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Yield performance and economic impact of sulphur and foliar boron application in sunflower (*Helianthus annuus* L.)

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Abstract
An agronomic investigation entitled "Effect of levels of sulphur and foliar application of boron on growth and yield of sunflower (*Helianthus annus* L.) in *kharif* season" was demonstrated during *kharif* 2023 at Experimental Farm of Agronomy Section, Oilseeds Research Station, Latur. The soil was black and had a clayey texture, with a slightly alkaline reaction indicated by a pH of 7.45. It contained low levels of available nitrogen (232.76 kg ha^{-1}), medium levels of available phosphorus (8.62 kg ha^{-1}) and very high levels of available potassium (470.87 kg ha^{-1}).
The experiment was laid out in randomized block design with three replications and eleven treatments. The treatment includes T_1 - RDF + 15 kg S/ha, T_2 - RDF + 20 kg S/ha, T_3 - RDF + 25 kg S/ha, T_4 - RDF + 15 kg S/ha + 0.2% Boron spray at flowering, T_5 - RDF + 20 kg S/ha + 0.2% Boron spray at flowering, T_6- RDF + 25 kg S/ha + 0.2% Boron spray at flowering and T_7 - RDF (Control).
The gross and net plot size of each experimental unit was 5.4 m × 4.5 m and 4.2 m × 3.9 m respectively. Sowing was done by dibbling method on 7th August, 2023 at spacing of 60 × 30 cm. the recommended cultural practices and plant protection measures were undertaken. The recommended dose of fertilizer 90:45:45 NPK kg ha^{-1} and sulphur was applied as per treatments, half dose of nitrogen along with full dose of phosphorus, potassium and sulphur applied as basal dose through urea, single super phosphate, muriate of potash and bensulf. Remaining half dose of nitrogen was applied at 30 days after sowing and spraying of 0.2% boron was done at ray floret stage (55 DAS). The crop was harvested on 3rd November, 2023.
The result showed that application RDF + 25 kg S ha^{-1} + 0.2% Boron spray at flowering treatment recorded significantly highest seed yield (1993.33 Kg h^{-1}), stalk yield (3974.67 kg ha^{-1}) and biological yield (5968 kg ha^{-1}), gross monetary return (107640 ₹/ha), net monetary return (65773 ₹/ha), Benefit cost ratio (2.57) which was found significantly superior over rest of treatments of the crop under study.

Keywords: Sunflower, sulphur, boron, foliar spray, economics

Introduction
Sunflower (*Helianthus annum* L.) is an annual, erect and herbaceous plant belongs to family Compositae. Originated in Southern part of the USA and Mexico. According to the Food and Agriculture Organization of the United Nations (FAO), the leading sunflower growing countries are Ukraine, Russia, Argentina, United States and China. In Maharashtra, sunflower is grown on 0.30 Lakh hectare area with a production of 0.15 Lakh tonnes and poroductivity of 498 kg ha^{-1}. Major sunflower growing district in Maharashtra are Osmanabad, Jalgaon, Solapur.
Sunflower seeds are highly nutritious and beneficial for health. Nearly all parts of the sunflower plant are utilized by humans in various ways, with its oil being particularly valuable. Sunflower seeds contain 35-42% oil, 14-19% protein, 21-27% hull, 7-9% soluble sugars and 30-35% carbohydrates. The oil extracted from sunflower is a rich source of linoleic acid (64%) which helps eliminate cholesterol in the coronary arteries, making it a recommended choice for heart patients. Additionally, sunflower oil contains oleic acid (20%) and is a source of vitamins A, D, E, and B complex, along with significant amounts of calcium and iron.
In addition to the primary plant nutrients (N, P and K), sulphur and boron are crucial for the

production phenology of oilseed crops, which tend to respond positively to the application of sulphur and boron (Chatterjee, 1985) [3]. For oilseeds, sulphur and boron are essential nutrients for optimal growth and development.

Sulphur is a vital nutrient for plant growth and plays a crucial role in crop production. For producers of oilseeds, the application of sulphur fertilizers is particularly significant, as oilseed crops have a higher sulphur requirement compared to cereal grains. To produce one ton of seed, the sulphur needs are approximately 3-4 kg for cereals (with a range of 1-6 kg), 8 kg for legume crops (ranging from 5-13 kg) and 12 kg for oil crops (with a range of 5-20 kg). In general, oil crops require about the same amount of S as, or more than, phosphorus for high yield and product quality (Jamal *et al*, 2010) [6].

Boron, an essential micronutrient, is also found to be lacking in soil and its immobile nature possess a significant challenge, leading to limited availability for plants. Boron plays several crucial roles, including the formation of cell walls, the transport of sugars, nucleic acids, phenolic compounds and maintaining membrane stability. Applying boron directly during the opening stages of ray florets enhances seed development, increases yield, and boosts oil content. Foliar applications of boron appear to mitigate the negative impacts of drought by addressing the molecular responses associated with water deficiency, thereby improving sunflower growth in conditions of limited moisture.

Materials and Methods

The field experiment was carried out during *kharif* 2023 at Experimental Farm of Agronomy Section, Oilseeds Research Station, Latur to study the effect of levels of sulphur and foliar application of boron on growth and yield of sunflower (*Helianthus annus* L.) in *kharif* season. The soil of experimental plot was clayey in texture with chemical composition such as low in available nitrogen (232.76 kg ha^{-1}), medium in available phosphorous (8.65 kg ha^{-1}) and very high in available potassium (470.87 kg ha^{-1}). The soil was slightly alkaline in reaction and having pH 7.45.

The experiment was laid out in randomized block design with three replications and eleven treat,ments. The treatment includes T_1 - RDF + 15 kg S/ha, T_2 - RDF + 20 kg S/ha, T_3 - RDF + 25 kg S/ha, T_4 - RDF + 15 kg S/ha + 0.2% Boron spray at flowering, T_5 - RDF + 20 kg S/ha + 0.2% Boron spray at flowering, T_6 - RDF + 25 kg S/ha + 0.2% Boron spray at flowering and T_7 - RDF (Control).

The gross and net plot size of each experimental unit was 5.4 m x 4.5 m and 4.95 m × 3.90 m respectively. Sowing was done by dibbling method on 07th August, 2023 at spacing of 60 x 30 cm. The recommended cultural practices and plant protection measures were undertaken. Fertilizer *viz*., nitrogen, phosphorus, potassium, sulphur and boron were applied in respective plots as per treatments. Full dose of phosphorus, potassium, sulphur along with 50 per cent dose of nitrogen of each treatment was applied as basal dose and remaining 50 per cent nitrogen dose of each treatment was given 30 days after sowing. Foliar spray of boron was done at flowering. The crop was harvested on 03 November 2023.

Results and Discussion

Effect of treatments

The effect of application of RDF + 25 kg S/ha + 0.2% Boron spray at flowering was observed on important yield parameters *viz*., seed yield (kg ha-1), stalk yield (kg ha^{-1}), biological yield (kg ha^{-1}), harvest index (%), GMR, CC, NMR, B:C ratio etc, under study.

Yield and yield attributes

Seed yield (kg ha^{-1})

Data showed that treatments were differed significantly with each other in respect to seed yield. The mean seed yield due to different treatments was (1704.83 kg ha^{-1}).

the application of nutrients as per RDF + 25 kg S/ha + 0.2% Boron spray at flowering (T_6) recorded significantly higher mean seed yield (1993.33 kg ha^{-1}) which was at par with treatment (T_3) RDF + 25 kg S/ha and RDF + 20 kg S/ha + 0.2% Boron spray at flowering under study. The results are confirmative with the finding of Deepika *et al.,* (2022) [4], Biswas and Poddar (2015) [2], Al-Doori *et al.,* (2017) [1], Poonia (2000) [9] and Geetha *et al.,* (2010) [5].

Stalk yield (kg ha^{-1})

Data on stalk yield (kg ha^{-1}) was influenced significantly due to different treatments After harvest of crop, the mean stalk yield was recorded 3530.82 kg ha^{-1}. The application of RDF + 25 kg S/ha + 0.2% Boron spray at flowering (T_6) recorded highest stalk yield (3975 kg ha^{-1}) and found at par with application of RDF + 25 kg S/ha (T_3) and RDF + 20 kg S/ha + 0.2% Boron spray at flowering(T_5) and which was significantly superior over rest of treatments under study. Similar results are reported with the finding of Poonia (2000) [9], Najar *et al.,* (2011) [8] and Reddy *et al.* (2002) [12].

Biological yield (kg ha^{-1})

Data on biological yield was influenced significantly due to different treatments. The mean biological yield was significantly influenced by different sulphur levels and boron treatments. Application of treatment RDF + 25 kg S/ha + 0.2% Boron spray at flowering (T_6) found at par with application of RDF + 25 kg S/ha (T_3) and RDF + 20 kg S/ha + 0.2% Boron spray at flowering (T_5). Similar results are reported with the finding of Najar *et al.,* (2011) [8] and Siddiqui *et al.* (2009) [13]

Harvest index (%)

Data on mean harvest index of sunflower as influenced by different treatment showed in table 1. The mean harvest index of sunflower was 33%. The maximum harvest index (33.40%) was recorded with treatment (T_6) RDF + 25 kg S/ha + 0.2% Boron spray at flowering and minimum harvest index (30.76%) recorded with treatment RDF (Control) (T_7). The present finding are in collaborative with those of Sofi *et al.* (2004), Rasool *et al.* (2013) [11], Rahul *et al.* (2021) [10], Geetha *et al.* (2010) [5] and Kabade *et al.* (2006) [7].

Economics

Gross monetary return (₹ ha^{-1})

The mean gross monetary return obtained from sunflower crop was (92061 ₹ ha^{-1}). Highest GMR obtained from the application of RDF + 25 kg S/ha + 0.2% Boron spray at flowering (T_6) (107640 ₹ ha^{-1}) which was found to be at par with application of RDF + 25 kg S/ha (T_3) and RDF + 20 kg S/ha + 0.2% Boron spray at flowering (T_5). Similar results are reported with the finding of Deepika *et al.,* (2022) [4], Rahul *et al.* (2021) [10] and Rasool *et al.* (2013) [11].

Cost of cultivation (₹ ha^{-1})

The mean cost of cultivation for different treatments was (41134 ₹ ha^{-1}). The highest cost of cultivation (41867 ₹ ha^{-1}) required for the application of RDF + 25 kg S/ha + 0.2% Boron spray at flowering (T_6). The lowest cost of cultivation required for the control (T_7) treatment was 40157 ₹ ha^{-1}). Similar results are

reported with the finding of Deepika *et al.*, (2022) [4] and Rahul *et al.* (2021) [10].

Net monetary return (₹ ha^{-1})

The application of RDF + 25 kg S/ha + 0.2% Boron spray at flowering (T_6) was received highest NMR (65773 ₹ ha^{-1}) which was comparable with RDF + 25 kg S/ha (T_3) and RDF + 20 kg S/ha + 0.2% Boron spray at flowering (T_5). The present finding are in collaborative with those of Reddy *et al.* (2002) [12], Rasool *et al.* (2013) [11], Rahul *et al.* (2021) [10] and Geetha *et al.* (2010) [5].

Benefit: Cost ratio

The mean B: C ratio was observed as 2.24 due to various treatments. The highest B: C ratio (2.57) was obtained with the treatment (T_6) RDF + 25 kg S/ha + 0.2% Boron spray at flowering among the different fertilizer treatments and followed by application of RDF + 25 kg S/ha (T_3). Similar results are reported with the finding of Geetha *et al.* (2010) [5], Rasool *et al.* (2013) [11], Rahul *et al.* (2021) [10] and Reddy *et al.*, (2002) [12].

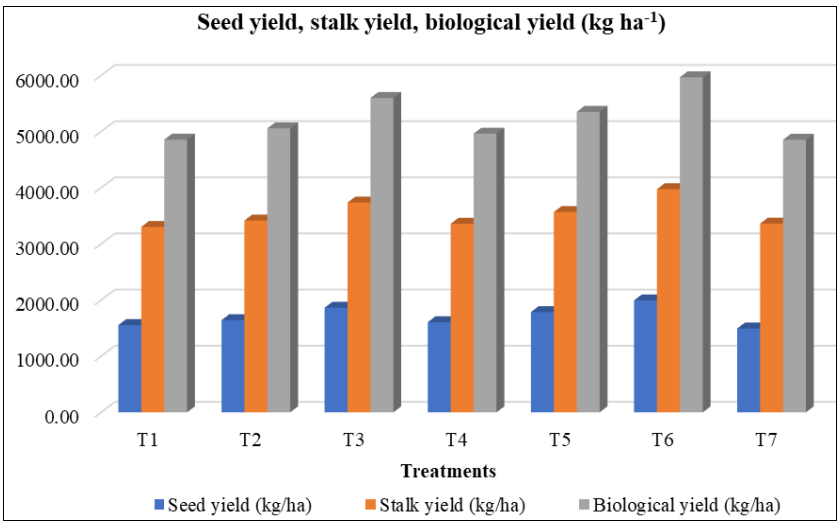

Fig 1: Effect of Sulphur and foliar Boron application of various treatments on yield attributes of sunflower

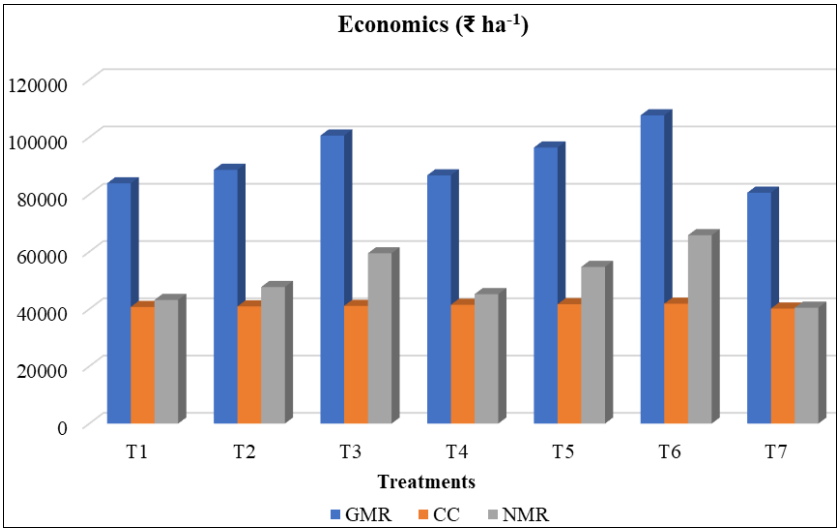

Fig 2: Effect of Sulphur and foliar Boron application of various treatments on economics of sunflower

Plate 1: General Layout View of Experimantal Field

Table 1: Effect of Sulphur and foliar Boron application of various treatments on yield attributes of sunflower

Treatment	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index (%)
T1 - RDF + 15 kg S/ha	1553.74	3302.15	4855.89	32.00
T2 - RDF + 20 kg S/ha	1641.07	3416.28	5057.35	32.45
T3 - RDF + 25 kg S/ha	1862.49	3736.08	5598.57	33.27
T4 - RDF + 15 kg S/ha + 0.2% Boron spray at flowering	1605.21	3358.03	4963.24	32.34
T5 - RDF + 20 kg S/ha + 0.2% Boron spray at flowering	1785.00	3567.34	5352.34	33.35
T6 - RDF + 25 kg S/ha + 0.2% Boron spray at flowering	1993.33	3974.67	5968.00	33.40
T7 - RDF (Control)	1492.95	3361.15	4854.11	30.76
SE ±	70.80	145.51	215.12	-
CD @5%	212.23	436.18	644.85	-
Mean	1704.83	3530.82	5236.22	33

Table 2: Effect of Sulphur and foliar Boron application of various treatments on economics of sunflower

Treatment	Economics				
	Seed yield (kg ha^{-1})	GMR	CC	NMR	B:C ratio
T1 - RDF + 15 kg S/ha	1553.74	83902	40727	43175	2.06
T2 - RDF + 20 kg S/ha	1641.07	88618	40917	47701	2.17
T3 - RDF + 25 kg S/ha	1862.49	100575	41107	59468	2.45
T4 - RDF + 15 kg S/ha + 0.2% Boron spray at flowering	1605.21	86681	41487	45194	2.09
T5 - RDF + 20 kg S/ha + 0.2% Boron spray at flowering	1785	96390	41677	54713	2.31
T6 - RDF + 25 kg S/ha + 0.2% Boron spray at flowering	1993.33	107640	41867	65773	2.57
T7 - RDF (Control)	1492.95	80619	40157	40462	2.01
SE ±	70.80	3823	-	3823	
CD @5%	212.23	11460		11460	
Mean	1704.83	92061	41134	50927	2.24

Conclusion

The application of treatment (T_6) RDF + 25 kg S/ha + 0.2% Boron spray at flowering recorded significantly highest yield attributes *viz*. seed yield, stock yield, biological yield, test weight, oil yield and number of filled seed plant^{-1}.The highest GMR (1,07,640 ₹/ha), NMR (65,773 ₹/ha) and B:C (2.57) ratio was obtained with application of treatment (T_6) RDF + 25 kg S/ha + 0.2% Boron spray at flowering.

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