International Journal of Plant & Soil Science

34(22): 310-316, 2022; Article no.IJPSS.90469
ISSN: 2320-7035

Effect of Spacing and Boron Levels on Growth and Yield of Black Gram (*Vigna mungo* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i2231381

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/90469

Original Research Article

Received 27 May 2022
Accepted 04 August 2022
Published 04 August 2022

ABSTRACT

A field experiment was conducted aiming to study the effect of Spacing and Boron levels on growth and yield of black gram during *Zaid* season 2022. The treatments comprised of row spacing (25, 30, 35 cm) and boron (1.0, 1.5, 2.0 kg/ha). The results showed that application of boron 2.0 kg/ha at 35 cm × 10 cm spacing has recorded significantly higher plant height (44.53 cm), number of branches per plant (9.27), number of nodules (35.53) and dry weight (10.44 g). However higher number of pods per plant (30.73), seeds per pod (6.40), test weight (42.48 g), seed yield (930.33 kg/ha) and stover yield (2040.33 kg/ha) were recorded with the application of boron 2.0 kg/ha at 25 cm ×10 cm spacing. Therefore, the spacing of 25 cm × 10 cm and application of Boron 2.0 kg/ha could be a promising option for the yield enhancement in black gram.

Keywords: Boron; black gram; growth; spacing; yield.

1. INTRODUCTION

"Black gram (*Vigna Mungo* L.) is one of the important pulse crops. It is cultivated in many tropical and sub-tropical countries of the world. It is grown throughout India. Black gram is a widely grown grain legume and belongs to the family Fabaceae and assumes considerable importance from the point of food and nutritional security in the world. It is also known as urad bean, urad

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dal, and urad. It also acts as a cover crop and its deep root system protects the soil from erosion. Besides, this green fodder of the urad bean is very nutritive and is especially useful for mulch cattle. Urad bean being leguminous can fix atmospheric nitrogen and thus helps in restoring soil fertility" [1].

"Black gram is short duration pulse crop which is grown in India area of 50.31 lakh hectare having the production of 32.84 lakh tons with productivity 652 kg/ha". (Ministry of Agriculture and Farmer Welfare, 2017-18). "It accounts for 10 per cent of country's total pulse production" [2]. "Black gram seed contain 55-60% carbohydrate, 22-24% protein and 1.0-1.3% of fat besides, phosphoric acid (H3PO4), being 5-10 times more than other pulses [3] and sulphur containing amino acid (methionine and cysteine)". "Dried black gram contains about 9.7% water, 23.4% protein, 1.0% fat, 57.3% carbohydrate and 3.8% fibre along with 154 mg Calcium, 9.1 mg Iron, 0.37 g riboflavin and 0.42 g Thiamine in each gram of black gram" [4] Due to cheaper protein source, it is designated as "poor man's meat" [5]. "Because of their vital role in nutritional protection and soil development, pulses have been an integral part of sustainable agriculture since ancient times" [6].

"The continuous cultivation of traditional low potential cultivars, the use of low seed rate, and improper agronomic practises were important reasons for the low average yield of black gram in farmers' fields. Among the various crop production constraints, the most important are appropriate varieties and crop spacing, both of which contribute significantly to black gram seed yield. Many research studies have revealed that most of the growth and yield contributing attributes were significantly and positively correlated with the seed yield of crop plants viz., black gram" [7], soybean [8] and sunflower [9].

"Plant density can have a major effect on the final yield of most of the legumes and the general response of yield to increasing population is well documented. To realize the maximum yield potential of black gram during the summer and rainy season, maintenance of optimum space made available to the individual plant is of prime importance. Row and plant spacing must be worked out to get desired spacing. The spacing requirement depends upon the growth behaviour of the genotype. So, it is required to maintain spacing for obtaining higher a yield" [10]. "It is prime necessity to maintain optimum plant population by maintaining inter and intra row spacing properly. Maximum or minimum plant density may minimize yield of black gram causing physiological change in plant. Hence appropriate fertilizer dose with adequate plant population may increase crop yield of black gram" [11-13]. Similar results were noted by [14].

"Boron (B) is an essential non-metal micronutrient plays a decisive role in maintaining cell wall structure, cell division, membrane stability, nitrogen assimilation, sugar translocation, K+ transport, protein and sucrose synthesis, phenol, carbohydrate, nucleic acid and IAA metabolism" [15]. "Calcareous soils and those with low organic matter content are more prone to B deficiency" [16,17]. "Boron is retained in soils by adsorption on to minerals and humic particles and by forming insoluble precipitates" [18]. "4-5 lines related to boron importance for pulse crops. The potential B deficiency in soils of India was estimated as 33 per cent" [19]. It has been reported that boron deficiency limits reproductive growth. Havlin et al. [20] documented that "due to shortage of boron, flowering and fruit development were highly restricted". "In recent times, management of boron is a challenging aspect as the optimum level of B application range is narrow" S Sharmila [21]. With these considerations in mind, the current research was aimed to examine the effect of spacing and boron on black gram growth and yield.

2. MATERIALS AND METHODS

The experiment was conducted during the *Zaid* season 2022, at the CRF (Crop Research Farm), Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh. The CRF is located at 25^0 30' 42''N latitude, 81^0 60' 56" E longitude and 98 m altitude above the mean sea level (MSL). This area is situated on the right side of the river Yamuna and by the opposite side of Prayagraj city. The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 6.9), low in organic carbon (0.112 %), available N (278.93 kg/ha), available P (10.8 kg/ha) and available K (206.4 kg/ha).

The experiment was laid out in Randomized Block Design with nine treatments each replicated thrice. The crop was shown on 28^{th} February 2022 using Shekhar-2 variety. The experiment was laid out in Randomized Block

Design with nine treatments each replicated thrice viz **T_1** (25 cm ×10 cm + B 1.0 kg/ha), **T_2** (25 cm ×10 cm + B 1.5 kg/ha), **T_3** (25 cm ×10 cm + B 2.0 kg/ha), **T_4** (30 cm × 10 cm + B 1.0 kg/ha),**T_5** (30 cm ×10 cm + B 1.5 kg/ha), **T_6** (30 cm × 10 cm + B 2.0 kg/ha), **T_7** (35 cm ×10 cm + B 1.0 kg/ha), **T_8** (35 cm ×10 cm + B 1.5 kg/ha), **T_9** (35 cm ×10 cm + B 2.0 kg/ha).

Fertilizers were applied as band placement, for which 4-5cm deep furrows were made along the seed rows with a hand hoe. The nutrient sources were Urea, SSP and MOP to fulfil the requirement of nitrogen, phosphorous and potassium. The recommended dose of 20 kg/ha nitrogen,40 kg/ha phosphorous and 20 kg/ha potassium and Boron 1.0, 1.5, 2.0 kg/ha were applied according to the treatments. The sources used for applying N P K and Boron were Urea (N 46%), Single Super Phosphate (P 16%) and Muricate of Potash (K 60%), Boron (Di Sodium Tetra Borate Penta Hydrate) (B 14.5%) respectively.

Seeds were sown in line manually on 28 Feb 2022 at a depth of 4-5 cm in furrows with seed rate of 15-20 kg/ha. Entire doses of NPK and Boron were applied as basal for respective plots. Seeds are then covered with soil immediately. The row-row spacing between crop 25, 30, 35 cm and plant to plant 10 cm were according to the treatment details. The growth parameters were recorded at periodical intervals of 15,30,45,60 DAS and at harvest stage from the randomly selected five plants in each treatment. Statistically analysis was done for all the parameters in one-way Anova and mean compared at 5% probability level of significant results.

3. RESULTS AND DISCUSSION

Effect of Spacing and Boron levels on growth parameters are given in Table 1.

3.1 Growth Attributes

3.1.1 Plant height (cm)

At harvest, significantly highest plant height (44.53 cm) was recorded with the application of (2.0 kg/ha boron at 35 cm × 10 cm spacing) T_9 and T_8 (35 cm × 10 cm + B 1.5 kg/ha) (44.00 cm) was recorded statistically at par with T_9. The spacing practices had significant effects on plant height. An increasing trend in plant height with optimum geometry level could be noticed. This may be due to the less competition between the inter and intra plant roots for sunlight, water, nutrients and space at wider spacing. Significant results were obtained due to the optimum spacing of 35 cm × 10 cm and similar results were obtained by Singh et al. [22]. **"**The increase in plant height may be due to an appropriate dose of boron because B plays important role in various enzymatic and other biochemical reactions". Similar results were discussed by Zahoor et al. [23], Gitte et al. [24].

3.1.2 No. of branches/plant

At harvest, significantly highest No. of branches (9.27) was recorded with the application of (2.0 kg/ha boron at 35 cm × 10 cm spacing) T_9 and T_8 (35 cm ×10 cm + B 1.5 kg/ha) (9.20) was recorded statistically at par with T_9. The optimum plant spacing between plants resulted in enhanced space, sunlight, nutrients and soil moisture for increased photosynthesis, and metabolic activities which resulted in higher number of branches. The results were following Amruta et al. [25] and Jiotode et al. [26]. "Significantly maximum number of branches/plan ts was due to the application of boron. This might be due to the reason for the increase in this yield attribute that the boron plays important role in plant metabolism and translocation of photosynthates from source to sink". These are similar findings obtained by [27].

3.1.3 No. of nodules/plant

"At harvest, significantly highest No. of nodules (6.33) was recorded with the application of (2.0 kg/ha boron at 35 cm × 10 cm spacing) T_9 and T_8 (35 cm × 10 cm + B 1.5 kg/ha) (6.13) was recorded statistically at par with T_9. The optimum spacing resulted in the increase of nodulation, root development and growth, this might be due to availability of more space to roots for proliferation and nodule formation. Prasad et al. [28]. Number of nodules in black gram was significantly influenced by application of boron. This 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.

Table 1. Effect of Spacing and Boron levels on growth attributes of Black gram

	At Harvest				60-75 DAS	
Treatments	**Plant height (cm)**	**No. of Branches/ plant**	**No. of Nodules/ plant**	**Plant dry weight (g/plant)**	**Crop growth rate ($g/m^2/day$)**	**Relative growth rate (g/g/day)**
25 cm ×10 cm + B 1.0 kg/ha	39.67	7.60	4.40	9.55	3.64	0.02
25 cm ×10 cm + B 1.5 kg/ha	39.90	7.80	4.67	9.65	2.26	0.02
25 cm ×10 cm + B 2.0 kg/ha	40.93	8.00	4.93	9.76	4.50	0.02
30 cm ×10 cm + B 1.0 kg/ha	41.57	8.20	5.20	9.84	3.27	0.02
30 cm ×10 cm + B 1.5 kg/ha	41.90	8.40	5.40	9.95	3.37	0.02
30 cm ×10 cm + B 2.0 kg/ha	42.70	8.60	5.67	10.16	4.51	0.02
35 cm ×10 cm + B 1.0 kg/ha	43.33	8.80	5.87	10.24	3.28	0.02
35 cm ×10 cm + B 1.5 kg/ha	44.00	9.20	6.13	10.39	3.45	0.02
35 cm ×10 cm + B 2.0 kg/ha	44.53	9.27	6.33	10.44	3.50	0.02
F test	S	S	S	S	NS	NS
S. EM (±)	0.18	0.07	0.07	0.02	0.59	0.01
CD (P=0.05)	0.53	0.20	0.20	0.05	---	---

Table 2. Effect of Spacing and Boron levels on yield attributes of Black gram

	At harvest					
Treatments	**Pods/plant (No's)**	**Seeds/pod (No's)**	**Test weight (g)**	**Seed yield (kg/ha)**	**Stover yield (kg/ha)**	**Harvest index (%)**
25 cm ×10 cm + B 1.0 kg/ha	29.67	5.87	40.48	828.33	2032.67	28.95
25 cm ×10 cm + B 1.5 kg/ha	30.33	6.13	42.14	862.67	2045.33	29.66
25 cm ×10 cm + B 2.0 kg/ha	30.73	6.40	42.48	930.33	2040.33	31.32
30 cm ×10 cm + B 1.0 kg/ha	28.80	5.20	37.63	739.67	1981.67	27.17
30 cm ×10 cm + B 1.5 kg/ha	29.20	5.40	38.53	772.00	1989.00	27.95
30 cm ×10 cm + B 2.0 kg/ha	29.40	5.60	39.36	793.67	2002.00	28.39
35 cm ×10 cm + B 1.0 kg/ha	28.00	4.33	34.40	651.00	1957.00	24.96
35 cm ×10 cm + B 1.5 kg/ha	28.40	4.60	35.78	685.00	1968.00	25.81
35 cm ×10 cm + B 2.0 kg/ha	28.60	4.93	36.27	713.33	1977.00	26.51
F test	S	S	S	S	S	S
S. EM (±)	0.16	0.09	0.14	4.47	3.56	0.12
CD (P = 0.05)	0.47	0.27	0.41	13.41	10.66	0.35

3.1.4 Dry matter accumulation

At harvest, significantly highest dry weight (10.44 g) was recorded with the application of (2.0 kg/ha boron at 35 cm × 10 cm spacing) T_9 however T_8 (35 cm × 10 cm + B 1.5 kg/ha) (10.39 g) which was recorded statistically at par to T_9. Higher dry matter production is observed in 35 × 10 cm^2 spacing due to better photosynthetic activity because of greater exposure to light and increased availability of nutrients to plants have also resulted in higher root dry weight on the plants. Similar results were reported by Khan et al. [29].

Effect of Spacing and Boron levels on yield parameters of Black gram are given in Table 2.

3.2 Yield Attributes and Yield

3.2.1 Pods/plant (No’s)

At harvest, the treatment T_3 (25 cm × 10 cm + B 2.0 kg/ha) recorded a significantly highest number of pods/plant (30.73). However, T_2 (25 cm × 10 cm + B 1.5 kg/ha) (30.33) was found to be statistically at par with T_3. The higher number of pods/plants might be possible due to more vigour and strength attained by the plants because of better photosynthetic activities with sufficient availability of light, and supply of nutrients in the balanced quantity of the plants at growing stages. Jitendra kumar et al. [30] observed similar results.

3.2.2 Seeds/pod (No’s)

“At harvest, the treatment T_3 (25 cm × 10 cm + B 2.0 kg/ha) recorded significantly highest number of Seeds/Pod (6.40). However, T_2 (25 cm × 10 cm + B 1.5 kg/ha) (6.13) was found to be statistically at par with T_3. The increase in the number of seeds per pod might be due to an increase in translocation of assimilates from source to sink”. Shivay and Shekawat [31].

3.2.3 Test weight (g)

At harvest, significantly highest Test weight (42.48 g) was recorded with T_3 (25 cm × 10 cm + B 2.0 kg/ha) and T_2 (25 cm × 10 cm + B 1.5 kg/ha) (42.14 g) was statistically at par with T_3. Test weight of black gram seeds was increased due to the role of boron in increasing pollen viability and stigmatic receptivity which brings in increased seed set & increased translocation of photosynthesis to sink which increases test weight Prasad et al. (2015). **“**Better availability of moisture and moderation of soil temperature led to greater uptake of nutrients and reduced number of days taken to meet the required heat units for proper growth and development of plants and ultimately the yield attributes”. The results were recorded similar to Anand et al. [32].

3.2.4 Seed yield (Kg/ha)

At harvest, the treatment T_3 (25 cm × 10 cm + B 2.0 kg/ha) recorded significantly higher seed yield (930.33 kg/ha) over rest of the treatments. The B application improved the seed yield because it maintains a good balance between photosynthesis and respiration. Boron removal alters the cell wall structure, with a transitory decrease in elasticity modulus, flowed by a secondary hardening and reduction in the incidence of plasma membrane bound reductase activity for better translocation to sink Shekawat and shivay [31]. Similar results were obtained by Yu et al. [33].

3.2.5 Stover yield (kg/ha)

At harvest, the treatment T_3 (25 cm × 10 cm + B 2.0 kg/ha) stover yield (2045.33 kg/ha) was found significantly higher. However, T_2 (25 cm × 10 cm + B 1.5 kg/ha) (2040.33 kg/ha) was found to be statistically at par with T_3. The stover yield was significantly influenced by different levels of boron application M.A. Khan [34]. Higher stover yield of black gram at closed row spacing might be due to more population per unit area which contributed to more biomass and hence higher stover yield. Sathyamoorthi K. et al. [35]. Similar results were obtained by Kailash Raman Bhatt [36].

3.2.6 Harvest index (%)

Significantly highest harvest index (31.32%) was observed in T_3 (25 cm × 10 cm + B 2.0 kg/ha) and is superior to rest of all treatments. “Highest harvest index was observed due to cell activities, enhanced cell multiplication and enlargement and luxuriant growth and yield attributes of the crops probably due to more absorption and utilization of available nutrients leading to overall improvement of crop growth reflected to source-sink relationship, which in turn enhanced the yield attributes that ultimately more yield” Kokani et al. [37].

4. CONCLUSION

Based on the findings of the experiment it can be concluded that maintaining a spacing of 25 cm ×

10 cm and application of Boron 2.0 kg/ha along with recommended dose of fertilizer in black gram during *zaid* season was found to be more productive as well as economically viable.

ACKNOWLEDGEMENT

I express my sincere gratitude to my advisor Dr.(Mrs) Shikha Singh for her constant support, guidance and valuable suggestions for improving the quality of this work. I am indebted to all the faculty members of Department of Agronomy, SHUATS, Prayagraj, Uttar Pradesh (U.P), India for their cooperation, encouragement and for providing indispensable facilities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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