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Effect of sulphur and boron on growth and yield of soybean

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Abstract
A field experiment was conducted at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Prayagraj, UP, during the *Kharif* season of 2023. The experiment was laid out in Randomized Block Design with ten treatment combinations and three replications in which there were three levels of sulphur (10,20 and 30 kg/ha) and three levels of boron (0.5, 01 and 1.5 kg/ha) and a control (25-60-25 NPK kg/ha). Among the various treatment combinations significantly highest plant height (50.92 cm), dry weight (17.58 g), pods/ plant (29.00), seeds/pod (2.93), test weight (88.06 g), seed yield (2.06 t/ha), stover yield (3.42 t/ha) and oil content (20.09%) were recorded in treatment-9 with application of sulphur 30 kg/ha + boron 1.5 kg/ha. Maximum gross returns (82,243.33 INR/ha), net return (54,332.40 INR/ha) and benefit cost ratio (1.95) were also obtained in treatment-9 with application of sulphur 30 kg/ha + boron 1.5 kg/ha in soybean crop.

Keywords: Boron, economics, growth, soybean, yield, sulphur

Introduction

Soybean [*Glycine max* (L.) Merrill.] popularly known as Golden Bean, or “Miracle crop” of the 21st century because of its high nutritional value and myriad form of uses. Soybean is an important leguminous crop, rich in protein (40-42%), oil content (18-20%) and has the high economic potential to be used in food industries worldwide (Dheri *et al.*, 2021) [2]. In present scenario, global production of soybean was 6.5 million tonnes and India with 18% of the world’s total. Soybean is being cultivated in India in an area of about 12.27 million hectares with a production of 12.99 million tonnes and an average productivity of about 1059 kg/ha and Uttar Pradesh contributes an area about 5.51 million hectares with a 44.94% in all over India and productivity is 978 kg/ha, (Agricultural Statistics at a Glance, 2022).

Among the various nutrients required for optimum growth of soybean, sulphur is the most important secondary nutrient for which soybean responds most. Sulphur is a constituent of three amino acids, i.e. cystine, cysteine and methionine and plays an important role in the nutrition of oilseeds (Dheri *et al*., 2021) [2]. It positively affects not only the quantity but also the quality of crude protein in the harvested crop, especially in the case of legumes. Besides it is involved in various metabolic and enzymatic process including photosynthesis, respiration and legume rhizobium symbiotic nitrogen fixation. In the absence of sulphur, they produce protein with much lower content of sulphur-containing amino acids, especially methionine, which is one of the most valuable amino acids determining the nutritional value of plants (Glowacka *et al*., 2023) [3]. The impact of sulphur management has been found to be complementary on the nodulation in soybean leading to nitrogen economy and higher monetary returns (Lakshman *et al.*, 2015) [6].

Boron (B), an essential micronutrient, plays an important role in cell wall structure, membrane stability, sugar transportation and phenol, carbohydrate, nucleic acid and IAA (Indole acetic acid) metabolism. In oil seeds, it is important for pollen tube growth, flowering, fruit-setting and seed development. It plays a vital role in the transportation of nutrients and water to newly growing plant parts, and in the translocation of photosynthates from source to sink (Harshanand *et al*., 2023; Sharma *et al.*, 2020) [5, 10]. Boron deficiency is one of the major constraints to crop production. Its deficiency has been realized as the second most important micronutrient constraint in crops after that of zinc (Zn) on global scale (Yadav *et al.*, 2016) [12]. The quality of seeds deteriorated with low B as reflected in decreased content of B, starch, protein and oil along with stimulated concentrations of sugars and phenols (Ram *et al.*, 2014) [8]. Keeping in the view the immense importance of sulphur and boron fertilization, the present study "Effect of Sulphur and boron on Growth and Yield of Soybean" was undertaken

Materials and Methods

The experiment was conducted during the *Kharif* season 2023, at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) which is located at 25°39' 42''N latitude, 81°67'56" E longitude and 98 m altitude above the mean sea level. This area is situated on the right side of the Yamuna river by the side of Prayagraj - Rewa road about 12 km from the city. The soil had a sandy loam texture, a pH of 7.8, organic carbon (0.954%), nitrogen (242.48 kg/ha), potassium (239.5 kg/ha) and phosphorus (46.1 kg/ha). The experiment was laid out in Randomized Block Design with ten treatments each replicated thrice. The treatments consist of three levels of sulphur (10, 20, 30 kg/ha) and three levels of boron (0.5, 01, 1.5 kg/ha) and one control (25-60-25 NPK kg/ha) were used and an analysis of each treatment was completed to determine the best treatment combination for soybean cultivation. From each treatment, 5 plants were selected and tagged for the measurement of plant height and yield attributes. Net returns and benefit cost ratio were computed based on cost of cultivation, and seed yields with their prevailing market price. The data collected for different parameters were statistically analyzed using (Gomez, K.A. and Gomez, A.A. 1984) [4] randomized block design. The results are presented at 5% level of significance (p=0.05) for making comparison between treatments.

Results and Discussion

Growth attributes

Plant height - At 75 DAS, significantly higher plant height (50.92 cm) was recorded with the application sulphur 30 kg/ha along with boron 1.5 kg/ha, whereas with application of sulphur 30 kg/ha along with boron 01 kg/ha (50.74 cm) was found to be statistically at par with the highest. This could be function of various external and internal factors, nutrient supply being one of the factor. It might be due to the improvement of sulphur in synthesis of amino acids. Soybean has been reported to be much responsive to sulphur in promoting growth characters (Singh *et al.*, 2017) [11]. The increase in plant height because sulphur increased activity of meristematic tissue resulting in increase in plant height and cell elongation and boron also helps in cell elongation, photosynthesis and translocation of photosynthates (Sharma *et al.*, 2020; Dheri *et al.*, 2021) [10, 2].

Plant Dry Weight (g/plant): At 75 DAS, significantly higher dry weight (17.58 g) was recorded with the application of sulphur 30 kg/ha and boron 01 kg/ha. However, with the application of sulphur 30 kg/ha along with boron 01 kg/ha (17.33 g) were found to be statistically at par with the highest. Significant increase in dry weight might be due to the synergetic effect of sulphur and boron in cell elongation, cell division and biomass accumulation. It is possible that B concentration in plants at initial and vegetative growth stage may be main determinant of normal growth and development of plants (Rohitashv Nagar and Manoj Kumar., 2022) [9]. Boron and sulphur helps in formation of deep green colour due to synthesis of chlorophyll which in turn provide the larger area for photosynthesis and triggers the growth of the plant thus helps in dry matter accumulation (Sharma *et al.,* 2020) [10].

Yield attributes and Yield

The recorded and analysis of data on yield attributes indicate that a significantly higher number of pods/plant (29.00), number of seeds/pod (2.93), test weight (88.06 g) [Table.1], grain yield (2.06 t/ha) and straw yield (3.42 t/ha) in soybean crop [Table.2] were recorded with the application of Sulphur 30 kg/ha along with boron 1.5 kg/ha. However, the treatment- 8 was found to be statistically at par with highest. Significant increase in yield attributes and yield is recorded which might be due to the adequate supply of graded levels of sulphur and boron. S application positively affects cell division, enlargement, and elongation, resulting in faster and uniform vegetative of the crop growth (Dheri *et al.*, 2021) [2],which helps in plant in flowering and seed setting that ultimately increases the quantity and quality of seed (Ram *et al.*, 2014) [8].This might also be due to applying of boron through soil, which improves the ability of crop to absorb micronutrient leading to beneficial indirect effect on uptake of nitrogen, phosphorus, potassium and yield of crop increased (Rohitashv Nagar and Manoj Kumar, 2022) [9]. The beneficial effect of B on yield attributes may be due to its role in flower development, pollen grain formation, pollen viability, pollen tube growth for proper pollination and seed development. (Yadav *et al.*, 2016) [12].

Oil Content

Significantly highest oil content in soyabean seed (20.0 9%) is recorded in treatment-9 with application of sulphur 30 kg/ha along with boron 1.5 kg/ha. However, treatment-7 and treatment-8 were found to be statistically at par with the highest. The increase in oil content might be due to the fact that sulphur is a constituent of glutathione which helps in the synthesis of oil. This might also be due to direct involvement of sulphur in the synthesis of lipids, in fatty acid synthesis acetyl-CoA enzyme activity. In this conversion an enzyme thiokinase is involved in sulphur supply, moreover, acetyl Co- enzyme itself contain sulphur and sulpho-hydryl groups (Mamatha *et al.*, 2018) [7] Boron also had a positive role on the enhancement of oil content probably due to its indirect effect on the synthesis of fatty acids (Yadav *et al.*, 2016; Ram *et al*., 2014) [12, 8].

Economics

Highest Gross returns (82,243.33 INR/ha), Net returns (54,332.40 INR/ha) and B: C ratio (1.95) were recorded with the application of sulphur 30 kg/ha along with boron 1.5 kg/ha.

Table 1: Effect of sulphur and boron on growth and yield attributes in Soybean

S. No	Treatments	Plant Height (cm)	Dry weight (g/plant)	Number of pods/plant	Number of seeds/pod	Test weight
1	Sulphur 10 kg/ha + Boron 0.5 kg/ha	49.44	15.23	22.10	1.73	83.80
2	Sulphur 10 kg/ha + Boron 01 kg/ha	49.59	16.08	22.63	1.93	84.41
3	Sulphur 10 kg/ha + Boron 1.5 kg/ha	49.69	16.16	24.60	2.20	84.74
4	Sulphur 20 kg/ha + Boron 0.5 kg/ha	49.93	16.37	24.77	2.27	85.17
5	Sulphur 20 kg/ha + Boron 01 kg/ha	50.09	16.53	25.60	2.40	86.56
6	Sulphur 20 kg/ha + Boron 1.5 kg/ha	50.31	16.84	26.57	2.53	86.85
7	Sulphur 30 kg/ha + Boron 0.5 kg/ha	50.59	17.04	27.57	2.60	87.61
8	Sulphur 30 kg/ha + Boron 01 kg/ha	50.74	17.33	28.73	2.73	87.73
9	Sulphur 30 kg/ha + Boron 1.5 kg/ha	50.92	17.58	29.00	2.93	88.06
10	25-60-25 NPK kg/ha (Control)	49.31	15.03	21.63	1.73	82.92
	F-test	S	S	S	S	S
	SEm (±)	0.06	0.14	0.10	0.06	0.45
	CD (5%)	0.19	0.43	0.30	0.20	1.34

Table 2: Effect of sulphur and boron on yield, oil content and economics of soybean

S. No	Treatments	Seed yield	Stover yield	Harvest index	Oil content (%)	Gross Returns (INR/ha)	Net Returns (INR/ha)	Benefit Cost Ratio
1.	Sulphur 10 kg/ha + Boron 0.5 kg/ha	1.13	2.14	34.31	18.26	45,853.33	18,160.10	0.66
2.	Sulphur 10 kg/ha + Boron 01 kg/ha	1.15	2.22	34.17	18.55	46,910.00	19,214.60	0.69
3.	Sulphur 10 kg/ha + Boron 1.5 kg/ha	1.34	2.45	35.45	18.90	54,376.66	26,679.00	0.96
4.	Sulphur 20 kg/ha + Boron 0.5 kg/ha	1.41	2.55	35.63	19.17	57,010.00	29,210.10	1.05
5.	Sulphur 20 kg/ha + Boron 01 kg/ha	1.50	2.82	34.70	19.42	60,833.33	33,031.20	1.19
6.	Sulphur 20 kg/ha + Boron 1.5 kg/ha	1.59	2.88	35.54	19.55	64,416.66	36,612.40	1.32
7.	Sulphur 30 kg/ha + Boron 0.5 kg/ha	1.75	3.05	36.44	19.71	70,410.00	42,503.40	1.52
8.	Sulphur 30 kg/ha + Boron 01 kg/ha	1.98	3.28	37.70	19.90	79,130.00	51,221.20	1.84
9.	Sulphur 30 kg/ha + Boron 1.5 kg/ha	2.06	3.42	37.67	20.09	82,243.33	54,332.40	1.95
10.	25-60-25 NPK kg/ha (Control)	1.05	2.06	33.68	18.10	43,056.66	15,472.30	0.56
F-test		S	S	NS	S	--	--	--
SEm (±)		0.07	0.09	1.30	0.16	--	--	--
CD (p=0.05)		0.23	0.27	-	0.48	--	--	--

Conclusion

Based on the study is concluded that in soyabean crop with application of sulphur 30 kg/ha and boron 1.5 kg/ha along with the recommended dose of NPK recorded higher growth, yield and economic returns under eastern Uttar Pradesh Agro-Climatic conditions.

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