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Effect of boron and sowing dates on yield, yield attributes and economics of yellow mustard (*Sinapis alba*)

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Abstract
A field experiment was conducted during *rabi* 2020 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil was sandy loam in texture, low in organic carbon and medium in available nitrogen, phosphorous and low in potassium. The experiment was laid out in Randomized Block Design with nine treatments each replicated thrice. The results showed that *viz*: number of siliquae per plant (144.1), seeds per siliquae (41.4) and test weight (3.3 g), Maximum seed yield (17.2 q/ha), stover yield (58.1 q/ha) and harvest index (22.8%) were significantly recorded with the application of Boron-2kg/ha + D_1-26-October-2020 compared to all other treatments. However, the maximum gross returns (103200.00 INR/ha), net returns (68241.00 INR/ha) and B:C ratio (1.95) was significantly recorded significantly with the application of Boron 2 kg/ha + D_1 -26 October 2020 as compared to all other treatments.

Keywords: Mustard, boron, sowing dates, yield and economics

Introduction
In India mustard is the second important edible oilseed crop after groundnut. It plays an important role in the oilseed economy of the country. Among the seven edible oilseeds cultivated in India, rapeseed-mustard contributes 28.6% in the total oilseeds production and ranks second after groundnut sharing 27.8% in the India's oilseed economy. Mustard seed in general, contains 30-33% oil, 17-25% proteins, 8-10% fibers, 6-10% moisture, and 10-12% extractable substances. Demand of edible oil has increased with increasing population and improvement in the living standard of the people, resulting thereby in short supply of edible oils which is being met with imports of edible oil worth 44,000 crores per annum. Major mustard growing states in India are Rajasthan (40.82%), Haryana (13.33%), Madhya Pradesh (11.76%), Uttar Pradesh (11.40%) and West Bengal (8.64%) according to 2018-19 year (Rathi *et al*., 2019). The seeds are highly nutritive containing 38-57% erucic acid, 5-13% linoleic acid and 27% oleic acid. They are not only rich sources of energy and carriers of fat soluble vitamins A, D, E and K but they form the ingredients of foods and flavours, cosmetics and condiments, soap and detergents, lubricants and laxatives and also known for their medical and therapeutic use (Chauhan *et al*., 2020) [3].
Boron is one of the mineral nutrients required for normal plant growth. The most important functions of boron in plants are thought to be its structural role in cell wall development, cell division, seed development and stimulation or inhibition of specific metabolic pathways for sugar transport and hormone development (Ahmed *et al*., 2009). Boron also plays an important role in production of any crop in terms of yield, quality and control of some diseases. A part from major plant nutrients, B plays an important role in the production phenology of mustard and this crop responds to applied B (Karthikeyan and Shukla 2008) [4]. Thus, B fertilization is necessary for improvement of crop yield as well as nutritional quality. Mustard as a Brassica group generally has a high B requirement (Mengel and Kirkby 1987) [10]. This crop is mainly grown in winter season (October- March). The recommended sowing calendar for mustard varies across the major growing regions. Sowing at proper time allows sufficient growth and development of the crop to obtain a satisfactory yield and different sowing dates provide variable environmental conditions within the same location for growth and development of crop and yield stability (Pandey *et al.* 1981) [11]. If the mustard sown late, duration is reduced due to the high temperature during the reproductive phase which results in reduction of yield. (Kumari *et al.* 2005) [6].

Materials and Methods

A field experiment was conducted during Rabi season 2020 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) which is located at 25 degree 39' 42''N latitude, 81 degree 67'56''E longitude and 98 m altitude above the mean sea level, during Kharif season 2020. The soil was sandy loam in texture, low in organic carbon and medium in available nitrogen, phosphorous and low in potassium. Nutrient sources were Urea, DAP, MOP to fulfill the requirement of Nitrogen, phosphorous and potassium. Gypsum used to fulfill the requirement of sulphur. Nitrogen applied as split dose half as basal dose remaining as top dressing. The treatment consisted 3 levels of Boron and 3 Dates of sowing T1: Boron-1kg/ha + D_1-26-October-2020, T2: Boron-1kg/ha + D_2-5-November-2020, T3: Boron-1kg/ha + D_3-15-November-2020, T4: Boron-1.5kg/ha + D_1-26-October-2020, T5: Boron-1.5kg/ha + D_2-5-November-2020, T6 Boron-1.5kg/ha + D_2-5-November-2020, T7: Boron-2kg/ha + D_1-26-October-2020, T8: Boron-2kg/ha + D_2-5-November-2020, T9: Boron-2kg/ha + D_3-15-November-2020 used. The Experiment was laid out in Randomized Block Design, with nine treatments which are replicated thrice. The seed rate of 4-5 kg/ha used for sowing. In the period from germination to harvest several growth parameters were recorded at frequent intervals along with it after harvest several yield parameters like siliquae per plant, seeds per siliquae, grain yield, test weight (1000 seeds), stover yield and harvest index were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez K.A. and Gomez A.A. 1984).

Results

Yield and Yield attributes

Siliquae per plant

Data in Table 1 revealed Siliquae per plant (143.6) was more and significant in treatment with treatment 7 with Boron at 2 kg/ha+ October 26 (D_1) sowing date was recorded significantly higher from treatments expect treatment 8 with Boron at 1.5 kg/ha+ October 26 (D_1) sowing date is statistically at par with sowing date of Boron at 2 kg/ha+ October 26 (D_1) sowing date.

Seeds per Siliquae

Data in Table 1 revealed Seeds per Siliquae (41.4) was more and significant in treatment with treatment 7 with Boron at 2 kg/ha+ October 26 (D_1) sowing date was recorded significantly higher from treatments expect treatment 4 with sowing date of October 26 (D_1) + Boron at 1.5 kg/ha and treatment 8 with Boron at 1.5 kg/ha+ October 26 (D_1) sowing date is statistically at par with Boron at 2 kg/ha+ October 26 (D_1) sowing date.

Test weight (g)

Data in Table 1 revealed Test weight (3.3 g) was more and significant in treatment with treatment 7 with Boron at 2 kg/ha+ October 26 (D_1) sowing date was recorded significantly higher from treatments expect treatment 4 with Boron at 1.5 kg/ha+ sowing date of October 26 (D_1) and treatment 8 with Boron at 1.5 kg/ha+ October 26 (D_1) sowing date is statistically at par with Boron at 2 kg/ha+ October 26 (D_1) sowing date.

Seed yield (q/ha)

Data in Table 1 revealed Seed yield (17.2 q/ha) was more and significant in treatment with treatment 7 with Boron at 2 kg/ha+ October 26 (D_1) sowing date was recorded significantly higher from treatments expect treatment 4 with Boron at 1.5 kg/ha+ sowing date of October 26 (D_1) and treatment 8 with Boron at 1.5 kg/ha+ October 26 (D_1) sowing date is statistically at par with Boron at 2 kg/ha+ October 26 (D_1) sowing date.

Stover yield (q/ha)

Data in Table 1 revealed that Stover yield (58.1 q/ha was more and significant in treatment with treatment 7 with Boron at 2 kg/ha+ October 26 (D_1) sowing date was recorded significantly higher from treatments expect treatment 8 with Boron at 1.5 kg/ha+ October 26 (D_1) sowing date is statistically at par with Boron at 2 kg/ha+ October 26 (D_1) sowing date.

Harvest Index (%)

Data in Table 1 revealed that Harvest Index was Non-significant in treatments while, with treatment 2 with sowing date of November 05 (D_2) + Boron at 1.5 kg/ha shows highest (24.1), while lowest value shown in treatment 9 with Boron at 2 kg/ha+ sowing date of November 15 (D_3) (22.3).

Table 1: Effect of Dates of sowing and Boron levels on yield and yield parameters in yellow mustard

Treatments	Siliquae per plant	Seeds per Siliquae	Test weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
1- Boron-1kg/ha + D_1-26-October-2020	138.8	39.5	2.9	15.2	50.7	23.1
2 - Boron-1kg/ha + D_2-5-November-2020	134.4	38.7	2.9	14.5	45.9	24.1
3 - Boron-1kg/ha + D_3-15-November-2020	132.9	38.3	2.9	14.0	44.7	23.9
4 - Boron-1.5kg/ha + D_1-26-October-2020	142.9	40.5	3.2	16.3	56.1	22.4
5 - Boron-1.5kg/ha + D_2-5-November-2020	140.9	39.8	3.0	15.7	53.6	22.7
6 - Boron-1.5kg/ha + D_3-15-November-2020	136.6	39.2	2.9	14.9	49.3	23.3
7- Boron-2kg/ha + D_1-26-October-2020	144.1	41.4	3.3	17.2	58.1	22.8
8 - Boron-2kg/ha + D_2-5-November-2020	143.6	40.8	3.2	16.8	57.3	22.7
9 - Boron-2kg/ha + D_3-15-November-2020	141.7	40.0	3.1	15.8	55.2	22.3
F test	S	S	S	S	S	NS
S.Em(+)	0.44	0.34	0.03	0.29	0.87	0.54
CD (5%)	0.54	1.03	0.10	0.86	2.60	-

Economics

Gross returns (INR/ha)

Data in Table 2 revealed that Gross returns (103200.00 INR/ha) was found to be highest in treatment 7 with Boron at 2 kg/ha+ October 26 (D_1) sowing date, and the minimum gross returns (84000.00 INR/ha) was found to be in treatment

3 with sowing date of November 15 (D_3) + Boron at 1.0 kg/ha as compared to other treatments.

Net returns (INR/ha)

Data in Table 2 revealed that Net returns (68241.00 INR/ha)) was found to be highest in treatment 7 with Boron at 2 kg/ha+ October 26 (D_1) sowing date, and the minimum net returns (50145.00 INR/ha) was found to be in treatment 3 with sowing date of November 15 (D_3) + Boron at 1.0 kg/ha as compared to other treatments.

Benefit Cost ratio (B: C)

Data in Table 2 revealed that Benefit Cost ratio (1.95) was found to be highest in treatment 7 with Boron at 2 kg/ha+ October 26 (D_1) sowing date, and the minimum B:C ratio (1.48) was found to be in treatment 3 with sowing date of November 15 (D_3) + Boron at 1.0 kg/ha as compared to other treatments.

Table 2: Effect of Dates of sowing and Boron levels on Economics in yellow mustard

Treatments	Cost of cultivation (INR/ha)	Gross returns (*INR*/ha)	Net returns (*INR*/ha)	Benefit cost ratio (B:C)
1- Boron-1kg/ha + D_1-26-October-2020	33855.00	91200.00	57345.00	1.69
2 - Boron-1kg/ha + D_2-5-November-2020	33855.00	87000.00	53145.00	1.56
3 - Boron-1kg/ha + D_3-15-November-2020	33855.00	84000.00	50145.00	1.48
4 - Boron-1.5kg/ha + D_1-26-October-2020	34407.00	97800.00	63393.00	1.84
5 - Boron-1.5kg/ha + D_2-5-November-2020	34407.00	94200.00	59793.00	1.73
6 - Boron-1.5kg/ha + D_3-15-November-2020	34407.00	89400.00	54993.00	1.59
7- Boron-2kg/ha + D_1-26-October-2020	34959.00	103200.00	68241.00	1.95
8 - Boron-2kg/ha + D_2-5-November-2020	34959.00	100800.00	65841.00	1.88
9 - Boron-2kg/ha + D_3-15-November-2020	34959.00	94800.00	59841.00	1..71

Discussion

Higher temperatures accelerated flowering which was observed in early sown crop, while the flowering occurred later in late sowings were more sensitive to the lower temperatures. The findings were in accordance with Lallu *et al*. (2010) [8]. The application of boron to yellow mustard generally improves fruit growth by synthesizing tryptophan and auxin. The enhancement effect on seeds per silique attributed to the favorable influence of boron application to crops on nutrient metabolism, biological activity and growth parameters which in turn influenced higher enzyme activity which in turn encouraged more seeds/siliqua and silique/plant. Similar findings were observed by Yadav *et al* (2016) [15]. Boron plays the vital role in increasing because it takes place in many physiological process of plant such as chlorophyll formation, stomatal regulation, starch utilization which enhanced seed yield, Mallik and Raj (2015) [9]. Early sowing resulted in the early flowering which helps in early siliqua development and increase in reproductive phase and ultimately the seed yield, thus the November 10 sowing obtained the higher yield attributes and yield, Kumari *et al*.(2012) [7] obtained the similar results in the early sown crop. November 11th sowing helped the plants to encounter higher amount of sunlight and heat which resulted in the higher bio mass accumulation, higher plant height and higher number of branches. This ultimately resulted in higher stover yield Patel *et al*. (2017). Arun *et al.* (2001) [2] stated that application of 2% DAP + 5% $ZnSO_4$ + 0.5% boric acid as foliar spray noticed maximum net returns (36,347 Rs ha^{-1}) and B: C ratio (2.44) in groundnut crop. Paramasivam *et al.* (2003) [12] reported that, seed treatment and foliar spray of DAP 0.5 per cent, Ammonium molybdate 0.2 per cent, Boric acid 0.1 percent, NAA 40 ppm and Salicylic acid 100 ppm and phytohormones increased B: C ratio (1.61) as compared to recommended dose of NPK fertilizers (1.48) alone in sesame. Keerthi *et al.* (2017) [5] found that the maximum net profit (Rs.50566/ha and Rs.47493/ha) and BC ratio (1.94 and 1.82) was recorded with October 15 with 100 kg N/ha sown crop during 2013-14 and 2014-15, respectively

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Conclusion

On the basis of one season of experiment it may be concluded that the application of 2.0 kg/ha Boron + sowing date October 26 (D_1) dates of sowing recorded seed yield (17.2q/ha) as well as with greater B: C ratio (1.95). Since, the findings were based on the research done in one season under agro-ecological conditions of Prayagraj it may be repeated for confirmation and farmer recommendations.

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