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Effect of Biofertilizers and Foliar application of Boron on Growth and Yield of Greengram (*Phaseolus radiatus* L.)

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ABSTRACT: The field experiment was conducted at Crop Research Farm during *Zaid* season 2022, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) to study the effect of Biofertilizers and Foliar application of Boron on Growth and Yield of Greengram. The result showed that treatment 9 (Rhizobium (10 g) + PSB (10 g)) + 0.6% Boron recorded significant higher plant height (47.91 cm), maximum number of nodules/plant (8.00), higher plant dry weight (7.70 g), maximum crop growth rate (11.63 g/m^2/day), and yield attributes namely higher number of pods/ plant (27.50), higher number of seeds/pod (8.63), higher test weight (40.33g), higher seed yield (1.52 t/ha), higher stover yield (3.67 t/ha) and higher harvest index (29.42 %) compared to other treatment combinations. The maximum gross return (90940.00 INR/ha), maximum net return (59183.00 INR/ha), highest benefit cost ratio (1.86) was also recorded in treatment 9 [Rhizobium (10 g) + PSB (10 g)] + 0.6% Boron when compared to other treatments.

Keywords: Greengram, Biofertilizers, Boron, Growth, Yield and Economics.

INTRODUCTION

Greengram is one of the most important pulse crops and an excellent source of high-quality protein. It is also used as sprout, salad, vegetable, and some Indian dishes like curry, sevpuri, or Indian chat sprout salad. India alone accounts for 65% of its world acreage and 54% of the total production. Pulse are important in agriculture and society for a variety of reasons, including their nutritional value, vegetarian diet, capacity to enhance soil fertility, minimal resource (Patel *et al*., 2020). Greengram has a calorific content of 334 calories per 100 g. It has a high nutritional value with 24.0% crude protein, 1.3% fat, 56.6% carbohydrates, 3.5% minerals, and 4.43, 0.10, and 0.04 percent lysine, methionine, and tryptophan. Greengram will be produced in India in the years 2020–21 on an estimated 30.37 lakh/ha, yielding 2.64 million tonnes at a productivity of 888 kg/ha, accounting for 10% of all pulse production. The largest producers of greengram in India include states like Rajasthan (19.23 lakh/ha), Karnataka (4.23 lakh/ha), Maharashtra (4.03 lakh/ha), Madhya Pradesh (2.10 lakh/ha), Telangana (0.73 lakh/ha), and Uttar Pradesh (0.30 lakh/ha) (GOI, 2021).

Boron supports a plant's normal growth, sugar translocation, root elongation, and the synthesis of nucleic acids. The boron improves the grain and straw yield, nutrient content, nutrient uptake and quality in legumes crops. The most important functions of boron in plants are thought to be its structural role in cell wall development (Janaki *et al*., 2018). The structural role of boron in plants contributes to hormone formation, cell division, seed development, and the stimulation or inhibition of particular metabolic pathways for sugar transport. Pollen germination, pollen grain count, and other factors are decreased by boron deficit. Moreover, it affects the parameters of growth and seed germination. It is usually accepted that boron availability is decreased under dry soil conditions. Thus, boron deficiency is often associated with dry weather and low soil moisture conditions. Boron deficiency is often associated with dry weather and low soil moisture conditions. This behaviour may relate to restricted release of boron from organic complexes which ultimately impaired ability of plants to extract boron from soil due to lack of moisture in the rhizosphere (Praveena *et al.,* 2018).

Biofertilizers such as (PSB) solubilise insoluble soil phosphates like tri-calcium phosphates and produce plant growth substances in soil. Among various bio-fertilizers Rhizobium is of paramount importance. Rhizobium is fixes atmospheric nitrogen symbiosis with legumes.PSB inoculation showed more available phosphorus in soil, which favoured better root growth. The resulted in a beneficial effect of nodulation with increased PSB bacterial activity. For maximizing the yield, it is essential that green gram should not suffer due to inadequate mineral nutrient especially nitrogen and phosphorus. Since chemical fertilizers are scarce and costly, it is necessary to use them economically in combination with bio fertilizers, as green gram shows high response to bio fertilizers. Phosphorus plays a key role in various physiological processes concerning root and dry matter production, nodulation and N2 fixation and also in metabolic activities especially in protein synthesis (Bhatt *et al.,* 2013). Keeping in view the

above facts, the present experiment was undertaken to find out "Effect of Biofertilizers and foliar application of Boron on growth and yield of Greengram *(Phaseolus radiatus* L.)".

MATERIALS AND METHODS

The field experiment was carried out during Zaid season 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, (U.P). The experimental field's soil had a sandy loam texture, a pH of 7.8 that was virtually neutral, a low level of organic carbon (0.62%), medium levels of available N (225 kg/ha), a high level of available P (38.2 kg/ha), and a low level of available K (240.7 kg/ha). The treatment consists of 3 levels of Biofertilizers [Rhizobium (20 g), PSB (20 g), [Rhizobium (10 g) + PSB (10 g)] and Boron (0.2%, 0.4%, 0.6%) as foliar spray and a control. The experiment was laid out in Randomized Block Design (RBD) with 10 treatments and replicated thrice. The treatment combinations are T_1 Rhizobium (20g) + 0.2% Boron, T_2 Rhizobium (20g) + 0.4% Boron, T_3 Rhizobium (20g) + 0.6% Boron, T_4 PSB (20g) + 0.2% Boron, T_5 PSB (20g) + 0.4% Boron, T_6 PSB (20g) + 0.6% Boron, T_7 [Rhizobium (10g) + PSB (10g)] + 0.2% Boron, T_8 [Rhizobium (10g) + PSB (10g)] + 0.4% Boron, T_9 [Rhizobium (10g) + PSB (10g)] + 0.6% Boron, T_{10} (Control) N:P:K 20:40:20 kg/ha. The growth, yield and economics was recorded at 60 DAS from randomly selected plants in each plot. The data was computed and analysed by following statistical method of Gomez and Gomez (1976).

RESULT AND DISCUSSION

Growth parameters

Plant height (cm): The data revealed that significantly and higher plant height (47.91 cm) was recorded in treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron] which was significantly superior over rest of the treatments (Table 1). Significant and maximum plant height was observed with the application of Rhizobium (10g) and alongwith PSB (10g) might be due to fact that seed inoculation with Rhizobium alongwith PSB led to better uptake and translocation of plant nutrient to greengram plant, and its inoculation might have benefitted the plants by providing atmospheric nitrogen and rendering the insoluble phosphorous available form. Similar results were also reported by Singh and Singh (2019). Further the application of 0.6% boron might be due to prominent role of boron on boosting up the carbohydrate metabolism, sugar transport, cell wall structure, root growth, stimulating other physiological processes such as metabolic regulation, enzymatic process including photosynthesis, respiration and nitrogen fixation which resulted in better enhancement of growth characters. Similar results were also reported by Sharmila *et al.* (2020).

Number of nodules/plant: The data revealed that significantly and higher number of nodules (8.00) was recorded in treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron]. However, treatment 8 [Rhizobium (10g) + PSB (10g) + 0.4% Boron] were found to be statistically at par with treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron] (Table 1). Significant and maximum number of nodules/plant was observed with the application of Rhizobium (10g) and along with PSB (10g) might be due to Rhizobium and PSB helps in higher nitrogen fixation and phosphorous solubilization, respectively, which helped with higher root growth and nodules development. Further, the highest number of nodules per plant was observed with the application of 0.6% Boron might be due to direct involvement of boron in nodulation, symbiotic nitrogen fixation in legume crops, buffering action and regulatory effect boron on other nutrients. Further, boron fertilization could have helped in retaining the cell wall and membrane integrity of nodules thereby expanding the nodulation. These results were also reported by Sharmila *et al.* (2020).

Table 1: Effect of Biofertilizers and foliar application of Boron on growth attributes of Greengram.

Sr. No.	Treatments	60 DAS			45-60 DAS	
		Plant height (cm)	Number of nodules/plant	Plant dry weight(g)	CGR ($g/m^2/day$)	RGR (g/g/day)
1.	Rhizobium (20g) + 0.2% Boron	43.89	4.53	5.03	7.93	0.082
2.	Rhizobium (20g) + 0.4% Boron	45.04	4.87	6.68	10.55	0.083
3.	Rhizobium (20g) + 0.6% Boron	45.45	5.20	7.07	11.63	0.075
4.	Phosphate solubilizing bacteria (20g) + 0.2% Boron	43.82	5.67	7.50	10.30	0.064
5.	Phosphate solubilizing bacteria (20g) + 0.4% Boron	43.92	6.13	6.59	8.07	0.053
6.	Phosphate solubilizing bacteria (20g) + 0.6% Boron	44.76	6.67	7.09	8.96	0.055
7.	[Rhizobium (10g) + PSB (10g)] + 0.2% Boron	45.36	7.13	6.80	7.87	0.048
8.	[Rhizobium (10g) + PSB (10g)] + 0.4% Boron	45.57	7.67	6.88	7.52	0.045
9.	[Rhizobium (10g) + PSB (10g)] + 0.6% Boron	47.91	8.00	7.70	9.04	0.050
10.	Control [N:P:K (20:40:20 Kg/ha)]	42.64	4.13	5.73	9.62	0.095
	F-test	S	S	S	S	NS
	Sem ±	0.74	0.17	0.33	0.78	0.011
	CD (P=0.05)	2.21	0.51	0.98	2.33	--

Plant dry weight (g/plant): The data recorded that significantly and higher plant dry weight (7.70 g/ plant) was recorded in treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron]. However, treatment 3 [Rhizobium (20g) + 0.6% Boron], treatment 4 [PSB (20g) + 0.2% Boron], treatment 6 [PSB (20g) + 0.6% Boron], treatment 7 [Rhizobium (10g) + PSB (10g) + 0.2% Boron], treatment 8 [Rhizobium (10g) + PSB (10g) + 0.4% Boron] were found to be statistically at par with treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron] (Table 1). Significant and maximum plant dry weight was observed with the application of Rhizobium (10g) and along with PSB (10g) might be due to increase in yield characteristics led to improved growth and plant height, which in turn produced a larger dry weight. This may be the result of biofertilizer inoculation of co-ordinate interplay of growth and development character. Similar results were also reported by Singh and Singh (2019). Further, the highest plant dry weight was observed with the application of 0.6% Boron might be due to in general, boron affects cell division, and nitrogen uptake from the soil may have accelerated plant growth as measured by plant dry weight.

Crop Growth Rate (g/m^2/day): The data revealed that significantly and higher crop growth rate (11.63 g/ m^2 / day) was recorded in treatment 3 [Rhizobium (20g) + 0.6% Boron]. However treatment 2 [Rhizobium (20g) + 0.4% Boron], treatment 4 [PSB (20g) + 0.2% Boron], treatment 10 Control [N:P:K (20:40:20) kg/ha] were found to be statistically at par with treatment 3 Rhizobium (20g) + 0.6% Boron (Table 1). Significant and maximum crop growth rate was observed with the application of Rhizobium (10g) and along with PSB (10g) might be due to positive influence of PSB inoculation on plant growth parameter was observed due to higher enzyme activities in the PSB and better nutrient availability besides the production of the plant growth regulators by bioinoculants which stimulated plant growth. Similar results were also reported by Sekhar *et al.* (2020). Further, the highest crop growth rate was observed with the application of Boron 0.6% might be due to boron on growth of green gram, in terms of dry matter and crop growth rate can be interpreted in terms of the metabolic function of micronutrients in the plant.

Yield parameters:

Number of pods/plant: The significantly and higher number of pods/ plant (27.50) was recorded in treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron]. However treatment 8 [Rhizobium (10g) + PSB (10g) + 0.4% Boron] were found to be statistically at par with treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron] (Table 2). Significant and maximum number of pods/plant was observed with the application of Rhizobium (10g) and along with PSB (10g) might be due to through the inoculation of biofertilizers (rhizobium and PSB), which improve the availability of Nitrogen and Phosphorous, more pods are generated as a result of higher rates of primordial production. Further, the maximum number of pods/plant was observed with the application of Boron 0.6% might be due to one of boron's beneficial effects may be its crucial function in plant metabolism and the creation of nucleic acids (Ghanshyam *et al.*, 2010).

Number of seeds/pods: The significantly and higher number of seeds /pods (8.63) was recorded in treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron]. However, treatment 8 [Rhizobium (10g) + PSB (10g) + 0.4% Boron] were found to be statistically at par with treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron] (Table 2). Significant and maximum number of seeds/ pods was observed with the application of Rhizobium (10g) and along with PSB (10g) might be due to in addition to accelerating growth overall, increased nodulation, an extensive root system, and higher metabolite production and translocation, particularly to productive structures (pods and seeds), may have contributed to an increase in the number of pods per plant. Similar results were also reported by Ghanshyam *et al.* (2010). Further, the maximum number of seeds/ pods was observed with the application of Boron 0.6% might be due to through synthesising tryptophan and auxin, boron in greengram crops generally enhances fruit growth. The improvement in seed/pod quality is a result of crops' beneficial effects on nutrient metabolism, biological activity, and growth characteristics.

Test weight (g): The significantly and higher test weight (40.33g) was recorded in treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron]. However, treatment 8 [Rhizobium (10g) + PSB (10g) + 0.4% Boron] were found to be statistically at par with treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron] (Table 2). Significant and maximum test weight was observed with the application of Rhizobium (10g) and along with PSB (10g) might be due to applying a medium degree of fertility may have increased test weight because it improved the removal and translocation of nutrients, notably phosphorus, which led to hold seed production by growing the size and weight of grains. Similar results were also reported by Kumar *et al.* (2003). Further, the maximum test weight was observed with the application of Boron 0.6% might be due to increase in this characteristic by foliar spray may be attributed to the sprayed boron's role in early stages of starch utilization, chlorophyll production, enzyme activation, membrane integrity, and stomatal balancing, which led to a rise in assimilate accumulation and heavier grains.

Seed yield (t/ha): The significantly and higher seed yield (1.52 t/ha) was recorded in treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron]. However, treatment 8 [Rhizobium (10g) + PSB (10g) + 0.4% Boron] were found to be statistically at par with treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron] (Table 2). Significant and maximum seed yield was observed with the application of Rhizobium (10g) and along with PSB (10g) might be due to the use of biofertilizers has been linked to the production of additional plant hormones (auxin, cytokinin, gibberellins etc.) by the microorganisms inoculated or

by the root resulting from reaction to microbial population. Further, the maximum seed yield was observed with the application of Boron 0.6% might be due to boron is involved in many physiological processes of plants, including chlorophyll production, stomatal control, and starch utilisation, which improve seed yield, it is essential for boosting seed yield. In addition to being essential for many physiological processes and plant growth, nutrition is also important for boosting crop yields and quality. Similar results were also reported by Debata *et al.* (2022).

Table 2: Effect of Biofertilizers and foliar application of Boron on yield attributes of Greengram.

Sr. No.	Treatments	Number of pods/plant	Number of Seeds /pod	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1.	Rhizobium (20g) + 0.2% Boron	17.55	6.06	33.00	1.08	2.80	27.84
2.	Rhizobium (20g) + 0.4% Boron	19.21	6.43	34.00	1.14	2.93	28.04
3.	Rhizobium (20g) + 0.6% Boron	23.07	7.00	34.33	1.28	3.17	28.79
4.	Phosphate solubilizing bacteria (20g) + 0.2% Boron	19.98	5.87	36.00	1.25	3.33	27.30
5.	Phosphate solubilizing bacteria (20g) + 0.4% Boron	19.99	6.06	37.00	1.30	3.43	27.46
6.	Phosphate solubilizing bacteria (20g) + 0.6% Boron	21.11	6.53	38.00	1.32	3.41	27.88
7.	[Rhizobium (10g) + PSB (10g)] + 0.2% Boron	24.20	6.87	39.00	1.39	3.54	28.27
8.	[Rhizobium (10g) + PSB (10g)] + 0.4% Boron	24.97	7.20	40.00	1.44	3.63	28.38
9.	[Rhizobium (10g) + PSB (10g)] + 0.6% Boron	27.50	8.63	40.33	1.52	3.67	29.42
10.	Control [N:P:K (20:40:20 Kg/ha)]	15.55	4.87	32.33	1.06	2.70	28.13
	F-test	S	S	S	S	S	S
	Sem ±	0.95	0.52	1.43	0.05	0.03	0.72
	CD (P=0.05)	2.83	1.55	4.25	0.14	0.10	1.32

Stover yield (t/ha): The significantly and higher stover yield (3.67 t/ha) was recorded in treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron]. However, treatment 8 [Rhizobium (10g) + PSB (10g) + 0.4% Boron] were found to be statistically at par with treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron] (Table 2). Significant and maximum stover yield was observed with the application of Rhizobium (10g) and along with PSB (10g) might be due to maximum stover yield were obtained owing to higher dry matter accumulation and better root development, resulting into maximum uptake of nutrient and moisture which ultimately led to higher stover yield. Similar results were also reported by Rajesh *et al.* (2013). Further, the maximum stover yield was observed with the application of Boron 0.6% might be due to requirement of more boron at reproductive stage and foliar applied is instantly present for plant in compare to soil applied boron foliar applied boron in greengram increased the stover yield. The higher biological yield may be due to enlarge in terms of dry matter and number of branches per plant, vegetative development creates too many sites for photosynthetic translocation, resulting in an increasing in the number of biological yield characteristics. Similar results were also reported by Karthik *et al.* (2021).

Harvest index (%): The significantly and higher harvest index (29.42%) was recorded in treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron], However treatment 8 [Rhizobium (10g) + PSB (10g) + 0.4% Boron] were found to be statistically at par with treatment 9 [Rhizobium (10g) + PSB (10g) + 0.6% Boron] (Table 2). Significant and maximum harvest index was observed with the application of Rhizobium (10g) and along with PSB (10g) might be due to better translocation of photosynthates from source to sink. Similar results were also reported by Singh *et al.* (2018).

Economics: The maximum gross return (90940.00 INR/ha), maximum net return (59183.00 INR/ha), highest benefit cost ratio (1.86) was also recorded in treatment 9 with the application of Rhizobium (10g) + PSB (10g)] + 0.6% Boron when compared to other treatments (Table 3). Significant and maximum economics was observed with the application of Rhizobium (10g) and along with PSB (10g) might be due to increase in grain and straw yield as compared to cost of cultivation with increasing levels of phosphorus. It increased benefit cost ration and net return with increasing levels of phosphorus. Similar results were also reported by Singh *et al.* (2018).

Table 3: Effect of Biofertilizers and Foliar application of Boron on economics (INR) of Greengram.

Sr. No.	Treatments	Cost of cultivation (INR/ha)	Gross Return (INR/ha)	Net return (INR/ha)	Benefit cost ratio (B:C)
1.	Rhizobium (20g) + 0.2% Boron	31,634.00	65000.00	33366.00.	1.04
2.	Rhizobium (20g) + 0.4% Boron	31,694.00	68560.00	36866.00	1.16
3.	Rhizobium (20g) + 0.6% Boron	31,754.00	76740.00	44986.00	1.41
4.	Phosphate solubilizing bacteria (20g) + 0.2% Boron	31,640.00	75410.00	43770.00	1.38
5.	Phosphate solubilizing bacteria (20g) + 0.4% Boron	31,700.00	78360.00	46660.00	1.47
6.	Phosphate solubilizing bacteria (20g) + 0.6% Boron	31,760.00	79420.00	47660.00	1.50
7.	[Rhizobium (10g) + PSB (10g)] + 0.2% Boron	31,637.00	83530.00	51893.00	1.37
8.	[Rhizobium (10g) + PSB (10g)] + 0.4% Boron	31,697.00	86460.00	54763.00	1.72
9.	[Rhizobium (10g) + PSB (10g)] + 0.6% Boron	31,757.00	90940.00	59183.00	1.86
10.	Control [N:P:K (20:40:20 Kg/ha)]	31,544.00	63700.00	32156.00	1.01

CONCLUSIONS

It can be concluded that the foliar application of boron and biofertilizers performs positively and improves the growth and yield of greengram. Maximum gross return, net return and benefit cost ratio was recorded with the application of Rhizobium (10g) and PSB (10g) with foliar application of 0.6% Boron.

FUTURE SCOPE

As that conclusion are based on research conducted over a single season in Allahabad's agro-ecological environments, more experiment may be necessary before it could be considered a recommendation.

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