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Direct and Residual Effects of Sulphur from Organic Manures and Single Super Phosphate Integration on Microbial Activity in Groundnut – Sunflower Cropping System

P. Premanandarajah[*], W. Shanika

Department of Agricultural Chemistry, Faculty of Agriculture, Eastern University, Chenkalady, Sri Lanka

Abstract

Potculture experiments were conducted using different sulphur sources to improve organic carbon content and to maintain a better microbial population in groundnut (*Arachis hypogaea*) sunflower (*Helianthus annuus*) 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 S basis at 75 kg S ha^{-1}. The six treatments, including a no-S (control) were replicated four times in a completely randomized design. The main crop of groundnut was followed by the residual crop of sunflower. 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 increased the microbial population and biomass carbon content. 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

Organic Carbon, Biomass Carbon, Sulphur Source, Organic Manure, Microbial Population

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1. Introduction

Oilseeds and their derivatives vegetable oil and meal are in demand globally, and there is a need to identify and quantify the key issues for their production for different stakeholders to develop and support actions that will ensure a viable future of such crops (Muhammad Farhan et al., 2013). In oil seeds sulphur plays a vital role in the development of seed and improving the quality (Naser et al., 2012).

Although inorganic fertilization is very important for the healthy plant growth, soil fertility cannot be maintained with the application of inorganic fertilizers alone. Besides inorganic chemical fertilizers, there are several sources of plant nutrients like organic manures, crop residues, and industrial wastes. No single source can meet the increasing nutrient demands for agriculture. Soil organic matter is considered nature's signature of a productive soil. Organic carbon from manure provides the energy source for the active healthy soil microbial environment that both stabilizes nutrient sources and makes those nutrients available to crops. Subrahmaniyan et al. (1999) observed that soil organic C changed significantly with the addition of organic manures after a three-year period, but not with inorganic fertilization, in a groundnut-based cropping system.

The organic source of nutrients have the advantage of consistent and slow release of nutrients, maintaining ideal C:N ratio, improvement in water holding capacity and microbial biomass of soil, without any adverse residual

*Corresponding author:
Email address: puni_prem@yahoo.com (P. Premanandarajah)

effects (Yadav et al., 2010). In addition to that soil organic matter is the primary source of plant-available SO4 -S in surface soil. Therefore to achieve sustainability in oil seed production there is a need to integrate both organic and inorganic sources of nutrients. Deshmukh et al. (2005) reported that if integrated nutrient management system is adopted, then higher levels of nutrient uptake by plant as well as its availability in soil could be maintained even after harvest of the crop.

2. Materials and Methods

The soil used in the present study was loamy sand and the organic carbon content was 6.3 %. 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 S basis at the rate of 75 kg S ha-1. The six treatments, including no-sulphur (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 sulphur 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.

3. 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).

4. Results and Discussion

4.1. Main Crop (Groundnut)

4.1.1. Soil Organic Carbon Content

Application of sulphur significantly altered the organic carbon status of post-harvest soil. Maximum organic carbon content was observed under farmyard manure application (6.9 g kg-1). Vermicompost was the next best source that increased the soil organic carbon content to 6.5 g kg-1. The organic carbon content in superphosphate was the lowest among the sulphur sources (5.2 g kg-1) and in control the value registered was 4.2 g kg-1.

The increase in organic carbon content of the soil in the fertilized plot is probably due to enhanced root growth leading to accumulation of more organic residues in the soil. This may be due to the vegetative growth and yield attributes by the better supply of nutrient through sulphur application over control. The application of sulphur increased the chlorophyll formation, which enhances the formation of photosynthesis resulting in an increase in plant attributes in green gram (Singh and Sharma, 1997). The application of sulphur had positive effect on biomass accumulation (Daniela et al., 2008). This might be the reason for higher organic carbon content in sulphur treated plots.

Among treatments, in manurial treatment organic carbon content was higher than chemical treatment. It might be due to the addition of organic manure, which stimulated the growth and activity of microorganism, and also due to better root growth. These observations are in line with the finding of Malik et al. (2013).

Table 1. Effect of Sulphur sources on post-harvest soil nutrient availability.

Sulphur sources	Organic C (%)
Control	4.2d
Farmyard manure	6.9a
Poultry manure	6.2ab
Vermicompost	6.5ab
Sewage sludge	6.1b
Superphosphate	5.2c
P value	< 0.05

4.1.2. Microbial Population and Biomass Carbon

i. Microbial Population

Addition of sulphur through different organic sources increased the microbial population in the post-harvest soil after the harvest of groundnut. The maximum population of bacteria (33 cfu x 10^6 g^{-1}), fungi (12 cfu x 10^4 g^{-1}) and Actinomycetes (30.1 cfu x 10^3 g^{-1}) were observed in the treatment that received poultry manure, vermicompost and poultry manure, respectively. The population of bacteria, fungi and Actinomycetes in chemical fertilizer treatment was lower (17 cfu x 10^6 g^{-1}, 5.7 cfu x 10^4 g^{-1} and 16 cfu x 10^3 g^{-1} respectively) than the organic manure treatments.

The attributed reason could be due to enhanced organic carbon content of the soil as a result of organic manure application as compared to inorganic fertilizer. Besides this organic manure addition might have helped to increase the micronutrients and secondary nutrients in the soil. This might have helped to increase the microbial population (Krishnakumar *et al.,* 2007). In the present investigation, it was observed that poultry manure increased the bacterial and fungal population. Soil bacteria, CO_2 evolution and enzymatic activities like amylase, invertase and dehydrogenase were also found higher in poultry dung amended soil. Lakshmikanti and Pramod (2012) supported the effectiveness of poultry dung in enhancing soil productivity.

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. Similar results of increased enzyme activity due to poultry manure application have been reported by Boomiraj (2003) in bhendi.

ii. Biomass carbon

The soil biomass carbon content was significantly influenced by the different treatments imposed. Among the treatments, poultry manure (302 mg kg^{-1}) and vermicompost (300 mg kg^{-1}) treatments increased significantly the biomass carbon more than any other treatment. This was followed by farmyard manure and swage treatments (244 and 242 mg kg^{-1}, respectively). Inorganic fertilizer treatment recorded the lowest value among the sulphur sources which was significantly higher than control.

The increase in microbial biomass due to addition of organic residues might be due to the availability of higher amounts of mineralizable nitrogen and carbon. Dinesh Kumar *et al.* (2007) confirmed that the amendment of soil with organic residues increased the microbial biomass carbon. Among organic manures poultry manure increased the content as it is the rich source of nutrients.

Table 2. Effect of sulphur source on microbial population and biomass carbon content.

Sulphur 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	167c	11.0d	4.0c	12.0c
Farmyard manure	244b	24.6b	9.0b	21.0b
Poultry manure	302a	33.0a	11.0ab	30.1a
Vermicompost	300a	29.0ab	12.0a	30.0 a
Sewage sludge	242b	25.0b	8.0b	21.0b
Superphosphate	178c	17.0c	5.7c	16.0c
P value	< 0.05	< 0.05	< 0.05	< 0.05

4.2.Residual Crop (Sunflower)

4.2.1 Soil Organic Carbon Content

The results revealed that post-harvest soil organic carbon content was significantly influenced by the treatments imposed. Poultry manure registered the highest soil organic carbon (5.0 g kg^{-1}) in post-harvest soil after residual crop and was on par with sewage sludge. The organic content in superphosphate was the lowest among the sulphur sources. The value registered in control was 2.0 gkg^{-1}.

Table 3. Effect of sulphur source on post-harvest soil nutrient availability.

Sulphur sources	Organic C (%)
Control	2d
Farmyard manure	4b
Poultry manure	5a
Vermicompost	4b
Sewage sludge	5a
Superphosphate	3c
P value	< 0.05

Residual organic carbon content was higher in organic manure treated soils than in chemical fertilizer treated soils and in control. Slow mineralization of organic matter might lead to the buildup of organic carbon (Yadav *et al*., 2003).

4.2.2. Microbial Population and Biomass Carbon

i. Microbial population

As in the case of microbial population in the soil after the harvest of main crop of groundnut, an identical trend was observed to be similar in microbial population in the soil after the harvest of residual crop of sunflower. The population was lowest in the residual crop soil than in the post-harvest soil after first crop. The bacterial fungi and Actinomycetes population was ranged from 12 – 29 cfu x 106 g-1, 3 -11 cfu x 104 g-1 and 11- 27 cfu x 103 g-1 respectively.

Increased population of microorganisms was observed in the treatments that received organic manures. 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. Yadav and Christopher (2007) confirmed that poultry manure addition to rice increased the bacteria, fungi and Actinomycetes population as well as dehydrogenase, urease, and phosphatase activities.

But the population was lower than in soil after first crop. The initial high microbial population might be due to the high availability of nutrients released during the decomposition of the organic residues by the action of microbial enzymes such as protease, cellulose, amylase, phosphatase and urease. This was supported by Nur et al. (2009) that the Soil organic C and soil microbial biomass, protease, urease, alkaline phosphatase, and dehydrogenase activity were significantly higher in the organic system than in the conventional system.

ii. Biomass carbon

The microbial biomass was higher in organic manure treated plots and was followed the trend that was reported earlier in the post-harvest soil after the main crop of groundnut. 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).

In residual crop the increase in biomass carbon content than control indicates that in addition to the organic matter supplied through organic sources the organic exudates from growing roots and ground roots of previous crop (groundnut). This was confirmed by Rasse *et al*. (2005).

Table 4. Effect of sulphur source on microbial population and biomass carbon content.

Sulphur 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	121d	12.0e	3.0d	11.0c
Farmyard manure	213b	19.0c	7.0b	18.0b
Poultry manure	288a	29.0a	10.0a	27.0a
Vermicompost	275a	26.0b	11.0a	27.0a
Sewage sludge	207b	19.0c	7.0b	19.0b
Superphosphate	153c	15.0d	5.0c	14.0c
P value	< 0.05	< 0.05	< 0.05	< 0.05

5. Conclusion

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 sulphur sources poultry manure exhibited the greatest influence. The microbial population and organic carbon content was also higher in poultry manure treated soil. Among the sulphur sources tried, poultry manure was the best source in increasing post- harvest soil microbial population and biomass carbon content in main and residual crop.

Future Suggestions

- Influence of the treatments on the yield and quality of groundnut and sunflower.
- Impact of the integration on soil fertility and health.
- Field trials to ensure the performance of these treatments**.**

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