Original research article

"Evaluation of growth and yield of Chickpea (*Cicer arietinum* L.) influenced by Biofertilizers and Phosphorus"

ABSTRACT

The field experiment entitled "Evaluation of growth and yield of Chickpea (*Cicer arietinum* L.) influenced by Biofertilizers and Phosphorus" was conducted during *rabi* season, 2022 at Crop Research Farm in the Department of agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj Uttar Pradesh. The treatment consisted of three levels of Biofertilizer *Rhizobium*, PSB and *Rhizobium* + PSB Phosphorus (20, 40 and 60 kg/ha) and control. The experiment was layout in Randomized Block Design (RBD) with 10 treatments and replicated thrice. Application of (*Rhizobium* + PSB + Phosphorus 60 kg/ha) produces higher plant height (48.85 cm), maximum number of nodules/plant (23.73) and higher dry weight (36.87 g), maximum number of pods/plant (49.67), maximum number of grains/pod (1.93), higher seed yield (1537.20 kg/ha), straw yield (3195.12 kg/ha).

Keywords: Chickpea, Biofertilizer, Phosphorus, growth and yield.

Introduction

The importance of pulses is crucial, and they hold a special place in Indian agriculture.

It offers a diet high in protein to the nation's vegetarian majority. *Leguminosae* is the family to which the chickpea (*Cicer arietinum* L.) belongs. It is often referred to as Bengal gram, gram, and the king of pulses. During the *Rabi* (winter) season, it is mostly grown as a rain-fed crop using stored soil moisture from the previous monsoon **(Singh *et al.* 2011)**. Desi chickpea (chromosome number 2n = 14, 16) and *Kabuli* chickpea (chromosome number 2n = 16) are the two types of chickpea.

Protein (18–22%), carbohydrate (52–70%), fat (4–10%), minerals (calcium, phosphorus, iron etc.), and vitamins are all abundant in chickpeas. It makes a superior source of animal feed, and the straw has good forage value **(Prasad 2012)**.

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. 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. 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).**

The importance of bio-fertilizers, which provide the macro and micronutrients required for plant growth, is also well acknowledged. By preserving soil fertility, soil physical qualities, ecological balance, and providing stability to the production without contaminating soil, water, or air, bio-fertilizers also help to establish a sustainable agriculture system. Crop productivity and nutrient use efficiency are increased when biofertilizers are used in conjunction with chemical fertilizers, organic manures, and crop wastes **(Mahajan *et al.*, 2003)**. The efficient use of fertilizers is greatly improved by the use of biofertilizers. *Rhizobium*-inoculated pulse seeds are seeded in such soils, which boosts the rhizosphere's population. *Rhizobium* and pulse plants work together to increase soil fertility. Living microorganisms are present in bio-fertilizers, which improve soil biochemistry and reduce pathogens.

Rhizobium is special because it is the only nitrogen-fixing bacterium that coexists symbiotically with legumes. *Rhizobium* inoculation may increase the production of leguminous crops grown on dry soil **(Abdelgani *et al.* 2003)**. The number of nodules and dry weight of the chickpea shoots, roots, and nodules were considerably increased after *Rhizobium* multi strain inoculation. It has also been shown that

Rhizobium sp. can suppress chickpea illnesses **(Arfaoui *et al*. 2006)**. In India, chickpeas are a significant pulse crop. By utilizing improved root and rhizosphere colonization caused by the addition of potent nitrogen-fixing bacteria to the seed or soil, there is a good chance that production will increase. This can reduce the amount of nitrogenous fertilizer used, which is quite expensive in this nation.

According to **Rudresh *et al*. (2005)**, *Rhizobium* and phosphate solubilizing bacteria (PSB) have advantages in boosting chickpea productivity. Plant nutrients can be obtained via microbial inoculants, which are affordable, environmentally benign, and renewable **(Khan *et al*. 2007)**. Due to their crucial roles in N_2-fixation and P-solubilization, *Rhizobium* and PSB acquire a significant amount of significance.

Phosphorus (P) is regarded as one of the most crucial nutrients for plants **(Nosheen and Shafique 2006)**. In chickpea, phosphorus has a sizable impact on nodule growth, plant height, branches/plant, pods/plant, grain yield, and harvest index (HI) **(Singh *et al*. 2010)**. Phosphorus application helps improve the availability of nutrients and water to the growing sections, resulting in improved root development and nodulation, which increases the production of dry matter in chickpea **(Das *et al*. 2008)**. Additionally, phosphorus is essential for pod filling, which eventually increases grain output. By providing sufficient amounts of nutrients, particularly phosphorus (P) and sulphur (S), legumes' ability to fix nitrogen can be improved **(Islam *et al*. 2011)**.

The addition of phosphorus to these crops also increases nodulation, improves grain quality, and promotes plant growth, all of which lead to higher yields **(Kumar *et al*., 2016)**.

2. MATERIALS AND METHODS

This experiment was laid out during the *Rabi* season of 2022 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The crop research farm is situated at 25^0 39” 42” N latitude, 81^0 67” 56” E longitude and at an altitude of 98 m above mean sea level. The experiment was laid out in Randomized Block Design Which consisting of ten treatments with T_1 – *Rhizobium* + Phosphorus 20 kg/ha, T_2 – PSB + Phosphorus 20 kg/ha, T_3 – *Rhizobium* + PSB + Phosphorus 20 kg/ha, T_4 - *Rhizobium* + Phosphorus 40 kg/ha, T_5 - PSB + Phosphorus 40 kg/ha, T_6 - *Rhizobium* + PSB + Phosphorus 60 kg/ha, T_7 - *Rhizobium* + Phosphorus 60 kg/ha, T_8 - PSB + Phosphorus 60 kg/ha, T_9 - *Rhizobium* + PSB + Phosphorus 60 kg/ha, T_{10} - Control (RDF 20-50-20).The soil in the experimental area was sandy loam with pH (8.0), Organic Carbon (0.42%), Available N (180.58 kg/ha), Available P (15.54 kg/ha), and Available K (198.67 kg/ha). Seeds are sown at a spacing of 30×10 cm^2 to a seed rate of 80 kg/ha. The recommended dose of nitrogen (20 kg/ha), phosphorus (50 kg/ha) and potassium (20 kg/ha) and Biofertilizer and phosphorus were applied as per the treatments. Data recorded on different aspects of crop, *viz.*, growth, yield attributes were subjected to statistically analysis by analysis of variance method. (**Gomez and Gomez, 1976)** and economic data analysis mathematical method.

RESULT AND DISCUSSION:

Growth parameters

Plant height (cm)

The data revealed that a significantly and higher plant height (48.85 cm) was recorded in treatment 9 [*Rhizobium* + PSB + Phosphorus (60 kg/ha)]. However, the treatment 6 [*Rhizobium* + PSB + Phosphorus (40 kg/ha)] (48.13 cm), treatment 3 [*Rhizobium* + PSB + Phosphorus (20 kg/ha)] (47.07 cm), treatment 8 [PSB + Phosphorus (60 kg/ha)] (46.09 cm), treatment 2 [PSB+ Phosphorus (20 kg/ha)] (45.25 cm), treatment 7 [*Rhizobium* + Phosphorus (60 kg/ha)] (44.79 cm) were found to be statistically at par with treatment 9 [*Rhizobium* + PSB + Phosphorus (60 kg/ha)] in (Table 1).

Significant increase in 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 **Singh *et al.* (2018).** Further application of phosphorus (60 kg/ha) may be due to the stimulating effect of phosphorus on plant process as phosphorus is a major constituent of plant cell nucleus and growing root tips which help in cell division and root elongation which results in vigorous growth of plants and extension root system leading to increase in growth parameters. Similar findings were observed by **Choudhary *et al.* (2005)**

Number of nodules/plant

The data revealed that a significant and maximum number of nodules/plant (23.73) was recorded in treatment 9 [*Rhizobium* + PSB + Phosphorus (60kg/ha)]. However, treatment 6 [*Rhizobium* + PSB + Phosphorus (40 kg/ha)] (23.27) treatment 3 [*Rhizobium* + PSB + Phosphorus (20 kg/ha)] (22.33), treatment 7 [*Rhizobium* + Phosphorus (60 kg/ha)] (22.27) and treatment 8 [PSB+ Phosphorus (60 kg/ha)] (21.93) were found to be statistically at par with treatment 9 [*Rhizobium* + PSB + Phosphorus (60 kg/ha)] in (Table 1).

Significant and maximum number of nodules/plant was with 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).**

At harvest the significant and maximum number of nodules per plant was with application of phosphorus (50 kg/ha) might be due to with increased levels of P function in most of the physiological and metabolic processes resulting in increased growth and development, resulting in higher plants height. Similar result was also reported by **Yumnam *et al.* (2018).**

Plant dry weight

The data revealed that significant and maximum plant dry weight (36.87 g) was recorded in treatment 9 [*Rhizobium* + PSB + Phosphorus (60kg/ha)]. However, the treatment 6 [*Rhizobium* + PSB + Phosphorus (40kg/ha)] (35.82 g), treatment 3 [*Rhizobium* + PSB + Phosphorus (20kg/ha)] (34.11 g), treatment 7 [*Rhizobium* + Phosphorus (60 kg/ha)] (34.09) and treatment 5 [PSB+ Phosphorus (40 kg/ha)] (33.20 g) was statistically at par with treatment 9 [*Rhizobium* + PSB + Phosphorus (60kg/ha)] in (Table 1).

Significant and maximum number of dry weight was with application of *Rhizobium*, increase the dry matter by availability of nitrogenase enzyme PSB increasing the Dry matter production from advanced growth stages to at harvest in which seed treatment with *Rhizobium* had fixed atmospheric nitrogen in the soil into available forms and PSB increased availability of phosphates to plants by mineralizing organic phosphorus compounds. The results are in accordance with **Singh *et al*., (2018)**. Further application of phosphorus (60 kg/ha) being an energy bond compound and its major role is transformation of energy essential for almost all metabolic processes photosynthesis, respiration, cell elongation and cell division, activation of amino acids for synthesis of protein and carbohydrate metabolism which ultimately increase all the growth attributes and dry weight of plants. Similar results have been reported by **Singh *et al*., (2010)**.

Number of pods/plant

The data revealed that Treatment 9 [*Rhizobium* + PSB + Phosphorus (60 kg/ha)] was recorded significant and maximum number of pods/plant (49.67) which was superior over all other treatments. However, the treatment 6 [*Rhizobium* + PSB + Phosphorus (40 kg/ha)] and treatment 3 [*Rhizobium* + PSB + Phosphorus (20 kg/ha)] treatment 5 [PSB (20 g/kg seed) + Phosphorus (40 kg/ha)], treatment 7 [*Rhizobium* + Phosphorus (60kg/ha)], treatment 4 [*Rhizobium* + phosphorus 40 kg/ha)] and treatment 8 [PSB (20g/kg seed + phosphorus 60 kg/ha], was found to be statistically at par with the treatment 9[*Rhizobium* + PSB + Phosphorus (60kg/ha)] (Table 2).

Significant and higher number of pods/plants was with the application of phosphorus which it might be the reason of moderate plant nutrients availability due to which the plant produces more pods/plant as compare 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 **Abid *et al.*, (2017)**.

Number of seeds/pod:

The data revealed that Treatment 9 [*Rhizobium* + PSB (10 g/kg seed + 10 g/kg seed) + Phosphorus (60 kg/ha)] was recorded significant and maximum number of seeds/pod (1.93) which was superior over all other treatments. However, the treatment 6 [*Rhizobium* + PSB (10 g/kg seed + 10 g/kg seed) + Phosphorus (40 kg/ha)], treatment 3 [*Rhizobium* + PSB (10 g/kg seed + 10 g/kg seed) + Phosphorus (20 kg/ha)] and treatment 5 [PSB (20 g/kg seed) + Phosphorus (40kg/ha)] was found to be statistically at par with the treatment 9 [*Rhizobium* + PSB (10 g/kg seed + 10 g/kg seed) + Phosphorus (60 kg/ha) in (Table 2).

Significant and higher number of seed/plants was 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 seed/pod is a genetically controlled character and the difference among genotypes was due to their different genetic ability for this parameter. Similar results also reported by **Rahman *et al.*, (2013)**.

Seed Yield (kg/ha):

The data revealed that Treatment 9 [*Rhizobium* + PSB + Phosphorus (60 kg/ha)] was recorded significantly maximum Seed yield (1537.20 kg/ha) which was superior over all other treatments. However, the treatment 6 [*Rhizobium* + PSB + Phosphorus (40 kg/ha)], treatment 3 [*Rhizobium* + PSB + Phosphorus (20 kg/ha)] were found to be statistically at par with the treatment 9 [*Rhizobium* + PSB + Phosphorus (60 kg/ha)] in (Table 2).

Significant increase in seed yield might be due to the Dual inoculation of *Rhizobium* can increase seed yield in pulse crop up to 10 to 15% while PSB increase availability of insoluble phosphorous into soil. Results were similar to **Singh *et al.* (2018)**. Further seed yield was with application of phosphatic fertilizer therefore provided balance nutrition to the crop which resulted in higher seed yield of lentil. Phosphorus also increased the photosynthesis and translocation of assimilates to different plant parts for enhanced growth and yield attributing characters of the crop as observed in number of pods per plant and number of seeds per pod. In the later stage, the excess assimilates stored in the leaves was translocated towards sink development which ultimately contributed to higher seed yield. These findings were supported by **Choubey *et al*., (2013)**.

Stover yield (kg/ha):

The data revealed that Treatment 9 [*Rhizobium* + PSB + Phosphorus (60 kg/ha)] was recorded significantly maximum Stover yield (3195.12 kg/ha) which was superior over all other treatments. However, the treatment-6 [*Rhizobium* + PSB + Phosphorus (40 kg/ha)], 3 [*Rhizobium* + PSB + Phosphorus (20 kg/ha)], treatment 4 [*Rhizobium* + phosphorus 40 kg/ha)] and treatment 8 [PSB + phosphorus 60 kg/ha] and treatment 5 [PSB + Phosphorus (40 kg/ha)] was found to be statically at par with treatment-9 [*Rhizobium* + PSB + Phosphorus (60 kg/ha)] in (Table 2).

Significant increase in stover yield with Dual inoculation of *Rhizobium*, PSB increase in nitrogen availability in soil leads to increase in content of nitrogen in seed and increase in P availability through solubilization of insoluble native P and production of plant growth promoting substances. Results were similar to **(Singh *et al*., 2014)**. Significant and higher stover yield was with application of phosphorus might have contributed for better growth of plant as expressed in terms of plant height, number of nodules/plants, dry weight, which improved nutrient uptake, resulted increased in stover yield. Similar findings were reported by **Choubey *et al*., (2013)**.

CONCLUSION:

Based on the above findings it can be concluded that Chickpea with the application of *Rhizobium* + PSB along with the application of Phosphorus 60 kg/ha (Treatment 9) recorded highest plant height, no. of nodules, dry weight, no. of pods/plant, no. of seeds/pod, seed yield and stover yield.

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Table: 1 Effect of Biofertilizer and Phosphorus on growth of Chickpea.

S.No.	Treatment combinations	At 80 DAS		
		Plant height (cm)	Number of nodules/plant	Dry weight (g/plant)
1.	*Rhizobium* + Phosphorus 20 kg/ha	43.44	20.60	30.60
2.	PSB + Phosphorus 20 kg/ha	45.25	20.73	29.42
3.	*Rhizobium* + PSB + Phosphorus 20 kg/ha	47.07	22.33	34.11
4.	*Rhizobium* + Phosphorus 40 kg/ha	44.08	21.13	32.74
5.	PSB + Phosphorus 40 kg/ha	42.66	20.40	33.20
6.	*Rhizobium* + PSB + Phosphorus 40 kg/ha	48.13	23.27	35.82
7.	*Rhizobium* + Phosphorus 60 kg/ha	44.79	22.27	34.09
8.	PSB + Phosphorus 60 kg/ha	46.09	21.93	32.42
9.	*Rhizobium* + PSB + Phosphorus 60 kg/ha	48.85	23.73	36.87
10.	Control (NPK 20-50-20 kg/ha)	39.85	19.93	28.42
	F-test	S	S	S
	SEm(±)	1.50	0.65	1.37
	CD (p=0.05)	4.44	1.94	4.07

Table: 2 Effect of Biofertilizer and Phosphorus on yield attributes and yield of Chickpea

S.No.	Treatment combination	Number of pods/plants	Number of seeds/pod	Seed Yield (kg/ha)	Stover Yield (kg/ha)
1.	*Rhizobium* + Phosphorus 20 kg/ha	44.53	1.53	1163.78	2802.96
2.	PSB + Phosphorus 20 kg/ha	43.13	1.47	1195.68	2843.36
3.	*Rhizobium* + PSB + Phosphorus 20 kg/ha	48.27	1.67	1383.03	3086.92
4.	*Rhizobium* + Phosphorus 40 kg/ha	46.93	1.47	1245.45	2925.04
5.	PSB + Phosphorus 40 kg/ha	45.87	1.60	1355.80	2953.61
6.	*Rhizobium* + PSB + Phosphorus 40 kg/ha	48.73	1.80	1416.56	3142.4
7.	*Rhizobium* + Phosphorus 60 kg/ha	45.73	1.53	1202.97	2912.16
8.	PSB + Phosphorus 60 kg/ha	46.47	1.40	1294.87	3040.72
9.	*Rhizobium* + PSB + Phosphorus 60 kg/ha	49.67	1.93	1537.20	3195.12
10.	Control (NPK 20-50-20 kg/ha)	41.53	1.33	1145.42	2714.23
	F-test	S	S	S	S
	SEm(±)	1.35	0.12	54.72	89.90
	CD (p=0.05)	4.01	0.35	162.57	267.07

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