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Effect of levels of sulphur and boron on performance of sunflower (*Helianthus annuus* L.)

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Abstract
A Field trial was laid out during *Zaid* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of investigational plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha).The treatments consist of two levels of sulphur soil application and four levels of boron, with a control treatment respectively. The experiment was laid out in randomized block design with nine treatments each replicated thrice. The result showed that *viz.:* Plant height (126.47 cm) and recorded considerably higher with application of 40 kg/ha Sulphur + 1.5 kg/ha Boron. Number of leaves per plant (21.52) was recorded significantly higher with application of 40 kg/ha sulphur + 1.0 kg/ha boron. Whereas, dry weight (13.16 g/plant), maximum crop growth rate (4.84 g/m^2/day) at 30-45 DAS interval and also, relative growth rate (0.039 g/g/day) at 30-45 DAS interval recorded significantly higher application of 40 kg/ha sulphur + 0.5 kg/ha boron Capitulam diameter (14.86 cm), number of seeds per capitulam (333.43), seeds yield (1429.28 kg/ha), stover produce (2476.33 kg/ha) and oil content (41.5%) recorded considerably greater with the application of 40 kg/ha sulphur + 1.5 kg/ha boron.

Keywords: Sunflower, sulphur, boron, oil content, yield attributes

Introduction
Oilseeds and their byproducts vegetables oil and meal are in demand globally, and there is a need to identify and quantify the key issues for their production by different stakeholders to develop and support actions that will ensure a viable future of such crops (Muhmmad *et al.*, 2013) [4]. Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops containing high quality edible oil, also known as 'Premium oil'. Sunflower oil has excellent nutritional properties, and has a relatively high application of linoleic acid (Seiler, 2007) [8]. Sulphur is increasingly being recognized as the fourth major plant nutrient after nitrogen, phosphorus and potassium (Tandon and Messick, 2002) [11]. In oilseeds sulphur plays a vital role in the development of seed and improving the quality (Naser *et al.*, 2012) [5]. Sulphur helps in the synthesis of cystein, methionine, chlorophyll, vitamin-B, metabolism of carbohydrates, oil content, protein content and also related with growth and metabolism, especially by its effect on the protolytic enzymes (Najar *et al.*, 2011). Boron has a synergistic effect on N uptake, which is directly linked with amino acids, RNA, and protein synthesis thereby enhancing the relative growth rate and absolute growth rate. The oil content is enhanced due to boron application due to phyto-biomass partition at reproductive stage (Martin *et al.*, 2010) [3]. Although several studies highlighted the positive effects of sulphur application on growth, yield and oil content of sunflower, limited evidence is available on the influence of boron nutrient in sunflower crop. Therefore, the current study was planned to explore the impact of sulphur and boron soil application upon the growth and yield attributes of sunflower.

Materials and Methods
In order to study the two levels of sulphur and four levels of boron on the growth and yield characters of sunflower. The trial was laid out at during *Zaid* 2021 Crop Research Farm, Naini Agricultural Institute, SHUATS, Prayagraj. The experimental site of the study is geographically located at 25.28ºN latitude, 81.54ºE longitude and 98 m altitude above the mean sea level (MSL). The soil of the experimental field constituting a part of central Gangetic alluvium is neutral and deep. Pre- sowing soil samples were taken from a depth of 15 cm with the help of an auger. The composite samples were used for the chemical and mechanical analysis. The soil was sandy loam in texture, low in organic carbon (0.36%) and medium in available nitrogen (171.48 kg/ha), phosphorous (15.2 kg/ha) and low in potassium (232.5 kg/ha).

The treatments consist of two levels of sulphur (20 and 40 kg/ha) soil application and four levels of boron (0, 0.5, 1.0 and 1.5 kg/ha) respectively. The experiment was laid out in randomized block design with nine treatments each replicated thrice and control *i.e.*, recommended N, P and K (80:60:40 kg/ha) alone. The plots were prepared with dimension of 5 m × 3 m and seeds of variety DRSH-1 were sown with a spacing of 45cm × 15cm. At 4-5 leaf stage plants were thinned to appropriate density. Weeds were controlled manually at 5-leaf stage, stem elongation and flowering stage to maintain a uniform plant population. Growth characteristics plant height (cm), number of leaves per plant, dry weight per plant (g), crop growth rate (g/m^2/day) and relative growth rate (g/g/day) were recorded, with following formulas (A & B). Irrigation were given uniformly and regularly to all plots as per requirement so as to prevent the crop from water stress at any stage. The crop was completely harvested at physiological maturity stage and their biometric observations such as capitulam diameter (cm), number of seeds per capitulam, 1000 seed weight (g), seed yield (kg/ha), stover yield (kg/ha) and oil content (%) were recorded.

Formulas

A. Crop growth rate (CGR) denotes overall growth rate of the crop plants and measured after fixed period of time, irrespective of the previous growth rate (Leopold and Kridemann, 1975) [2].

$$CGR = \frac{W_2 - W_1}{P\,(t_2 - t_1)}$$

Where, W_2 and W_1 are dry weight of plant (g) recorded at time t_2, t_1 (days) and P is ground area respectively.

B. The relative growth rate (RGR) indicates the amount of growth per unit dry weight of plant per unit time (Leopold and Kridemann, 1975) [2]. It is expressed as grams of dry matter produced by a gram of existing dry matter in a day.

$$RGR = \frac{Log_e W_2 - Log_e W_1}{t_2 - t_1}$$

Where Log_e: Logarithm to the base, W_1: Dry weight of the plant at t_1, W_2: Dry weight of the plant at t_2.

Result

Growth parameters

Table. 1 pertaining those details of influence of sulphur and boron on sunflower yield attributes.

Table 1: Influence of sulphur and boron on growth of sunflower crop

Treatment	Plant height (cm)	Number of leaves/plant	Dry weight (g)	Crop growth rate (g/m^2/day)	Relative growth rate (g/g/day)
T_1: Control	124.30	20.18	12.03	3.81	0.036
T_2: 20 kg/ha S + 0 kg/ha B	124.51	20.07	12.52	3.60	0.033
T_3: 20 kg/ha S + 0.5 kg/ha B	124.20	20.20	12.56	3.72	0.034
T_4: 20 kg/ha S + 1.0 kg/ha B	124.62	20.37	12.92	4.16	0.035
T_5: 20 kg/ha S + 1.5 kg/ha B	125.30	20.09	12.99	4.31	0.036
T_6: 40 kg/ha S + 0 kg/ha B	125.33	20.77	13.04	4.29	0.037
T_7: 40 kg/ha S + 0.5 kg/ha B	125.40	21.48	13.16	4.84	0.039
T_8: 40 kg/ha S + 1.0 kg/ha B	126.30	21.52	13.02	4.73	0.038
T_9: 40 kg/ha S + 1.5 kg/ha B	126.47	21.15	13.10	4.65	0.036
SEm (±)	0.42	0.15	0.13	0.21	0.0005
CD (p=0.05)	1.25	0.44	0.38	0.64	0.001

Plant height (cm)

At harvest considerably greater plant height was observed in treatment with the application of 40 kg/ha sulphur + 1.5 kg/ha boron (165.93cm) which is statistically at par with application of 20 kg/ha sulphur + 1.5 kg/ha boron (125.30cm) and 40 kg/ha sulphur + 0 kg/ha boron (125.33cm), 40 kg/ha sulphur + 0.5 kg/ha boron (125.40cm) and 40 kg/ha sulphur + 1.0 kg/ha boron (126.30cm).

Number of leaves per plant

Similarly, the considerably maximum number of leaves per plant were observed in 40 kg/ha sulphur + 1.0 kg/ha boron (21.52) which was statistically at par with the application of 40 kg/ha sulphur + 1.5 kg/ha boron (21.15) and 40 kg/ha sulphur + 0.5 kg/ha boron (21.48).

Dry weight (g/plant)

Considerably greater dry weight was observed in 40 kg/ha sulphur + 0.5 kg/ha boron (13.16 g/plant) which is statistically at par with the application of 40 kg/ha sulphur + 1.5 kg/ha boron (13.10 g/plant), 40 kg/ha sulphur + 1.0 kg/ha boron (13.02 g/plant), 40 kg/ha sulphur + 0 kg/ha boron (13.04 g/plant), 20 kg/ha sulphur + 1.5 kg/ha boron (12.99 g/plant) and 20 kg/ha sulphur + 1.0 kg/ha boron (12.92 g/plant).

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

At 45-60 DAS the considerably greater crop growth rate was observed in 20 kg/ha sulphur + 0.5 kg/ha boron (3.15 g/m^2/day), Which was statistically at par with the application of 20 kg/ha sulphur + 0 kg/ha boron (3.12 g/m^2/day), Control (2.77 g/m^2/day) and 20 kg/ha sulphur + 1.0 kg/ha boron (2.74 g/m^2/day).

Relative growth rate (g/g/day)

At 45-60 DAS the considerably greater relative growth rate was observed in 20 kg/ha sulphur + 0 kg/ha boron and 20 kg/ha sulphur + 0.5 kg/ha boron (0.019 g/g/day). Which is statistically at par with the treatment control (0.018 g/g/day).

Yield attributes

Table.2 pertaining that details of influence of sulphur and boron on sunflower yield attributes.

Table 2: Influence of sulphur and boron on yield and yield attributes of sunflower crop

Treatment	Capitulam diameter (cm)	Number of seeds per capitulam	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
T_1: Control	12.28	277.13	34.35	1223.80	2248.05
T_2: 20 kg/ha S + 0 kg/ha B	12.88	279.91	34.23	1321.19	2308.19
T_3: 20 kg/ha S + 0.5 kg/ha B	13.41	287.32	34.34	1337.16	2335.22
T_4: 20 kg/ha S + 1.0 kg/ha B	13.43	294.29	34.41	1360.94	2354.23
T_5: 20 kg/ha S + 1.5 kg/ha B	13.42	301.01	34.58	1386.26	2389.81
T_6: 40 kg/ha S + 0 kg/ha B	14.11	311.67	34.62	1405.54	2425.52
T_7: 40 kg/ha S + 0.5 kg/ha B	14.51	325.46	34.71	1418.13	2443.15
T_8: 40 kg/ha S + 1.0 kg/ha B	14.69	331.65	34.71	1420.41	2462.42
T_9: 40 kg/ha S + 1.5 kg/ha B	14.89	333.43	34.87	1429.28	2476.33
SEm (±)	0.24	3.38	0.41	6.12	6.92
CD (p=0.05)	0.71	10.12	-	18.35	20.73

Diameter of capitulam (cm): The considerably greater capitulam diameter was observed in 40 kg/ha sulphur + 1.5 kg/ha boron (14.86 cm). Which is statistically at par with the application of 40 kg/ha sulphur + 1.0 kg/ha boron (14.69 cm) and 40 kg/ha sulphur + 0.5 kg/ha boron (14.51 cm).

Number of seeds per capitulam: The considerably greater number of seeds per capitulam was observed in 40 kg/ha sulphur + 1.5 kg/ha boron (333.43). Which is statistically at par with the application of 40 kg/ha sulphur + 1.0 kg/ha boron (331.65) and 40 kg/ha sulphur + 0.5 kg/ha boron (325.46).

Test weight (g): The higher test weight was observed in 30 40 kg/ha sulphur + 1.5 kg/ha boron (34.67 g). And lowest was observed in 20 kg/ha sulphur + 0 kg/ha boron (34.23 g). There was no significant difference among the treatments.

Grain yield (kg/ha): The considerably higher seed produce was observed in 40 kg/ha sulphur + 1.5 kg/ha boron (1429.28 kg/ha). Which is statistically at par with 40 kg/ha sulphur + 1.0 kg/ha boron (1420.41 kg/ha) and 40 kg/ha sulphur + 0.5 kg/ha boron (1418.13 kg/ha).

Straw yield (kg/ha): The considerably higher stover produce was observed in 40 kg/ha sulphur + 1.5 kg/ha boron (2476.33 kg/ha). Which is statistically at par with the application of 40 kg/ha sulphur + 1.0 kg/ha boron (2462.42 kg/ha).

Influence of Sulphur and Boron on oil content (%) of sunflower: Table.3 pertaining that considerably greater oil content (%) was observed in 40 kg/ha sulphur + 1.5 kg/ha boron (41.5%).Which was statistically at par with the application of 40 kg/ha sulphur + 1.0 kg/ha boron (41.2%), 40 kg/ha sulphur + 0.5 kg/ha boron (41%) and 40 kg/ha sulphur + 0 kg/ha boron (40.5%).

Table 3: Influence of sulphur and boron on oil content of sunflower yield

Treatment	Oil content (%)
T_1: Control	34.3
T_2: 20 kg/ha S + 0 kg/ha B	36.1
T_3: 20 kg/ha S + 0.5 kg/ha B	35.8
T_4: 20 kg/ha S + 1.0 kg/ha B	36.4
T_5: 20 kg/ha S + 1.5 kg/ha B	36.7
T_6: 40 kg/ha S + 0 kg/ha B	40.5
T_7: 40 kg/ha S + 0.5 kg/ha B	41.0
T_8: 40 kg/ha S + 1.0 kg/ha B	41.2
T_9: 40 kg/ha S + 1.5 kg/ha B	41.5
S.Em(±)	0.42
CD (p=0.05)	1.27

Discussion

In present series of study the increase in growth qualities might be due to more synthesis of amino acids, increase in chlorophyll content in growing region and improving the photosynthetic activity, ultimately enhancing cell division resulted in an increment in plant height and DMP. This was showed through the studies of Shivay and Shekhawat (2009) [9] and Raja *et al.* (2007) [6].

Sulphur and boron application resulted in significance increase in growth individualities such as plant height, number of leaves per plant, dry weight CGR and RGR, where as in yield attributes significantly effected on capitulam diameter and number of seeds per capitulam. Obviously these have jointly contributed and increased the yield potential of the crop as reflected by the higher seed yield. Such a response to increasing levels of 'S' might be ascribed to adequate supply of nutrients resulted in high production of photosynthates and their translocation to sink Shivay and Shekhawat (2009) [9]. A greater amount of dry matter accumulation was observed due to boron application since it is an essential element for growth and development of crops. Akcam and Demiray (2004) [1] also reported that the boron application increased root and shoot length due to increase in Indole acetic acid (IAA) content, a growth promoter hormone. Seed yield enhanced due to B application was probably because of a good balance between photosynthesis and respiration. Since the final yield depends upon the translocation of photosynthates from the source to sink, B is supposed to play an important role here. Boron maintains assembly and mechanical properties of cell walls; it maintains structural and functional integrity of cell walls. Boron removal alters cell wall physics, with a transitory decrease of elasticity modulus and followed by a secondary hardening and a reduction in incidence plasma membrane bound reeducates activity for better translocation to sink. This reduces the total seed yield as reported by Yu *et al.* (2002) [13]. This increase in seed yield of sunflower might be due to significant increase in yield attributes *viz.* capitalism's diameter, number of seeds per capitulam and 1000-seed weight with S application. Boron was also found to be a good nutrient. Increase in the each successive level of B application increased significantly the seed yield. Increase in oil content by sulphur application might be attributed to involvement of sulphur in the biosynthesis of oil (Ravikumar *et al.,* 2016). Renukadevi and Savithri (2003) [7] found that oil content of sunflower increased with boron application from his study. Oil yield increases with boron application in sunflower Sumathi *et al.* (2005) [10].

Conclusion

It can be inferred from the present study that application of 40 kg sulphur per ha, 1.5 kg boron per ha is sufficient to sustain the greater growth, physiological parameters and productivity of sunflower under north Indian conditions. These findings are based on one season; therefore, further trail may be required for further confirmation.

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