International Journal of Environment and Climate Change

Volume 13, Issue 4, Page 148-155, 2023; Article no.IJECC.97394
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Response of Boron and Biofertilizers on Growth and Yield of Summer Blackgram (*Vigna mungo* L.)

Venigandla Jyothika [a++*], Joy Dawson [a#] and Chilakala Vamshi Krishna [a++*]

[a] *Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj- 211007, 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/v13i41721

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/97394

Original Research Article

Received: 07/01/2023
Accepted: 10/03/2023
Published: 13/03/2023

ABSTRACT

During the summer of 2022, the experiment was carried out at a crop research farm for agricultural research in the department of agronomy. The treatments included three levels of boron application to the soil (1.0, 1.5, and 2.0 kg/ha), Rhizobium seed inoculation at 10 and 20 g/kg, and PSB seed inoculation at 10 and 20 g/kg and a control. Ten treatments were used in the experiment, which was designed as an RBD and triple replicated. Inoculating seeds with 2.0 kg of boron and 10g/kg each of Rhizobium and PSB resulted in the maximum plant height, number of branches, number of nodules, maximum plant dry weight, CGR, RGR, and yield parameters such as more pods per plant, seeds per pod, test weight, and seed yield and stover yield.

[++] *M.Sc Scholar;*
[#] *Professor and Head;*
**Corresponding author: E-mail: venigandlajyothika00@gmail.com;*

Keywords: Yield; boron; biofertilizers.

1. INTRODUCTION

A significant pulse crop is blackgram (*Vigna mungo* L.). All tropical and subtropical nations heavily rely on food legumes, particularly grains and pulses. It is developed all over India. Blackgram is a widely cultivated grain legume that is a part of the genus Vigna and family Leguminoseae. It has significant global food and nutritional security implications. It is also described to as urad, urdbean, udad dal, or urad. From roughly 4.6 million hectares of land, it generates about 24.5 lakh tonnes of urad yearly, with an average yield of 533 kg per hectare in 2020–21. Around 19% of all pulse acres in India are in the Blackgram area, which generates 23% of all pulse production. With more than 70% of the world's black gram production, India is currently the biggest producer. Pakistan and Myanmar are next, then India. In India, the area planted with black gram during zaid 2019–20 is 37.52 lakh hectares, down from 38.18 lakh ha the year before. With a yield of 775 kg/ha on average, Tamil Nadu is the most productive state. Together with sufficient quantities of calcium, phosphorus, and vital vitamins, it also contains 24.7% protein, 0.6% fat, 0.9% fibre, and 3.7% ash. It is referred to as "poor man's meat" due to the cheaper protein source.

A variety of operations, such as sugar transport, nodulation, nitrogen fixation, protein and sucrose synthesis, cell wall composition, membrane stability, K+ transport, pollen viability, pollen germination, pollen tube growth, pollination, and seed germination, all depend on the presence of the factor boron. In the case of soybean and canola, a deficiency of boron usually causes unfilled pollen grains, weak pollen vitality, and reduced flowers per plant in addition to poor root growth. Boron deficiency has been shown to inhibit reproductive growth. Poor anther and pollen formation, low grain set, and stunted growth are all impacts of B deficiency in wheat. The amount of B and clay-forming minerals in soils varies greatly, which has a significant impact on the availability of B. Its interactions with most of the other factors are both antagonistic.

It is typical agronomic practise apply rhizobium culture to many legumes to increase pulse output. To boost the productivity of pulses, all pulse crops require rhizobium injection. It is a type of biofertilizer that boosts symbiotic nitrogen fixation and, as a result, raises crop output. Because phosphorus is fixed by the symbiosis, the nitrogen response to legumes is more crucial than the former. An increase in these microbes speeds up the microbial process, increasing the amount of available nutrients in forms that the plant can easily absorb. the methods that involve maximising fertiliser inputs with a focus on productivity P. Sasidhar [11]. The PSB, which dissolves interlocked phosphates, appears to have significant implications for Indian agriculture.

2. MATERIALS AND METHODS

The materials, methodology, and techniques used in the current experiment, entitled "Response of Boron and Biofertilizers on Growth and Yield of Blackgram (*Vigna mungo* L.), with a Brief Description Regarding Site of Experiment, Soil Properties, Sampling Techniques, Climate During Crop Growing Period, Cropping History, Calendar Operations, and Statistical Analysis," are presented in this chapter under the headings mentioned below.

In order to research the Response of boron and biofertilizers on growth and yield of summer blackgram. The experiment was carried out at the Naini Agricultural Institute, 2022, Crop Research Farm, SHUATS, Prayagraj. Geographically, the study's experimental site is situated at 25.28oN latitude, 81.54oE longitude, and 98 m elevation above mean sea level (MSL). The experimental field's neutral, deep soil is made up of central Gangetic alluvium. With the aid of an auger, pre-sowing soil samples were extracted from a depth of 15 cm. The chemical and mechanical analyses were conducted on the composite samples. The soil had a sandy loam texture, had a low organic carbon content (0.36%), and had medium levels of nitrogen (171.48 kg/ha), phosphorus (15 kg/ha), and potassium (232.5 kg/ha) that were readily available.The three levels of boron (1, 1.5, and 2 kg/ha) and biofertilizer (20 g Rhizobium 20 g/kg seed, 20 g PSB 20 g/kg seed, and 10 g/kg seed Rhizobium + PSB 10 g/kg seed) are used in the treatments, respectively. The experiment was set up using a randomised block design, with ten treatments reproduced three times each, and the control group receiving only the suggested amounts of N, P, and K (20:40:20 kg/ha). The plots were set up with dimensions of 3 m x 3 m, and seeds of the Shekar-II variety

List 1. List of treatment combinations for the study

Treatment No.	Treatment combination
1	Boron (1kg/ha) +Rhizobium (20g/kg seed)
2	Boron (1kg/ha) +PSB (20g/kg seed)
3	Boron (1kg/ha) +Rhizobium (10g/kg seed) + PSB (10g/kg seed)
4	Boron (1.5 kg/ha) +Rhizobium (20g/kg seed)
5	Boron (1.5 kg/ha) +PSB (20g/kg seed)
6	Boron (1.5 kg/ha) +Rhizobium (10g/kg seed) + PSB (10g/kg seed)
7	Boron (2 kg/ha) +Rhizobium (20g/kg seed)
8	Boron (2 kg/ha) +PSB (20g/kg seed)
9	Boron (2 kg/ha) +Rhizobium (10g/kg seed) + PSB (10g/kg seed)
10	20-40-20 NPK kg/ha (control)

were planted with a 30 cm x 10 cm spacing. In determining growth characteristics, the following formulas were used: plant height (cm), number of branches per plant, number of nodules per plant, dry weight per plant (g), crop growth rate (g/m2/day), and relative growth rate (g/g/day) (A & B). To prevent the crop encountering water stress at any point, irrigation was applied uniformly and often to all plots as needed. The crop was completely harvested at the point of physiological maturity, and biometric observations were made, including the number of pods per plant, the number of seeds per pod, the test weight in (g) of 1,000 seeds, the seed yield in tonnes per hectare (t/ha), and the stover yield in tonnes per hectare (t/ha).

3. RESULTS

3.1 Growth Parameters

Table.1 Details of influence of boron and biofertilizers on growth attributes of Blackgram.

3.2 Plant Height (cm)

At 75 DAS, the highest plant height (44.52 cm) was recorded with the treatment of boron 2 kg + rhizobium 10 g/kg seed + PSB 10 g/kg seed, which was statistically at par to treatment with boron 1.5 kg + rhizobium 10 g/kg seed (43.91cm).

3.3 Number of Branches for Plant

Maximum Branches (7.89) were recorded at 75 DAS after applying Boron 2 kg, Rhizobium 10 g/kg seed, and PSB 10 g/kg seed. This was statistically at par to the treatments of boron 1.5 kg + rhizobium 10 g/kg seed + PSB10 g/kg seed (7.11) and boron 1.5 kg + rhizobium 20 g/kg seed (7.11).

3.4 Number of Nodules for Plant

The application of Boron 2kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed resulted in the highest number of nodules (40.11) at 45 DAS, which was statistically at par to the treatment of Boron 1.5kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed but significantly superior to all other treatments.

3.5 Dry Weight (g/plant)

The application of Boron 2kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed resulted in the highest number of nodules (40.11) at 45 DAS, which was statistically at par to the treatment of Boron 1.5kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed but significantly superior to all other treatments.

3.6 Crop Growth Rate (g/m^2/day)

At 45-60 DAS, crop growth rate(g/m^2/day) maximum (9.14 g/m^2/day) was recorded with application of Boron 1.5kg/ha + PSB 20g/1kg seed which was significantly superior over all the treatments and statistically at par with treatment of Boron 1.5kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed (7.62), Boron 2 kg/ha + Rhizobium 20g/kg seed (9.07) and Boron 2 kg/ha + PSB 20g/1kg seed (8.35) and Boron 2kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed (8.50).

3.7 Relative Growth Rate (g/g/day)

At 45-60 DAS, Relative growth rate (g/g/day) maximum (0.056 g/g/day) was recorded with application of Boron 1.5 kg/ha + Rhizobium 20g/1kg seed which was significantly superior over all the treatments and statistically at par with Boron 1.5kg/ha + PSB 20g/kg seed (0.054 g/g/day) and Boron 2 kg/ha + PSB 20g/kg seed (0.0049 g/g/day).

Table 1. Influence of boron and biofertilizers on growth of blackgram crop

Treatment	Plant height (cm)	Number of branches/plant	Number of nodules/plant	Dry weight (g)	Crop growth rate ($g/m^2/day$)	Relative growth rate (g/g/day)
Boron 1kg/ha + Rhizobium 20g/kg seed	38.09	6.44	34.89	8.25	5.16	0.039
Boron 1kg/ha + PSB 20g/kg seed	41.35	6.67	35.78	8.50	6.99	0.044
Boron 1kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed	40.55	6.56	36.11	9.61	5.87	0.037
Boron 1.5 kg/ha + Rhizobium 20g/kg seed	41.21	7.11	36.78	9.69	5.62	0.035
Boron 1.5kg/ha + PSB 20g/kg seed	42.76	6.67	36.67	10.27	9.14	0.054
Boron 1.5kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed	43.91	7.11	39.56	10.73	7.62	0.041
Boron 2 kg/ha + Rhizobium 20g/kg seed	42.57	6.78	38.11	9.50	9.07	0.056
Boron 2 kg/ha + PSB 20g/kg seed	42.31	6.89	37.89	9.22	8.35	0.049
Boron 2kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed	44.52	7.89	40.11	11.08	8.50	0.044
Control (20:40:20 NPK kg/ha)	37.03	5.67	34.44	7.70	5.14	0.039
F-Test	S	S	S	S	S	S
S.EM (±)	0.52	0.32	0.62	0.21	0.61	0.003
CD (p=0.05)	1.57	0.95	1.85	0.63	1.82	0.011

Table 2. Influence of boron and biofertilizers on yield and yield attributes of blackgram crop

Treatment	No.of pods/plant	No. of seeds/pod	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index(%)
Boron 1kg/ha + Rhizobium 20g/1kg seed	19.44	3.55	29.03	0.67	1.51	30.53
Boron 1kg/ha + PSB 20g/1kg seed	19.88	3.66	31.55	0.76	1.53	33.31
Boron 1kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed	20.33	3.55	30.81	0.74	1.65	30.97
Boron 1.5 kg/ha + Rhizobium 20g/1kg seed	21.22	3.77	30.19	0.80	1.78	31.11
Boron 1.5kg/ha + PSB 20g/1kg seed	21.77	4.22	32.54	1.00	1.83	35.21
Boron 1.5kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed	22.44	4.55	34.23	1.16	1.95	37.39
Boron 2 kg/ha + Rhizobium 20g/1kg seed	21.33	4.00	32.54	0.93	1.75	34.64
Boron 2 kg/ha + PSB 20g/1kg seed	22.00	4.11	33.49	1.00	1.90	34.55
Boron 2kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed	22.66	4.77	34.42	1.24	2.03	37.95
Control (20:40:20 NPK kg/ha)	19.11	3.11	28.51	0.56	1.30	30.34
SEM (±)	0.22	0.15	0.62	0.02	0.04	0.95
CD (p=0.05)	0.68	0.44	1.85	0.08	0.12	2.84

3.8 Yield Attributes

Table 2 Details of influence of boron and biofertilizers on yield and yield attributes and Blackgram

3.9 Number of Pods/ Plants

The maximum number of pods per plant (26.33) was recorded in the treatment with application of boron 2 kg + rhizobium 10 g/kg seed + PSB 10 g/kg seed, which was statistically at par to the treatment with boron 1.5 kg + rhizobium 10 g/kg seed + PSB 10 g/kg seed (22.44) and boron 2 kg/ha + PSB 20 g/kg seed. This treatment was significantly superior to all other treatments (22.00).

3.10 Number of Seeds/ Pod

Treatment with application of Boron 2kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed was recorded maximum number of pods/plant (4.77) which was significantly superior over all other treatments and statistically at par with treatment of Boron 1.5kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed (4.55).

3.11 Test Weight (g)

Treatment with application of Boron 2kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed was recorded maximum number of pods/plant (34.42g) which was significantly superior over all other treatments and statistically at par with treatment of Boron 1.5kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed (34.23g) and Boron 2 kg/ha + PSB 20g/kg seed (33.49g).

3.12 Seed Yield (t/ha)

The treatment with application of Boron 2kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed recorded the highest number of pods/plant (1.24t/ha), which was statistically at par to the treatment with Boron 1.5kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed (1.16t/ha) and significantly better than all other treatments.

3.13 Straw Yield (t/ha)

The treatment with application of Boron 2kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed recorded the highest number of pods/plant (2.03t/ha), which was statistically at par to the treatment with Boron 1.5kg+ Rhizobium 10g/kg seed (1.95t/ha) but significantly better than all other treatments.

3.14 Harvest Index (%)

Treatment with application of Boron 2kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed was recorded maximum harvest index (37.95%) which was significantly superior over all other treatments and statistically at par with treatment of Boron 1.5 kg/ha + PSB 20g/kg seed (35.21%), Boron1.5kg+ Rhizobium 10g/kg seed + PSB 10g/kg seed (37.39%).

4. DISCUSSION

The soyabean plant's improved growth and development, as well as its increased height and number of primary branches, may be attributable to the beneficial effects of boron on hormonal balance [2].

Rhizobium + PSB seed inoculation significantly improved green pod yield (176.47 g/plant and 110.09 q/ha) over Rhizobium + PSB seed inoculation in terms of plant height, leaf area index, stem girth, number of nodules per plant, number of branches per plant, and total dry matter at harvesting stage of crops. The impact of microbial fertilisation, specifically Rhizobium, PSB, and Rhizobium + PSB, on the nutritional environment and involvement in a variety of physiological processes in the plant system, which are thought to be prerequisites for crop growth, appears to be the cause of the overall improvement in crop growth and yield parameters. Improved nodulation in combination inoculation may be brought about by improved biological N2 fixation and greater PSB P availability [3].

Nodules:Rhizobium inoculation has a major effect on plant nodulation. The number of nodule plants-1, nodule plants-1 by fresh weight, and nodules plants-1 by dry weight were all significantly impacted by various Rhizobium inoculations. Plant nodulation is considerably increased by rhizobia strain. Nodulation significantly increases crop production. The effective symbiosis between the rhizobia and legume strains may have caused the increased nodulation, which adversely affected the yield. The experiment's findings show that the inoculation was greatly impacted by the Rhizobium inoculation. That had the most nodulations, obviously N. Islam [4].

The improvement in photosynthetic efficiency, which led to increased synthesis of photosynthates, which in turn led to improved growth and, eventually, higher dry accumulation, were responsible for the increase in total dry matter production.
[5].

RGR of blackgram was considerably impacted by Zn and B at various growth stages. The application of B levels, B-1.5 kg ha-1, was found to be more effective in producing higher RGR, while B-untreated plants produced the lowest RGR [6].

This may be because boron is easily accessible to crops during the entire growing season. In the differentiation of tissues and the metabolism of carbohydrates, boron is essential. Moreover, it is a part of the cell membrane and necessary for cell division, the maintenance of conducting tissue, and the regulation of other elements. Moreover, it is required for the transfer of sugar in plants and the growth of new cells in meristematic tissue. Comparable trends show that boron has a major impact on the mung bean plant's height, number of branches, pods, and seed production [7].

The component yields of pods plant 1, seeds pod 1, and 1000 seed weight combined to produce the highest seed yield. This might have occurred as a result of certain synergistic effects of up to a certain amount of simultaneous application of sulphur and boron fertilization [2].

It might be as a result of the prospect further disclosed that the Rhizobium and PSB inoculation increased the test weight greatly enhanced the test weight of grain in comparison to the remainder of the treatment [1].

Enhanced growth parameters as a result of sufficient sulphur application. Through increasing seed production, 1000 test weight, leaf area expansion, and biological yield, boron enhances yield. Boron controls vital metabolic and cellular processes and is necessary for cell differentiation at all plant growth points [8].

The highest output under this treatment may be attributable to either direct or cumulative influence of provided macro-and micronutrients on metabolic processes of black gramme. Higher grain and straw production is a direct result of increased root growth, rapid cell division, and plant vigour, all of which are directly impacted by the availability of nutrients, particularly the micronutrients, at the optimum level [9].

The number of pods per plant is the most important yield factor that has the highest association with seed production. Chickpea grain and stover yield were significantly affected by higher boron concentrations. Which boosted microbial survival and reproduction, nitrogen fixation, sugar transport, and greater nutrient uptake and assimilation by plants during their whole growth cycle [5,10].

5. CONCLUSION

The results show that the treatment combination T9 (boron 2.0 kg/ha + Rhizobium 10 g/kg seed + PSB 10 g/kg seed) significantly increased plant height, nodule number, branch number, dry weight, pod number, seed yield, and stover yield**.**

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/97394