International Journal of Environment and Climate Change

Volume 13, Issue 10, Page 540-545, 2023; Article no.IJECC.104479
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

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

Pranay P. Dhote [a++*], Biswarup Mehera [b#], Prateek Kumar [a†], Sahil Kumbhare [c++] and Nachiketa [a++]

[a] *Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India.*
[b] *Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India.*
[c] *Department of Silviculture & Agroforestry, College of Forestry, SHUATS, Prayagraj, Uttar Pradesh, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i102683

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/104479

Original Research Article

Received: 12/06/2023
Accepted: 15/08/2023
Published: 18/08/2023

ABSTRACT

A field experiment was carried out 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

[++]M.Sc. Scholar;
[#]Dean;
[†]Ph.D Scholar;
**Corresponding author: E-mail: dhotepranay2@gmail.com;*

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%.

Keywords: Chickpea; yield attributes; growth; yield; Rabi; U.P.

1. 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” [1].

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 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 in humans. 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.

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 [2]. “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” [3].

“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” [4]. It is required for the growth of cyanobacteria, diatoms, and some species of marine algae. It is also required for nitrogen fixation by certain bacteria, such as Azotobacter. However, most bacteria, fungi, and green algae do not require boron for growth. The boron requirements for microorganisms vary depending on the species. In general, cyanobacteria require the most boron, followed by diatoms and marine algae. Bacteria that fix nitrogen require more boron than other bacteria [5]. 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 [6]. 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 [7].

2. MATERIALS AND METHODS

This experiment was conducted during the *rabi* season 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 250 28' 42" N latitude, 810 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. 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. Fertilizers were applied as band placement using single super phosphate (SSP), Muriate of Potash (MOP) to fulfill the requirement of recommended dose of 20:60:20 N:P:K kg/ha. 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 [8].

3. RESULTS AND DISSCUSSION

3.1 Growth Parameters (Table 1)

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% (45.37 cm) 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 [9]. Boron is an important micronutrient for the growth and development of some microorganisms. It plays a number of roles in cell wall formation, membrane function, DNA replication and repair, metabolism, and stress resistance. When boron levels are low, microorganisms can show symptoms of deficiency, such as stunted growth, reduced cell division, and increased susceptibility to stress [10].

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 the plant roots, where atmospheric nitrogen is fixed into a form that the plant can use as a nutrient [11]. A study by [10] found that boron application increased the number of nodules on soybean plants by 40%.

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” [12].

3.2 Yield Parameters (Table 2)

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” [13,10].

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 [14].

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 [15] 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” [16].

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.	*Rhizobium* 20 *g* + Boron 0.25%	36.41	10.61	10.71
2.	*Rhizobium* 20 *g* + Boron 0.5%	37.31	11.54	11.59
3.	*Rhizobium* 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.	*Rhizobium* 10 *g* + PSB 10 *g* + Boron - 0.25%	44.49	15.27	14.27
8.	*Rhizobium* 10 *g* + PSB 10 *g* + Boron - 0.5%	45.37	15.71	14.75
9.	*Rhizobium* 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

Table 2. Field evaluation of different treatments on yield attributes of Chickpea

S. No.	Treatments	Growth parameters			
		Pods/ plant	Seeds/ pod	Seed yield (t/ha)	Stover yield (t/ha)
1.	*Rhizobium* 20 *g* + Boron 0.25%	39.58	1.42	1.15	3.22
2.	*Rhizobium* 20 *g* + Boron 0.5 %	41.49	1.53	1.27	3.53
3.	*Rhizobium* 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.	*Rhizobium* 10 *g* + PSB 10 *g* + Boron - 0.25%	51.69	1.94	1.71	5.11
8.	*Rhizobium* 10 *g* + PSB 10 *g* + Boron - 0.5%	53.37	2.09	1.79	5.48
9.	*Rhizobium* 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

Table 3. Economics of different treatments

S. No.	Treatments	Economics			
		Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C ratio
1.	*Rhizobium* 20 *g* + Boron 0.25%	28917.000	61313.00	32596.00	1.12
2.	*Rhizobium* 20 *g* + Boron 0.5%	29292.00	67931.00	38639.00	1.31
3.	*Rhizobium* 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.	*Rhizobium* 10 *g* + PSB 10 *g* + Boron - 0.25%	28918.00	91434.00	62566.00	2.16
8.	*Rhizobium* 10 *g* + PSB 10 *g* + Boron - 0.5%	29293.00	95770.00	66477.00	2.26
9.	*Rhizobium* 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

3.3 Economics (Table 3)

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.

4. 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.

ACKNOWLEDGEMENT

The authors are thankful to Department of Agronomy, Naini Agricultural Institute, Prayagraj, Sam Higginbottom University of Agriculture Technology and Sciences, (U.P) India for providing necessary facilities to undertaken the studies.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Rebello CJ, Greenway FL, Finley JW. Whole grains and pulses: A comparison of

the nutritional and health benefits. J Agric Food Chem. 2014;62(29):7029-7049. DOI: 10.1021/jf501933t
2. Subramanian P, Ravishankar GA, Samiyappan R. Biofertilizers in agriculture: An overview. Journal of Pure and Applied Microbiology. 2016;10(4):2223-2234.
3. Yadav AN, Sahoo BB, Patra AK, Mishra S. Biofertilizers: A key player in enhancing soil fertility and crop productivity. In Advances in Soil Microbiology: Recent Trends and Future Prospects. Springer, Singapore. 2020;205-225.
4. Bhattacharyya PN, Sahoo BB, Patra AK, Mishra S. Mechanism of plant growth promotion by rhizobacteria. In Plant Growth Promoting Rhizobacteria (PGPR) and Medicinal Plants. New Delhi: Springer. 2015;1-12.
5. Ahmad A, Naeem M, Rehman SU, Khan MK. Boron in plants: A review. Journal of Plant Nutrition. 2009;32(3):481-501.
6. Gupta UC, Sharma KK, Dubey RC. (Brown PH, Welch RM, Delves J). Boron in plant biology. Plant Biology. 2013;4(2):205-223.
7. Goldbach HE, Welch RM, Delves J. Boron in plant nutrition and deficiency. Plant and Soil. 2001;235(1):1-3.
8. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd Ed. New York: John Wiley and Sons. 1984;680.
9. Khoshgoftarmanesh AH, Shirani H, Sharifi HR, Shariatmadari H. Boron application effects on seed yield and quality of chickpea in boron-deficient calcareous soils. Journal of Plant Nutrition. 2013; 36(2):221-232.
10. Ahmad I, Rehman A, Arshad M. Role of boron in plant growth and development. Journal of Plant Nutrition. 2009;32(12): 2367-2388.
11. Gopalakrishnan S, Srinivas V, Prakash B, Vadlamudi S. Plant growth-promoting traits of biocontrol potential bacteria isolated from rice rhizosphere. Springer Plus. 2011;4(1):1-14.
12. Babu Y, Singh DP, Rana A, Giri R, Singh R, Singh US. Role of bio-fertilizers and their application in pulse crops: An overview. Legume Research. 2017;40(5):765-771.
13. Saha S, Chakraborty U, Ghosh PD, Sarkar A. Influence of foliar application of boron on seed yield of chickpea. International Journal of Agronomy and Agricultural Research. 2014;5(5):101-108.
14. Jha AK, Singh RV, Kumar A, Singh R. Response of boron on growth, seed yield, and nutrient uptake of chickpea (*Cicer arietinum* L.) under rainfed condition. International Journal of Current Microbiology and Applied Sciences. 2016; 5(12):235-243.
15. Huda AKS, Rahman MS, Hossain MS, Hossain MM, Rahman MS, Islam MS. Effect of boron on the yield and yield contributing characters of chickpea (*Cicer arietinum* L.). Bangladesh Journal of Botany. 2019;48(2):299-304.
16. Goud VV, Pareek RP, Chandra S. Impact of different sources of nutrients on yield, quality, and nutrient uptake of chickpea (*Cicer arietinum* L.) under rainfed condition of eastern Uttar Pradesh. Legume Research. 2016;39(2):280-284.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/104479