-1})	Bacteria (cfu x $10^6 g^{-1}$)	Fungi (cfu x $10^4 g^{-1}$)	Actinomycetes (cfu x $10^3 g^{-1}$)
Control	164d	13.0f	4.0d	11.0d
Farmyard manure	315a	30.0b	9.0b	24.0ab
Poultry manure	325a	36.0a	11.0a	28.0a
Vermicompost	311a	25.0c	7.0c	21.0bc
Sewage sludge	258b	21.3d	6.0c	19.0c
Superphosphate	190c	18.0e	4.0d	14.0d
P value	< 0.05	< 0.05	< 0.05	< 0.05

(cfu: colony forming units). Mean followed by the same letters in each column are not significantly different at p<0.05 according to DMRT.

b. Biomass carbon

The microbial biomass carbon content in post-harvest soil was higher in poultry manure treated soil and was comparable with farmyard manure treatment (325 and 315 mg kg^{-1} respectively). This was followed by vermicompost treated soil. Single superphosphate treatment recorded the lowest value for biomass carbon among the phosphorus sources, though significantly superior to control (Table 1). Increased amount of microbial biomass was due to the amendment of soil with different organic sources. Increase in microbial biomass carbon content in poultry manure and farmyard manure treated soil might be due to the increased availability of water-soluble carbon and nutrients, which stimulated microbial growth. This view was confirmed by Zaman *et al.* (2002). There was a significant correlation between organic carbon content and biomass carbon content in soybean-wheat cropping sequence with farmyard manure application Manna *et al.* (1996). Increase in microbial biomass carbon in enriched soil could be attributed to the easily available biodegradable in the soil which stimulated the biomass (Bhattacharrya *et al.*, 2001).

B. Residual effect of phosphorus sources

1. Soil organic carbon content in post-harvest soil after sunflower

Statistical analysis showed that the organic carbon content was higher in farmyard manure treated (4.9%) soil and that was on par with poultry manure (4.5%) and sewage sludge (4.6%) treatments. In vermicompost treatment, organic carbon content was 4.0% which was on par with poultry manure and sewage sludge treatments (Figure 2).

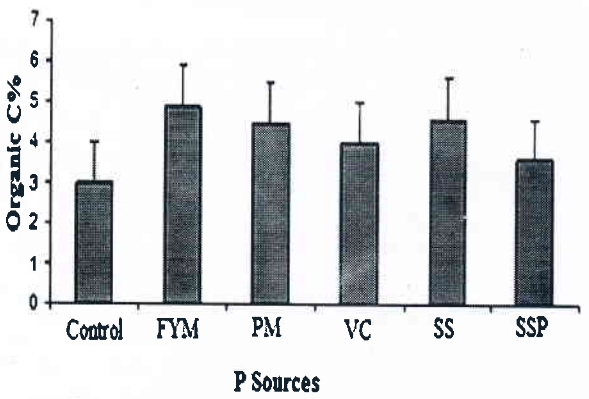

Figure 2. Effect of phosphorus sources on soil organic carbon content after sunflower. (P: Phosphorus, PM: Poultry manure, FYM: Farmyard Manure, VC: Vermicompost, SS: Sewage sludge, SSP: Superphosphate)

The results of the present investigation revealed that the organic carbon content was higher in organic manure treated soil than in the chemical fertilizer treatment and control. It might be postulated that more production of biomass and their subsequent decomposition have contributed towards improving the organic carbon status of the soil (Chahal *et al.*, 1984). The organic carbon content was lower in soil after the harvest of residual crop (sunflower) than the first crop (groundnut). This may be due to the decomposition of organic manure added. This result draws support from the work of Singh *et al.* (2001). Results of a long-term experiment indicated that there had been a decline in organic carbon status on application of fertilizers (Swarup, 1999).

2. Microbial population and biomass carbon in post-harvest soil after sunflower

a. Microbial population

The results pertaining to the residual microbial population indicated that as in microbial population in soil after the main crop of groundnut, the highest bacteria, fungi and actinomycetes population was recorded in poultry manure treated soil (27 cfu x $10^6 g^{-1}$, 9 cfu x $10^4 g^{-1}$ and 25 cfu x $10^3 g^{-1}$, respectively). The population was lower in residual soil than the soil after the first crop (Table 2). The data on microbial population indicated that organic sources increased the microbial population more than the inorganic treatments.

Among the organic sources, poultry manure increased the microbial population significantly in residual soil. Higher population of microbes under organic treatments acted as an index of soil fertility because it serves as temporary sink of nutrients flux as observed by Hassink *et al.* (1991). The lowest microbial load was due to inorganic fertilizers which might be due to the inhibitory nature of chemical fertilizers on the growth and development of microbes. This was supported by Leka *et al.*, 2011. Poultry manure addition to rice increased the bacteria, fun actinomycetes population as well as dehydrogenase, urease, and phosphatase activities (Yadav and Christopher, 2007).

Table 2. Effect of phosphorus sources on microbial population and biomass carbon content

Phosphorus source	Biomass carbon (mg kg^{-1})	Bacteria (cfu x $10^6 g^{-1}$)	Fungi (cfu x $10^4 g^{-1}$)	Actinomycetes (cfu x $10^3 g^{-1}$)
Control	118^{e}	10.0^{d}	3.0^{b}	10.0^{d}
Farmyard manure	290^{ab}	23.0^{b}	7.0^{a}	18.0^{c}
Poultry manure	304^{a}	29.0^{a}	9.0^{a}	25.0^{a}
Vermicompost	272^{b}	22.0^{b}	8.0^{a}	22.0^{ab}
Sewage sludge	238^{c}	27.0^{a}	7.0^{a}	19.0^{bc}
Superphosphate	154^{d}	14.0^{c}	4.0^{b}	16.0^{c}
P value	< 0.05	< 0.05	< 0.05	< 0.05

Mean followed by the same letters in each column are not significantly different at $p<0.05$ according to DMRT.

b. Biomass carbon

Microbial biomass carbon content in the residual soil was lower than the post-harvest soil after first crop. But there was a significant influence on biomass carbon content by different treatments. Among treatments, poultry manure exerted the highest content. That was followed by farmyard manure treatment (Table 2). Organic manure treatment increased the biomass carbon content in residual soil and the increase was higher in poultry manure treated soil. This was probably due to higher availability of substrate as carbon from applied organic manures, intense rooting activity and better soil water status. Increased availability of water-soluble carbon and nutrients might stimulate microbial growth (Patra *et al.*, 1992).

Conclusions

Biomass carbon content was higher in organic manure treated soil than in control but, it was lower in residual soil than the post-harvest soil after first crop. Among the phosphorus sources, poultry manure exhibited the greatest influence. The microbial population and organic carbon carbon content was also higher in poultry manure treated soil. Among the phosphorus sources tried, poultry manure was the best source in increasing post-harvest soil microbial population and biomass carbon content in main and residual crop.

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