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Research Notes

Integrated phosphorus management in chickpea

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Indian soils are generally rich in phosphorus but more than two-thirds of the native phosphorus are unavailable and applied P fertilizers are rendered unavailable within a short period due to its fixation in the soil. Phosphorus is the main limiting input for chickpea (*Cicer arietinum* L.), without which higher production is impossible. Phosphate fertilization of chickpea has been known to promote growth and increase yield (Prasad and Sonoria, 1981). However, the efficiency of applied phosphorus seldom exceeds 15% (Roy *et al.* 1978). Phosphate solubilizing micro-organisms play an important role in making P available to the plants which increases the yield of crop plants. Application of phosphate solubilizing bacteria is known to increase solubilization of phosphorus by production of organic acids (Subba Rao, 1986) and growth promoting substances like auxins and gibberellins. Rachewad *et al.* (1992) reported that use of phosphate solubilizing inoculant (*Bacillus megaterium* var. *phosphoticum*) in the presence of applied P enhanced the P availability in soil and its uptake by the crops (Ramasamy and Sankaran, 2001). The present attempt has been made in order to evaluate the efficacy of rock phosphate (a cheaper source of P supplier to crops) in association of phosphorus solubilizing microorganisms like bacteria and fungi for increasing the nodulation and yield of chickpea.

The experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during rabi season of 1996-97. The experimental site is located at 11°N latitude and 77°E longitude at an altitude of 426.7m above mean sea level. The soil of the experimental field was clay loam in texture, classified under Typic haplustalf with a pH of 7.1. The fertility status of the soil has been classified as low in available N (179 kg ha^{-1}), P (6.7 kg ha^{-1}) and high in available K (693 kg ha^{-1}). The experiment consisted of 15 treatment combinations replicated thrice and laid out in randomised block design with CO 3 chickpea variety as test crop. The phosphorus solubilizing bacteria and fungi were each applied at 500 g ha^{-1}.

The data on the number of nodules $plant^{-1}$ revealed that application of 40 kg P_2O_5 ha^{-1} through rock phosphate with PSB (*Bacillus megaterium*) (T_{14}) significantly increased the number of nodules $plant^{-1}$ (18.00) over the control, which recorded a lower nodule number (8.33). This may be due to the solubilization of rock phosphate by PSB, which has been attributed to the liberation of organic acid end products like lactic, citric and succinic acid (Hebbara and Susheeladevi, 1990). This treatment (T_{14}) was comparable with the application of 40 kg P_2O_5 ha^{-1} through PSF (*Aspergillus awamori*) (17.75) (T_{15}) and application of 40 kg P_2O_5 ha^{-1} through rock phosphate (17.70) (T_{11}). Similarly Tiwari *et al.* (1989) have also reported that seed inoculation with PSB, markedly increased the nodulation and yield of chickpea with or without P fertilizers.

Application of 20 kg P_2O_5 ha^{-1} through DAP with PSB (T_6) significantly produced taller plants, higher number of pods $plant^{-1}$, higher seed weight with higher grain yield of 809 kg ha^{-1}. This may be attributed to the solubilization of P by PSB and the resultant increased availability of P in forms that can be easily assimilated by plants. This treatment was on par with the treatments receiving 40 kg P_2O_5 ha^{-1} through rock phosphate with PSB (T_{14}) with a grain yield of 798 kg ha^{-1}, application of PSB (78[illegible] kg ha^{-1}) (T_4) and also with the application of 40 kg P_2O_5 ha^{-1} through DAP with PSB (773 kg ha^{-1}) (T_{12}). The yield produced by application of PSB alone was comparable to application of fertilizer P since more than 70 per cent of applied P fertilizers get fixed in the soil rendering them unavailable for plant uptake (Stevenson, 1986). Moreover the phosphorus solubilising microorganisms have the capacity to mobilize the fixed forms of phosphorus (Gaur 1990). The control recorded the lower yield (511 kg ha^{-1}) and yield attributes. Sarawgi *et al.* (1999) recorded 13.4 per cent more grain yield through application of PSB over no P application and reported that the increase in

Table 1. Effect of different sources of phosphorus and phosphorus solubilizing microorganisms on the productivity of chickpea

Treatments	No. nodule plant^{-1}	Plant height at harvest (cm)	No. pods plant^{-1}	100 seed weight (g)	Grain yield (kg ha^{-1})	BC ratio
Control	8.33	25.2	14.10	28.02	511	1.31
T_1 - 20 kg P_2O_5 - DAP	10.40	27.2	17.50	29.01	610	1.51
T_2 - 20 kg P_2O_5 - RP	13.30	26.3	15.70	28.81	593	1.45
T_3 - PSB alone	10.70	33.4	24.60	30.30	785	1.99
T_4 - PSF alone	10.60	26.5	16.00	28.88	595	1.51
T_5 - 20 kg P_2O_5 - DAP + PSB	13.60	34.9	27.57	30.60	809	1.99
T_6 - 20 kg P_2O_5 - DAP + PSF	11.30	30.4	21.40	28.33	690	1.69
T_7 - 20 kg P_2O_5 RP + PSB	16.70	29.2	20.30	29.20	655	1.58
T_8 - 20 kg P_2O_5 RP + PSF	13.90	27.8	17.87	29.05	610	1.48
T_9 - 40 kg P_2O_5 - DAP	13.90	31.5	23.50	29.73	714	1.69
T_{10} - 40 kg P_2O_5 - RP	17.70	29.0	19.27	29.10	643	1.50
T_{11} - 40 kg P_2O_5 - DAP + PSB	15.25	32.8	24.10	30.17	773	1.81
T_{12} - 40 kg P_2O_5 - DAP + PSF	14.20	31.1	23.03	29.60	704	1.65
T_{13} - 40 kg P_2O_5 RP + PSF	18.00	34.0	25.17	30.56	798	1.85
T_{14} - 40 kg P_2O_5 RP + PSF	17.75	31.0	22.90	29.52	702	1.63
SEd	0.37	1.40	1.31	1.02	31.1	-
CD (P=0.05)	0.76	2.90	2.68	2.08	63.7	-

grain yield was five times more than under 30 kg P + PSB over application of 30 kg P alone. With regard to economics, application of 20 kg P_2O_5 ha^{-1} through DAP with PSB (T_6) and application of PSB (T_4) recorded higher BC ratio of 1.99, followed by the application of PSB and 40 kg P_2O_5 ha^{-1} through rock phosphate with PSB (1.85) (T_{14}). It can be concluded that application of 20 kg P_2O_5 ha^{-1} through DAP with PSB, application of PSB and 40 kg P_2O_5 ha^{-1} through rock phosphate with PSB can be recommended for enhancing the yield of chickpea.

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