

Original Research Article

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Effects of *Rhizobium*, PSB Inoculation and Phosphorus Management on Soil Nutrient Status and Performance of Cowpea in Acid Soil of Arunachal Pradesh, India

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ABSTRACT

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An investigation was carried out to study the effects of *Rhizobium*, PSB inoculation and phosphorus management on soil nutrient status and performance of cowpea at College of Horticulture and Forestry, CAU, Pasighat during *pre-kharif* seasons of 2017. The present study shows the effects of *Rhizobium*, PSB in single and dual combination with or without P₂O₅ on cowpea. The results of these experiment reveals that dual inoculation with fertilizer (P₂O₅) significantly increase plant growth parameters *viz.* Plant height, number of green leaves, branching, plant biomass, etc., yield attributes, green pod yield, soil available N, P, K status and root nodulation. It is concluded dual inoculation along with P₂O₅ fertilizer (PSB + *Rhizobium* + 40 kg P₂O₅) is 34 % better than dual inoculation without phosphatic fertilizer for improving pod yield of cowpea. Application of biofertilizer (PSB and *Rhizobium*) along with 40 kg P₂O₅ also improves root nodulation and *Rhizobium* population in soil. It was observed that the nutrient availability to the crop without breaking the sustainability of the soil can be increase only by combined application biofertilizers (PSB and *Rhizobium*) along with phosphatic fertilizers.

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] is an important legume vegetable crop as well as pulse grown in India. It is warm season crop of humid tropics and sub tropical zones, well adapted to many areas of the country including North East India. It has manifold uses such as vegetable, pulse, green manuring and fodder crop (Singh *et al.*, 2012). Cowpea leaves and green pods are consumed as vegetable and the dried grain is used in many different food preparations. In India, cowpea is grown on about 0.5 million ha with an

average productivity of 600 to 750 kg grains/ha (Meena *et al.*, 2010). Yield potential of cowpea can be exploited by the application of adequate amount of nutrients required by the legumes.

Generally, Indian soils under natural condition are lacking in effective and specific strain of *Rhizobium*, which is responsible for symbiotic nitrogen fixation and in turn economic grain yield of pulse (Shaktawat, 1998). *Rhizobium* inoculation also serves as a

cheaper and usually more effective agronomic practice for ensuring adequate nitrogen nutrition of legumes than the application of nitrogen fertilizer (Wange, 1989). Studies on inoculation of pulses with PGPR and *Rhizobium* cause growth stimulation of plant and enhances crop yield (Sharma *et al.*, 2007). The synergism has also been reported between *Rhizobium* spp. and PSB in urdbean (Prasad *et al.*, 2002). Although pulses are capable of fixing atmospheric nitrogen yet they need a small basal dose of nitrogenous fertilizer for quick and better start. Next to nitrogen, phosphorus is regarded as the pioneer plant nutrient, since it is needed by the leguminous crop for rapid and healthy root development, which becomes helpful in greater nodulation by *Rhizobium* bacteria (Singh *et al.*, 2007). The report on application of biofertilizers on yield of legumes for soil of North-Eastern hill region, particularly Arunachal Pradesh is very meager. Hence, the present investigation was therefore undertaken to study the effects of *Rhizobium*, PSB inoculation and phosphorus management in cowpea.

Materials and Methods

A field study was conducted to assess the response of cowpea on application of *Rhizobium* and PSB with or without phosphorus at NRM farm (28° 07' N latitude and 95° 33' E longitude) of College of Horticulture and Forestry, Central Agricultural University, Pasighat, East Siang, Arunachal Pradesh during *pre-kharif* cropping season of 2017. The soil of the experimental site was sandy loam with a pH of 5.2, organic carbon 2.1 % medium in available nitrogen and potassium and high in phosphorus. Seven different nutrients treatments comprising of viz. T₁: PSB + *Rhizobium*, T₂: PSB + *Rhizobium*+ 20 kg P₂O₅, T₃: PSB + 20 kg P₂O₅, T₄: *Rhizobium* + 20 kg P₂O₅, T₅: PSB + *Rhizobium* + 40 kg P₂O₅, T₆: PSB + 40 kg

P₂O₅, T₇: *Rhizobium* + 40 kg P₂O₅ were evaluated in Randomized Block Design with three replications. Bush type Cowpea variety Kashi Kanchan developed from IIVR, Vanarasi (U.P.) was sown on 8th February, 2017 at 50 x 20 cm row to row and plant to plant spacing, respectively, using seed rate 50 kg/ha. Recommended dose of fertilizers (20 kg N and 30 kg K₂O) was applied as basal application through Urea and MOP in all the plots.

Phosphatic fertilizer (SSP) was applied as recommended. Various weather parameters were recorded during crop growing period. The crop in its life cycle experienced 884.2 mm rainfall, 4.9 mm evaporation, relative humidity 65 to 96.3 % and the maximum and minimum temperature in the range of 21.4 to 31.5 and 11 to 19^oC, respectively. The observations on nutrient management for growth parameters and yield attributes were recorded. Pods were harvested from net plot in six pickings. The data on individual plots presents in the experimental field were recorded at 35 DAS, 70 DAS and at harvest by tagging five plants. The soil sample from 0-15 cm depth were taken for chemical analysis after the harvest of the cowpea and soil parameters viz. Organic carbon, Electrical conductivity, Nitrogen, Phosphorus and Potassium status of soil were estimated by standard analytical methods (Jackson, 1973, Tandon, 1999). *Rhizobium* population count were made from each individual plots using nodulation dilution frequency method (Katura Tuzimura and Iwao Watanade, 1961) and most probable number (MPN) were counted. For recording number of nodules, five plants were randomly selected and removed from each plot at 45 DAS. The standard error of mean (SEM±) and critical difference (CD) values at p=0.05 were used to determine the significance difference between the mean values.

Results and Discussion

Effects on crop growth parameters

The data on crop growth parameters such as plant height, number of leaves, number of branches, LAI, days to flower initiation, days to 50% flowering are presented in table 1. Results revealed that the *Rhizobium* inoculation with phosphorus application enhanced the growth parameters of cowpea. The finding was also validated with result of Singh *et al.*, 2007. *Rhizobium* inoculation along with application of 40 kg P₂O₅/ha (T₇) significantly increased the plant height, number of leaves, number of branches and LAI which was at par with *Rhizobium* + 20 kg P₂O₅ (T₄) and PSB + *Rhizobium* + 40 kg P₂O₅ (T₅). In case of flower initiation and 50 % flowering, inoculation of *Rhizobium* with Phosphate solubilising bacteria and phosphatic fertilizer *i.e.* PSB + *Rhizobium* + 40 kg P₂O₅ (T₅), PSB + *Rhizobium* + 20 kg P₂O₅ (T₂) and PSB + 40 kg P₂O₅ (T₆) recorded highest values. The treatment using PSB + *Rhizobium* (T₁) was found to be inferior for all the growth parameters of cowpea. This was also supported by Singh *et al.*, 2007.

Effects on yield attributes and yield

Phosphatic fertilizer levels exerted significant effect on yield indices in cowpea. Seed inoculation with *Rhizobium* or PSB along with phosphatic fertilizer proved superior compared to biofertilizers (*Rhizobium* and PSB) alone with respect to yield and yield contributing characters. Table 2 shows that combined inoculation of seed with *Rhizobium* + 40 kg P₂O₅ (T₇) recorded highest fresh weight (140 g/plant) and dry weight (28.1 g/ha) of cowpea which was followed by T₄ (*Rhizobium* + 20 kg P₂O₅) and T₅ (PSB + *Rhizobium* + 40 kg P₂O₅). The highest weight of pods (10 g/plant), number of pods/plant (14.4), pod yield in g/ha (108.1) and pod yield

in q/ha (78.3) were found in the plot treated with PSB + *Rhizobium* + 40 kg P₂O₅ (T₅) which was at par with T₇ and T₂. The increase in yield and yield attributes under combined inoculation of seeds (PSB and *Rhizobium*) with phosphatic fertilizer treatment might be owing to adequate quantities of plant nutrients supplied to the crop during growth period, resulting in favourable increase in growth and development of crop plant which leads towards increase in yield indices (Pandey *et al.*, 2015). *Rhizobium* inoculation, nitrogen and phosphorus application enhanced grain and straw yield of cowpea which was due to increasing growth and yield attributing characters. These results support the findings of Jain *et al.*, (1993) and Singh *et al.*, (2007).

Effects on soil chemical properties

Application of *Rhizobium* + 40 kg P₂O₅ (T₇) recorded highest available nitrogen (385.7 kg/ha) and organic carbon content (3.1 %) of the soil followed by T₄ (*Rhizobium* + 20 kg P₂O₅). The available P and K were observed to be maximum in a plot treated with PSB + *Rhizobium* + 40 kg P₂O₅ (T₅, 95.4 kg/ha) and *Rhizobium* + 20 kg P₂O₅ (T₄, 560.9 kg/ha), where both was at par with T₇ treatment (*Rhizobium* + 40 kg P₂O₅) (Table 3). This may be due to fact that biofertilizers enhanced soil fertility by solubilising unavailable sources of elemental nitrogen, bound phosphorus and non-exchangeable potassium into forms to facilitate the plant to absorb them (Goud and Kale, 2011). Mostly all the plots treated with only biofertilizers (PSB + *Rhizobium*) was observed to be lowest. In case of soil parameters such as EC and Soil pH lowest were also estimated under the treatments without phosphatic fertilizer (PSB + *Rhizobium*) while the other treatments was found to be at par with each other. Pandey *et al.*, (2015) also reported that combined inoculation of *Rhizobium*, PSB and PGRR improved the nutrient status of soil through

their synergistic effect on nitrogen fixation and solubilisation of native soil phosphorus which increased availability and uptake of these nutrients by the crop plant (Urd bean) resulted in enhanced yield indices. Higher NPK uptake in combined inoculation of

Rhizobium + PSB + PGRR is due to their additive effects (Prasad *et al.*, 2002). Seed inoculation with biofertilizers reduced the bulk density and enhanced organic carbon and available N, P, K contents of the soil.

Table.1 Effects of *Rhizobium* and PSB inoculation on the growth parameters

Treatments	Plant Height		Leaf		Branch	LAI	Days to flower initiation	Days to 50 % flowering
	35 DAS	70 DAS	35 DAS	70 DAS	70 DAS			
T1 PSB + <i>Rhizobium</i>	17.1	90.4	8.3	94.7	2.4	17.9	65.0	71.0
T2 PSB + <i>Rhizobium</i> + 20 kg P2O5	19.1	107.1	11.0	105.4	2.4	22.0	66.3	72.3
T3 PSB + 20 kg P2O5	17.8	106.3	10.0	95.1	3.0	19.8	65.7	72.0
T4 <i>Rhizobium</i> + 20 kg P2O5	21.4	117.2	11.7	110.7	4.0	22.7	65.3	71.3
T5 PSB + <i>Rhizobium</i> + 40 kg P2O5	20.7	107.7	11.0	108.8	4.1	22.2	66.3	72.3
T6 PSB + 40 kg P2O5	18.0	106.7	10.0	102.8	2.8	21.2	66.3	72.0
T7 <i>Rhizobium</i> + 40 kg P2O5	21.6	125.5	12.4	116.1	4.3	24.4	66.0	72.0
SEm	0.62	2.36	0.62	3.61	0.18	0.95	0.29	0.40
CD(0.05%)	1.56	5.95	1.57	9.10	0.45	2.39	0.73	1.00

Table.2 Effects of *Rhizobium* and PSB inoculation yield and yield attributes

Treatments	Days to pod initiation	fresh wt (g/plant)	Dry wt. (g/plant)	Pod wt. (g/pod)	No. of pods/plant	Pod yield (g/plant)	Pod yield (q/ha)
T1 PSB + <i>Rhizobium</i>	69.3	90.0	18.1	6.2	11.1	80.1	58.3
T2 PSB + <i>Rhizobium</i> + 20 kg P2O5	70.3	123.3	25.0	8.5	13.5	91.9	67.0
T3 PSB + 20 kg P2O5	69.7	103.3	20.3	7.4	12.0	85.6	62.3
T4 <i>Rhizobium</i> + 20 kg P2O5	69.3	136.7	27.3	8.4	13.2	87.5	62.3
T5 PSB + <i>Rhizobium</i> + 40 kg P2O5	70.7	133.3	26.7	10.0	14.4	108.1	78.3
T6 PSB + 40 kg P2O5	70.3	106.7	22.1	7.5	13.1	86.0	62.3
T7 <i>Rhizobium</i> + 40 kg P2O5	70.0	140.0	28.1	9.5	14.3	95.2	69.3
SEm	0.43	30.28	3.91	0.74	2.17	8.68	5.96
CD(0.05%)	1.09	76.30	9.87	1.87	5.48	21.87	15.02

Effects on root nodulation and soil microbial properties

The results revealed that seed inoculation with *Rhizobium* as well as PSB with Phosphatic fertilizers exhibited superior performance. Table 3 shows that plots treated with PSB + *Rhizobium* + 40 kg P₂O₅ (T₅) recorded highest number of nodules *i.e.* 22.7 which was at par with treatment PSB + *Rhizobium* + 20 kg P₂O₅ (T₂, 19.0). The *Rhizobium* population was also recorded higher under treatment T₅ (2.5 x 10⁶) followed by T₂ (5.4 x 10⁵). Coinoculation of *Rhizobium* and PSB recorded significantly higher nodule number and its fresh as well as dry weight than *Rhizobium* and PSB alone. The increase in nodulation might be due to synergistic effect of the two types of microorganisms for biological nitrogen fixation as against their individual application. Results of the similar kind have also been reported by Rudresh *et al.*, (2005). It is also due to the fact that phosphate solubilizing bacteria by virtue of their property of producing organic acids solubilize insoluble or fixed form of phosphorus in the rhizosphere and make it available to the growing plants, which promotes root development in plants (Rao, 1986). In the present study, a significant response of dual inoculation with *Rhizobium* and PSB was observed with respect to dry weight per plant. Observations of the similar kind have also been recorded by Gupta and Namdeo (2000) and Barea *et al.*, (2005).

In conclusion, based on above results, it can be concluded that combined treatments of PSB + *Rhizobium* + 40 kg P₂O₅ is superior over the remaining treatments with respect to growth parameters, yield and yield attributes, soil chemical properties, its nodulation and *Rhizobium* population in sandy loam soil of Arunachal Pradesh. Thus, Cowpea variety Kashi Kanchan and inoculation of *Rhizobium*,

PSB along with phosphatic fertilizer may be recommended to realize higher yield of crops in this region.

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