Effect of sulphur and boron on growth characterstics, yield components and productivity parameters of mustard (*Brassica juncea* L.) under rainfed condition of Chitrakoot region

Abstract

The present field experiment was conducted during Kharif season of 2021–22 at Mahatma Gandhi Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.) to evaluate the effect of Sulphur and Boron on growth parameters, yield attributes and yield of mustard (*Brassica juncea* L.) under rainfed condition of Chitrakoot area. The experimental soil is sandy loam in texture having medium status of available sulphur and available boron. The experiment comprised of 9 treatment combinations in factorial randomized block design with three replications. Mustard variety *Pusa Mahak* was grown with the recommended agronomic practices. On the basis of the results emanated from present investigation, it could be concluded that application of 35 kg S ha^{-1} + 2.5 kg B ha^{-1} 40 DAS applied in mustard to significantly increases growth parameter i.e. plant height, no. of leaves and no. of branches and yield attributes i.e. number of pods per plant, number of seeds per pod and 1000 seed weight (gm). Results showed that among the different fertility levels, application of 35 kg S ha^{-1} + 2.5 kg B ha^{-1} 40 DAS significantly enhanced productivity parameter i.e. seed yield (q ha^{-1}) over the control.

Key Words: Boron, Mustard, Sulphur and yield.

Introduction

Globally, India is the fourth largest oilseed crops producing country after United States, China and Brazil. However, it secures first position in sesame, niger, castor and safflower production and second position in groundnut production after China **(Gupta and Gupta, 2016, DAC&FW, 2020)**. In India, the oilseeds are grown on 14.4% of total gross cropped area (25.50 million ha), which produced 32.26 million tonnes oilseeds with 1265 kg/ha productivity **(DAC&FW, 2020).**

Rapeseed-mustard is second most important edible oilseed crop in our country after soybean, among all the nine oilseed crops **(DAC&FW, 2020).** India occupies the third position in area and production of rapeseed-mustard after Canada and China **(USDA, 2020).** Globally, the area and production of rapeseed-mustard is 36.81 million hectares and 72.61 million tonnes, respectively **(USDA, 2020).** India is having 6.23 million ha area under rapeseed-mustard and 9.34 million tonnes production with average productivity of 1499 kg/ha, which is about three forth of the world's average productivity (1960 kg/ha) **(DAC&FW, 2020).** Among the different states and union territories, Rajasthan, Haryana, Uttar Pradesh and Madhya Pradesh contribute 74% acreage and 81% production of total rapeseed-mustard. Rajasthan ranks first in area (38.1%) and production (43.7%) while Haryana ranks first in productivity (2058 kg/ha) of rapeseed-mustard. Uttar Pradesh secured third position in country in respect of both acreage (0.75 million ha) and production (1.12 million tonnes) of rapeseed-mustard with 1483 kg/ha productivity **(DAC&FW, 2020).** Bundelkhand region covers 121.58 thousand ha area under rapeseed-mustard crop with the production of 92.80 thousand tonnes. The average productivity of rapeseed-mustard crop in Bundelkhand region is very low (763 kg/ha) as compared to national productivity **(DRMR, 2019).**

Indian mustard **(***Brassica juncea* L**.** Czernj & Cosson***)*** belongs to the family *Brassicaceae* and commonly called as *rai* or Indian mustard**.** It contain good amount of oil usually 30–38% **(Thomas *et al*., 2004).** The mustard oil contains low amount of saturated fatty acids among vegetable oils.

The soils of UP Bundelkhand region (Banda, Chitrakoot, Hamirpur, Jalaun, Jhansi, Lalitpur and Mahoba district) are flat, swallow in nature, alluvial, sandy texture with mixture of black and red soil with low to very low in available N and P, medium to high in available K, low to medium in available S, and medium in available Zn. However, in MP Bundelkhand region (Datia, Tikamgarh, Newari, Sagar, Damoh, Panna and Chattarpur), undulating land with deep to very deep heavy texture with low fertility status mainly low in available N, low to medium in available P, low to high in available K, deficient in sulphur and 40–80% deficient in available Zn **(Singh *et al*., 2018).** Low fertility status in this region is mainly due to poor attention of farmers towards soil degradation beside indiscriminate use of fertilizers comprises mainly of primary nutrients N, P and K, which leads to multi-nutrient deficiency in Bundelkhand region *viz.* S, Zn and B. Thus, balanced and adequate amount of macronutrient and micro-nutrients is the need of hour to improve soil fertility and crop productivity.

Sulphur is the fourth most important nutrient in crop production to increase quality and productivity of mustard next to N, P and K. It is essential for synthesis of cystine (27% S), cysteine (26% S) and methionine (21% S) amino acids which contain 90% of total sulphur **(Havlin *et al*., 2013).** It is also an essential component for chlorophyll formation, activation of various enzymes and sulfhydryl (SH-) linkages, protein and oil synthesis **(Rathore *et al*., 2015).** Sulphur is also a constituent of glucosinolate and glycosidase enzyme, which are responsible for pungency in mustard oil **(Thompson *et al*., 1986).** Oilseeds require more amount of sulphur (12 kg) to produce one tonne of economic yield as compared to pulses (8 kg) and cereals (3-4 kg) **(Kumar and Chauhan, 2005).** Sulphur application enhances mustard yield both under irrigated and rainfed conditions by 12–48% and 17–24%, respectively **(Aulakh and Pasricha, 1988).**

Boron is the second most essential micronutrient in mustard after Zn **(Ahamad *et al.*, 2012).** It plays an important role in the cell division, differentiation, and elongation of meristemic region **(Shireen *et al.*, 2018).** It also helps regulation of various physiological and metabolic reactions of the plant such as nucleic acid synthesis, cell wall synthesis, glucose synthesis, root elongation and carbohydrate transportation **(Yadav *et al.*, 2016).** It is essential for reproductive growth of plant and increases flower production, pollen viability, seed and fruit development in crop plant **(Havlin *et al.*, 2013).** Mustard crop responded well to B application with the average response ranging from 21-31% **(Shekhawat *et al.*, 2012).**

Material and Methods

Study place and Weather Condition

The experiment was conducted at the Research farm of at Agriculture farm of Mahatma Gandhi Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.) during October, 2021 to March 2022 to examine effect of Sulphur and boron on Mustard (*Brassica juncea* L.) Under rainfed condition of Chitrakoot area. It is located on **$25^0$14' N** latitude, **$80^0$85' E** longitude and at an altitude of **190-210 meters** above mean sea level. Experimental site area is situated in Bundelkhand Zone of northern Madhya Pradesh and have typically sub-tropical and semi-arid with monsoon commencing by the third week of June and with drawing by end of September. Total rainfall received during the crop growing period was 264 mm.

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Experimental Soil

The experimental field is sandy loam in texture, neutral in reaction (pH 7.3), low in organic carbon (0.20%), available N (94.68 kg ha^{-1}), medium in available P (16.00 kg ha^{-1}), high in available K (308.90 kg ha^{-1}) and high in available S (26.41 kg ha^{-1}).

Study design

The experiment was laid out in a factorial randomized block design (FRBD) assigning treatment combinations

Table-1: Treatment details:

Levels of sulphur	Levels of boron

S_1	-	0 kg ha^{-1}	B_0	-	0 kg ha^{-1}
S_2	-	15 kg ha^{-1}	B_1	-	1.5 kg ha^{-1}
S_3	-	25 kg ha^{-1}	B_2	-	2.5 kg ha^{-1}
S_4	-	35 kg ha^{-1}			

Application of manures and fertilizers.

FYM was applied @ 10 q ha^{-1} as basal dose. After the layout of experimental plot, the fertilizers were weighed and applied in the plots and thoroughly mixed with soil. As per the experimental recommended doses of Nitrogen, Phosphorus, Potassium and Sulphur were applied to all the plots. Recommended dose of Nitrogen, Phosphorus and Potassium were applied through Urea, DAP and MOP (80:40:40 kg ha^{-1}) whereas Sulphur and Boron were applied through wettable powder (15, 25, 35 kg S ha^{-1} and 1.5, 2.5 kg B ha^{-1})

Statistical analysis

The data recorded during the course of investigation was subjected to statistical analysis by “Analysis of variance technique”. The significant and non-significant treatment effects were judged with the help of ‘F’ (variance ratio) table. The significant differences between the means were tested against the critical difference at 5% probability level. **Chandel (1998).**

Result and Discussion

Growth Parameters

Plant Height

At a glance over the data given in the Table-2 clearly shows that the increasing level of sulphur up to 35 kg ha^{-1} increased the plant height significantly at of 30 DAS 14.70 cm to 19.23 cm, 60 DAS 110.26 to 119.16 cm and 90 DAS 179.60 cm to 195.76 cm. In the similar way due to the increasing levels of boron application plant height was recorded in the range of 30 DAS 16.50 cm to 17.85 cm, 60 DAS 114.15 cm to 116.97 cm and 90 DAS 186.05 cm to 190.82 cm under different level of boron control, 1.5 kg B ha^{-1} and 2.5 kg B ha^{-1} at 30, 60, 90 DAS, respectively. The interaction effect due to sulphur (control, 15 kg ha^{-1}, 25 kg ha^{-1} and 35 kg ha^{-1}) and boron (control, 1.5 kg B ha^{-1} and 2.5 kg B ha^{-1}) on plant height was found statistically non-significant at all the observation stages. The results of the present investigation are also in agreement with the findings of **Öztürk (2010), Solanki *et al.* (2016) and Negi *et al.* (2017)**

No. of Leaves Plant^{-1}

A critical perusal of the data given in Table-2 clearly reflected that the number of leaves plant^{-1} ranged from 30 DAS 4.96 to 6.10, 60 DAS 16.96 to 19.13 and 90 DAS 33.20 to 37.00 under different level of sulphur (control, 15 kg ha^{-1}, 25 kg ha^{-1} and 35 kg ha^{-1}) at 30, 60 and 90 DAS respectively. Number of leaves plant^{-1} ranged from 5.47 to 5.75, 17.67 to 18.45 and 34.05 to 35.40 under different level of boron (control, 1.5 kg B ha^{-1} and 2.5 kg B ha^{-1}) at 30, 60 and 90 DAS, respectively. The interaction effect due to sulphur and boron on number of leaves plant^{-1} mustard was found statistically significant at all the observation stages. The consequences of the current investigation are additionally in concurrence with the investigation of **Jamal *et al.* (2010), Rajput *et al.* (2018) and Singh *et al.* (2018)**

No. of Branches Plant^{-1}

It is visualized from the data given in Table-2 that number of branches plant^{-1} observed in the range of 1.93 to 2.76, 8.46 to 10.63 and 11.06 to 12.30 under different level of sulphur (control, 15 kg ha^{-1}, 25 kg ha^{-1} and 35 kg ha^{-1}) at 30, 60 and 90 DAS, respectively. Number of branches plant^{-1} ranged from 2.25 to 2.52, 9.20 to 9.92 and 11.42 to 11.90 under different level of boron (control, 1.5 kg B ha^{-1} and 2.5 kg B ha^{-1}) at different observation stage of present study. The interaction effect due to sulphur and boron on number of branches plant^{-1} was found statistically significant at all the observation stages except harvest stage. Comparative findings were detailed by **Singh *et al.* (2017), Upadhyay *et al.* (2018) and Rajput *et al.* (2018).**

Yield Components and Yield

Number of Siliqua Plant^{-1}

An appraisal of the data given in Table-3 that number of siliquae plant^{-1} mustard observed in the range of 304.43 to 321.06 under different level of sulphur control, 30 kg ha^{-1} and 40 kg ha^{-1} at harvest stage. Maximum number of siliquae plant^{-1} was observed with application of 35 kg S ha^{-1} (S_2) which was significantly higher to 0, 15 and 25 kg S ha^{-1} but statistically at par with 25 kg S ha^{-1}. Number of siliquae plant^{-1} mustard observed in the range of 311.55-315.87 no. under different level of boron (control, 1.5 kg B ha^{-1} and 2.5 kg B ha^{-1}) at harvest stage. Application of 2.5 kg B ha^{-1} resulted significantly higher number of siliquae plant^{-1} as compared to control and 1.5 kg B ha^{-1}.

The interaction effect due to sulphur (control, 15 kg ha^{-1}, 25 kg ha^{-1} and 35 kg ha^{-1}) and boron (control, 1.5 kg B ha^{-1} and 2.5 kg B ha^{-1}) on number of siliquae plant^{-1} was found statistically significant. The consequences of the current investigation are additionally in concurrence with the investigation of **Ray *et al.* (2015), Dhruw *et al.* (2017) and Masum *et al.* (2019)**

Number of Seed Siliqua^{-1}

It is inferred from Table-3 that the number of seeds per siliqua was significantly influenced by different treatments. Number of seeds per siliqua mustard noted in the range of 10.00 to 11.26 under different level of sulphur (control, 15 kg ha^{-1}, 25 kg ha^{-1} and 35 kg ha^{-1}). The increasing level of sulphur up to 35 kg ha^{-1} increased the number of seeds per siliqua mustard significantly. Number of seeds per siliqua mustard observed in the range of 10.45 to 10.90 under different level of boron (control, 1.5 kg B ha^{-1} and 2.5 kg B ha^{-1}) at harvest stage. The interaction effect due to sulphur (control, 15 kg ha^{-1}, 25 kg ha^{-1} and 35 kg ha^{-1}) and boron (control, 1.5 kg B ha^{-1} and 2.5 kg B ha^{-1}) on number of seeds per siliqua mustard was found statistically non-significant at harvest stage. Similar findings was also reported by **Yadav *et al.* (2016), Ray *et al.* (2015) and Rana *et al.* (2020)**

1000 Seed weight (gm)

It is evident from Table-3 that significant increase was noted in 1000 seed weight under different levels of sulphur as compared to the control. It is observed in the range of 7.30-8.13 g under different treatments of sulphur (control, 15 kg ha^{-1}, 25 kg ha^{-1} and 35 kg ha^{-1}). Maximum test weight (8.13 g ha^{-1}) was observed with the application of 35 kg S ha^{-1} (S_1) which was significantly higher to 0, 15 and 25 kg S ha^{-1}. Test weight of seeds observed in the range of 7.55 to 7.85 g under different level of boron at harvest stage. Application of 2.5 kg B ha^{-1} resulted significantly highest weight of mustard seeds as compared to control but statistically at par with one spray treatments. Test weight of seeds observed in the range of 4.08 to 4.21 g ha^{-1} under different level of boron at harvest stage. The interaction effect due to sulphur (control, 15 kg ha^{-1}, 25 kg ha^{-1} and 35 kg ha^{-1}) and boron (control, 1.5 kg B ha^{-1} and 2.5 kg B ha^{-1}) on test weight of mustard seeds was found statistically significant. Comparative findings were detailed by **Singh *et al.* (2016), Awal *et al.* (2020) and Rana *et al.* (2020).**

Productivity Parameters

Seed Yield (kg ha^{-1})

It is clear from Table-4 Mustard Seed yield varied from 9.90 to 11.30 q ha^{-1} under different levels of sulphur (control, 15 kg ha^{-1}, 25 kg ha^{-1} and 35 kg ha^{-1}). Increasing level of sulphur increase the mustard seed yield significantly up to 35 kg ha^{-1}. Maximum yield (11.30 q ha^{-1}) was observed with the application of 35 kg S ha^{-1} (S_2). Mustard Seed yield observed in the range of 10.42 to 10.74 q ha^{-1} under different level of boron Control, 1 spray 2 ppm and 2 spray 2 ppm. Maximum yield (10.74 q ha^{-1}) was observed with 2.5 kg B ha^{-1}. The interaction effect due to sulphur (control, 15 kg ha^{-1}, 25 kg ha^{-1} and 35 kg ha^{-1}) and boron (control, 1.5 kg B ha^{-1} and 2.5 kg B ha^{-1}) on mustard seed yield was found statistically significant. The consequences of the current investigation are additionally in concurrence with the investigation of **Singh *et al.* (2016), Sahoo *et al.* (2017), Singh *et al.* (2018) and Sinha *et al.* (2022)**

Table-2: Effect of different level of sulphur and boron on growth parameters of mustard at different growth intervals.

Treatments	Plant Height (cm)			No. of Leaves plant^{-1}			No. of Branches		
	30 DAS	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**
S_1: 0 kg ha^{-1}	14.70	110.26	179.60	4.96	16.96	32.20	1.93	8.46	11.06
S_2: 15 kg ha^{-1}	16.60	115.36	186.50	5.46	17.80	33.80	2.31	9.20	11.46
S_3: 25 kg ha^{-1}	18.36	117.83	192.30	5.93	18.46	35.73	2.56	9.90	11.86
S_4: 35 kg ha^{-1}	19.23	119.16	195.76	6.10	19.13	37.00	2.76	10.63	12.30
S.E. (m)±	0.14	1.12	1.59	0.04	0.13	0.28	0.09	0.08	0.10
C.D. (5%)	0.43	3.32	4.71	0.13	0.39	0.83	0.28	0.25	0.30
B_0: 0 kg ha^{-1}	16.50	114.15	186.05	5.47	17.67	34.05	2.25	9.20	11.42
B_1 : 1.5 kg ha^{-1}	17.32	115.85	188.75	5.62	18.15	34.60	2.40	9.52	11.70
B_2 : 2.5 kg ha^{-1}	17.85	116.97	190.82	5.75	18.45	35.40	2.52	9.92	11.90
S.E. (m) ±	0.12	0.97	1.38	0.04	0.11	0.24	0.08	0.07	0.08
C.D. (5%)	0.37	2.92	4.13	0.11	0.34	0.72	0.25	0.22	0.26
S X B (Interactions)	NS	S	S	S	S	S	S	S	S

Table-3: Effect of different level of sulphur and boron on yield components of mustard.

Treatments	Yield attribute character's		
	No. of siliquae plant^{-1}	**No. of seeds siliqua^{-1}**	**1000 seed weight (g)**
S_1: 0 kg ha^{-1}	304.43	10.00	7.30
S_2: 15 kg ha^{-1}	311.66	10.50	7.50
S_3: 25 kg ha^{-1}	318.00	10.93	7.86
S_4: 35 kg ha^{-1}	321.06	11.26	8.13
S.E. (m)±	2.61	0.10	0.06
C.D. (5%)	7.71	0.31	0.20
B_0: 0 kg ha^{-1}	311.55	10.45	7.55
B_1 : 1.5 kg ha^{-1}	313.95	10.67	7.70
B_2 : 2.5 kg ha^{-1}	315.87	10.90	7.85
S.E. (m) ±	2.26	0.09	0.05
C.D. (5%)	6.79	0.28	0.17
S X B (Interactions)	S	NS	S

Table-4: Effect of different level of sulphur and boron on productivity of mustard.

Treatments	**Yield (q ha^{-1})**
S_1: 0 kg ha^{-1}	9.90
S_2: 15 kg ha^{-1}	10.43
S_3: 25 kg ha^{-1}	10.78
S_4: 35 kg ha^{-1}	11.30
S.E. (m)±	0.10
C.D. (5%)	0.31
B_0: 0 kg ha^{-1}	10.42
B_1 : 1.5 kg ha^{-1}	10.66
B_2 : 2.5 kg ha^{-1}	10.74
S.E. (m) ±	0.09
C.D. (5%)	0.28
S X B (Interactions)	S

Conclusion

On the basis of result emanated from present investigation it can be concluded that application of sulphur @ 35 kg ha^{-1} and 2.5 kg B ha^{-1}can increased growth characters of mustard as well as yield component and yield of mustard. Therefore it can be suggested that farmers of Bundelkhand zone can achieved higher yield of mustard with the application of sulphur @ 35 kg ha^{-1} and 2.5 kg B ha^{-1}along with recommended dose of fertilizers (N:P:K 80:40:40).

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