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Effect of sulphur and boron application of mustard (*Brassica juncea* L.) crop, grain yield through conduct on farm trails at farmers fields district Shravasti

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Abstract
The field experiment on farm trial (OFT) was conducted on "Effect of Sulphur and Boron application of Mustard (*Brassica juncea* L.) crop, Grain Yield through conduct on Farm Trails at Farmers Fields District Shravasti" during the Rabi season of the year 2022-23 and 2023-24 in order to develop fertilizer prescriptions for the desired yield targets treatments *viz*., T_1-Farmers Practices, T_2- Recommended dose of fertilizer (RDF) and T_3- Recommended dose of fertilizer (RDF)+Refinement treatment use Sulphur and Boron. In this experiment application of chemical balanced fertilizers- N- 120 kg/ha, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} +Sulphur 5 kg ha^{-1} and Boron 2 kg ha^{-1} (Whole P and K+1 /3 N as Basal dose & remaining N as Two split at 25 and 45 DAS+ Boron Foliar spray at before Flowering stage) increased 38.0 per cent in economic yield than the farmers practice during the year. The net return also showed increase of Rs. 65277/- ha^{-1} under chemical balanced fertilizers - N- 120 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} +Sulphur 5 kg ha^{-1} and Boron 2 kg ha^{-1}. Application of Boron Foliar spray at flowering recorded maximum yield (18.69 q ha^{-1}) higher net return (Rs. 65277 ha^{-1}) with benefit cost ratio of 1.77.

Keywords: Balanced fertilizer, *Brassica juncea*, yield and soil properties

Introduction
Mustard is an important group of edible oil seed crops and contributes about 26.1% of the total oilseed production and contributes about 85% of the total Mustard produced in India (Pachauri *et al*., 2012) [9]. The first position in the area and second position in Production after China (*Anonymous* 2022-23). More than 65% of the present area under oilseeds is un-irrigated and oilseeds production depends on success to achieve in changing the oilseeds scenario in the country is attributed mainly the expansion of the area under oilseeds and due to favorable price structure, it is evident from the area and production data that nearly half increases in oil seed productivity through improved management. Sulphur is the fourth important nutrient after nitrogen, phosphorus and potassium for Indian agriculture. Sulphur deficiency has been found to occur in soils which are coarse textured and low in organic matter. Sulphur requirements of crop plants is quite high and high yielding varieties require higher amounts of sulphur as compared to low yielding varieties of the crops. About 46.3%, Indian soils and 43.0% U.P. soils are deficient in sulphur. It is well accepted that sulphur deficiency in Indian soils is wide spread and major constraint in the way of increasing crop productivity, produce quality and farm incomes (*Singh et al*. 2015) [13]. Oilseed crops have been reported to deplete the soil sulphur relatively to a greater extent. Knowledge of the concentration of plant nutrients in a crop and the amount of nutrients removed by a particular crop from the soil may be a helpful guide for the formulation of a sound fertilizer management programme. Boron has a vital role in promoting the growth and productivity of crops. In addition to the primary plant nutrients, it plays a significant role in the phenological development of mustard plants and its application has been observed to elicit a response in this crop. Therefore, the application of Boron is crucial for enhancing both crop productivity and nutritional value. There have been reports indicating a positive correlation between mustard plants and the use of Boron (*Bhavana et al*., 2022) [1]. The siliquae count, seed setting and seed yield of mustard plants impacted by boron levels, particularly in cases when the

soil exhibits boron deficiency (Rai *et al.* 2014) [10]. Many of them apply fertilizer in quantities that are inconsistent with the recommendations for mustard, which negatively impacts yield. However, there is a dearth of study and information regarding the disproportionate utilization of fertilizers by agricultural practitioners.

Materials and Methods

An on farm testing (OFT) was conducted at the locations in Hariharpur Rani, Sirsiya and Ikauna Block district Shravasti Uttar Pradesh Rabi season during on 2023-24. Mustard RH-749 was grown under the irrigated conditions. Soils of the experimental sites were testes and rated as per the data given in Table1. In general the soils were neutral in reaction. Organic carbon content was found low in all the locations. In all the locations the average availability of Nitrogen phosphorus and potassium were medium, respectively. Generally farmers were utilizing more only Nitrogen and Phasphorus fertilizers than recommendation but not use balanced proper method and time which resulted into high cost of cultivation and also affected the soil health. Therefore the treatments were T_1-Farmers Practices (N-80kg ha^{-1}, P- 30 kg ha^{-1} and K- 15 kg ha^{-1}), T_2- Recommended dose of fertilizer N- 100 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} and Sulphur 5 kg ha^{-1} (Whole P, K and 1 /3 N as Basal dose & remaining N as Two split at 25 and 45 DAS)) and T_3- Recommended dose of fertilizer (RDF)+Refinement treatment use Sulphur and Boron. The details of the treatment are given in Table 2. The data observed by Plant height (cm) at harvest, Number of branches^{-1}, Leaf-area index at harvest, Length of siliqua (cm), Siliquae plant^{-1}, Seeds siliqua^{-1} and Test weight (g) were counted from five tagged plants at harvest. The total produce from each net plot was weighed to determine the biological yield followed by threshing and cleaning. The seed yield was determined by recording the weight of the seeds obtained and while the stover yield was calculated by subtracting the seed yield from the total biological yield of the respective plots and measured in q/ha. The harvest index (HI) was calculated using the formula developed. Oil content in mustard seed was measured by soxhlet extraction procedure. The mustard seeds of individual plots were dried at 60oC for 6 hours; grinded in pestle & mortar and 2 g sample was weighed in thimble and placed in soxhlet extractor. The oil was extracted with petroleum ether (40-60 °C) for 6 hours in a distillation flask. After distillation of sample, petroleum ether was evaporated in an oven for one hour at 100-105 °C.

Table 1: Soil nutrient of selected location for conducted OFT

S. No.	Parameter	Result	Category
1.	pH	7.38	Normal
2.	Electrical Conductivity (dSm^{-1})	0.36	Normal
3.	Organic Carbon (%)	0.46	Low
4.	Available Nitrogen (Kg/ha)	144	Medium
5.	Available Phosphorus (Kg/ha)	20.1	Medium
6.	Available K (Kg/ha)	86.2	Medium

Table 2: Treatment Details of conducted OFT at farmers fields

S. No.	Treatment	Treatment Details
1.	T_1-Farmers Practices	Farmers Practices (N-80kg ha^{-1}, P- 30 kg ha^{-1} and K- 15 kg ha^{-1})
2.	T_2- Recommended dose of fertilizer (RDF)	N- 100 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} and Sulphur 5 kg ha^{-1} (Whole P, K and1 /3 N as Basal dose and remaining N as Two split at 25 and 45 DAS)
3.	T_3- Recommended dose of fertilizer (RDF)+Refinement treatment use Boron	N- 120 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} +Sulphur 5 kg ha^{-1}, Boron 2 kg ha^{-1} (Whole P and K+1 /3 N as Basal dose and remaining N as Two split at 25 and 45 DAS+ Boron Foliar spray at before Flowering stage

The sample was cooled and weighed and oil percentage was then calculated as per the given formula:

Oil content in seed (%) = (Weight of extracted oil/ Weight of sample) × 100

Oil yield was calculated from oil content of individual sample multiplied by respective seed yield and expressed in kg/ha. Data collected on growth, yield and quality were tabulated and statistically analyzed as per the standard analysis of variance to draw valid conclusions.

Results

Effect of sulphur and boron on growth and yield attributes characters

The data in Table 3 and 4 showed that all growth parameters increased the yield with sulphur application up to 5 kg ha^{-1} and Boron Foliar application up to 2 kg ha^{-1}, except at 25 and 45 DAS. Maximum plant height (182.65 cm), number of branches at harvest (13.24), Leaf area index (3.47), length of siliqua (4.69 cm), siliquae per plant (510) and seed per siliqua (46.85) were observed with sulphur and Boron application at 25 and 45 DAS. The increasing trend in yield was observed under different treatment. Treatment T_3- N- 120 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} +Sulphur 5 kg ha^{-1} and Boron 2 kg ha^{-1} (Whole P and K+1 /3 N as Basal dose & remaining N as Two split at 25 and 45 DAS+ Boron Foliar spray at before Flowering stage) recorded highest yield of Wheat (18.69 q ha^{-1}) as compared to treatment T_1- Farmers Practices (N-80kg ha^{-1}, P- 30 kg ha^{-1} and K- 15 kg ha^{-1}) and T_2- N- 100 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} and Sulphur 5 kg ha^{-1} respectively-. It was observed that farmers practice (T_1) recorded lower yield (13.54 q ha^{-1}) than that of recorded under exiting recommended practices (RDF). Similar findings of our studies are in line with by (*Keivanrad et al.* 2014) [5] reported that by the use of Sulphur and Boron foliar application all respects of mustard crop found very significant. However, all growth parameters i.e., plant height, number of branches at harvest, Leaf area index, length of siliqua, siliquae plant^{-1} and seed siliqua^{-1} were highest with T_3- N- 120 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} +Sulphur 5 kg ha^{-1}, Boron 2 kg ha^{-1} recorded highest yield of Wheat (18.69 q ha^{-1}) as compared to treatment. The increased growth parameters may be due to the role of Sulphur and Boron in carbohydrate metabolism as being a constituent of enzymes involved in photosynthesis and a precursor of IAA biosynthesis in auxin metabolism (*Jadav et al.* 2016) [4]. The results of the present investigation corroborated the findings of (*Yadav et al.* 2016) [14]. The balanced fertilizers application of treatment T_3- N- 120 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} +Sulphur 5 kg ha^{-1}, 2 kg ha^{-1} Boron at flowering stage recorded higher yield 18.69 q ha^{-1} over treatment T_2- (N- 100 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} and Sulphur 5 kg ha^{-1}, 2 kg ha^{-1} Boron and T_1-Farmers practice - N-80 kg/ha, P- 30 kg/ha and K- 15 kg/ha respectively.

Table 3: Effect of Sulphur and Boron on growth attributes of Indian mustard varieties

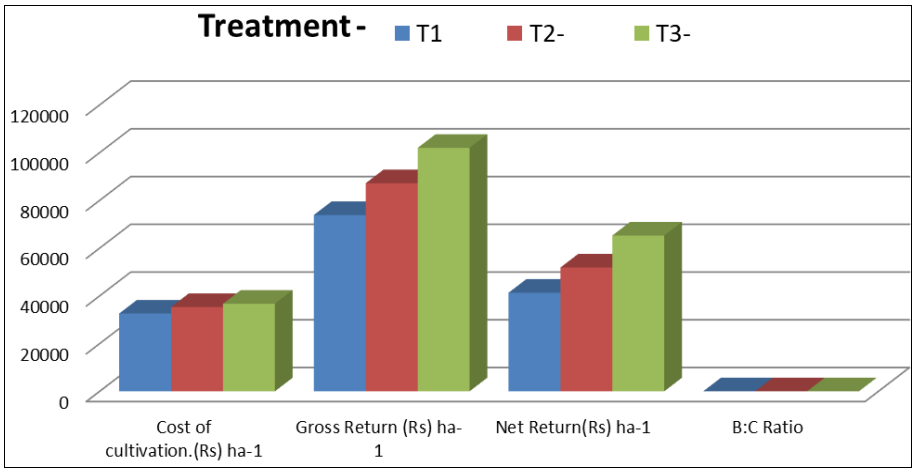
S. No.	Treatment	Plant height (cm) at harvest	Branches plant^{-1} at harvest	Leaf-area index at harvest	Length of siliqua (cm)	Siliquae plant^{-1}
1.	T_1-Farmers Practices	156.82	10.98	2.39	3.68	396
2.	T_2- Recommended dose of fertilizer (RDF)	173.61	12.56	3.26	4.35	465
3.	T_3- Recommended dose of fertilizer (RDF)+Refinement treatment use Boron	182.65	13.24	3.47	4.69	510

Table 4: Yield attributes and Economic as influence by different treatment

S. No.	Treatment	Seeds siliqua^{-1}	Test weight (g)	Seed yield (kg ha^{-1})	Harvest Index (%)	Oil content (%)
1.	T_1-Farmers Practices	39.25	3.58	13.54	46.14	36.84
2.	T_2- Recommended dose of fertilizer (RDF)	43.52	41.32	15.98	43.84	37.86
3.	T_3- Recommended dose of fertilizer (RDF)+Refinement treatment use Boron	46.85	42.54	18.69	44.65	38.21

Table 5: Yield attributes and Economic as influence by different treatment

S. No.	Treatment	Cost of cultivation. (Rs) ha^{-1}	Gross Return (Rs) ha^{-1}	Net Return (Rs) ha^{-1}	B:C Ratio
1.	T_1-Farmers Practices	32584	73874	41290	1.26
2.	T_2- Recommended dose of fertilizer (RDF)	35325	87186	51861	1.46
3.	T_3- Recommended dose of fertilizer (RDF)+Refinement treatment use Boron	36695	101972	65277	1.77



Test weight (g)

The data revealed that treatment T_3- N- 120 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} +Sulphur 5 kg ha^{-1}, Boron 2 kg ha^{-1} recorded higher test weight (42.54). However, treatment T_2- N- 100 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} and Sulphur 5 kg ha^{-1} and treatment T_1- Farmers Practices N-80kg ha^{-1}, P- 30 kg ha^{-1} and K- 15 kg ha^{-1}. higher test weight was observed with the T_3- N- 120 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} +Sulphur 5 kg ha^{-1} and Boron 2 kg ha^{-1} might be due to during growth and development stages the optimal number, size, and length of silique may have stimulated the availability of more photo assimilates and additionally an increased supply of photosynthates to siliqua allowed seeds to grow to their full potential and appeared to increase test weight. These results are in accordance with the findings of (Kumar *et al.* 2021) [6]. Further increased in test weight was recorded with growth through synthesis of tryptophan, auxin and enhanced nutrient metabolism, biological activity and growth parameters and furthermore enhanced enzyme activity that produced higher test weight of seeds. These results are in close conformity with the findings. Another reason, significantly increased in seed yield was resulted with application of boron might be due to its beneficial impact in boosting the vegetative structure for nutrient absorption and supply strong sink through the evolution of the reproductive structure and the synthesis of assimilates to fill crucial economic sites like siliqua and seed.

Oil content (%)

Oil content in the whole seed was determined by nuclear magnetic resonance spectroscopy employing non-destructive method of oil estimation as described. A simple and convenient method for the quantitative preparation of volatile methyl esters of fatty acids (FA) isolated by CS2 extraction and TLC technique. The concentration of individual FA in the Mustard seed samples is given as per cent by weight of the total FA in the oil from each treatment.

Economics

The results revealed that maximum gross return (Rs. 101972 ha^{-1}), net return (Rs. 65277 ha^{-1}) and B:C ratio (1.77) were recorded in treatment T_3- N- 120 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} +Sulphur 5 kg ha^{-1} and Boron 2 kg ha^{-1} as compared to T_2 N- 100 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} and Sulphur 5 kg ha^{-1} gross return (Rs. 87186 ha^{-1}), net return (Rs. 51861 ha^{-1}) and B:C ratio (1.46) and T_1 - Farmers Practices N-80kg ha^{-1}, P- 30 kg ha^{-1} and K- 15 kg ha^{-1} gross return (Rs. 73874 ha^{-1}), net return (Rs 41290 ha^{-1}) and B:C ratio (1.26) treatments. Higher B:C ratio was observed with the application N- 120 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} +Sulphur 5 kg ha^{-1}, Boron 2 kg ha^{-1} due to increased economical performance of crop such as seed yield

which in turned to higher gross returns and net returns.

Nutrient concentration in soil

Reported that it was found that increasing the nutrient availability of soil the application of sulphur and Boron and decreased the Soil pH: Soil pH and EC did not differ significantly after harvest of crop by application of different treatment of sulphur and boron. Application of different levels of sulphur and boron did not influenced organic carbon content increased in the soil after harvest of mustard. Available nitrogen, Phasphorus and Potassium among different treatments after harvest of the crop due to application of different Treatment of sulphur and boron. The study suggested that application of Sulphur 5 kg ha^{-1}, Boron 2 kg ha^{-1} along with RDF in soil might be useful in enhancing seed yield of mustard but significant increase in oil content was noticed when 5 kg/ha Sulphur was applied along with RDF, Sulphur 5 kg/ha and 2 kg Boron ha^{-1} in mustard grown under Bhavar Tarai zone District-Shravasti Uttar Pradesh.

Table 6: Soil fertility status as influence by different treatment

S. No.	Treatment	pH	EC	OC	N	P	K
1.	T_1-Farmers Practices	7.54	0.35	0.38	156.8	17.65	73.62
2.	T_2- Recommended dose of fertilizer (RDF)	7.54	0.41	0.39	174.2	20.31	86.92
3.	T_3- Recommended dose of fertilizer (RDF)+Refinement treatment use Boron	7.53	0.52	0.41	194.0	13.65	101.2

Conclusion

The results revealed that application of N- 120 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1} +Sulphur 5 kg ha^{-1}, Boron 2 kg ha^{-1} (Whole P, K and 1 /3 N as Basal dose and remaining N as Two split at 25 and 45 DAS+ Sulphur and Boron Foliar spray at before Flowering stage) formed better in terms of seed yield, Test Weight, oil content and economics of mustard. Therefore, it could be recommended that N- 120 kg ha^{-1}, P- 40 kg ha^{-1}, K- 40 kg ha^{-1}, Sulphur 5 kg ha^{-1} and Boron 2 kg ha^{-1} should be applied in Indian mustard for higher seed yield and net returns particularly under irrigated condition of Bhavar Tarai zone regions. The farmers suggested that application of Sulphur and Boron Foliar spray along with RDF in soil might be useful in enhancing seed yield of mustard but significant increase in oil content.

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