International Journal of Environment and Climate Change

Volume 13, Issue 6, Page 56-63, 2023; Article no.IJECC.98413
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Impact of Sulphur and Boron Levels on Growth, Yield, and Economics of Summer Green Gram (*Vigna radiata L.*)

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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/v13i61797

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/98413

Original Research Article

Received: 04/02/2023
Accepted: 06/04/2023
Published: 10/04/2023

ABSTRACT

A field experiment was conducted during *Zaid* 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P). To determine the "Impact of sulphur and boron levels on growth, yield, and economics of summer green gram (*Vigna radiata* L.)". To study treatments consisting of three Sulphur *viz.* 5, 10 and 15 kg/ha and three levels of Boron 0.2%, 0.4% and 0.6%. There were 10 treatments, each of which was replicated three times and laid out in a random block design. The results showed that treatment 9 [Sulphur (15 kg/ha) + Boron (0.6%)] showed the highest performance of all treatments with a plant height of (47.5 cm), number of branches/plants (8.80), plant dry weight (7.38 g), number of nodules/plant (7.40). Where as, maximum number of pods/plant (29.4), maximum number of seeds/pod (10.33), higher seed yield (1.21 t/ha), higher haulm yield (2.81 t/ha), higher harvest index (30.3 %), was recorded in treatment 9 [Sulphur (15 kg/ha) + Boron (0.6%)]. Similarly, maximum gross returns (82,022.00 INR/ha), higher net returns (53,522.30 INR/ha) and highest benefit cost ratio (1.88) was also recorded in treatment 9 [Sulphur (15 kg/ha) + Boron (0.2%)] as compared to other treatments.

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Keywords: Sulphur; boron; growth; yield; economic.

1. INTRODUCTION

Mung bean (*Vigna radiata* L.) commonly known as greengram is an important conventional pulse crop of India. It is originated from India and central Asia. It is also called as "Golden Bean" because of its nutritive values and suitability for increasing the soil, by the way of addition of nitrogen to the soil. "It is considered as poor men's meat containing almost triple amount of protein as compared to rice. It as high nutritive value, and due to this, has advantage over the other pulses. Mung bean is a short day, warm season crop, grown mainly in semi arid to sub humid tropics and tropics with 600 to 1000 mm annual rainfall, for a high yield, a warm climate and deep well drained loam or sandy loam soils are desired. The seed contains protein (24.20%), fat (1.30%), and carbohydrates (60.4%), calcium is 118 and phosphorus is 340 mg/100gram of seed, respectively" [1]. Greengram improves physical properties of soil and fixes atmospheric nitrogen [2]. "Greengram contains about 24.3 % protein and is good source of riboflavin and thiamine" [3].

"Greengram is one of the important pulse crops, which ranks third in area and production after pigeon pea and chickpea and is grown in almost all parts of the country over a wide range of agro-climatic condition. In India, Green gram is grown over an area about 51.30 lakh ha with an average production of 3.85 lakh tonnes and productivity of 601 kg/ha under 2020-2021. Total coverage under green gram in Uttar Pradesh 0.86 Lakh/ha with a production 0.61 Lakh tonnes and the productivity 709 kg/ha" [4]. According to government fourth advance estimates, greengram production in 2021-22 is at 3.15 million tonnes.

"Sulphur plays an important role in growth and development of crops. it plays important role in the formation of S-containing amino acids like cysteine (27% S), cysteine (26% S), methionine (21% S), which act as building blocks in the synthesis of proteins" [5]. "It has role to play in increasing chlorophyll formation and aiding photosynthesis and also plays a role in the activation of enzymes, nucleic acids and forms a part of biotin and thiamine. Sulphur is considered as critical for seed yield and protein synthesis and for improvement in quality of produce in legumes through their enzymatic and metabolic effects" [6].

"Boron is a trace element that can be applied in soil as well as foliar. It is many times observed that foliar applied boron causes increased in yield more than soil applied boron because boron is required more at reproductive stage and foliar applied is instantly present for plant in compare to soil applied boron. Boron is very important in plant metabolism through acting activity of certain enzyme, cell division, carbohydrate transport, and calcium and potassium uptake and protein synthesis; ultimately it may enhance in pod and seed formation. Boron ranks third place among micronutrients in its concentration in seed and stem as well as its total amount after zinc. Boron is an essential micronutrient for plant, but the range between deficient and toxic B concentration is smaller than for any other nutrient element. Plant responds directly to the activity of B soil solution and only indirectly to B adsorbed on the soil constituents. Soil factors affecting availability of B to plants are *viz*; pH, texture, moisture, temperature, organic matter and clay mineralogy" [7].

Sulphur is essential in forming plant proteins because it is a constituent of certain amino acids. It is actively involved in metabolism of the B vitamins biotin and thiamine and co-enzyme A. Its mostly aids in seed production, chlorophyll formation, nodule formation in legumes, and stabilizing protein structure. The process of tissue differentiation from somatic to reproductive meristematic activity and development of floral primordial have increased and also more flowers and pods longer and increases the yield .So there is a scope of increasing the mungbean unit area by using balanced sulphur.

Boron deficiency seen in upper internodes of the stem are shortened, giving the plants a rosette appearance. Upper leaves near the growing points turn yellow and sometimes red.Symptoms are most severe at the leaf tips while the leaf base remain green. Pollen grains, poor pollen vitality and reduced number of flowers/plant besides stunted root growth.

Boron is necessary in the synthesis of one of the bases for RNA formation and in cellular activities and promote root growth. It is essential for pollen germination and growth of the pollen tube and also formation of flowers, and for development of seed. Born has been associated with lignin synthesis, activities of certain enzymes, seed and cell wall formation, and sugar transport. Its helps in absorption and utilization of calcium in plants. Keeping in view the above facts, the present investigation was undertaken to find out " Impact of sulphur levels and boron on growth and yield of summer greengram (*Vigna radiata* L.)"

2. MATERIALS AND METHODS

The experiment was conducted during the *Zaid* season 2022 at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.). The soil of the field constituting a part of central gangetic alluvium is neutral and deep. The soil of the experimental field was sandy loamy in texture, nearly neutral in soil reaction (pH 7.8), low level of organic carbon (0.62%), available N (225 kg/ha), P (38.2 kg/ha), K (240.7 kg/ha). The treatment consists of three different levels of sulphur *viz,* 5kg/ha, 10kg/ha, 15kg/ha with combination of different levels of boron *viz*, 0.2%, 0.4%, 0.6%. The experiment was laid out in RBD with 10 treatments each replicated thrice. The treatment combinations are T1 – Sulphur (5kg/ha) + Boron (0.2%), T2 – Sulphur (5kg/ha) + Boron (0.4%) , T3 – Sulphur (5kg/ha) + Boron (0.6%), T4 – Sulphur (10kg/ha) + Boron (0.2%), T5 – Sulphur (10kg/ha) + Boron (0.4%), T6 - Sulphur (10kg/ha) + Boron (0.6%), T7 – Sulphur (15kg/ha) + Boron (0.2%), T8 – Sulphur (15kg/ha) +Boron (0.4%), T9 – Sulphur (15kg/ha) + Boron (0.6%), T10 – (Control) N:P:K 20:40:20kg/ha.

All agronomic practices are followed in order in the crop period. Experimental data collected was subjected to statistical analysis of variance (ANOVA) as outlined by Gomez and Gomez (1984). Critical Difference (CD) values were calculated wherever the 'F' test was found significant at 5 percent level.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

The data revealed that significant and higher plant height (47.5cm) was observed in treatment 9 [Sulphur (15 kg/ha) + Boron (0.6%)]. However, treatment 8 [Sulphur (15 kg/ha) + Boron (0.4%)] were statistically at par with the treatment 9 [Sulphur (15 kg/ha) + Boron (0.6%)] [Table 1]. The significant and higher plant height was with application of Sulphur (15kg/ha) might be due to involvement of sulphur in stimulation of cell division, photosynthetic process as well as formation of chlorophyll Arunraj et al. [8]. Further, the application of boron(0.6%) this might be due to enhances the differentiation of tissue cell division and nitrogen absorption from the soil. Similar result was found by Singh et al. [9].

3.1.2 Number of branches/plant

The data revealed that treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)] recorded significant and maximum number of branches/plant (8.80) which was superior to all the treatments and the treatment 8 [Sulphur (15 kg/ha) + Boron 0.4%)], treatment 6 [Sulphur (10 kg/ha) + Boron (0.6%)]and treatment 5 [Sulphur (10 kg/ha) + Boron 0.4%)] were statistically at par with the treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)]. The significant and maximum number of branches/plant was with the application of sulphur (15kg/ha) might be due to the penetration of roots to deeper depths, resulting in more absorption of water and nutrients. Similar results have been reported by Aman et al. [10] in black gram. Further, maximum number of branches/plant might be due to the application of boron (0.6%) promoting root and shoot growth, flower fertility and essential nutrient for nodule forming bacteria therefore, increased nodule count resulting in increasing in effect of number of branches/ plant. Similar findings also reported by Movalia et al. [7].

3.1.3 Plant dry weight (g)

Data found that significant and higher plant dry weight (7.38 g) was obtained in the treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)]. However, no treatment was statistically at par with the treatment 9. The significant and higher plant dry weight was with the application of sulphur (15kg/ha) might be due to the continuous and slow release of nutrients Arunraj et al. [8]. Further, maximum plant dry weight was observed by application of boron (0.6%) might due to the stabilizing certain constituents of cell wall and plasma membrane, enhancement of cell division, tissue differentiation and metabolism of nucleic acids, carbohydrates, proteins, auxins and phenols. Similar results were reported by Padbhushan et al. [11].

3.1.4 Number of nodules/plant

Results revealed that treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)] recorded significantly maximum number of nodules/plant (7.40). However, treatment 8 [Sulphur (15 kg/ha) +

Boron 0.4%)] were statistically at par with the treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)]. The significant and maximum number of nodules/plant was with application of sulphur (15kg/ha) might be due to the increasing leg haemoglobin pigment formation in nodules Parry et al. [12]. Further, maximum number of nodules/plant might be due to the application of boron (0.6%) root and shoot growth, flower fertility and essential nutrient for nodule forming bacteria. Similar results were reported by Movalia et al. [7].

3.1.5 Crop growth rate (g/m^2/day)

The data revealed that during 45-60 DAS no significant difference among all the treatments. However, highest crop growth rate (4.95 g/m^2/day) was observed in treatment treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)].

3.1.6 Relative growth rate (g/g/day)

The data revealed that during 45-60 DAS, treatment 9 [Sulphur(15kg/ha) + Boron 0.6%)] recorded higher relative growth rate (0.0409 g/g/day), though there was no significant difference among the treatments.

3.2 Yield Attributes

3.2.1 Number of pods/plant

The data showed that (29.4) treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)] recorded significantly higher number of pods/plant (29.4). However, treatment 8 [Sulphur (15 kg/ha) + Boron 0.4%)] were statistically at par with the treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)] [Table 2]. The significant and higher number of pods/plant was with the application of sulphur (15kg/ha) might be due to the tissue differentiation from somatic to reproductive meristematic activity and development of floral primordial might have increased with increasing in more flowers and pods Mazed et al. [13] Further, maximum number of pods/plant was observed with the application of boron(0.6%) might be due to the formation of flower and pollen grain thus increases the pods/plant. Similar findings also reported by Padbhushan et al. [11].

3.2.2 Number of seeds/pod

The data recorded that significant and higher number seeds/pod(10.33) was recorded in treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)] and though there was significant difference among the treatments. The significant and higher number of seeds/pod was with the application of sulphur (15kg/ha) might be due to it improves the metabolic enzymatic process in the plant thus increases the seeds/pod. Similar results were reported by Laxmi et al. [14]. Further increase in number of seeds/pod was observed with the application of boron(0.6%) might be due to increase in germination percentage of seed inside the pod. Similar findings were reported by Padbhushan et al. [11].

3.2.3 Test weight (g)

Significant and maximum test weight (29.80 g) was recorded in treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)], and though there was no significant difference among all treatments.

3.2.4 Seed yield (t/ha)

Significant higher seed yield (1.21t/ha) was obtained in treatment 9 [Sulphur (15kg/ha) + Boron 0.6%)]. However, treatments 8 [Sulphur (15 kg/ha) + Boron 0.4%)], treatment 6 [Sulphur (10 kg/ha) + Boron 0.6%)] and treatment 5 [Sulphur (10 kg/ha) + Boron 0.4%)] were statistically at par with the treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)]. The significant and higher seed yield was with the application of sulphur (15/ha), might be due to sulphur in stimulation of cell division, photosynthetic process as well as formation of chlorophyll ultimately helped in realization of higher grain yield Arunraj et al. [8]. Further, maximum in seed yield with the application of boron (0.6%) might be due to physiological processes and plant growth also adequate nutrition is a critical for increases yield and quality of crops. Similar result was reported by Banoth et al. [15].

3.2.5 Haulm yield (t/ha)

Significant and higher haulm yield (2.81t/ha) was recorded in treatment 9 [Sulphur (15 kg/ ha) + Boron 0.6%)]. However, treatments 8 [Sulphur (15 kg/ha) + Boron 0.4%)], treatment 6 [Sulphur (10 kg/ha) + Boron 0.6%)] and treatment 5 [Sulphur 10 kg/ha + Boron 0.4% were statistically at par with the treatment 9 [Sulphur(15 kg/ha) + Boron 0.6%)]. The significant and higher haulm yield was observed with the application of sulphur(15 kg/ha) might be due to sulphur enhances the plant metabolism and photosynthetic activity. Similar results have been

Table 1. Impact of sulphur levels and boron on growth parameters of green gram

S No	Treatments	Plant height (cm)	Number of branches/ plant	Plant dry weight (g)	Number of nodules/plant	CGR ($g/m^2/day$)	RGR (g/g/day)
1.	Sulphur 5 kg/ha + Boron 0.2%	44.2	7.60	5.18	5.20	4.88	0.0238
2.	Sulphur 5 kg/ha + Boron 0.4%	44.5	7.80	5.78	5.80	4.88	0.0251
3.	Sulphur 5 kg/ha + Boron 0.6%	44.6	7.80	5.98	6.00	4.88	0.0260
4.	Sulphur 10 kg/ha + Boron 0.2%	44.7	8.00	6.18	6.20	4.88	0.0270
5.	Sulphur 10 kg/ha + Boron 0.4%	45.4	8.40	6.78	6.80	4.88	0.0303
6.	Sulphur 10 kg/ha + Boron 0.6%	45.9	8.60	6.98	7.00	4.88	0.0317
7.	Sulphur 15 kg/ha + Boron 0.2%	44.8	8.20	6.58	6.60	4.88	0.0292
8.	Sulphur 15 kg/ha + Boron 0.4%	46.9	8.73	7.18	7.20	4.88	0.0366
9.	Sulphur 15 kg/ha + Boron 0.6%	47.5	8.80	7.38	7.40	4.95	0.0409
10.	Control N:P:K (20:40:20 Kg/ha)	42.4	7.40	4.78	4.87	4.68	0.0230
	F-test	S	S	S	S	NS	NS
	SEm(±)	0.39	0.15	0.04	0.13	0.11	0.0008
	CD at 5%	1.15	0.45	0.13	5.20	--	--

Table 2. Impact of sulphur levels and boron on yield attributes of greengram

S No	Treatments	Number of pods/plant	Number of seeds/pod	Test weight (g)	Seed yield (t/ha)	Haulm yield (t/ha)	Harvest index (%)
1.	Sulphur 5 kg/ha + Boron 0.2%	22.2	8.00	26.00	0.79	2.34	25.3
2.	Sulphur 5 kg/ha + Boron 0.4%	22.8	8.20	26.60	0.83	2.38	26.1
3.	Sulphur 5 kg/ha + Boron 0.6%	23.0	8.60	26.80	0.89	2.44	26.9
4.	Sulphur 10 kg/ha + Boron 0.2%	23.2	8.80	27.40	0.95	2.50	27.7
5.	Sulphur 10 kg/ha + Boron 0.4%	26.0	9.40	28.00	1.02	2.57	28.1
6.	Sulphur 10 kg/ha + Boron 0.6%	27.4	9.80	28.40	1.08	2.63	28.4
7.	Sulphur 15 kg/ha + Boron 0.2%	24.0	9.00	27.60	0.99	2.54	28.1
8.	Sulphur 15 kg/ha + Boron 0.4%	28.8	10.07	29.20	1.18	2.71	30.1
9.	Sulphur 15 kg/ha + Boron 0.6%	29.4	10.33	29.80	1.21	2.81	30.3
10.	Control N:P:K (20:40:20 Kg/ha)	21.8	7.80	25.20	0.75	2.30	24.4
	F-test	S	S	NS	S	S	S
	SEm(±)	0.28	0.11	0.24	0.07	0.08	1.04
	CD at 5%	0.84	0.33	0.72	0.22	0.25	3.10

Table 3. Impact of sulphur levels and boron on economics of greengram

S No	Treatments	Total cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1	Sulphur 5 kg/ha + Boron 0.2%	26989.30	54158.00	27168.30	1.01
2	Sulphur 5 kg/ha + Boron 0.4%	27244.30	56806.00	29561.30	1.09
3	Sulphur 5 kg/ha + Boron 0.6%	27499.30	60778.00	33278.30	1.21
4	Sulphur 10 kg/ha + Boron 0.2%	27489.30	64750.00	37260.30	1.36
5	Sulphur 10 kg/ha + Boron 0.4%	27744.30	69384.00	41639.30	1.50
6	Sulphur 10 kg/ha + Boron 0.6%	27999.30	73356.00	45356.30	1.62
7	Sulphur 15 kg/ha + Boron 0.2%	27989.30	67398.00	39408.30	1.41
8	Sulphur 15 kg/ha + Boron 0.4%	28244.30	79952.00	51707.30	1.83
9	Sulphur 15 kg/ha + Boron 0.6%	28499.30	82022.00	53522.30	1.88
10	(Control) N:P:K 20:40:20 Kg/ha	26234.30	51510.00	25275.30	0.96

Data was not subjected to statistical analysis

reported by Jat et al. [16] in cowpea. Further, maximum haulm yield was observed with the application of boron(0.6%) might be due to required for cell differentiation, development and growth of pollen grains. It acts as a greater role in translocation of photosynthates, resulting in increased pollination and seed setting and plant metabolism Movalia et al. [7].

3.2.6 Harvest index (%)

The data revealed that treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)] recorded the higher harvest index (30.3%). However, treatment 8 [Sulphur (15 kg/ha + Boron 0.4%)], treatment 6 [Sulphur (10 kg/ha) + Boron 0.6%)], treatment 5 [Sulphur (10 kg/ha) + Boron 0.4%)]and treatment 4 [Sulphur (10 kg/ha) + Boron 0.2%)] were statistically at par with the treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)]. The significant and higher harvest index was obtained with the application of sulphur (15/ha) might be due to the part of aminoacid,which helps in chlorophyll formation, photosynthetic process, activation of enzymes and grain formation Arunraj et al. [8]. Further, maximum harvest index was observed with application boron (0.6%) might be due to affects cell division, carbohydrate metabolism, sugar and starch formation. Similar result was observed by Padbhushan et al. [11].

3.2.7 Economics

The result showed that maximum gross return (82,022.00 INR/ha), higher net returns (53,522.30 INR/ha), and highest benefit cost ratio (1.88) was recorded in treatment 9 [Sulphur (15 kg/ha) + Boron 0.6%)] as compared to other treatments [Table 3]. Higher gross returns, net returns, benefit cost ratio was recorded with application of sulphur (15kg/ha) might be due to maximum recovery from application of sulphur with less expenditure and higher seed and stover yields obtained from these treatments. These results are in conformity with those observed by Anandamai et al. [17] in chickpea.

4. CONCLUSION

Based on the above findings it can be concluded that application of Sulphur 15kg/ha and Boron 0.6% as foliar spray has performed better in growth parameters and yield attributes of green gram (*PDM139-Samrat*) and also proven profitable. Since the findings are based on one season, further trails are needed to confirm the results.

ACKNOWLEDGEMENTS

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

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:
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