

The role of Biofertilizers and Phosphorus on Growth and Yield of Chickpea (*Cicer arietinum* L.)

ABSTRACT

An agronomic investigation to study the response of Biofertilizers and Phosphorus in chickpea crop. Experiment was conducted during *Rabi* season of year 2023 at Crop Research Farm, Department of Agronomy. The treatments consisted of three levels of Biofertilizers (PSB-20, Rhizobium-20, and Rhizobium+PSB-20g/kg seed) and 3 levels of Phosphorus (30, 45, 60 kg/ha) along with RDF control (20-40-20 kg N-P-K/ha). The experiment was laid out in Randomized Block Design with three replications. 10 treatments viz. T₁-Phosphorus 30 kg/ha + PSB 20g/kg seed, T₂- Phosphorus 30 kg/ha + Rhizobium 20g/kg seed, T₃- Phosphorus 30 kg/ha + *Rhizobium* 20g/kg seed + PSB 20g/kg seed, T₄- Phosphorus 45 kg/ha + PSB 20g/kg seed, T₅- Phosphorus 45 kg/ha + *Rhizobium* 20g/kg seed, T₆ - Phosphorus 45 kg/ha *Rhizobium* 20g/kg seed + PSB 20g/kg seed, T₇- Phosphorus 60 kg/ha+ PSB 20g/kg seed, T₈- Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed, T₉- Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed + PSB 20g/kg seed and T₁₀- Control. Application of Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed + PSB 20g/kg seed (Treatment 9) was recorded highest growth attribute (plant height, maximum plant dry weight, no. of nodules, CGR and RGR) and yield attribute (pods per plant, seeds per pod and test weight) along with produced higher seed yield (20.71 kg/ha), straw yield (4147.13 kg/ha) and harvest index (28.98%).

Keywords: Biofertilizers, chickpea, phosphorus, rhizobium, growth and yield attribute

INTRODUCTION

Pulses play a pivotal role and occupy a unique position in Indian agriculture. It provides protein rich diet to vegetarian mass of the country. Chickpea (*Cicer arietinum* L.) belongs to the family Leguminosae. It is also known as Gram, Bengal gram and king of pulses but its vernacular name is “Channa” which is an important pulse crop grown in northern India during *Rabi* season. Chickpea is the most important seed legume and improving its yield and quality is a necessity. It is mainly grown as a rain-fed crop during the *Rabi* season on conserved soil moisture from the preceding monsoon (Singh *et al.* 2011). The desi type however, is more prominent – it accounts for close to 80-85% and the kabuli type around 15-20% of the world’s total production. India produces mostly the desi type chickpeas.

Chickpea is a major *Rabi* pulse crop and is largely grown in marginal and sub marginal lands of semi-arid tropics, which are characterized by poor fertility status and moisture stress. Chickpea is grown in about 50 countries around the world covering an area of 149.66 lakh ha with an average global productivity of 1252 kg/ha. In India pulses are grown nearly in 28.83 m ha with an annual production of 25.72 m t and productivity of 0.8 t ha. Some of the states like Uttar Pradesh is about 8.24 m ha with an annual production of 9.97 m t and productivity of 1.08 t ha major producer of chickpea in India as advocated by Ministry of agriculture and Farmers Welfare. (GOI, 2020-21). India is the leading producer of chickpea contributing to about 70% of the world's chickpea production. In India, Madhya Pradesh (39%), Maharashtra (14%), Rajasthan (14%), Uttar Pradesh (7%), Karnataka (6%), and Gujarat (5%) are the major chickpea growing states.

Chickpea is an excellent source of protein (18-22%), carbohydrates (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron etc.) and vitamins. It is an excellent animal feed and its straw has good forage value (Prasad, 2012).

The role of Bio-fertilizers is also well recognized which supplies macro and micro nutrients necessary for the plant growth. Bio-fertilizers also develops a sustainable agriculture system by maintaining soil fertility, soil physical properties, ecological balance and providing stability to the production without polluting soil, water and air. Biofertilizers- a cost-effective renewable energy source play a crucial role in reducing the inorganic fertilizer application and at the same time increasing the crop yield besides maintaining soil fertility. *Rhizobium* is unique in that they are the only nitrogen-fixing bacteria living in a symbiotic relationship with legumes. The productivity of leguminous crops in dry land could be improved by *Rhizobium* inoculation (Abdelganiet al. 2003). *Rhizobium* multi strain inoculation significantly increased dry weight of shoots, roots and nodules and number of nodules of chickpea. *Rhizobium* sp. to control the chickpea diseases has also been reported (Arfaoui et al. 2006). Chickpea is a major pulse crop in India. There is a good possibility to increase its production by exploiting better colonization of the roots and rhizospheres through application of effective nitrogen fixing bacteria to the seed or to the soil. This can minimize uses of nitrogenous fertilizer, which is very costly in this country. Using high yielding varieties of chickpea along with use of effective rhizobial strains can enhance the yield (Bhuyan et al. 2008). Use of PSB culture increase nodulation, crop growth, nutrient uptake and crop yield. phosphate solubilizing bacterial (PSB) inoculants play an important role in making P available to crop plants as they increase the yield *Rhizobium* and phosphate solubilizing bacteria (PSB) had shown advantage in enhancing chickpea productivity. The enhanced root

development and nodulation through application of phosphorus helps in improving the supply of nutrients and water to the growing parts resulting in more dry matter production in chickpea (**Das et al. 2008**). Phosphorus also plays a key role in pod filling and ultimately enhances the grain yield. The nitrogen-fixing capability of legumes can be enhanced by the supply of adequate amounts of nutrients, especially phosphorus (P) and sulphur (S) (**Islam et al. 2011**). The addition of phosphorus in these crops also provides shoot hardiness, photosynthesis regulation, enhances nodulation, improved grain quality and plant growth, ultimately superior yields (**Kumar et al, 2016**).

MATERIALS AND METHODS

The experiment was conducted during the *Rabi* season 2023, at the Crop Research Farm (CRF), Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) which is located at 25° 39' 42" N latitude, 81° 67' 56" E longitude, and 98 m altitude above the mean sea level (MSL). This area is situated on the right side of the river *Yamuna* by the side of Allahabad Rewa Road about 5 km away from Prayagraj (U.P.) city. This farm has sufficient irrigation facilities accessible. The lowest 7.6 temperature during the growing season is between and 18.6°C, while the highest temperature during that time is between 18.6 and 35°C. During the cropping period, relative humidity ranged from 38.75 to 94.57 percent. The experiment was laid out in Randomized Block Design with three replications. 10 treatments *viz.* T₁-Phosphorus 30 kg/ha + PSB 20g/kg seed, T₂ – Phosphorus 30 kg/ha + *Rhizobium* 20g/kg seed, T₃ – Phosphorus 30 kg/ha + *Rhizobium* 20g/kg seed + PSB 20g/kg seed, T₄– Phosphorus 45 kg/ha + PSB 20g/kg seed, T₅– Phosphorus 45 kg/ha + *Rhizobium* 20g/kg seed, T₆ – Phosphorus 45 kg/ha *Rhizobium* 20g/kg seed + PSB 20g/kg seed, T₇– Phosphorus 60 kg/ha+ PSB 20g/kg seed, T₈– Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed, T₉ – Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed + PSB 20g/kg seed and T₁₀– Control. All plots of experiment were equally fertilized with recommended dose of fertilizers. Fertilizers were applied at 3-5cm deep furrows were made along the seed rows with a hand hoe. The nutrient source was Urea, MOP to fulfill the requirement of nitrogen, phosphorous and potassium. The recommended dose of N 20 kg/ha, P 40 kg/ha and K 20 kg/ha were applied according to the treatment details. Nitrogen, phosphorus and potash was applied as basal at the time of sowing. Seed treatment with *Rhizobium*, PSB will be done before 24 hours of sowing according to the treatment details. The soil at the test location was sandy loam, with medium amounts of organic carbon (0.62 %), available nitrogen (225 kg ha⁻¹), available phosphorus (38.2 kg ha⁻¹), and available potash (240.7 kg ha⁻¹) with a moderate response that was somewhat alkaline (8 pH). Seeds were sown in line manually on 7th

November 2023 at a depth of 3 cm in furrows with seed rate of 80 kg/ha. Seeds are covered with soil immediately after sowing the seeds. The spacing of crop between row-row and plant to plant was 30x10 cm. The data recorded for different characteristics were subjected to statistical analysis by adopting the method of analysis of variance (ANOVA) as described by **Gomez and Gomez (1984)**.

RESULTS AND DISCUSSION

Effect of Biofertilizer and Phosphorus on growth attributing characters in chickpea.

At 100 DAS, significantly and higher plant height (66.87 cm) and dry weight (18.49g/plant) was recorded with Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed + PSB 20g/kg seed (Table 1). However, the treatment Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed was found to be statistically at par with treatment 9. Plant height with *Rhizobium* and PSB might be due to increase in uptake of N and P by the plants, which might be due to more N-fixation and P-solubilization through micro-organisms. Similar findings also reported earlier by (**Patel et al. 2022 and Singh et al. (2018)**). Significantly maximum number of nodules per plant (21.66, 31.99 and 29.55 at 40, 60 and 90 DAS respectively) was recorded with application of Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed + PSB 20g/kg seed. However, treatment Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed was found statistically at par with Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed + PSB 20g/kg seed. Application of *Rhizobium*, increase the number of nodules by availability of nitrogenase enzyme PSB facilitates the nodule formation by proper development of nodules by increasing availability of phosphorus through the mobilizing the unavailable phosphorus present in soil **Singh et al. (2018)**.

Effect of Biofertilizer and Phosphorus on Crop Growth Rate (Table 2) at 20-40, 40-60 and 60-80 DAS were found no significant difference to used various treatments. However, at 80-100 DAS, was recorded significantly maximum crop growth rate (37.23 g/m²/day) with Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed. Significantly higher RGR recorded (0.4, 0.07 and 0.03 g/g/day at 20-40, 40-60 and 80-100 DAS respectively) with Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed. CGR and RGR were higher might be due to application of Phosphorus which increased the chlorophyll content and higher photosynthates. Similar finding also reported by (**Kumar et al. 2019 and Chauhan et al. 2017**)

Effect of Biofertilizer and Phosphorus on yield and yield attributing characters in chickpea.

Increases in growth-related characters eventually showed up in yield-related characters viz. number of pod/plants, number of seeds/pod and test weight (Table. 3); which were recorded

higher (67.60, 2.20 and 42.2g respectively) with T₉(Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed + PSB 20g/kg seed). Higher number of pod/plants, number of seeds/pod and test weight were recorded with the application of phosphorus which it might be the reason of moderate plant nutrients availability due to which the plant produces more number of pod/plants, number of seeds/pod and test weight as compared to other treatments and also phosphorus strongly increases the reproduction of the plants i.e., flowering and fruiting. These results were similar with that of **Abidet *et al.* (2017)**.

The benefits of Biofertilizer and Phosphorus on different yield-contributing traits such as *viz.* pod/plants, number of seeds/pod and test weight & growth characters (plant height, number of nodules, CGR, RGR and dry matter accumulation) resulted in Higher grain yield, straw yield, and harvest index (2071 kg/ha, 4147.13kg/ha and 28.98% respectively). Effect of Biofertilizer and Phosphorus on yield and yield attributing characters have been also reported by **(Singh *et al.* 2014 and Choubey *et al.* 2013)**.

CONCLUSION

It can be concluded from the present investigation that Biofertilizer and Phosphorus with Phosphorus 60 kg/ha+ *Rhizobium* 20g/kg seed + PSB 20g/kg seed was recorded maximum growth & yield attributing characters along with yield of chickpea.

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UNDER PEER REVIEW

Table no. 1 Effect of Biofertilizer and Phosphorus on growth attributing characters in chickpea.

Treatments	Plant height at 100 DAS	Dry weight at 10 DAS	Number of nodules		
			40DAS	60DAS	80DAS
T ₁ -Phosphorus 30kg/ha+PSB20g/kgseed	60.31	17.05	16.23	25.78	21.01
T ₂ -Phosphorus 30kg/ha+ <i>Rhizobium</i> 20g/kgseed	63.90	17.11	17.20	24.81	22.45
T ₃ -Phosphorus 30kg/ha+ <i>Rhizobium</i> 20g/kgseed+PSB20g/kgseed	64.18	17.80	17.27	27.92	23.60
T ₄ -Phosphorus 45kg/ha+PSB20g/kgseed	61.31	17.54	18.00	28.45	24.23
T ₅ -Phosphorus 45kg/ha+ <i>Rhizobium</i> 20g/kgseed	64.48	17.84	18.21	25.36	22.92
T ₆ -Phosphorus 45kg/ha+ <i>Rhizobium</i> 20g/kgseed+PSB20g/kgseed	65.62	17.93	18.63	26.14	23.86
T ₇ -Phosphorus 60kg/ha+PSB20g/kgseed	62.58	16.89	19.67	29.33	26.26
T ₈ -Phosphorus 60kg/ha+ <i>Rhizobium</i> 20g/kgseed	66.27	18.07	20.53	29.00	26.63
T ₉ -Phosphorus 60kg/ha+ <i>Rhizobium</i> 20g/kgseed+PSB20g/kgseed	66.87	18.49	21.66	31.99	29.55
Control	58.78	16.82	14.57	24.11	22.68
SE m _±	0.64	0.23	1.25	1.27	0.91
C.D. at 5%	1.90	0.71	3.72	3.78	2.70

Table no. 2 Effect of Biofertilizer and Phosphorus on CGR and RGR in chickpea.

Treatments	CGR				RGR			
	20-40DAS	40-60DAS	60-80DAS	80-100DAS	20-40DAS	40-60DAS	60-80DAS	80-100DAS
T ₁ -Phosphorus30kg/ha+PSB20g/kgseed	2.88	8.71	9.60	3.96	0.04	0.05	9.60	0.01
T ₂ -Phosphorus30kg/ha+ <i>Rhizobium</i> 20g/kgseed	2.89	9.33	9.55	3.48	0.04	0.05	9.55	0.01
T ₃ -Phosphorus30kg/ha+ <i>Rhizobium</i> 20g/kgseed+PSB20g/kgseed	2.91	9.39	9.04	5.22	0.04	0.05	9.04	0.02
T ₄ -Phosphorus45kg/ha+PSB20g/kgseed	2.79	9.61	9.35	4.79	0.04	0.05	9.35	0.01
T ₅ -Phosphorus45kg/ha+ <i>Rhizobium</i> 20g/kgseed	2.84	9.40	9.46	4.77	0.04	0.05	9.46	0.01
T ₆ -Phosphorus45kg/ha+ <i>Rhizobium</i> 20g/kgseed+PSB20g/kgseed	2.86	9.26	9.64	5.10	0.03	0.05	9.64	0.01
T ₇ -Phosphorus60kg/ha+PSB20g/kgseed	2.88	9.36	9.55	2.99	0.04	0.05	9.55	0.01
T ₈ -Phosphorus60kg/ha+ <i>Rhizobium</i> 20g/kgseed	2.98	9.36	9.33	5.37	0.03	0.06	9.33	0.01
T ₉ -Phosphorus60kg/ha+ <i>Rhizobium</i> 20g/kgseed+PSB20g/kgseed	2.86	9.33	9.85	5.28	0.04	0.07	9.85	0.03
Control	2.72	9.28	8.65	5.23	0.03	0.04	8.65	0.01
SE m _±	0.06	0.19	0.44	0.48	0.002	0.0008	0.0011	0.0009
C.D. at 5%	NS	NS	NS	1.45	0.006	0.002	NS	0.002

Table no. 3 Effect of Biofertilizer and Phosphorus on yield and yield attributing characters in chickpea.

Treatments	No. of pods /plant	Number of seeds/pod	Test weight (g)	Seed Yield (kg/ha)	Straw Yield (kg/ha)	Harvest index (%)
T ₁ -Phosphorus 30kg/ha+PSB20g/kgseed	49.30	1.75	39.3	1225.18	2956.10	23.49
T ₂ -Phosphorus 30kg/ha+ <i>Rhizobium</i> 20g/kgseed	50.6	1.88	40.6	1275.06	3695.23	25.89
T ₃ -Phosphorus 30kg/ha+ <i>Rhizobium</i> 20g/kgseed+PSB20g/kgseed	53.73	1.90	40.9	1305.00	3757.03	21.26
T ₄ -Phosphorus 45kg/ha+PSB20g/kgseed	52.8	1.94	39.6	1339.57	3024.01	25.90
T ₅ -Phosphorus 45kg/ha+ <i>Rhizobium</i> 20g/kgseed	56.46	1.95	41.5	1508.01	3847.30	22.67
T ₆ -Phosphorus 45kg/ha+ <i>Rhizobium</i> 20g/kgseed+PSB20g/kgseed	58.06	1.90	41.6	1514.00	3992.18	22.78
T ₇ -Phosphorus 60kg/ha+PSB20g/kgseed	58.73	1.92	39.7	1477.17	3161.07	32.22
T ₈ -Phosphorus 60kg/ha+ <i>Rhizobium</i> 20g/kgseed	64.33	1.97	41.8	1748.00	4074.11	27.57
T ₉ -Phosphorus 60kg/ha+ <i>Rhizobium</i> 20g/kgseed+PSB20g/kgseed	67.60	2.20	42.2	2071.10	4147.13	28.98
Control	48.80	1.35	39.6	1149.09	2667.05	26.24
SE m±	2.53	0.14	1.17	0.78	40.15	1.3
C.D. at 5%	7.52	0.42	NS	2.32	119.29	3.15