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Influence of boron and sulphur levels on growth and yield of yellow mustard (*Sinapis alba*)

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Abstract
The field experiment was conducted during *rabi* 2020 at Central Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.). To study the "Influence of boron and sulphur levels on growth and yield attributes of Yellow Mustard (*Sinapis alba*)". There were 9 treatments each replicated thrice. The treatment consists of 3 levels of sulphur *viz.* S_1 (20 kg ha^{-1}), S_2 (25 kg ha^{-1}), S_3 (30 kg ha^{-1}) and 3 levels of boron *viz*. B_1 (1 kg ha^{-1}), B_2 (2 kg ha^{-1}) and B_3 (3 kg ha^{-1}) as basal application, whose effect was observed on mustard. The experiment was laid out in Randomized Block Design. The results revealed that growth parameters *viz.* plant height (135.25cm) and dry weight (34.04 g/plant) at 100 DAS were recorded superior with the application of Sulphur 30 kg/ha + Boron 3 kg/ha. Whereas, crop growth rate (13.11 g/m^2/day) at 80-100 DAS were recorded superior with the application of Sulphur 30 kg/ha + Boron 2 kg/ha. As well as significantly maximum Yield parameters *viz.* number of silique/plant (96), length of silique (5.8cm), test weight (2.93g), number of seeds//silique (32), stover yield (4.02 t/ha) and seed yield (1.78 t/ha) were recorded superior with the application of Sulphur 30 kg/ha + Boron 3 kg/ha.

Keywords: Boron, sulphur, soil application, yellow mustard

Introduction
Oilseeds are the major contributors in the agricultural and industrial sector of India and hold its position only next to cereals in terms of area, production and value. Among the rapeseed and mustard group, yellow sarson which belongs to family Brassicaceae is an important crop in terms of its high seed oil and protein content. Over the years, yellow sarson has gained tremendous importance in these areas owing to its high yield potential, seed yield, oil content, protein content and its short period of maturity.

Nutrient management stands among the most crucial factors in crop production. It has been noticed that intensive cultivation of modern crop varieties through application of higher doses of NPK fertilizers have increased the crop yields mining out the inherent micronutrients from soils. As a result, deficiency of essential micronutrients is very much pronounced in some parts of the country. Micronutrients play a very crucial role in plant nutrition and biomass production. Their deficiency drastically affect the growth, metabolism and reproductive phase in plants.

Due to the intensification of agriculture coupled with the use of high analysis fertilizers widespread deficiency of various secondary or micronutrients has occurred. The deficiencies of sulphur, zinc and boron are common in so many areas. The rapeseed and mustard crop respond greatly to the application of sulphur, moreover, the sulphur requirement is the highest in oilseed crops in comparison with other crops, which is related to the role of this nutrient in oil biosynthesis Ahmad *et al*. (2007) [2]. Most of the oilseeds suffer from sulphur deficiency which results in low yield. Sulphur ranks thirteenth in terms of abundance in the earth's crust and is the fourth most important nutrient after nitrogen, phosphorus and potassium for Indian agriculture. Sulphur is the nutrient which plays a multitudinous role in providing nutrition to oilseed crops, particularly those belonging to crucifereae family. The importance of sulphur is obvious in oilseed production as it is required for the synthesis of sulphur containing amino acids methionine (21%), cysteine (26%) and cysteine (27%), which are essential components of protein and oil as well as for vegetative growth of the plant, it is involved in the formation of chlorophyll. glucosides and glucosinolates (mustard oils), activation of enzymes and sulfhydryl (-SH) linkages that are the source of pungency in oils and increases the root growth and stimulate seed formation. Likewise, boron also plays a key role in a diverse range of functions including cell wall formation and stability, maintenance of structural and functional integrity of biological membranes, movement of sugar or energy into growing parts of plants, and pollination and seed set and also required for reproduction and germination of pollen seeds in plants. Its primary role concerns with Ca metabolism by keeping the Ca in soluble form within the cell and acts as a regulator of K/Ca ratio, constitute cell membrane and essential for cell division. It also play a major role in maintaining the growth of apical growing point. But its demand peaks during the reproductive growth stage. Adequate boron is required to ensure effective nodulation and nitrogen fixation in legumes. Deficiency of boron causes restriction of water absorption and carbohydrate metabolism which ultimately affects seed and pod formation and thus reduce the yield In general. Brassicas need higher requirement of boron and severe deficiency may result in floral abortion and significant drop in seed production.

Materials and Methods

The experiment was conducted during *rabi* season 2020, at the Crop Research farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (7.3), available N (230 kg/ha), available P (32.10 kg/ha), available K (346 kg/ha). The treatment consists of levels of sulphur and boron. There were 9 treatments each replicated thrice. The experiment was laid out in Randomised Block Design. The crop was sown on 27 November 2020 at a spacing of 30cm*10 cm. The recommended dose of 80 kg N, 40 kg P, 40 kg K per ha was applied according to treatment details through urea, DAP, MOP along with micro nutrients like sulphur and boron. The half dose of nitrogen and full dose of phosphorous, potassium along with sulphur and boron were applied as basal. The split dose of nitrogen applied at 50 days after sowing. Five random plants were selected from each plot to record observations on plant growth attributes. Similarly, five random plant samples were collected from each plot at the time of harvest for recording observations on plant growth and yield attributes. Experimental data collected was subjected to statistical analysis by adopting Fishers method of Analysis of Variance (ANOVA) as outlined by Gomez and Gomez (2010). Critical Difference (CD) value were calculated whenever the 'F' test was found significant at 5% level.

Results and Discussion

The growth parameters like plant height, dry weight and crop growth rate was significantly affected by application of sulphur and boron at different stages.

Plant height (cm)

(Table 1) revealed that yellow mustard crop fertilized with Sulphur 30 kg/ha + Boron 3 kg/ha significantly resulted maximum plant height (135.25cm). However, Sulphur 30 kg/ha + Boron 1 kg/ha (131.68cm) at 100 days after sowings are statistically at par with Sulphur 30 kg/ha + Boron 3 kg/ha. Kumar and Yadav. (2007) [6] The application of sulphur enhance the nutritional environment for plant growth at active vegetative stages as a result of improvement in root growth, cell multiplication, elongation and cell expression in the plant body. Application of Boron play a major role in cell elongation, photosynthesis and translocation of photosynthates. These results are also in close conformity with the results of Verma *et al.* (2012) [13].

Dry weight (g) per plant

The analysed data presented in (Table 1) shown significant variation among all other treatments. At 100 DAS significantly maximum plant dry weight (34.04g) were recorded in Sulphur 30 kg/ha + Boron 3 kg/ha. However, Sulphur 25 kg/ha + Boron 2 kg/ha (30.30g), Sulphur 30 kg/ha + Boron 1 kg/ha (31.83g) and Sulphur 30 kg/ha + Boron 2 kg/ha (32.63g) were statistically at par with the application of Sulphur 30 kg/ha + Boron 3 kg/ha. Kumar and Yadav. (2007) [6] The increase in dry matter accumulation under higher level of sulphur fertilization was probably due to adequate application of sulphur which was directly involved in better absorption of applied nutrients and cell division as well as expansion of deep green colour leaves due to higher chlorophyll synthesis resulting into increase in photosynthetic rate in comparison with plants deficient in sulphur.This might be due to increased CO_2 assimilation and stomatal conductance, activities of Rubisco, NADP- glyceraldehyde-3 phosphate dehydrogenase (NADP-GAPDH) and stomatal fructose -1,6 bis phosphate were lower in B deficient leaves than in control. These results are also in close conformity with the results of Mallick and Raj (2015) [7].

Crop growth rate (g/m²/day)

The analysed data presented in (Table 1) shown significant variation among all other treatments. At 80 to 100 DAS significantly maximum Crop growth rate (29.66 g/m^2/day) were recorded in Sulphur 30 kg/ha + Boron 3 kg/ha. However, Sulphur 25 kg/ha + Boron 3 kg/ha (10.44 g/m^2/day), Sulphur 30 kg/ha + Boron 1 kg/ha (11.75 g/m^2/day) and Sulphur 30 kg/ha + Boron 3 kg/ha (11.63 g/m^2/day) were statistically at par with Sulphur 30 kg/ha + Boron 3 kg/ha. The sulphur and boron application made higher nutrients available to plants resulted in to more shoot biomass accumulation and crop growth rate which might have resulted higher photosynthetic activity at higher fertility levels. These results are also in close conformity with the results of Chakraborty and Das (2000) [3].

Yield and Yield Attributes

The Yield and Yield parameters like number of silique per plant, length of silique, number of seeds per silique, test weight, stover yield and grain yield were significantly affected by application of boron and sulphur at harvest.

Number of Silique per Plant

The analysed data presented in (Table 2) represents that significantly superior Number of silique per Plant (96) was recorded in 30 kg/ha + Boron 3 kg/ha. However, Sulphur 30 kg/ha + Boron 1 kg/ha (94) and Sulphur 30 kg/ha + Boron 2 kg/ha (93) were statistically at par with 30 kg/ha + Boron 3 kg/ha. Nadian *et al.* (2010) [8] Sulphur and boron enhance the primary and secondary branches which are silique bearing organs as flowers are borne at the terminals of the branches. Therefore with increased number of branches, there was increase in the number of silique per plant. These results are also in close conformity with the results of Singh and Mukherjee (2004).

Length of siliqua (cm)

The analysed data presented in (Table 2) significantly maximum Length of silique (5.8 cm) were recorded in Sulphur 30 kg/ha + Boron 3 kg/ha over all rest of the treatments respectively. Adequate supply of nutrients facilitated better growth and development of crop plant, enhanced nutrient uptake which resulted significant increase in length of silique. Similar results have also been reported by Sharma (2008).

Number of seeds per siliqua

The analysed data presented in (Table 2) significantly maximum number of seeds per silique (32.5) were recorded in Sulphur 30 kg/ha + Boron 3 kg/ha. However, Sulphur 30 kg/ha + Boron 1 kg/ha (28) and Sulphur 30 kg/ha + Boron 2 kg/ha (31) were statistically at par with Sulphur 30 kg/ha + Boron 3 kg/ha. Verma *et al*. (2012) [13] the increase in yield attributes might be due to that application of Sulphur where they improved over all nutritional environments of the rhizosphere as well as in the plant system, which in turn enhanced the plant metabolism and photosynthetic activity. This resulted in to better growth and development of plants and ultimately reflected in better yield traits. These results are also in close conformity with the results of Kumar and Yadav (2007) [6].

Test weight (g)

The analysed data presented in (Table 2) test weight (g) data showing that significant variation among all the treatments. The highest test weight (2.93 g) recorded significantly in Sulphur 25 kg/ha + Boron 2 kg/ha and Sulphur 30 kg/ha + Boron 2 kg/ha. However, Sulphur 25 kg/ha + Boron 1 kg/ha (2.70g), Sulphur 25 kg/ha + Boron 3 kg/ha (25.3g), Sulphur 30 kg/ha + Boron 1 kg/ha (2.92g) and Sulphur 30 kg/ha + Boron 3 kg/ha (2.85g) were statistically at par with Sulphur 25 kg/ha + Boron 2 kg/ha and Sulphur 30 kg/ha + Boron 2 kg/ha. Kour *et al.* (2017) [5] boron and sulphur was more pronounced on most of the yield attributes of mustard, because it plays a positive role in improving the vegetative structure for nutrient absorption and supply strong sink through evolution of reproductive structure as well as production of assimilates to fill important economical site i.e. siliqua and seed. These results are also in close conformity with the results of Abid *et al.* (2014) [1].

Stover yield (t/ha)

The analysed data presented in (Table 2) Stover yield (4.02 t/ha) data showing that significant variation among all the treatments. The highest Stover yield was recorded significantly in Sulphur 30 kg/ha + Boron 3 kg/ha. However, Sulphur 30 kg/ha + Boron 1 kg/ha (3.52t/ha) and Sulphur 30 kg/ha + Boron 2 kg/ha (3.88t/ha) were statistically at par with Sulphur 30 kg/ha + Boron 3 kg/ha. Singh *et al.* (2010) Sulphur is being an essential constituent of several biological active compounds like amino acids (Cystine, cysteine and methionine), vitamins (Thiamine and Biotin) lipoic acid, acetyl Co-A, Ferrodoxin and glutathione-S play multiple roles in the plant metabolism. It engages in activation of a number of enzymes participating in dark reaction of photosynthesis via improvement in chlorophyll content of leaves. Hussain *et al.* (2008) [4] Application of boron enhanced more uptakes of major nutrients resulting greater photosynthetic activities and led to greater vegetative growth of plants. Ultimately this accelerated growth due to proper metabolic activities produced higher stover yield in mustard. These results are also in close conformity with the results of Singh and Mukherjee (2004).

Grain yield (t/ha): The analysed data presented in (Table 2) represented the highest seed yield (1.78t/ha) was recorded significantly superior in Sulphur 30 kg/ha + Boron 3 kg/ha. However, Sulphur 25 kg/ha + Boron 2 kg/ha (1.39t/ha), Sulphur 25 kg/ha + Boron 3 kg/ha (1.38t/ha), Sulphur 30 kg/ha + Boron 1 kg/ha (1.50t/ha) and Sulphur 30 kg/ha + Boron 2 kg/ha (1.66 t/ha) were statistically at par with Sulphur 30 kg/ha + Boron 3 kg/ha. Sharma *et al.* (2009) Sulphur and boron application might be attributed to sum total effect of increased growth and yield attributing characters. Due to increased supply of sulphur and boron results in better translocation of photosynthates to seeds and thus increased to value of harvest index. These results are also in close conformity with the results of Chakraborty and Das (2000) [3].

Table 1: Effect of sulphur and born on growth attributes of Yellow mustard

S. No.	Treatments	Plant Height (cm) (100 DAS)	Dry weight/plant (g) (100 DAS)	Crop growth rate (g/m^2/day) (80-100 DAS)
1.	Sulphur 20 kg/ha + Boron 1 kg/ha	124.38	21.53	8.22
2.	Sulphur 20 kg/ha + Boron 2 kg/ha	126.86	24.76	7.70
3.	Sulphur 20 kg/ha + Boron 3 kg/ha	128.30	25.87	8.44
4.	Sulphur 25 kg/ha + Boron 1 kg/ha	129.22	26.47	10.19
5.	Sulphur 25 kg/ha + Boron 2 kg/ha	129.14	30.30	10.30
6.	Sulphur 25 kg/ha + Boron 3 kg/ha	129.95	28.90	10.44
7.	Sulphur 30 kg/ha + Boron 1 kg/ha	131.68	31.83	11.75
8.	Sulphur 30 kg/ha + Boron 2 kg/ha	130.02	32.63	13.11
9.	Sulphur 30 kg/ha + Boron 3 kg/ha	135.25	34.04	11.63
	F-test	S	S	S
	S.Em±	1.7	1.491	0.922
	CD (0.05)	5.20	4.470	2.76

Table 2: Effect of sulphur and boron on Yield and Yield attributes of Yellow mustard.

S. No.	Treatments	Number of Silique/plant	Length of Silique (cm)	Test weight (g)	Number of seeds/silique	Stover yield (t/ha)	Seed yield (t/ha)
1.	Sulphur 20 kg/ha + Boron 1 kg/ha	79	4.5	2.10	23	2.63	1.11
2.	Sulphur 20 kg/ha + Boron 2 kg/ha	81	4.5	2.60	25	2.95	1.18
3.	Sulphur 20 kg/ha + Boron 3 kg/ha	84	4.7	2.20	26	2.81	1.12
4.	Sulphur 25 kg/ha + Boron 1 kg/ha	85	4.8	2.70	26	2.95	1.22
5.	Sulphur 25 kg/ha + Boron 2 kg/ha	86	4.74	2.93	25	3.24	1.39
6.	Sulphur 25 kg/ha + Boron 3 kg/ha	91	4.8	2.70	24	3.01	1.38
7.	Sulphur 30 kg/ha + Boron 1 kg/ha	94	5.3	2.92	28	3.52	1.50
8.	Sulphur 30 kg/ha + Boron 2 kg/ha	93	5.38	2.93	31	3.88	1.66

9.	Sulphur 30 kg/ha + Boron 3 kg/ha	96	5.8	2.85	32	4.02	1.78
	F-test	S	S	S	S	S	S
	S.Em±	1.053	0.126	0.075	1.515	0.198	0.148
	CD (P=0.05)	3.157	0.37	0.227	4.54	0.593	0.443

Conclusion

In the light of the above study, application of Sulphur 30 kg/ha + Boron 3 kg/ha is more productive.

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