Interaction 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 2020–21 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.Mustardvariety *PusaMahak*was grown with the recommended agronomic practices.On the basis of the results emanated from present investigation, it could be concluded that application of 40 kg S ha^{-1}+ Two spray (2ppm) 40 DASapplied 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 40 kg S ha^{-1}+ Two spray (2ppm) 40 DASsignificantly enhanced productivity parameter i.e. seed yield (q ha^{-1})and stalk yieldover 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 positionin 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

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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).**

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Indian mustard **(***Brassica junceaL***.** 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 andproductivity 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 ofvarious 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

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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 ofmeristemic region **(Shireen *et al.*, 2018).** It also helps regulation of various physiological andmetabolic reactions of the plant such as nucleic acid synthesis, cell wall synthesis, glucosesynthesis, root elongation and carbohydrate transportation **(Yadav *et al.*, 2016).** It is essentialfor reproductive growth of plant and increases flower production, pollen viability, seed andfruit development in crop plant **(Havlin*et al.*, 2013).** Mustard crop responded well to Bapplication 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, 2020 to March 2021to examine effect of Sulphur and boron on Mustard (*Brassica juncea* L.) Under rainfed condition of Chitrakootarea. It is located on **24^{0}31' N** latitude, **81^{0}15' E** longitude and at an altitude of **306meters** 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.

Experimental Soil

The experimental field is sandy loam in texture, neutral in reaction (pH 7.78), low in organic carbon (0.33%), available N (222.36 kg ha^{-1}), medium in available P (11.36 kg ha^{-1}), high in available K (342.22 kg ha^{-1}) and medium in available S (10.88 kg ha^{-1}).

Study design

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

Table-1: Treatment details:

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Levels of sulphur			Levels of boron		
S_0	-	0 kgha^{-1}	B_0	-	Control
S_1	-	30 kgha^{-1}	B_1	-	One spray (2ppm) 30 DAS
S_2	-	40 kgha^{-1}	B_2	-	Two spray (2ppm) 40 DAS

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Application of manures and fertilizers.

FYM was applied @ 10qha^{-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 (60:20:20 kg ha^{-1}) whereas Sulphur was applied through wettable powder (15,30 kg S ha^{-1})

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1. Method of measuring:Growth Parameters
2. Yield Components and Yield
3. Productivity
4etc

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 showsthat the increasing level of sulphur up to 40 kg ha^{-1} increased the plant height significantly at of 30 DAS 20.35 cm to 23.58 cm, 60 DAS 74.08 to 85.13 and 90 DAS 81.55cm to 93.20 cm. In the similar way due to the increasing levels of boron application plant height was recorded in the range of 30 DAS 20.35 cm to 23.58cm,60 DAS 74.08 cm to 85.13 cm and 90 DAS 81.55cm to 93.20 cm under different level of boron Control,1 spray 2ppm and 2 spray 2ppm at 30, 60, 90 DAS respectively. The interaction effect due to

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sulphur Control, 30 kg ha^{-1} and 40 kg ha^{-1}and boron Control,1 spray 2ppm and 2 spray 2ppm 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 thenumber of leaves plant^{-1} ranged from30 DAS 8.36cm to 9.84, and 60 DAS15.08 to 18.84cm under different level of sulphur Control, 30kg ha^{-1} and 40kg ha^{-1} at 30and 60 DAS respectively. Number of leaves plant^{-1} ranged from 8.42to 10.11cm, and 15.62to 18.53cm under different level of boron (Control, 2ppm one spray, 2 ppm 2 spray)at 30and 60 DAS respectively. The interaction effect due to sulphur and boron on number of leaves plant^{-1}mustard was found statistically non-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 BranchesPlant^{-1}

It is visualized from the data given in Table-2 that number of branches plant^{-1}observed in the range of 1.97 to 2.34cm, 9.36 to 12.93cm, 13.07 to 16.52cm and 13.27 to 17.34cm under different level of sulphur Control, 30 kg ha^{-1} and 40 kg ha^{-1} at 30, 60, 90 DAS and harvest stage respectively. Number of branches plant^{-1}ranged from 2.04to 2.33 cm under different level of boron Control, 1 spray 2 ppm and 2 sprays 2 ppm at different observation stage of present study. The interaction effect due to sulphur Control, 30kg ha^{-1} and 40kg ha^{-1}and boron Control, one spray 2ppm and 2 spray 2ppmon number of branches plant^{-1}was found statistically non-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 thatnumber of siliquaeplant^{-1}mustard observed in the range of 114.87to 159.96 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 40 kg Sha^{-1} (S_2) which was significantly higher to 0 and 30 kg Sha^{-1} but statistically at par with 40 kg S ha^{-1}. Number of siliquaeplant^{-1}mustard observed in the range of 129.38 to 140.90 no. under different level of boronControl,1 spray 2ppm

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and 2 spray 2ppmat harvest stage. Application of two spray of boron (2ppm each) resulted significantly higher number of siliquaeplant^{-1} as compared to control and one spray 2ppm treatments. The interaction effect due to sulphur control, 30, 40 kg ha^{-1} and boron Control,1 spray 2ppm 135.32 and 2 spray 2ppm 140.90 on number of siliquaeplant^{-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)**

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Number of Seed Siliqua^{-1}

It is inferred from Table-3 that the number of seeds per siliqua was significantly influenced by different treatments are presented in Table 4. Number of seeds per siliqua mustard noted in the range of 10.56 to 12.30 under different level of sulphur control, 30 kg ha^{-1} and 40 kg ha^{-1}. The increasing level of sulphur up to 40 kg ha^{-1} increased the number of seeds per siliqua mustard significantly. Number of seeds per siliqua mustard observed in the range of 10.94 to12.05 under different level of boron Control, 1 spray 2ppm 11.64 and 2 spray 2ppm 12.05 at harvest stage. The interaction effect due to sulphur control, 30 kg ha^{-1}, 40 kg ha^{-1} and boron Control,1 spray 2ppm 11.94 and 2 spray 2ppm 12.05 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)**

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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 3.91-4.40 gha^{-1} under different treatments of sulphur control, 30 kg ha^{-1}, 40 kg ha^{-1}.Maximum test weight (4.44 gha^{-1}) was observed with the application of 30 kg S ha^{-1} (S_1) which was significantly higher to 0, 30 and 40 kg Sha^{-1}. Test weight of seeds observed in the range of 4.08to 4.21 gha^{-1}under different level of boron at harvest stage. Application of two spray of boron (1ppm each) 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 4.08to 4.21 gha^{-1}under different level of boron at harvest stage. The interaction effect due to sulphur control, 30 kg ha^{-1}, 40 kg ha^{-1} and boron Control,1 spray 2ppm and 2 spray 2ppmontest weight of mustard seedswas

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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 1008.48 -1326.32 kg ha^{-1} under different levels of sulphur control, 30 kg ha^{-1}, 40 kg ha^{-1}. Increasing level of sulphur increase the mustard seed yield significantly up to 40 kg ha^{-1}. Maximum yield (1326.32 kg ha^{-1}) was observed with the application of 40 kg S ha^{-1} (S_2). Mustard Seed yield observed in the range of 1129.47to 1201.48 kg ha^{-1} under different level of boronControl,1 spray 2ppm and 2 spray 2ppm. Maximum yield (1201.48 kg ha^{-1}) was observed with two sprays of boron whichwas 26.22, and 9.33 percent significantly higher over to control and one spray 2ppm of boron treatments respectively. The interaction effect due to sulphur control, 30 kg ha^{-1}, 40 kg ha^{-1} and boron Control,1 spray 2ppm and 2 spray 2ppm 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) and Singh *et al.* (2018)**

Stover Yield (kg ha^{-1})

Table-4, indicated that there was a significant response in mustard Stover yield due to different levels of sulphur control, 30 kg ha^{-1}, 40 kg ha^{-1} and boron Control,1 spray 2ppm and 2 spray 2ppm and boron as compared to respective control. Increasing level of sulphur increases the mustard Stover yield significantly up to 40 kg ha^{-1}. Stover yield varied from 1258.81 to 1551.17 kg ha^{-1} under different levels of sulphur control, 30 kg ha^{-1}, 40 kg ha^{-1} and Maximum mustard yield (1551.17 kg ha^{-1}) was observed with the application of 40 kg S ha^{-1} (S_2) which was significantly higher to 0 and 30 kg S ha^{-1} but statistically at par with 40 kg S ha^{-1} treatments respectively Stover yield mustard observed in the range of 1387.20to 1431.59 kg ha^{-1} under different level of boron Control, 1 spray 2ppm and 2 spray 2ppm. Maximum yield (1563.53 kg ha^{-1}) was observed with two sprays of boron 2ppmwhich was significantly higher over to control but statistically at par with one spray 2ppm of boron respectivelyThe interaction effect due to sulphur control, 30 kg ha^{-1}, 40 kg ha^{-1} and boron Control,1 spray 2ppm and 2 spray 2ppm on mustard Stover yield was found statistically non-significant.The results of

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the present investigation are also in agreement with the findings of**Nath *et al.* (2018),Yadav *et al.* (2017) and Singh *et al.* (2018)**

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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**	**30 DAS**	**60 DAS**	**90 DAS**	**Harvest**
S_0: 0 kgha^{-1}	22.40	75.40	83.04	8.36	15.08	1.97	9.36	13.07	13.27
S_1: 30 kgha^{-1}	21.80	78.22	86.02	9.48	17.81	2.24	10.81	14.88	15.61
S_2: 40 kgha^{-1}	22.47	88.17	94.73	9.84	18.84	2.34	12.93	16.52	17.34
S.E. (m)±	**1.01**	**2.48**	**2.96**	**0.35**	**0.71**	**0.03**	**0.12**	**0.07**	**0.12**
C.D. (5%)	**NS**	**7.51**	**8.95**	**1.07**	**2.15**	**0.09**	**0.39**	**0.21**	**0.38**
B_0: Control	20.35	74.08	81.55	8.42	15.62	2.04	10.70	14.55	14.42
B_1 : 1 Spray (2ppm)	22.74	82.57	89.04	9.16	17.58	2.19	10.90	14.83	15.61
B_2 : 2 Spray (2ppm)	23.58	85.13	93.20	10.11	18.53	2.33	11.51	15.09	16.18
S.E. (m) ±	**1.01**	**2.48**	**2.96**	**0.35**	**0.71**	**0.03**	**0.12**	**0.07**	**0.12**
C.D. (5%)	**NS**	**7.51**	**8.95**	**1.07**	**2.15**	**0.09**	**0.39**	**0.21**	**0.38**
S X B (Interactions)	**NS**	**NS**	**NS**	NS	**NS**	**0.16**	**0.67**	**NS**	**0.66**

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

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Treatments	Yield Attribute Character's		
	No. of siliquaeplant^{-1}	**No. of seeds siliqua^{-1}**	**1000 seed weight (g)**
S_0: 0 kgha^{-1}	114.87	10.56	3.91
S_1: 30 kgha^{-1}	130.76	11.77	4.44
S_2: 40 kgha^{-1}	159.96	12.30	4.40
S.E. (m)±	**0.47**	**0.08**	**0.11**
C.D. (5%)	**1.44**	**0.25**	**0.35**
B_0: Control	129.38	10.94	4.08
B_1 : 1 Spray (2ppm)	135.32	11.64	4.45
B_2 : 2 Spray (2ppm)	140.90	12.05	4.21
S.E. (m) ±	**0.47**	**0.08**	**0.11**
C.D. (5%)	**1.44**	**0.25**	**NS**
S X B (Interactions)	**S**	**NS**	**S**

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

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Treatments	Yield (kg ha^{-1})	
	Seed Yield	**Stover Yield**
S_0: 0 kgha^{-1}	1008.48	1258.81
S_1: 30 kgha^{-1}	1154.00	1443.43
S_2: 40 kgha^{-1}	1326.32	1551.17
S.E. (m)±	**10.09**	**4.04**
C.D. (5%)	**30.51**	**12.22**
B_0: Control	1129.47	1387.20
B_1 : 1 Spray (2ppm)	1157.84	1434.62
B_2 : 2 Spray (2ppm)	1201.48	1431.59
S.E. (m) ±	**10.09**	**4.04**
C.D. (5%)	**30.51**	**12.22**
S X B (Interactions)	**52.85**	**7.00**

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Conclusion

On the basis of result emanated from present investigation it can be concluded that application of sulphur @ 40 kg ha^{-1} and two spray of boron (2 ppm) 40 DAS can increased growth characters of mustard as well as yield component and yield of mustard. Therefor it can be suggested that farmers of Bundelkhand zone can achieved higher yield of mustard with the application of sulphur @ 40 kg ha-1 and two spray of boron (2 ppm) 40 DAS along with recommended dose of fertilizers (N:P:K 60:20:20).

Comment [A25]: Acknowledgments
A brief acknowledgment section may be given after the conclusion section just before the references.

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Comment [A26]: Writing the manuscript is adjusted to the guidelines for the author.

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