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Effect of sulphur and boron on growth and yield of greengram (*Vigna radiata* L.)

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Abstract
A field experiment was conducted during zaid season of 2021 at Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, SHUATS, Prayagraj, Uttar Pradesh to evaluate the effect of different levels of sulphur and boron on growth and yield of greengram. The treatment consists of three different levels of Sulphur (10, 20, 30 kg/ha) and Boron (0.5, 1.0, 2.0 kg/ha). The experiment was laid out in Randomized Block Design with Nine treatments replicated thrice. Results revealed that significantly higher plant height (39.7 cm), plant dry weight (13.27 g/plant), number of branches per plant (6.20), Number of pods per plant (22.60), Number of seeds per pod (7.07), test weight (33.01 g), Grain yield (1.58 t/ha) and Stover yield (2.67 t/ha), were obtained by the application of sulphur at the rate 30 kg/ha along with boron 2 kg/ha. The successive increase in fertilizer levels of sulphur and boron increased the growth parameters, yield attributes and yield of greengram.

Keywords: Greengram, sulphur, boron, growth and yield

Introduction
Pulses have been regarded as the poor man's only source of protein in India. It is cultivated over an area of 23.4 million hectares, with a total production of 18.4 million tonnes (Anonymous, 2019) [1]. Pulses are important in agriculture and society for a variety of reasons, including their nutritional value, vegetarian diet, capacity to enhance soil fertility, minimal resource and water requirements, and so on. The ever-growing population demand for food cannot be neglected. Cereals and pulses have been major part of their diet for very long period. Cereal production in India have got the momentum that it needs to feed the growing population, but it is not the same in case of pulse production, whose relevance is in providing nutritionally balanced meals for the rising population demands requires rapid attention.

Greengram (*Vigna radiata* L.) is a one of the significant pulse crops grown in the world. It is known for its high nutritional content (24.0% protein, 1.3% fat, 56.6% carbohydrate, 3.5% minerals, 0.43% lysine, 0.10% methionine, and 0.04% tryptophan), (Kachroo, 1970) [4]. It has been primary source of dietary plant protein. It is cultivated in all tropical and subtropical regions of the world. In India cultivation of Greengram has been from prehistoric times, (Mohbe, *et al*., 2015) [5]. Among the Indian states, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Rajasthan, Bihar, Gujarat, and Orissa are the major producers of greengram. It is grown on around 300 million hectares in India. It also contributes to the maintenance and improvement of soil fertility by allowing root nodules to fix atmospheric nitrogen in the soil. Rhizobium bacteria create nodules on the roots of greengram, which fix roughly 35kg of atmospheric nitrogen per hectare (Yadav, 1992) [9].

Nutrition management in Greengram is one of the most important aspects in increasing productivity and quality. Multi-nutrient deficit is wreaking havoc on our soils. As a result of sulphur deficiency, pulse yields are being held back significantly. Because of its high protein content, mung bean and other pulses have a greater sulphur need than cereals. Heavy sulphur mining through crop removal and widespread use of high-analysis nitrogen, phosphorous, and potassium (NPK) fertilisers that are sulphur-free, with accompanying leaching losses, are some of the reasons that have contributed to its depletion in Indian soils.

Sulphur is a vital component of plant development, ranking alongside nitrogen and phosphorus in the production of plant proteins.

Sulphur insufficiency has been recorded in more than 70 nations throughout the world, including India (Balasubramanian *et al.*, 1990) [2]. Sulphur is also required for the production of vitamins (biotin and thiamine), sulphur-containing amino acids (cystine, cysteine, and methionine), and legume nodulation. According to Pandey and Singh (2001), sulphur treatment resulted in the maximum grain and straw production of greengram. Sulphur is also involved in the activation of enzymes and the production of chlorophyll.

Boron is the third most prevalent micronutrient, and it is necessary for the cell walls and membranes of plants to remain stable (Bassil *et al.*, 2004) [3]. It increases plant growth and yield by increasing leaf area expansion, 1000 test weight, nodule development, seed production, and biological yield. It regulates important cellular processes and metabolic activities and is essential for cell differentiation at all growing tips of plants (meristems) where cell division is happening. Boron treatment maximises the light interception ratio, biomass output, leaf area index, net absorption rate, crop growth rate, and seed yield in pulses, according to Renuka *et al.* (2002) [8]. One of the mineral elements essential for optimal plant development is boron, which is a micronutrient.

Materials and Methods

The experiment was carried out during *Zaid* season of 2021 at Crop Research Farm (SHUATS), Department of Agronomy, Naini Agricultural Institute, SHUATS, and Prayagraj (UP). The soil of the experimental plot was alluvium soil, nearly neutral in soil reaction (pH 7.2), medium in available N (75.3 Kg/ha), available P (31.78 Kg/ha) and available K (92.00 Kg/ha). The treatments combinations are Sulphur (10, 20, 30 kg/ha) and boron (0.5, 1.0, 2.0 kg/ha) effect is observed on Greengram (PDM-139). The experiment was laid out in Randomized Block Design with nine treatments replicated thrice. The experiment comprising of nine treatments possible combination of above factor, *viz.*, T_1: Sulphur 10 kg/ha + boron 0.5 kg/ha, T_2: Sulphur 10 kg/ha + boron 1.0 kg/ha, T_3: Sulphur 10 kg/ha + boron 2.0 kg/ha, T_4: Sulphur 20 kg/ha + boron 0.5 kg/ha, T_5: Sulphur 20 kg/ha + boron 1.0 kg/ha, T_6: Sulphur 20 kg/ha + boron 2.0 kg/ha, T_7: Sulphur 30 kg/ha + boron 0.5 kg/ha, T_8: Sulphur 30 kg/ha + boron 1.0 kg/ha and T_9: Sulphur 30 kg/ha + boron 2.0 kg/ha. Data pertaining to growth parameters were recorded at regular intervals *i.e.*, 15 DAS, 30 DAS, 45 DAS, 60 DAS and yield attributes were recorded at harvest and thereafter.

Results and Discussions

Growth

According to the recorded and analyses data, maximum plant height (39.7 cm), number of, number of nodules per plant (11.53) and plant dry weight (13.27 g) were recorded inferior in treatment with application of sulphur 30kg/ha + boron 2kg/ha.

Sulphur was involved in the protein synthesis and formation of chlorophyll there by promoted vegetative growth, consequently, increased the plant height. Similar findings were also reported by Prajapati *et al.* (2013) [6]. Application of sulphur in combination with boron showed a profound influence on the number of branches per plant up to 45 DAS and gradually decreases thereafter. This might be due to known role of sulphur in stimulation of cell division, photosynthetic process as well as formation of chlorophyll, whereas boron helped in sugar translocation in plant and development of new cell in meristematic tissue increases through all growth parameters. These results are in accordance with those of Yadav (2004) [10].

Application of sulphur showed a profound influence on the number of nodules per plant. This might be due to known role of sulphur in stimulation of cell division, photosynthetic process as well as formation of chlorophyll. These results are in accordance with those of Praveena *et al.* (2018) [7].

Yield and yield attributes

The analysed data pertaining to yield parameters clearly indicates that maximum number of pods per plant (22.60), Number of seeds per pod (7.07), test weight (33.01 g), seed yield (1.58 t/ha) and stover yield (2.67 t/ha) were recorded in treatment with application of sulphur 30kg/ha + boron 2.0kg/ha.

Successive increase in level of sulphur tended to increase significantly in yield attributes, grain and straw yields. The improvement in yield attributes seems to be due to the balanced nutritional environment. Supply of sulphur in adequate amount helped in the development of floral primordia *i.e.*, reproductive parts which resulted in the development of pods and grains in plant Parashar *et al.* (2020). Increased in straw yield was due to the cumulative effect of increased plant height, number of leaves per plant and number of branches per plant *i.e.*, increased growth parameters due to adequate sulphur application. Boron increases yield by increasing leaf area expansion, 1000 test weight, seed production, and biological yield. Boron regulates important cellular processes and metabolic activities and is essential for cell differentiation at all growing tips of plants (meristems) where cell division is happening Renuka *et al.* (2002) [8].

Table 1: Effect of Sulphur and Boron on growth of Greengram

S. No	Treatment	Plant height (cm)	Nodules/Plant (No.)	Dry weight (g/plant)
1	Sulphur 10 kg/ha + Boron 0.5 kg/ha	28.4	7.53	8.97
2	Sulphur 10 kg/ha +Boron 1 kg/ha	29.3	7.20	9.73
3	Sulphur 10 kg/ha + Boron 2 kg/ha	34.4	8.20	10.17
4	Sulphur 20 kg/ha + Boron 0.5 kg/ha	35.0	7.60	9.39
5	Sulphur 20 kg/ha + Boron 1 kg/ha	36.1	8.60	9.41
6	Sulphur 20 kg/ha + Boron 2 kg/ha	37.4	9.47	11.27
7	Sulphur 30 kg/ha + Boron 0.5 kg/ha	36.7	10.13	11.54
8	Sulphur 30 kg/ha + Boron 1 kg/ha	38.3	10.60	12.51
9	Sulphur 30 kg/ha +Boron 2 kg/ha	39.7	11.53	13.27
	F-Test	S	S	S
	S.Em(±)	0.40	0.63	0.25
	CD (5%)	1.22	1.90	0.76

Table 2: Effect of Sulphur and Boron on yield attributes of Greengram

S. No	Treatment	Pods per plant (No.)	Seeds per pod (No.)	Seed yield (t/ha)	Harvest Index (%)
1	Sulphur 10 kg/ha + Boron 0.5 kg/ha	15.93	5.20	0.80	29.94
2	Sulphur 10 kg/ha +Boron 1 kg/ha	18.13	5.27	0.93	31.89
3	Sulphur 10 kg/ha + Boron 2 kg/ha	18.47	5.93	1.09	35.69
4	Sulphur 20 kg/ha + Boron 0.5 kg/ha	17.20	5.47	0.92	32.58
5	Sulphur 20 kg/ha + Boron 1 kg/ha	18.33	5.87	1.04	36.99
6	Sulphur 20 kg/ha + Boron 2 kg/ha	20.33	6.40	1.29	38.18
7	Sulphur 30 kg/ha + Boron 0.5 kg/ha	19.87	6.13	1.19	34.25
8	Sulphur 30 kg/ha + Boron 1 kg/ha	21.00	6.60	1.36	36.21
9	Sulphur 30 kg/ha +Boron 2 kg/ha	22.60	7.07	1.58	39.75
	F-Test	S	S	S	S
	S.Em(±)	0.19	0.19	0.04	1.30
	CD (5%)	0.56	0.58	0.11	3.90

Conclusion

It is concluded that application of sulphur 30 kg/ha along with boron 2 kg/ha was found the most suitable dose of fertilizer to be adopted as it recorded higher performance in growth parameter, yield attributes and yield. It was also found economically productive during *Zaid* season under eastern Uttar Pradesh conditions.

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