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Effect of phosphorus, sulphur and biofertilizer on soil properties and yield of cowpea (*Vigna unguiculata)*

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ABSTRACT

A field experiment was conducted at research farm, R.B.S. College Bichpuri (Agra) Uttar Pradesh during the kharif seasons of 2012 and 2013 to study the effect of phosphorus, sulphur and rhizobium on soil properties and yield of cowpea (Vigna unguiculata L.) The experiment was laid out in split plot design with three replications. Data revealed that the different soil parameters viz., pH and organic carbon in post harvest soil slightly improved with phosphorus sulphur and biofertilizer compared to control treatment. Bulk density and EC were not affected significantly with P, S a d biofertilizer. However, a slight decrease in bulk density was recorded with P, S and biofertilizer over control. The available nutrient content in soil was also improved with phosphorus application over control. Sulphur application also enhanced the status of available N, P, K and S over control but amount of S was affected significantly with S application. Inoculation with Rhizobium proved superior to control in respect of available nitrogen status of the soil. The grain and straw yields increased significantly with application of 90 kg P_2O_5, 40 kg S ha^{-1} and rhizobium inoculation over their respective controls. Application of 90 kg P_2O_5 ha^{-1} gave 3.83 and 8.70q ha^{-1} higher grain and straw yield over control. The grain And straw yields of cowpea also increased significantly with S and maximum values were recorded with 40 kg S ha^{-1}.A significant increase in yields were also recorded with rhizobium inoculation.

Keywords: Phosphorus, sulphur, biofertilizer, soil properties, yield, cowpea

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Wala) is an important legume crop and it has manifold uses such as vegetable, pulse, green manuring and fodder for the live stock. Legumes play prominent role in increasing soil nitrogen level thereby boosting agricultural production. This is obviously due to their ability to fix atmospheric gaseous nitrogen in a symbiotic association with rhizobium. Seed treatment with rhizobium sp. is now well established as low cost technology for maximum of pulse production and maintenance of soil productivity. Chemical fertilizers no doubt have boosted the crop growth and yield, but to a large extent these have contributed to deterioration of soil organic carbon, and decline soil fertility (Begum *et al.* 2007). The results of the experiment conducted under the All India Co-ordinated Agronomic Research Project (AICARP) programmes have already indicated that sustaining the productivity at high level without impairing soil environment is beyond the capacity of a single type of nutrient source. Integration of major, secondary and biofertilizer and their efficient management has shown promise is not only sustaining the productivity and soil health but also in meeting a part of chemical fertilizer management of crops (Nusakho Nyelha *et al.* 2016). Keeping above facts in view, the present investigation was conducted to study the effect of phosphorus, sulphur and biofertilizer on physico-chemical properties of alluvial soil and yield of cowpea.

MATERIALS AND METHODS

A field experimental was conducted during kharif season of 2012 and 2013 at R.B.S. College Research farm Bichpuri, Agra (U.P.). The soil was sandy loam in texture having pH 7.8, EC 0.29 dSm^{-1}, organic carbon 3.6 g kg^{-1}, available N 165 kg ha^{-1}, P 8.5 kg ha^{-1}, K 110 kg ha^{-1} and S 9.0 mg kg^{-1}. The experiment was laid out in split plot design with four levels of P (0, 30, 60 and 90 kg P_2O ha^{-1}), three levels of S (0, 20 and 40 kg S ha^{-1} with two levels of biofertilizer (no rhizobium and rhizobium) with three replications. A uniform dose of 20 kg N and 40 kg K_2O ha^{-1} was applied through urea and muriate potash, respectively at the time of sowing. Phosphorus and sulphur were applied through triple superphosphate and elemental sulphur respectively at the time of sowing. The cowpea seeds were inocuated with rhizovium as per treatments. Cowpea was sown in last week of June in both the years. Other agronomic management practices were followed as per standard recommendations. The crop was harvested at physiological maturity. Yields were recorded at harvest. The soil samples collected after harvest of crop were processed and analysed for physico chemical properties. The pH was determined in 1:2.5 soil-water suspension using pH meter. Electrical conductivity of the soil was determined in 1:2.5 soil-water suspension with the help of electrical conductivity meter. Organic carbon was determined by following Walkley and Black wet digestion method (Jackson 1973). The available nitrogen content was determined by alkaline $KMnO_4$ method (Subbiah and Asija 1956). The available phosphorus content was determined as per Olsen *et al.* (1954). Available K was determined flamphotometrically in neutral 1N NH_4OAc extract (Jackson 1973). Available S was determined by extracting soil sample with 0.15% $CaCl_2$ and S in the extract was determined by turbidimetric method (Chesnin and Yien 1951).

RESULTS AND DISCUSSION

Soil Properties

Bulk density of soil has not changed significantly due to phosphorus level, however there was a marginal reduction in bulk density than control due to phosphorus levels which could be attributed to the increased biomass production with consequent increase in organic matter content of the soil. Bulk density of post harvest soil was not changed significantly due to addition of sulphur (Table 1). However, there was a marginal reduction in bulk density compared with control due to increased organic matter content with biomass production (Selvi *et al.* 2005). Bulk density of soil was also not affected significantly with rhizobium inoculation. However, a slight decrease in bulk density was noted with inoculation treatment.The data on pH in post harvest soil are presented in Table 1. The pH ranged from 7.7 to 7.8 in post harvest soil with phosphorus level. The pH was not affected significantly with P levels. However, a slight increase in pH values was noted with phosphorus levels and maximum values were recorded with 30 kg P_2O_5 ha^{-1}. Application of sulphur tended to decrease the pH over control, however, this reduction was not significant. This may be attributed to oxidation of elemental sulphur in soil. The pH was also not affected with inoculation of biofertilizers. However, lower value of pH was noted with inoculation.The water soluble salts expressed as electrical conductivity were not affected with phosphorus level significantly over control. However, maximum value of EC was recorded with 90 kg P_2O_5 ha^{-1}. Sulphur application had no significant effect on the EC value of post harvest soil.

Table 1: Effect of phosphorus, sulphur and rhizobium inoculation of physico-chemical properties of post harvest soil (mean of 2 years)

Treatments	Bulk density (mg m^{-1})	pH	EC (dSm^{-1})	Organic Carbon (g kg^{-1})	Available N (kg ha^{-1})	Available P (kg ha^{-1})
Phosphorus (kg ha^{-1})						
0	1.34	7.7	0.29	.3.3	155.0	7.0
30	1.34	7.8	0.28	3.4	160.0	10.0
60	1.33	7.7	0.29	3.6	170.0	13.8
90	1.32	7.7	0.30	3.7	175.0	15.0
CD (P=0.05)	NS	NS	NS	0.21	4.2	3.8
Sulphur (kg ha^{-1})						
0	1.35	7.8	0.30	3.3	157.0	9.0
20	1.33	7.7	0.28	3.5	165.0	11.5
40	1.32	7.6	0.29	3.7	173.0	13.6
CD (P=0.05)	NS	NS	NS	0.26	5.3	NS
Biofertilizers						
No inoculation	1.34	7.8	0.30	3.4	160.0	10.5
Rhizobium	1.32	7.6	0.28	3.6	170.0	12.3
CD (P=0.05)	NS	NS	NS	NS	7.4	NS

But relatively higher value of soluble salts was noted with 40 kg S ha^{-1}. Inoculation of rhizobium did not affect the EC values of soil over no inoculation treatment. The organic carbon content ranged from 3.3 to 3.7 g kg^{-1} with 90 kg P_2O_5 ha^{-1}. Increasing levels of phosphatic fertilizers application has helped in increasing the organic carbon content, which may be due to increased contribution from the biomass, as it was also observed that with increasing P levels, the crop yields had increased, contribution from root stubble could also be follow the same trend. Application of sulphur was beneficial because it also improved the physical and biological characteristics of the soil and ultimately the yield of the crop. These investigations reveal that inoculation of seeds with rhizobium resulted in slight increase in soil organic carbon (Singh *et al.* 2009).

Soil fertility

Control plot showed reduction in the available N status due to removal of nutrients with cropping without fertilization. Available nitrogen content in soil ranged from 155 kg ha^{-1} at control to175 kg ha^{-1} with 90 kg P_2O_5 ha^{-1}. Increase in available N even under the plots receiving phosphorus in comparison to control could be explained by the priming effect of P on N mineralization. Beghum *et al.* (2007) reported similar results in mungbean with the application of P, the available N in post harvest soil also increased from initial value of 165 kg N ha^{-1}. The maximum value of available N in soil was noted with 40 kg S ha^{-1}. It was observed from Table 1 that the available N content of the soil increased from its initial value under rhizobium inoculation. Supplementing biofertilizer with P and S enhances the available N content of the soil due to fixation of atmospheric N_2 by rhizobium (Singh *et al.* 2009).The Olsen-P content of the soil after harvest increased from its initial value with the application of P levels. The maximum value of available P in soil was recorded with 90 kg P_2O_5 ha^{-1}. This increase in available P content may be attributed to addition of phosphatic fertilizers (Selvi *et al.*, 2005). Sulphur application also improved the status of available P in soil over no sulphur application. Available P increased from 9.0 kg ha^{-1} at control to 13.6 kg ha^{-1} with 40 kg S ha^{-1}. Inoculation of seeds with rhizobium did not affect the status of available P in post harvest soil (Singh et al, 2009).

Table 2: Effect of various treatments on status of available nutrients and yield of cowpea (mean of 2 years)

Treatments	Available K (kg ha^{-1})	Available S (mg kg^{-1})	Grain yield (q ha^{-1})	% Response	Straw yield (q ha^{-1})	% response
Phosphorus (kg ha^{-1})						
0	95	13.5	13.21	-	32.16	
30	100	13.8	15.31	15.9	36.75	
60	104	13.5	16.13	22.1	38.75	
90	106	14.0	17.04	29.0	40.86	
CD (P=0.05)	6.5	NS	0.62		2.03	
Sulphur (kg ha^{-1})						
0	100	13.3	13.33	-	30.26	-
20	109	14.7	15.39	15.4	36.74	21.4
40	112	15.5	16.05	20.4	38.49	27.2
CD (P=0.05)	8.3	0.63	0.80		1.85	
Biofertilizers						
No inoculation	100	13.2	14.22	-	33.36	
Rhizobium	102	13.3	16.46	15.7	37.60	12.7
CD (P=0.05)	11.4	ns	1.10	-	3.50	-

A perusal of the data (Table 2) indicated a declining trend from its initial value (110 kg ha^{-1}) of available K status which indicates considerable mining of available soil K. The maximum decline was observed in control followed by 30 kg P_2O_5 ha^{-1}. However, there was an increase in available K status with P levels and maximum value was recorded with 90 kg P_2O_5 ha^{-1}. Available K status was low with no sulphur and 20 kg S ha^{-1} than that of initial value. Available K status improved with 40 kg S ha^{-1} over initial status of K in soil. Rhizobium inoculation slightly improved the status of available K over no inoculation (Singh *et al.* 2009).The status of available S in soil was not affected significantly with P levels. However, relatively higher value of available S was noted with 90 kg P_2O_5 ha^{-1}. These results indicated a synergistic effect of P on the status of sulphur in post harvest soil. But an appreciable increase in available S content in post harvest soil was found in the treatment receiving sulphur fertilization. The amount of available S ranged from 13.3 to 15.5 mg kg^{-1} and maximum value was recorded with 40 kg S ha^{-1}. This may be attributed to increased amount of sulphur in soil due to addition of sulphur fertilizer. The status of available S was not affected with rhizobium inoculation.

Yield

The grain and straw yields of cowpea increased significantly by all the levels of phosphorus over control. Application of 90 kg P_2O_5 ha^{-1} recorded significantly higher yields of grain and straw. The increases in grain and straw yields with 90 kg P_2O_5 ha^{-1} over control were 29.0 and 27.0 %, respectively. The increases in yield may be attributed to the effective metabolic activities coupled with increased rate of photosynthesis leading to better translocation of nutrients in sink. Similar results were reported by Lal *et al.* (2016), Singh *et al.* (2015), Singh *et al.* (2016) in lentil. Application of P levels increased significantly the protein content in cowpea grain and straw and maximum values in gram (20.00%) and straw (6.69%) were recorded with 90 kg P_2O_5 ha^{-1}. Protein yield ranged from 252.6 kg ha^{-1} at control to 340 kg ha^{-1} with 90 kg P_2O_5 ha^{-1}. These findings are in confirmation with those of Singh *et al.* (2017).Data (Table 2) show that application of S significantly increased yield attributes and protein content in cowpea up to 40 kg S ha^{-1}. Application of 40 kg S ha^{-1} increased the grain and straw yield by 20.4 and 27.2% respectively over control. The marked response in yield due to sulphur application may be attributed to the deficiency of available S in the experimental soil, as its value was less than the critical limit of 10 mg kg^{-1}. Kumar *et al.* (2007) reported higher yield of cowpea with application of S. Singh *et al.* (2017) and Singh (2017) reported similar results.Data showed that the grain and straw yields of cowpea increased significantly with inoculation of rhizobium over no inoculation. The increases in yield due to rhizobium inoculation were 15.7 and 12.9% over no inoculation. The increase in yield might have resulted from the growth regulating substances produced by biofertilizer besides fixation of additional nitrogen from atmosphere thereby increasing nitrogen availability in the soil throughout the crop growth. Similar results were reported by Choudhary *et al.* (2013) and Singh *et al.* (2015).

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