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Effect of local amendments as a partial substitute for phosphorus on soil quality

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Abstract: In a pot culture experiment different organic phosphorus sources (farmyard manure, poultry manure, vermicompost and sewage sludge) were evaluated with standard inorganic source of single superphosphate to improve soil nutrient content, all applied on equal P basis @ 34 kg P_2O_5 ha^{-1}. The six treatments, including no-P (control) were replicated four times in a CRD. Groundnut was sown in each pot. The experimental results revealed that phosphorus increased the post-harvest soil nutrients availability. Highest availability of nitrogen, phosphorus, potassium and sulphur was recorded in poultry manure treatment and sewage sludge exhibited a considerable increase in available nitrogen and sulphur content.

Keywords: Inorganic phosphorus source, Organic phosphorus source,

Introduction

Oilseeds are energy rich crops and their nutrient requirement is high (Hegde, 2000). Low or no use of plant nutrients is one of the most important factors for low productivity of oilseeds. The estimated nutrient removal by oilseeds crop during 2003 – 2004 was 3.24 million tonnes (N, P and K), while the contribution to nutrient uptake from fertilizer was only 15.4 per cent (Hegde, 2006).

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. To achieve sustainability in production, there is a need to integrate both organic and inorganic sources of nutrients. Such an integration of nutrient sources will enhance the nutritional use efficiencies (Hegde and Sudhakarababu, 2001) besides maintaining soil fertility. Phosphorus can be termed as "life mineral" because of its crucial role in metabolic and energy transfer reactions in living systems. Phosphorus has a great role in energy storage and transfer and as a constituent of nucleic acid, phytin and phospholipids in plants. An adequate supply of phosphorus early in plant life is important for the reproductive parts of the plants.

The availability of phosphate in soils is often limited by fixation reactions, which convert the monophosphate ion to various insoluble forms. The availability of soil phosphate is enhanced by additions of organic manures, presumably due to chelation of polyvalent cations by organic acids and other decay products. Varalakshmi *et al*., (2005) demonstrated that incorporation of farm yard manure along with inorganic phosphorus increases the availability of phosphorus and this is attributable to reduction in fixation of water soluble phosphorus, increased mineralization of organic phosphorus due to microbial action and enhanced mobility of phosphorus. Specific attention needs to be given to harness the residual effect of phosphorus (Kumaran and Solaimalai, 2000).

Materials and Methods

The soil used in this study contained 15.5, 6.5 and 78.0 percent clay, silt and sand respectively and loamy sand in texture. The contents of available nitrogen, phosphorus potassium and sulphur were 261.8, 8.70 191.0 kg ha^{-1} and 8.07 mg kg^{-1} respectively and the organic carbon content was 6.3 g kg^{-1}. The phosphorus content of organic manures used was 1.12, 3.80, 0.94 and 1.81 percent in farmyard manure, poultry manure, vermicompost and sewage sludge respectively.

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. The six treatments, including a no-P (control) were replicated four times in a completely randomized design (making a total of 24 pots). To all the 24 pots, common basal applications of 17 kg N ha^{-1} as urea, 54 kg K_2O ha^{-1} as muriate of potash and 74.34 kg S ha^{-1} as gypsum were given. Organic sources of P were applied to each pot, also the inorganic SSP as reference source, all on equivalent P basis @ 34 kg P_2O_5 ha^{-1} (0.054 g P per pot).

Seeds of groundnut (five per pot) were sown in each pot. After the germination, the plants were thinned to 3 per pot. Routine cultural practices were adopted in raising the crop. After the harvest of groundnut, the soil in the pots were removed, and soil nutrient content was analyzed by using following methods (Tab 1).

Table 1: Analytical methods used in the study

Particulars	Procedure	Reference
Organic carbon	Chromic acid wet digestion	Walkley and Black (1934)
$KMnO_4$ Nitrogen	Alkaline permanganate method	Subbiah and Asija (1956)
Olsen's Phosphorus	0.5 *M* $NaHCO_3$ (pH 8.5)	Olsen *et al.* (1954)
NH_4OAc Potassium	Neutral *N* ammonium acetate	Stanford and English (1949)
0.15 % $CaCl_2$ Sulphur	Turbidimetry	Chesnin and Yien (1950)

Results and Discussion

Table 2: Effect of phosphorus sources on post-harvest soil nutrient availability

Phosphorus sources	Organic C (g kg^{-1})	Available P (kg ha^{-1})	Available N (kg ha^{-1})	Available K (kg ha^{-1})	Available S (mg kg^{-1})
Control	4.0d	10.9 e	272.7d	110.3d	7.3e
Farmyard manure	6.9b	25.2b	295.1b	194.5a	21.9bc
Poultry manure	6.5c	28.5a	311.9a	203.5a	26.7a
Vermicompost	7.2a	17.5d	286bc	180.3b	18.7cd
Sewage sludge	6.3c	22.2c	314.7a	170.3b	24.3ab
Superphosphate	5.7e	15.0d	285.3c	150.3c	17d
CD (P = 0.05)	**0.2**	**2.78**	**9.64**	**13.5**	**3.20**

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

Soil organic carbon content

Phosphorus application significantly increased the soil organic carbon content. Among the phosphorus sources, vermicompost was foremost (7.2 g kg^{-1}). Superphosphate treated soil recorded the lowest organic carbon content (5.7 g kg^{-1}) and was significantly higher 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 super phosphate) 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).

Soil available phosphorus content

The results pertaining to the available phosphorus content in post-harvest soils indicated that the phosphorus application through different sources significantly increased the phosphorus content in soil from 10.9 (control) to 28.5 kg ha^{-1} after the harvest of groundnut. The highest phosphorus content was recorded in poultry manure treated soil. Farmyard manure was the second best source. Among organic sources vermicompost recorded the lowest value (17.5 kg ha^{-1}). But it was significantly superior to superphosphate treatment.

Phosphorus availability increased significantly from 10.9 kg ha^{-1} under control to 25.2 kg ha^{-1} with farmyard manure application and to 28.5 kg ha^{-1} with poultry manure. Organic acids and chelates are produced during microbial decomposition of organic residues. These organic acids help in the solubility of native phosphorus as a result of which increase in available phosphorus content in wheat (Tomar *et al.,* 1984). Applied organic manure leads to the formation of coating on the sesquioxides because of which the phosphorus fixing capacity of soil was reduced in manure treated plots in groundnut (Seshadri Reddy, 2005). Mohamad Tariq and Stephen Robinson (2003) confirmed the decreases in soil phosphorus sorption characteristics following the application of animal manures and effluents.

Kalita and Kalita (1992) reported that the available phosphorus and exchangeable calcium contents increased after harvest of green gram with increasing rates of phosphorus added to green gram through single superphosphate. This increase in phosphorus availability might be attributed to the humic substances secreted by roots, mineralization effect of soil microflora and carbon-di-oxide production by greengram roots and associated microorganisms.

Soil available nitrogen content

The analysis of the post-harvest soil for available nitrogen indicated that the application of phosphorus sources significantly increased the nitrogen availability. Among the organic sources sewage sludge exhibited a considerable increase in available nitrogen content (314.7 kg ha^{-1}). It was comparable with poultry manure treatment (311.9 kg ha^{-1}). Vermicompost recorded the lowest nitrogen content in post-harvest soil (286 kg ha^{-1}). Vermicompost and superphosphate treatments did not show any significant difference among them but were significantly superior to control.

Application of organic manures had significant impact on the available nitrogen content. Among the organic sources poultry manure and sewage sludge exhibited a considerable increase in available nitrogen content. Organic manures provide energy for nodulation and nitrogen fixation by microorganisms. Similar views were expressed by Rao (2003).

Soil available potassium content

Application of phosphorus sources exhibited considerable increase in soil available potassium content in post-harvest soil after groundnut. Poultry manure recorded the highest available potassium content in soil (203.5 kg ha^{-1}). It was comparable with farmyard manure treatment (194.5 kg ha^{-1}). Superphosphate recorded the lowest value among treatments. But it was significantly higher than control.

The higher availability of potassium in soil might be due to the beneficial effects of organic manures on the reduction of potassium fixation; added organic matter interacted with potassium - clay to release potassium from the non-exchangeable fraction to the available pool (Seshadri Reddy, 2005).

Soil available sulphur content

The results of sulphur content in post-harvest soil indicated that poultry manure recorded the highest available sulphur in soil (26.7 mg kg^{-1}). This was on par with sewage sludge treatment (24.3 mg kg^{-1}). Farmyard manure treated soil had 21.9 mg kg^{-1} of sulphur after the harvest of groundnut. But this was significantly lower than poultry manure and sewage sludge treated soils. Among the phosphorus treatments superphosphate recorded the lowest value (17 mg kg^{-1}). Pandey *et al.* (2000) confirmed that sulphur availability was significantly and positively influenced by organic matter due to release of organic acids on decomposition of organic matter, causing solubilization of insoluble sulphur complexes. Post-harvest soil nutrients availability was significantly higher in phosphorus treated soils. Organic carbon, available nitrogen, available phosphorus, available potassium and available sulphur contents of soil were significantly improved with different phosphorus sources. Among the different phosphorus sources, poultry manure increased the available nitrogen, phosphorus, potassium and sulphur status over control more than other sources. Poultry manure is rich organic manure since solid and liquid excreta are excreted together resulting in no urine loss (Mohamed Amanullah *et al.,* 2007).

Conclusion

The highest availability of phosphorus, potassium and sulphur in post-harvest soil after groundnut was recorded in poultry manure treatment. Sewage sludge exhibited a considerable increase in available nitrogen content of post-harvest soil and was comparable with poultry manure treatment.

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