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Nishant Meena
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Maku Sanathkumar
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Amit Nain
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Sanwarmal Jat
M.Sc. Scholar, Department of Soil Science, Banaras Hindi University, Varanasi, Uttar Pradesh, India

Corresponding Author:
Nishant Meena
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Effect of potassium and boron on yield and economics of mustard (*Brassica juncea* L.)

Nishant Meena, Maku Sanathkumar, Amit Nain and Sanwarmal Jat

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Abstract
The field experiment was conducted at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) during Rabi, 2023. The treatments consisted of three levels Potassium levels (20 kg/ha, 30 kg/ha, and 40 kg/ha) and boron (1 kg/ha, 1.5 kg/ha and 2 kg/ha). The experiment was laid out in a Randomized Block Design with ten treatments each replicated thrice. The treatments which are T_1: Potassium 20 kg/ha + Boron 1 kg/ha, T_2: Potassium 20 kg/ha + Boron 1.5 kg/ha, T_3: Potassium 20 kg/ha + Boron 2 kg/ha, T_4: Potassium 30 kg/ha + Boron 1 kg/ha, T_5: Potassium 30 kg/ha + Boron 1.5 kg/ha, T_6: Potassium 30 kg/ha + Boron 2 kg/ha, T_7: Potassium 40 kg/ha + Boron 1 kg/ha, T_8: Potassium 40 kg/ha + Boron 1.5 kg/ha, T_9: Potassium 40 kg/ha + Boron 2 kg/ha, T_{10}: Control (80:40:40) NPK kg/ha. Application of Potassium 40 kg/ha along with Boron 2 kg/ha (treatment 9) recorded significantly higher plant height (184.44 cm), maximum number of branches/plant (14.8), higher plant dry weight (24.01 g), maximum number of siliqua/plant (125.75), maximum number of seeds/silique (15.13), higher test weight (3.41 g), higher seed yield (2135.15 kg/ha), higher stover yield (4043.38 kg/ha) and highest harvest index (35.76%). The maximum Gross returns (136795.99 INR/ha), Net return (97295.99 INR/ha) and B:C (2.46) were also recorded with application of Potassium 40 kg/ha along with Boron 2 kg/ha (treatment 9) was found to be productive as well as economically feasible.

Keywords: Boron, economics, mustard, potassium, and yield

Introduction
One member of the Brassicaceae family that goes by the name mustard is Indian mustard (*Brassica juncea* L.). Old French mostarde and Anglo-Norman mustarde are the sources of the word "mustard" (contemporary French is moutarde). The word "young wine" (mustum) in Latin is the source of the first element. Originally, pulverized seeds were mixed with must to make the condiment. The Latin word "ardens" (hot, burning) is also the source of the second ingredient. In business, medicine, and cuisine, mustard oil is employed. In addition to being rich in omega-3 fatty acids, mustard seed has vitamins and minerals.
Currently, only groundnut and soybean are the two most important oilseed crops in India, after rapeseed-mustard. India is the biggest oilseed producer, importer, and consumer in the world. Raabi (winter crop): One of the nine principal oilseeds cultivated in India is Indian mustard (*Brassica juncea* L.). In order to become self-sufficient, rapeseed-mustard output must rise due to the rising imbalance between supply and demand.
In India, 9.80 mha of rapeseed-mustard are grown, yielding 11.4 mt of product and 1179 kg/ha of productivity (Agricultural Statistics at a glance, 2021-22). The states that cultivate the most rapeseed and mustard are Rajasthan, Madhya Pradesh, Uttar Pradesh, Haryana, and West Bengal. Together, these states account for 82% of the nation's total rapeseed and mustard acreage and 85% of its total production.
Though most field crops only need small amounts of this essential element, boron has a significant impact on crop productivity. Many data indicate mustard's favorable response to boron fertilizer. In mustard, farmers often apply smaller amounts of N, P, and K and do not use boron fertilizer. Boron plays a major role in seed yield, especially in areas where soil contains insufficient amounts of B. Additionally, they reported that boron boosted mustard output and the amount of siliqua. In general, the brassica group has a high boron requirement. According to (Sharma 2006) [6], boron significantly raised the quantity of pods and seed set. Boron treatment results in a 16–69% increase in seed production.

Crop development and output are impacted by either an excess or a shortage of boron. Boron deficiency limits the body's ability to absorb water and metabolize carbohydrates, which in turn impacts seed and pod production and lowers yield. A significant increase in seed yield can be achieved by using boron, which is essential for cell differentiation and development, photosynthesis, translocation of growth regulators from source to sink, and pollen grain expansion. The formation of viable pollen grains in the flower and, eventually, the yield are impacted by boron toxicity or lack. With nutrient addition and tillage modification, there is still room to grow the productivity of mustard and rapeseed in the cultivation practices.

In terms of nutrients required by plants, potassium (K) is deemed essential after nitrogen. It is also known as "the quality nutrient" because of its role in several physiological, chemical, and biological processes in plants. Potassium controls stomata's opening and closing, which controls CO2 intake and improves photosynthesis. It causes the production of Adenosine Triphosphate (ATP) by activating key biological enzymes. Other chemical and physiological functions, such the excretion of waste compounds by plants, depend on ATP for energy. It contributes to the osmoregulation of other salts and water in plant tissues and cells. Additionally, plants use potassium to synthesize carbohydrates and proteins. In addition to yield advantage, potassium influences the connection between plants, soil, and water, which helps plants become more drought-tolerant. Consequently, it is necessary in high concentrations for plants to grow and develop properly. Potassium activates around 60 different enzymes in plants. These enzymes directly contribute to the maintenance of turgor, which lessens wilting and water loss while enhancing drought tolerance. Potassium may have decreased transpirational water loss in plants. According to a number of studies, plants with inadequate potassium levels transpire more than plants with sufficient potassium levels when they are under moisture stress. In addition, potassium facilitates the transfer of sugars and starches throughout plants, encourages the growth of roots, and supports photosynthesis. Potassium controls the xylem and phloem's ability to carry nutrients and water throughout the plant. Similarly, Jakli *et al*. (2016) [23] reported that potassium (K) plays a significant effect in lowering plant stress, especially moisture stress, and enhances agricultural water use efficiency (WUE).

Materials and Methods

The investigation was carried out at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture Science and Technology (SHUATS), Naini, Prayagraj, UP, during rabi 2023-24. The treatment consists of T_1: Potassium 20 kg/ha + Boron 1 kg/ha, T_2: Potassium 20 kg/ha + Boron 1.5 kg/ha, T_3: Potassium 20 kg/ha + Boron 2 kg/ha, T_4: Potassium 30 kg/ha + Boron 1 kg/ha, T_5: Potassium 30 kg/ha + Boron 1.5 kg/ha, T_6: Potassium 30 kg/ha + Boron 2 kg/ha, T_7: Potassium 40 kg/ha + Boron 1 kg/ha, T_8: Potassium 40 kg/ha + Boron 1.5 kg/ha, T_9: Potassium 40 kg/ha + Boron 2 kg/ha, T_{10}: Control (80:40:40) NPK kg/ha. The experiment was laid out in Randomized Block Design, with 10 treatments replicated thrice. The observations were recorded for Plant height, Number of branches/plant, Dry weight of plant, Crop growth rate, Relative growth rate, Number of siliqua/plant, Number of seeds/siliqua, Test weight, seed yield, stover yield. The collected data was subjected to statistical analysis by analysis of variance method.

Results and Discussion

A. Yield attributes and Yield

1. Siliqua/Plant

Treatment 9 with application of Potassium 40 kg/ha along with Boron 2 kg/ha recorded significantly higher number of siliqua/plant (125.75), which was significantly superior over rest of the treatments. However, treatment-8 Potassium 30kg/ha + Boron 2 kg/ha was found to be statistically at par with treatment- 9 Potassium 40 kg/ha + Boron 2 kg/ha.

2. Seeds/siliqua

Significant and maximum number of seeds/siliqua (15.13) was observed in treatment-9 with application of Potassium 40 kg/ha along with Boron 2 kg/ha, which was significantly superior over rest of the treatments. However, treatment-8 Potassium 30 kg/ha + + Boron 2 kg/ha was found to be statistically at par with treatment- 9 Potassium 40 kg/ha + Boron 2 kg/ha.

3. Test weight (g)

Significantly higher test weight highest (3.41 g) was recorded in treatment 9 with application of Potassium 40 kg/ha along with Boron 2 kg/ha, though there was non-significant difference among the treatments.

4. Seed yield (t/ha)

ignificant and higher seed yield (2135.15 kg/ha) was observed in treatment-9 with application of Potassium 40 kg/ha along with Boron 2 kg/ha, which was significantly superior over rest of the treatments. However, treatment-8 Potassium 30 kg/ha + Boron 2 kg/ha was found to be statistically at par with treatment- 9 Potassium 40 kg/ha + Boron 2 kg/ha.

5. Stover yield (t/ha)

Treatment 9 with application of Potassium 40 kg/ha along with Boron 2 kg/ha recorded significant and higher stover yield (4043.38 kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 Potassium 30 kg/ha + Boron 2 kg/ha was found to be statistically at par with treatment- 9 Potassium 40 kg/ha + Boron 2 kg/ha.

B. Economics

Gross return, net return and benefit cost ratio were influenced due to different treatments.

a. Cost of Cultivation (INR/ha)

Cost of production (INR 39500.00/ha) was found to be highest in treatment 9 with application of Potassium 40 kg/ha along with Boron 2 kg/ha as compared to other treatment.

b. Gross return (INR/ha)

Gross return (INR 136795.99/ha) was found to be highest in treatment 9 with application of Potassium 40 kg/ha along with Boron 2 kg/ha as compared to other treatment.

c. Net return (INR/ha)

Net return (INR 97295.99/ha) was found to be highest in treatment 9 with application of Potassium 40 kg/ha along with Boron 2 kg/ha as compared to other treatment.

d. Benefit cost ratio (B:C)

Benefit cost ratio (2.11) was found highest in the treatment-6 (40 kg/ha Sulphur + NAA 100 ppm) and benefit cost ratio (0.98) was found in treatment-4 (25 kg/ha Sulphur + GA3 50 ppm) as compared to other treatments.

Table 1: Effect of Potassium and Boron on Yield Attributes of Mustard

S. No.	Treatments	Number of Siliqua/Plant	Number of Seeds/Siliqua	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)
1.	Potassium 20 kg/ha + Boron 1 kg/ha	104.18	9.44	2.97	1005.69	3634.50
2.	Potassium 20 kg/ha + Boron 1.5 kg/ha	109.83	10.74	2.99	1203.18	3665.00
3.	Potassium 20 kg/ha + Boron 2 kg/ha	110.84	12.15	3.04	1385.22	3892.50
4.	Potassium 30 kg/ha + Boron 1 kg/ha	114.16	12.98	3.05	1522.42	3862.50
5.	Potassium 30 kg/ha + Boron 1.5 kg/ha	119.50	12.87	3.22	1673.89	3814.50
6.	Potassium 30 kg/ha + Boron 2 kg/ha	121.50	12.67	3.15	1626.31	3843.00
7.	Potassium 40 kg/ha + Boron 1 kg/ha	121.83	13.73	3.24	1796.02	3964.50
8.	Potassium 40 kg/ha + Boron 1.5 kg/ha	124.83	14.04	3.33	1936.63	3990.00
9.	Potassium 40 kg/ha + Boron 2 kg/ha	125.75	15.13	3.41	2135.15	4043.38
10.	Control (RDF) – 80:40:40 NPK kg/ha	89.27	8.89	2.83	757.23	3399.83
	F-Test	S	S	S	S	S
	S.Em (±)	7.29	0.56	0.19	132.49	0.12
	CD (P=0.05)	21.66	1.66	-	393.58	0.36

Table 2: Effect of Potassium and Boron on Economics of Mustard

S. No.	Treatments	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1.	Potassium 20 kg/ha + Boron 1 kg/ha	36500	73235.76	36735.76	1.01
2.	Potassium 20 kg/ha + Boron 1.5 kg/ha	37500	83866.05	46366.05	1.24
3.	Potassium 20 kg/ha + Boron 2 kg/ha	38500	95095.33	56595.33	1.47
4.	Potassium 30 kg/ha + Boron 1 kg/ha	37000	102436.52	65436.52	1.77
5.	Potassium 30 kg/ha + Boron 1.5 kg/ha	38000	110466.96	72466.96	1.91
6.	Potassium 30 kg/ha + Boron 2 kg/ha	39000	108011.78	69011.78	1.77
7.	Potassium 40 kg/ha + Boron 1 kg/ha	37500	117885.16	80385.16	2.14
8.	Potassium 40 kg/ha + Boron 1.5 kg/ha	38500	125689.99	87189.99	2.26
9.	Potassium 40 kg/ha + Boron 2 kg/ha	39500	136795.99	97295.99	2.46
10.	Control (RDF) – 80:40:40 NPK kg/ha	33500	58343.83	24843.83	0.74

Conclusion

Based on the above findings it is concluded that, application of Potassium 40 kg/ha along with Boron 2 kg/ha. (Treatment 9) perform better in yield and ecomics in Mustard and hence can be recommended to the farmer.

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