Original Research Article

Effects of Biofertilizer and Phosphorus on Growth,Yield Components and Yield of Chickpea (*Cicerarietinum*L.)

ABSTRACT

A field experiment was conducted at Crop Research Farm (CRF), Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (UP) during*Rabi* 2021 to study the "Effects of Biofertilizer and Phosphorus on Growth, Yield Components and Yield of Chickpea (*Cicerarietinum* L.)". It was consisting of three combinations of Biofertilizer and Phosphorus. The experiment was laid out in Randomized Block Design with ten treatments each replicated threetimes. The experiment results were revealed that the growth and yield parameters such as plant height (54.94 cm), number of nodules per plant (36.28), plant dry weight (23.71 g/plant), number of pods per plant (34.29), number of seeds per pod (1.89), test weight (245.76 g) at harvest significantly recorded higher in application of Rhizobium+PSB + Phosphorus 60kg/ha. Moreover, grain yield (2.07 t/ha), stover yield (3.58 t/ha), gross return (108523.7 INR/ha), net return (75364.02 INR/ha) and B:C ratio (2.27) were also recorded higher in Rhizobium+PSB + Phosphorus 60kg/ha compared to other treatments.

Keywords: Rhizobium, PSB, Phosphorus, Chickpea, Yield

1. INTRODUCTION

Pulses play an important and diverse role in the farming system and in the diets of people around the world. Besides being rich in protein, they sustain the productivity of cropping systems. Pulse crop plays an important role in Indian Agriculture (Yadav*et al* 2017) India is the largest producer and consumer of pulses in the world. Pulses contain high percentage of quality protein nearly three times as much as cereals (Umadevi and Ganeshan 2007). Pulses are known for increasing productivity of soil through fixation of nitrogen from atmosphere, addition of biomass to soil and secretion of growth promoting substances.

Chickpea (*Cicerarietinum*L.) is the most important Rabi pulse crop of India.Among the pulse crops, chickpea occupies an important position due to its nutritious value (17-23%). Area under chickpea cultivation in India is around 8.3mha and in Andhra Pradesh it is 4.7lakh ha. All India production is around 7.1 million tonnes(Annual Report 2016-17, MoAF, GOI). The current average global yield of chickea is 0.9 t ha^{-1},which is much lower than its estimated potential of 6 t ha^{-1} under the optimum cultivated conditions,(FAO, 2012). The low production of chickpea is

due to improper use of fertilizers and least importance given to biofertilizers such as Rhizobium and PSB.

Plant nutrients are the main sources for improving quantity and quality of chickpea production. Phosphorus is known to improve crop quality. It is also an important constituent of vital substances like phospholipids and phosphoproteins. Sufficient supply of phosphorus to plant, hastens the maturity and increases the rate of nodulation and pod development. The increase in the nodulation might be due to the enhanced and established good rooting system with the application of Phosphorus. Phosphorus is one of the critical nutrient deficiency in Indian soils and may cause upto 29-45% yield losses in chickpea (Ahlawat*et al* 2007). Most of the phosphorus present in the soil is unavailable to plants which are made available through the activities of efficient microorganisms like bacteria, fungi and cyanobacteria with production of organic acid and increasing phosphatase enzyme activity(Rajneesh *et al* 2018).

Biofertilizers may colonizes the rhizosphere and promotes growth by increasing the availability and supply of nutrients to crop. Nitrogen fixer and phosphate solubilizing microorganisms play an important role in supplementing nitrogen and phosphorus to plants, allowing a sustainable use of nitrogen and phosphate fertilizer (Tambekar*et al* 2009). Chickpea establishes a symbiotic association with Rhizobium. Rhizobium is one of the nitrogen fixing bacteriawhich fix atmospheric nitrogen by the symbiotic association with leguminous plants. Rhizobium, originally called *Bacillus redicicola*, was first isolated by Beijerinck (1901). Rhizobium inoculation can increase the grain yield of pulse crops to the tune of 10 to 15% (Ali and Chandra 1985)However, PSB also increases the yield of chickpea by 10-30%. Both Rhizobium and PSB inoculation significantly increased the nodules mainly due to the fact that the nitrogenaseenzyme present in the bacteria get introduced through infection causes nodule formation. Phosphate solubilizing bacteria (PSB) have the consistent capacity to increase the availability of phosphates to plants by mineralizing organic phosphorus compounds (Parveen*et al* 2002). Application of PSB facilitates the root development vis-à-vis nodule formation and proper development of nodules by increasing the availability of phosphorus through mobilizing the unavailable phosphorus present in the soil.The use of bio-fertilizers with reduced quantityof chemical fertilizers is therefore recommended for better yield of chickpea (Dinesh *et al* 2015).Hence, an experiment was conducted to study the effects of biofertilizer and phosphorus on growth, yield components and yield of chickpea.

2. MATERIALS AND METHODS

2.1 Description of the study area

The experiment was carried out during *Rabi* 2021-2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, Uttar Pradesh, which is located at 25.28^{o}N latitude, 81.54^{o}E longitude and 98m altitude above the mean sea level.

2.2 Experimental design and treatments

The experiment laid out in Randomized Block Design which consisting of ten treatments with $T_{1:}$ Rhizobium 20g/kg seed + Phosphorus 20kg/ha, T_2:Rhizobium 20g/kg seed+ Phosphorus 40kg/ha, T_3: Rhizobium 20g/kg seed + Phosphorus 60kg/ha, T_4: PSB 20 g/kg seed + Phosphorus 20kg/ha, T_5: PSB 20g/kg seed + Phosphorus 40kg/ha, T_6: PSB 20g/kg seed + Phosphorus 60kg/ha, T_7: Rhizobium+PSB 20g/kg seed + Phosphorus 20kg/ha, T_8: Rhizobium+PSB 20g/kg seed + Phosphorus 40kg/ha, T_9: Rhizobium+PSB 20g/kg seed + Phosphorus 60kg/ha, T_{10}: Control in three replications.

2.3 Data collection

The observations on different growth parameters are Plant height (cm), Number of nodules per plant, Plant dry weight (g) and yield parameters are Number of pods per plant, Number of seeds per pod, Test weight (g), Seed yield (t/ha) and Stover yield (t/ha) were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez K.A and Gomez A.A 1984).

Table 1: Details of Treatment Combinations.

Treatment No.	Treatment Combinations
T_1	Rhizobium 20g/kg seeds + Phosphorus 20kg/ha
T_2	Rhizobium 20g/kg seeds + Phosphorus 40kg/ha
T_3	Rhizobium 20g/kg seeds + Phosphorus 60kg/ha
T_4	PSB 20g/kg seeds + Phosphorus 20kg/ha
T_5	PSB 20g/kg seeds + Phosphorus 40kg/ha
T_6	PSB 20g/kg seeds + Phosphorus 60kg/ha
T_7	Rhizobium + PSB 20g/kg seeds + Phosphorus 20kg/ha
T_8	Rhizobium + PSB 20g/kg seeds + Phosphorus 40kg/ha
T_9	Rhizobium + PSB 20g/kg seeds + Phosphorus 60kg/ha
T_{10}	Control

3. RESULTS AND DISCUSSION

Table 2 Chemical analysis of soil at pre-experiment stage of planting

Parameter	Value (unit)	Method (references)
Available Nitrogen	0.028%	Alkaline permanganate method (Subbiah and Asja, 1956)
Available Phosphorus	13.05 kg/ha	Olsen's colorimetric method (Olsen et al., 1956)
Available Potassium	156.44 kg/ha	Flame Photometer method (Jackson, 1973)
Organic Carbon	0.36 (%)	Walkley and Black method (Jackson, 1973)
pH	7.6	Glass electrode pH meter (Jackson, 1973)

3.1 Growth Attributes

3.1.1 Plant Height (cm)

As shown in Table 3, significantly highest plant height (54.94cm) was recorded inT_9Rhizobium+PSB 20g/kg seed + Phosphorus 60kg/ha, than all other treatments. However, T_8 Rhizobium+PSB 20g/kg seed +Phosphorus 40kg/ha was statistically at par with T_9Rhizobium+PSB 20g/kg seed + Phosphorus 60 kg/ha. The minimum plant height was recorded in control plot which is 49.41cm.The plant height of chickpea was significantly influenced by biofertilizers. The increase in growth might be due to enhanced photosynthetic efficiency of Rhizobium+PSB inoculated plant. Inoculations of PSB which are known to produce growth hormones are likely to favour increased plant height. Phosphorus applications increased plant height and number of branches, Dahiya*et al* 1993.

3.1.2 Number of Nodules per plant

Maximum number of nodules per plant (36.28) was recorded with the application of Rhizobium+PSB 20g/kg seed + Phosphorus 60kg/ha. However, T_8 Rhizobium+PSB 20g/kg seed + Phosphorus 40kg/ha was statistically at par with T_9 Rhizobium+PSB 20g/kg seed + Phosphorus 60kg/ha.The minimum number of nodulesper plant were recorded in control plot which is 28.46. The number of nodules per plant in chickpea were significantly influenced by Rhizobium and PSB inoculation at flowering stage of the crop growth.Inoculation of seed with Rhizobium+PSB produce significantly higher number of nodules in comparison to other

inoculants (Akansha 2018). Pawar*et al* 1998 investigated that seed inoculation increased the number of nodules per plant, nodules dry weight per plant as compared to un-inoculated seed (control) in a trail on chickpea. The data (Table 3)indicates that the increase of phosphorus levels has increased the number of nodules per plant with combined application of Rhizobium+PSB.

3.1.3 Plant Dry Weight (g)

Treatment with Rhizobium+PSB 20g/kg seed + Phosphorus 60kg/ha was recorded with significantly maximum plant dry weight (23.71g) than all other treatments. However, T_8 Rhizobium+PSB 20g/kg seed + Phosphorus 40kg/ha was statistically at par with T_9 Rhizobium+PSB 20g/kg seed + Phosphorus 60kg/ha. The minimum plant dry weight (16.15g) was observed in control plot. Application of Phosphorus significantly increased the dry matter accumulation in the plant and differences were seen in 60 kg P/ha. The response of phosphorus in terms of dry matter accumulation up to 60kg P/ha have also been reported Singh et al 2005 in chickpea. Seed inoculation with Rhizobium+PSB also produced significantly higher dry matter of chickpea.Thenua*et al* 2010 reported that application of phosphorus as single super phosphate (SSP) recorded significantly higher plant height, branches per plant and drymatter accumulation in chickpea.

Table 3: Effect of Biofertilizer and Phosphorus on Growth attributes of Chickpea

S.No	Treatments	Plant Height (cm)	Number of nodules/plant	Plant Dry weight (g)	Crop Growth Rate ($g/m^2/day$)	Relative Growth Rate (g/g/day)
1	Rhizobium+Phosphorus 20kg/ha	53.25	33.24	20.58	12.87	0.036
2	Rhizobium+Phosphorus 40kg/ha	52.16	32.87	19.75	12.33	0.037
3	Rhizobium+Phosphorus 60kg/ha	53.92	35.80	21.82	12.61	0.031
4	PSB+Phosphorus 20kg/ha	52.59	32.19	19.79	11.31	0.032
5	PSB+Phosphorus 40kg/ha	51.81	34.47	19.83	11.92	0.040
6	PSB+Phosphorus 60kg/ha	52.68	31.68	18.45	12.30	0.035
7	Rhizobium+PSB+Phosphorus 20kg/ha	52.75	33.13	20.67	11.53	0.034
8	Rhizobium+PSB+Phosphorus 40kg/ha	54.46	35.93	22.33	12.17	0.029
9	Rhizobium+PSB+Phosphorus 60kg/ha	54.94	36.28	23.71	12.76	0.030
10	Control	49.41	28.46	16.15	10.06	0.035
	F test	S	S	S	S	S
	SEm(±)	0.48	0.39	0.49	0.53	0.00

	CD (P=0.05)	1.42	1.15	1.45	1.58	0.00
	CV(%)	1.57	2.02	4.15	7.68	7.97

3.2. Yield Attributes

As shown in Table 3, yield parameters are summarized statistically. At the time of harvest, the significantly effective number of pods per plant (34.29) was recorded with a combined application of Rhizobium+PSB 20g/kg seed + Phosphorus 60kg/ha. However, Rhizobium+PSB 20g/kg seed + Phosphorus 40kg/ha was statistically at par with Rhizobium+PSB 20g/kg seed + Phosphorus 60kg/ha. The minimum effective pods per plant (26.65) were recorded in control plot. Significantly maximum number of seeds per pod (1.89) was recorded with application of Rhizobium+PSB 20g/kg seed + Phosphorus 60kg/ha. However, Rhizobium+PSB 20g/kg seed + Phosphorus 40kg/ha was statistically at par with Rhizobium+PSB 20g/kg seed + Phosphorus 60kgha. The minimum number of seeds per pod (1.11) was recorded in control plot. Significantly, maximum test weight (245.76g) was recorded in treatment combination Rhizobium+PSB 20g/kg seed + Phosphorus 60kg /ha. However, Rhizobium+PSB 20g/kg seed + Phosphorus 40 kg/ha was statistically at par with Rhizobium+PSB 20g/kg seed + Phosphorus 60kg/ha. The minimum test weight was recorded in control plot which is 194.39g.

Significantly, maximum grain yield (2.07t/ha) was recorded with Rhizobium+PSB 20g/kg seed + Phosphorus 60kg/ha. However, Rhizobium+PSB 20g/kg seed + Phosphorus 40kg/ha was statistically at par with Rhizobium+ PSB 20g/kg seed + Phosphorus 60kg/ha. The minimum grain yield (1.65t/ha) was recorded in the control plot. Significantly, maximum stover yield (3.58t/ha) was recorded in the treatment combination of Rhizobium+PSB 20g/kg seed + Phosphorus 60kg/ha. From the above study it is concluded that the Treatment 9 with Rhizobium+PSB 20g/kg seed + Phosphorus 40kg/ha was statistically at par with Rhizobium+PSB 20g/kg seed + Phosphorus 60kg/ha. The minimum stover yield (2.50t/ha) was recorded in control plot. Interaction of inoculation of biofertilizer and different levels of phosphorus was also found to be highly significant.

Application of Phosphorus + Rhizobium + PSB recorded higher value of growth as well as yield contributing characters.Similar result was given by Jarande*et al* 2006 than all other treatments. Application of phosphorus 60kg/ha significantly increased yield attributes like pods per plant, seeds per pod, test weight, seed yield and stover yield (Arya*et al* 2002, Meena*et al* 2002, Pramanik and Singh 2003). Combined effect of Rhizobium+PSB seed inoculation recorded significantly higher yield attributes than Rhizobium or PSB inoculation alone. The beneficial effect of Rhizobium and PSB inoculation was also reported by Singh *et al* 2011 observed significantly higher seed yield of chickpea with rhizobium inoculation than untreated treatment.

Table 4: Effect of Biofertilizer and Phosphorus on Yield attributes of Chickpea

S.No	Treatments	Pods/plant (No)	Seeds/pod (No.)	Test weight (g)	Seed Yield (t/ha)	Stover Yield (t/ha)
1	Rhizobium+Phosphorus 20kg/ha	29.74	1.33	197.83	1.67	2.57
2	Rhizobium+Phosphorus 40kg/ha	28.84	1.22	203.81	1.83	2.98
3	Rhizobium+Phosphorus 60kg/ha	31.74	1.56	229.89	1.92	3.26
4	PSB+Phosphorus 20kg/ha	28.19	1.11	218.58	1.87	2.78
5	PSB+Phosphorus 40kg/ha	30.94	1.11	198.86	1.69	2.61
6	PSB+Phosphorus 60kg/ha	27.17	1.22	212.48	1.88	2.84
7	Rhizobium+PSB+Phosphorus 20kg/ha	29.26	1.11	206.18	1.72	2.75
8	Rhizobium+PSB+Phosphorus 40kg/ha	32.86	1.78	237.04	1.98	3.47
9	Rhizobium+PSB+Phosphorus 60kg/ha	34.29	1.89	245.76	2.07	3.58
10	Control	26.65	1.11	194.39	1.65	2.50
	F test	S	S	S	S	S
	SEm(±)	0.49	0.12	5.29	31.39	66.01
	CD (P=0.05)	1.46	0.36	15.72	93.27	196.1
	CV(%)	2.84	15.61	4.27	2.96	3.89

4. CONCLUSION

From the above study it is concluded that the Treatment 9 with Rhizobium+PSB + Phosphorus 60kg/ha gave best results and performed better in growth and yield parameters of chickpea. It was found more productive, when compared to other treatments. As it was more productive, it can be recommended to farmers after further trails.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Overall view of chickpea field in Crop Research Farm at SHUATS.