

Original Research Article

**Response of Biofertilizer and Foliar Spray of Boron on Growth and Yield of Chickpea
(*Cicer arietinum* L.)**

ABSTRACT

A field experiment was conducted at Crop Research Farm, Naini Agriculture Institute, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during Rabi, 2022 on sandy loamy soil. The experiment was laid out in Randomized Block Design, Replicated thrice, consisting of ten treatments *i.e.*, *Rhizobium* 20 g + Boron 0.25%, *Rhizobium* 20 g + Boron 0.5 %, *Rhizobium* 20 g + Boron 0.75 %, PSB 20 g + Boron - 0.25 %, PSB 20 g + Boron - 0.5 %, PSB 20 g + Boron - 0.75 %, *Rhizobium* 10 g + PSB 10 g + Boron - 0.25 %, *Rhizobium* 10 g + PSB 10 g + Boron - 0.5 %, *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 %, and Control Plot. The field experiment result revealed that *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 % has significantly increased the growth parameters *viz.*, Plant height (46.54 cm), Number of nodules/plant (16.44), Plant dry weight (15.37 g/plant), pods/plant (55.61), seeds/pod (2.52), test weight (265.6 g), Seed yield (1.99 t/ha), Stover yield (5.95 t/ha) and Harvest index (25.06%). The economics of experiment, *i.e.*, maximum gross return (106464.00 INR/ha), net return (76796 INR/ha) and B:C ratio (2.58) was also recorded in *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 %.

Key words: *Chickpea, Yield Attributes, Growth, Yield, Rabi, U.P.*

Introduction:

"Pulses are a subset of the legume family with dry, edible seeds. They are well known for their nutritional advantages, versatility in the kitchen, and important contribution to sustainable agriculture. The advantages of eating pulses for health have been emphasized in numerous research. They have been associated with a lower chance of developing chronic illnesses like heart disease, diabetes, and some forms of cancer. In comparison to other foods high in carbohydrates, pulses are considered to have a low glycemic index, which means they raise blood sugar levels more gradually (Rebello *et. al.* 2014)".

Chickpeas are a crucial crop for the Rabi season because of their widespread acceptance and nutrient-dense uses. Chickpeas, scientifically known as *Cicer arietinum*, are

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one of the most widely cultivated and consumed pulses in India. Protein, fat, Fiber, and mineral elements are crucial parts of a balanced nutritional diet. With a total production of 11.09 million tonnes from an area of 14.56 million ha and a productivity of 1.31 t/ha, chickpea is the fourth largest grain legume crop in the world in India. India produced 11.09 million tonnes of chickpeas in 2014, which was 40% of the world's total production. The other top producers of chickpeas in 2014 were Iran (2.6 million tonnes), Pakistan (2.3 million tonnes), and Turkey (1.9 million tonnes). Chickpeas are a major crop in India, and they are grown in a variety of states across the country. The top five chickpea producing states in India are Madhya Pradesh (3.3 million tonnes), Rajasthan (2.9 million tonnes), Maharashtra (2.8 million tonnes), Uttar Pradesh (2.7 million tonnes) and Andhra Pradesh (2.6 million tonnes). Chickpeas are a versatile crop that can be grown in a variety of soil types and climatic conditions.

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Biofertilizers are eco-friendly and sustainable alternatives to chemical fertilizers. The use of biofertilizers promotes organic farming practices and reduces the dependency on synthetic fertilizers, thereby minimizing environmental pollution and ensuring sustainable agricultural practices (Subramanian *et. al.* 2016). Biofertilizers play a crucial role in enhancing soil fertility and improving crop productivity. They contribute to nutrient cycling, improve soil structure, and promote beneficial microbial activities. The use of biofertilizers can lead to increased nutrient availability, better nutrient uptake by plants, and reduced dependence on chemical fertilizers (Yadav *et. al.* 2020).

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Boron is an essential micronutrient for plants, playing a vital role in various physiological processes. It is also necessary for the movement of sugars and other nutrients within the plant and is involved in the synthesis and utilization of carbohydrates (Bhattacharyya *et. al.* 2015). Additionally, boron is important for reproductive processes in plants. It is essential for pollen germination, pollen tube growth, and fruit and seed development. Boron deficiency can lead to abnormalities in these processes, resulting in reduced fertility and poor crop yield (Gupta *et. al.* 2013). However, it is important to note that while boron is essential for plants, excessive amounts can be toxic and detrimental to plant growth. Therefore, maintaining a proper balance of boron in the soil is crucial for optimal plant health and productivity (Goldbach *et. al.* 2001).

Comment [IA5]: Please also provide a description of the boron requirement for microorganisms.

1. MATERIALS AND METHODS:

Comment [IA6]: Experimental design and the application of treatment (biofertilizer, Boron, PSB, etc) should be described in detail, before or after sowing. The time of foliar application of boron should also be provided.

This experiment was conducted during the *rabiseason* of 2022 at the Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, (U.P.), which is located at 25° 28' 42" N latitude, 81° 50' 56" E longitude, and 98 m altitude above mean sea level. This area is located on the right bank of the *Yamuna* River, along the Prayagraj, Rewa Road, about 5 km from Prayagraj city. Organic carbon (0.87%), accessible nitrogen (225 kg/ha), phosphorus (41.8 kg/ha), and potassium (261.2 kg/ha) are the most abundant elements. The region has a semi-arid subtropical climate. Two hand weeding were performed 30 days following sowing to prevent crop-weed competition. Two irrigations were administered at 15-day intervals. The growth characteristics observations were recorded using conventional technique at 20-day intervals and displayed at 80 DAS. Yield metrics were measured on harvest day, November 20th, 2023. All of the parameters were recorded and statistically analysed using appropriate analysis of variance techniques as described by **Gomez and Gomez (1984)**.

2. RESULT AND DISSCUSSION:

3.1 Growth parameters

3.1.1 Plant height (cm)

At 80 DAS the significantly highest plant height was observed in *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 % (46.54 cm). However, *Rhizobium* 10 g + PSB 10 g + Boron - 0.5 % (45.37cm) and *Rhizobium* 10 g + PSB 10 g + Boron - 0.25 % (44.49 cm) were statistically at par with *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 %.

Boron is an essential micronutrient for plant growth and plays a vital role in cell elongation and development. Foliar application of boron can help correct boron deficiencies in plants and potentially enhance growth, including plant height (**Khoshgofarmanesh et al., 2013**).

3.1.2 Numbers of nodules/plant

At 80 DAS the significantly highest number of nodules was observed in *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 % (16.44). However, *Rhizobium* 10 g + PSB 10 g + Boron - 0.5 % (15.71) and *Rhizobium* 10 g + PSB 10 g + Boron - 0.25 % (15.27) were statistically at par with *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 %.

Biofertilizers containing nitrogen-fixing bacteria, such as *Rhizobium* species, have been reported to improve nodulation in leguminous plants, including chickpea. These beneficial bacteria form a symbiotic relationship with legumes, leading to the formation of nodules on

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the plant roots, where atmospheric nitrogen is fixed into a form that the plant can use as a nutrient (Gopalakrishnan *et al.*, 2011).

3.1.3 Plant dry Weight (g/plant)

At 80 DAS the significantly highest dry weight was observed in *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 % (15.37 g/plant). However, *Rhizobium* 10 g + PSB 10 g + Boron - 0.5 % (14.75 g/plant) and *Rhizobium* 10 g + PSB 10 g + Boron - 0.25 % (14.27 g/plant) was statistically at par with *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 %.

Biofertilizers containing beneficial microorganisms such as nitrogen-fixing bacteria and phosphate-solubilizing bacteria have been reported to improve nutrient availability and enhance plant growth in leguminous crops, including pulse crops like chickpea. Enhanced nutrient uptake can lead to increased plant biomass, which can manifest in terms of plant dry weight (Babu *et al.*, 2017).

3.2 Yield parameters:

3.2.1 Number of pods per plant

The highest pods/plant was observed in *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 % (55.61 pods/plant). However, *Rhizobium* 10 g + PSB 10 g + Boron - 0.5 % (53.37 pods/plant), and *Rhizobium* 10 g + PSB 10 g + Boron - 0.25 % (51.69 pods/plant) was statistically at par with *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 %.

Boron is known to play a significant role in flowering and fruiting processes in plants. Adequate boron availability can positively impact flower and pod development in chickpea, potentially leading to an increase in the number of pods per plant (Saha *et al.*, 2014).

Comment [IA12]: Boron may increase the growth of phosphate solubilizing bacteria which then increase phosphorus availability in soil. This subsequently improve flowering in plants. Please find literature that discusses the role of boron in the growth of bacteria.

3.2.2 Number of seeds per pod

The observations on the seeds/pod of chickpea was statistically analysed. *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 % recorded significantly higher seeds/pod (2.52 seeds/pod). However, *Rhizobium* 10 g + PSB 10 g + Boron - 0.5 % (2.09 seeds/pod) was statistically at par with *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 %.

Boron is an essential micronutrient that plays a crucial role in various physiological processes in plants, including flowering, fruiting, and seed development. Adequate boron availability can positively influence the number of seeds per pod in chickpea (Jha *et al.*, 2016).

3.2.3 Seed yield (t/ha)

The data showed the significantly highest grain yield was observed in *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 % (1.99 t/ha). However, *Rhizobium* 10 g + PSB 10 g + Boron - 0.5

% (1.79 t/ha) and *Rhizobium* 10 g + PSB 10 g + Boron - 0.25 % (1.71 t/ha) were statistically at par with *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 %.

The study by (Huda *et al.*, 2019) investigated the effect of boron on the yield and yield contributing characters of chickpea (*Cicer arietinum* L.). The results showed that boron application significantly increased the seed yield of chickpea. The highest seed yield (1.84 t/ha) was obtained with the application of boron 1.0 kg/ha, which was 22.5% higher than the control. Boron application also increased the number of pods per plant, the number of seeds per pod, and the 100-seed weight. The authors concluded that boron application is an effective way to improve the yield and yield contributing characters of chickpea. They recommended that 1.0 kg B ha⁻¹ be applied to chickpea crops to achieve maximum yield.

3.2.4 Stover yield (t/ha)

The data showed the significantly highest straw yield was observed in *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 % (5.95 t/ha). However, *Rhizobium* 10 g + PSB 10 g + Boron - 0.5 % (5.48 t/ha) and *Rhizobium* 10 g + PSB 10 g + Boron - 0.25 % (5.11 t/ha) were statistically at par with *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 %.

Chickpea plants can benefit from biofertilizers that contain beneficial microorganisms like nitrogen-fixing bacteria and phosphate-solubilizing bacteria or fungus. Increased biomass production from plants, including increased stover output, may result from this improved nutrient availability (Goud *et al.*, 2016).

Economics:

The result showed that [Table 3] the maximum gross return (106464.00 INR/ha), net return (76796.00 INR/ha) and B:C ratio (2.58) was recorded in *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 % as compared to other Treatments.

3. CONCLUSION:

It is concluded that hybrid *Rhizobium* 10 g + PSB 10 g + Boron - 0.75 % was found to be best for obtaining maximum grain yield. It also fetched the maximum gross return, net return and B:C ratio.

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UNDER PEER REVIEW

Table 1. Field evaluation of different treatments on growth attributes of Chickpea.

S.No.	Treatments	Growth parameters		
		Plant height (cm)	Nodules/plant (No.)	Dry weight (g/plant)
1.	<i>Rhizobium</i> 20 g + Boron 0.25%	0	10.61	10.71
2.	<i>Rhizobium</i> 20 g + Boron 0.5 %	37.31	11.54	11.59
3.	<i>Rhizobium</i> 20 g + Boron 0.75 %	38.38	12.61	12.30
4.	PSB 20 g + Boron - 0.25 %	39.51	13.48	12.77
5.	PSB 20 g + Boron - 0.5 %	41.27	14.32	13.26
6.	PSB 20 g + Boron - 0.75 %	43.37	14.88	13.85
7.	<i>Rhizobium</i> 10 g + PSB 10 g + Boron - 0.25 %	44.49	15.27	14.27
8.	<i>Rhizobium</i> 10 g + PSB 10 g + Boron - 0.5 %	45.37	15.71	14.75
9.	<i>Rhizobium</i> 10 g + PSB 10 g + Boron - 0.75 %	46.54	16.44	15.37
10.	Control (N:P:K - 20-60-20 kg/ha)	35.35	9.51	9.55
	F-test	S	S	S
	SEm±	1.43	0.53	0.37
	CD(p=0.05)	4.22	1.58	1.11

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Table2. Field evaluation of different treatments on yield attributes of Chickpea.

S.No.	Treatments				
		Pods/plant	Seeds/pod	Seed yield (t/ha)	Stover yield (t/ha)
1.	<i>Rhizobium</i> 20 g + Boron 0.25%	39.58	1.42	1.15	3.22
2.	<i>Rhizobium</i> 20 g + Boron 0.5 %	41.49	1.53	1.27	3.53
3.	<i>Rhizobium</i> 20 g + Boron 0.75 %	43.27	1.59	1.39	3.87
4.	PSB 20 g + Boron - 0.25 %	45.37	1.66	1.48	4.24
5.	PSB 20 g + Boron - 0.5 %	47.40	1.71	1.59	4.53
6.	PSB 20 g + Boron - 0.75 %	49.51	1.85	1.67	4.92
7.	<i>Rhizobium</i> 10 g + PSB 10 g + Boron - 0.25 %	51.69	1.94	1.71	5.11
8.	<i>Rhizobium</i> 10 g + PSB 10 g + Boron - 0.5 %	53.37	2.09	1.79	5.48
9.	<i>Rhizobium</i> 10 g + PSB 10 g + Boron - 0.75 %	55.61	2.52	1.99	5.95
10.	Control (N:P:K - 20-60-20 kg/ha)	38.43	1.32	1.04	2.96
	F-test	S	S	S	S
	SEm±	1.81	0.18	0.09	0.16
	CD(p=0.05)	5.39	0.54	0.27	0.50

S.No.	Treatments	Economics			
		Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C ratio
1.	<i>Rhizobium</i> 20 g + Boron 0.25%	28917.000	61313.00	32596.00	1.12
2.	<i>Rhizobium</i> 20 g + Boron 0.5 %	29292.00	67931.00	38639.00	1.31
3.	<i>Rhizobium</i> 20 g + Boron 0.75 %	29667.00	74350.00	44683.00	1.50
4.	PSB 20 g + Boron - 0.25 %	28919.00	79170.00	50251.00	1.73
5.	PSB 20 g + Boron - 0.5 %	29294.00	85053.00	55759.00	1.90
6.	PSB 20 g + Boron - 0.75 %	29669.00	89340.00	59671.00	2.01
7.	<i>Rhizobium</i> 10 g + PSB 10 g + Boron - 0.25 %	28918.00	91434.00	62566.00	2.16
8.	<i>Rhizobium</i> 10 g + PSB 10 g + Boron - 0.5 %	29293.00	95770.00	66477.00	2.26
9.	<i>Rhizobium</i> 10 g + PSB 10 g + Boron - 0.75 %	29668.00	106464.00	76796.00	2.58
10.	Control (N:P:K - 20-60-20 kg/ha)	28530.00	58632.00	30102.00	1.05

Table 3. Economics of different treatments.