

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

## **Abstract**

The field experiment was conducted during fall 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 consists of 9 treatments combinations in factorial randomized block design with three replications consisted of three levels of sulphur (0, 30 and 40 kg ha<sup>-1</sup>), three boron levels (0, 2 ppm one spray and 2 ppm two spray). 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 40 kg S ha<sup>-1</sup> + Two spray (2ppm boron) 40 DAS applied on mustard significantly increases growth parameter i.e. plant height, no. of leaves and no. of branches; 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<sup>-1</sup> + Two spray (2ppm boron) 40 DAS significantly enhanced productivity parameter i.e. seed yield (kg ha<sup>-1</sup>) and stalk yield over the control.

*Key Words:* Boron, Mustard, Sulphur and yield.

## **Introduction**

Globally, India is the fourth largest oilseed crops producing country after the United States, China and Brazil. However, it secures first position in sesame, 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<sup>-1</sup> productivity (**Department of Agriculture Cooperation and Farmers Welfare, 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 ha and 72.61 million ton, 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<sup>-1</sup>, which is about three fourth of the world's average productivity (1960 kg ha<sup>-1</sup>) (**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<sup>-1</sup>) of rapeseed-mustard. Uttar Pradesh secured third position in country in respect of both acreage (0.75 million ha) and production (1.12 million ton) of rapeseed-mustard with 1483 kg ha<sup>-1</sup> productivity (**DAC & FW, 2020**). Bundelkhand region covers 121.58 thousand ha area under rapeseed-mustard crop with the production of 92.80 thousand ton. The average productivity of rapeseed-mustard crop in Bundelkhand region is very low (763 kg ha<sup>-1</sup>) 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**).

The objective of this present study is to examine the effect of sulphur and boron in relation to growth characteristics, yield components and yield of mustard.

## **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 2021 to examine effect of sulphur and boron on mustard (*Brassica juncea* L.). It is located on 24°31' N latitude, 81°15' E longitude and at an altitude of 306 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.

### **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<sup>-1</sup>), medium in available P (11.36 kg ha<sup>-1</sup>), high in available K (342.22 kg ha<sup>-1</sup>) and medium in available S (10.88 kg ha<sup>-1</sup>).

### **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 <sub>0</sub>	-	Control	B <sub>0</sub>	-	Control
S <sub>1</sub>	-	30 kg ha <sup>-1</sup>	B <sub>1</sub>	-	One spray (2 ppm) 30 days after sowing
S <sub>2</sub>	-	40 kg ha <sup>-1</sup>	B <sub>2</sub>	-	Two spray (2 ppm) 40 days after sowing

### **Application of manures and fertilizers.**

FYM was applied @ 10 q ha<sup>-1</sup> 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<sup>-1</sup>) whereas sulphur was applied through wettable powder (15, 30 kg S ha<sup>-1</sup>)

### **Observation Recorded**

#### **Height of the plant (cm)**

The height of the plant was measured by metre scale from ground level to tip of the plants.

#### **Number of branches per plant**

The number of branches per plant of the selected five tagged plants from each plot was counted and their average was calculated.

#### **Yield Attributing Characteristics**

##### **Number of pods per plant**

The pods were picked from all the five tagged plants of each plot. After counting the pods of each plant, their average was recorded.

##### **Number of seeds per pods**

Ten pods were taken from five tagged plants. Pods were shallow carefully by hand. Seeds were separated from stover and then they were counted and an average was worked out.

### **1000 seeds weight (g):**

Seed samples from each treatment of every plot were taken. Later on counting of 1000 seeds was carried out for each treatment separately and was weighed on an electric balance. The weight was recorded in gram.

### **Seed yield (kg ha<sup>-1</sup>)**

From the recorded data of seed yield per plot, seed yields were computed per hectare on multiplying the yield per plot by conversion factor.

### **Stover yield (kg ha<sup>-1</sup>)**

From the recorded data of straw yield per plot, straw yields were computed per hectare on multiplying the yield per plot by conversion factor.

### **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 40 kg ha<sup>-1</sup> 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 81.55 cm 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 23.58 cm, 60 DAS 74.08 cm to 85.13 cm and 90 DAS 81.55 cm to 93.20 cm under different level of boron Control, 1 spray 2 ppm and 2 spray 2 ppm at 30, 60, 90 DAS, respectively. The interaction effect due to sulphur control, 30 kg ha<sup>-1</sup> and 40 kg ha<sup>-1</sup> and boron control, 1 spray 2 ppm and 2 spray 2 ppm on plant height was found statistically non-significant at all the observation stages. The conclusions of this analysis concur with those made by **Öztürk (2010)**, **Solanki et al. (2016)** and **Negi et al. (2017)**

#### **No. of Leaves Plant<sup>-1</sup>**

A critical perusal of the data given in Table-2 clearly reflected that the number of leaves plant<sup>-1</sup> ranged from 30 DAS 8.36 cm to 9.84, and 60 DAS 15.08 to 18.84 cm under different level of sulphur Control, 30 kg ha<sup>-1</sup> and 40 kg ha<sup>-1</sup> at 30 and 60 DAS, respectively. Number of leaves plant<sup>-1</sup> ranged from 8.42 to 10.11 cm, and 15.62 to 18.53 cm under different level of boron (Control, 2 ppm one spray, 2 ppm 2 spray) at 30 and 60 DAS, respectively. At all observational stages, it was determined that the interaction impact of sulphur and boron on the number of leaves in plant<sup>-1</sup> mustard was statistically insignificant. 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<sup>-1</sup>**

It is visualized from the data given in Table-2 that number of branches plant<sup>-1</sup> observed in the range of 1.97 to 2.34 cm, 9.36 to 12.93 cm, 13.07 to 16.52 cm and 13.27 to 17.34 cm under different level of sulphur control, 30 kg ha<sup>-1</sup> and 40 kg ha<sup>-1</sup> at 30, 60, 90 DAS and harvest stage, respectively. Number of branches plant<sup>-1</sup> ranged from 2.04 to 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, 30 kg ha<sup>-1</sup> and 40 kg ha<sup>-1</sup> and boron control, one spray 2 ppm and 2 spray 2 ppm on number of branches plant<sup>-1</sup> 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<sup>-1</sup>**

An appraisal of the data given in Table-3 that number of siliqua plant<sup>-1</sup> mustard observed in the range of 114.87 to 159.96 under different level of sulphur control, 30 kg ha<sup>-1</sup> and 40 kg ha<sup>-1</sup> at harvest stage. Maximum number of siliqua plant<sup>-1</sup> was observed with application of 40 kg S ha<sup>-1</sup> (S<sub>2</sub>) which was significantly higher to 0 and 30 kg S ha<sup>-1</sup> but statistically at par with 40 kg S ha<sup>-1</sup>. Number of siliqua plant<sup>-1</sup> mustard observed in the range of 129.38 to 140.90 no. under different level of boron control, 1 spray 2 ppm and 2 spray 2 ppm at harvest stage. Application of two spray of boron (2ppm each) resulted significantly higher number of siliqua plant<sup>-1</sup> as compared to control and one spray 2 ppm treatments. The interaction effect due to sulphur control, 30, 40 kg ha<sup>-1</sup> and boron Control, 1 spray 2 ppm 135.32 and 2 spray 2 ppm 140.90 on number of

siliqua plant<sup>-1</sup> was found statistically significant. Additionally, the results of the current analysis are in agreement with those of **Ray *et al.* (2015)**, **Dhruw *et al.* (2017)** and **Masum *et al.* (2019)**

#### **Number of Seed Siliqua<sup>-1</sup>**

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<sup>-1</sup> and 40 kg ha<sup>-1</sup>. The increasing level of sulphur up to 40 kg ha<sup>-1</sup> increased the number of seeds per siliqua mustard significantly. Number of seeds per siliqua mustard observed in the range of 10.94 to 12.05 under different level of boron control, 1 spray 2 ppm 11.64 and 2 spray 2 ppm 12.05 at harvest stage. The interaction effect due to sulphur control, 30 kg ha<sup>-1</sup>, 40 kg ha<sup>-1</sup> and boron control, 1 spray 2 ppm 11.94 and 2 spray 2 ppm 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)**

#### **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 g ha<sup>-1</sup> under different treatments of sulphur control, 30 kg ha<sup>-1</sup>, 40 kg ha<sup>-1</sup>. Maximum test weight (4.44 g ha<sup>-1</sup>) was observed with the application of 30 kg S ha<sup>-1</sup> (S<sub>1</sub>) which was significantly higher to 0, 30 and 40 kg S ha<sup>-1</sup>. Test weight of seeds observed in the range of 4.08 to 4.21 g ha<sup>-1</sup> under different level of boron at harvest stage. Application of two spray of boron (1 ppm 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 4.08 to 4.21 g ha<sup>-1</sup> under different level of boron at harvest stage. The interaction effect due to sulphur control, 30 kg ha<sup>-1</sup>, 40 kg ha<sup>-1</sup> and boron control, 1 spray 2 ppm and 2 spray 2 ppm 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<sup>-1</sup>)**

It is clear from Table-4 Mustard Seed yield varied from 1008.48 -1326.32 kg ha<sup>-1</sup> under different levels of sulphur control, 30 kg ha<sup>-1</sup>, 40 kg ha<sup>-1</sup>. Increasing level of sulphur increase the mustard seed yield significantly up to 40 kg ha<sup>-1</sup>. Maximum yield (1326.32 kg ha<sup>-1</sup>) was observed with the application of 40 kg S ha<sup>-1</sup> (S<sub>2</sub>). Mustard seed yield observed in the range of 1129.47 to 1201.48 kg ha<sup>-1</sup> under different level of boron control, 1 spray 2 ppm and 2 spray 2 ppm. Maximum yield (1201.48 kg ha<sup>-1</sup>) was observed with two sprays of boron which was 26.22, and 9.33 percent significantly higher over to control and one spray 2 ppm of boron treatments, respectively. The interaction effect due to sulphur control, 30 kg ha<sup>-1</sup>, 40 kg ha<sup>-1</sup> and boron control, 1 spray 2 ppm and 2 spray 2 ppm 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)** and **Sachan et al. (2022)**

#### **Stover Yield (kg ha<sup>-1</sup>)**

Table-4, indicated that there was a significant response in mustard stover yield due to different levels of sulphur control, 30 kg ha<sup>-1</sup>, 40 kg ha<sup>-1</sup> and boron control, 1 spray 2 ppm and 2 spray 2 ppm and boron as compared to respective control. Increasing level of sulphur increases the mustard stover yield significantly up to 40 kg ha<sup>-1</sup>. Stover yield varied from 1258.81 to 1551.17 kg ha<sup>-1</sup> under different levels of sulphur control, 30 kg ha<sup>-1</sup>, 40 kg ha<sup>-1</sup> and Maximum mustard yield (1551.17 kg ha<sup>-1</sup>) was observed with the application of 40 kg S ha<sup>-1</sup> (S<sub>2</sub>) which was significantly higher to 0 and 30 kg S ha<sup>-1</sup> but statistically at par with 40 kg S ha<sup>-1</sup> treatments, respectively. Stover yield mustard observed in the range of 1387.20 to 1431.59 kg ha<sup>-1</sup> under different level of boron control, 1 spray 2 ppm and 2 spray 2 ppm. Maximum yield (1563.53 kg ha<sup>-1</sup>) was observed with two sprays of boron 2 ppm which was significantly higher over to control but statistically at par with one spray 2 ppm of boron, respectively. The interaction effect due to sulphur control, 30 kg ha<sup>-1</sup>, 40 kg ha<sup>-1</sup> and boron control, 1 spray 2 ppm and 2 spray 2 ppm on mustard Stover yield was found statistically non-significant. The results of the present investigation are also in agreement with the findings of **Nath et al. (2018)**, **Yadav et al. (2017)** and **Singh et al. (2018)**

**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 <sup>-1</sup>		No. of Branches			
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	30 DAS	60 DAS	90 DAS	Harvest
S <sub>0</sub> : 0 kg ha <sup>-1</sup>	22.40	75.40	83.04	8.36	15.08	1.97	9.36	13.07	13.27
S <sub>1</sub> : 30 kg ha <sup>-1</sup>	21.80	78.22	86.02	9.48	17.81	2.24	10.81	14.88	15.61
S <sub>2</sub> : 40 kg ha <sup>-1</sup>	22.47	88.17	94.73	9.84	18.84	2.34	12.93	16.52	17.34
<b>S.E. (m)±</b>	<b>1.01</b>	<b>2.48</b>	<b>2.96</b>	<b>0.35</b>	<b>0.71</b>	<b>0.03</b>	<b>0.12</b>	<b>0.07</b>	<b>0.12</b>
<b>C.D. (5%)</b>	<b>NS</b>	<b>7.51</b>	<b>8.95</b>	<b>1.07</b>	<b>2.15</b>	<b>0.09</b>	<b>0.39</b>	<b>0.21</b>	<b>0.38</b>
B <sub>0</sub> : Control	20.35	74.08	81.55	8.42	15.62	2.04	10.70	14.55	14.42
B <sub>1</sub> : 1 Spray (2ppm)	22.74	82.57	89.04	9.16	17.58	2.19	10.90	14.83	15.61
B <sub>2</sub> : 2 Spray (2ppm)	23.58	85.13	93.20	10.11	18.53	2.33	11.51	15.09	16.18
<b>S.E. (m) ±</b>	<b>1.01</b>	<b>2.48</b>	<b>2.96</b>	<b>0.35</b>	<b>0.71</b>	<b>0.03</b>	<b>0.12</b>	<b>0.07</b>	<b>0.12</b>
<b>C.D. (5%)</b>	<b>NS</b>	<b>7.51</b>	<b>8.95</b>	<b>1.07</b>	<b>2.15</b>	<b>0.09</b>	<b>0.39</b>	<b>0.21</b>	<b>0.38</b>
<b>S X B (Interactions)</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>0.16</b>	<b>0.67</b>	<b>NS</b>	<b>0.66</b>

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

Treatments	Yield Attribute Character's		
	No. of siliquae plant <sup>-1</sup>	No. of seeds siliqua <sup>-1</sup>	1000 seed weight (g)
S <sub>0</sub> : 0 kg ha <sup>-1</sup>	114.87	10.56	3.91
S <sub>1</sub> : 30 kg ha <sup>-1</sup>	130.76	11.77	4.44
S <sub>2</sub> : 40 kg ha <sup>-1</sup>	159.96	12.30	4.40
<b>S.E. (m)±</b>	<b>0.47</b>	<b>0.08</b>	<b>0.11</b>
<b>C.D. (5%)</b>	<b>1.44</b>	<b>0.25</b>	<b>0.35</b>
B <sub>0</sub> : Control	129.38	10.94	4.08
B <sub>1</sub> : 1 Spray (2 ppm)	135.32	11.64	4.45
B <sub>2</sub> : 2 Spray (2 ppm)	140.90	12.05	4.21
<b>S.E. (m) ±</b>	<b>0.47</b>	<b>0.08</b>	<b>0.11</b>
<b>C.D. (5%)</b>	<b>1.44</b>	<b>0.25</b>	<b>NS</b>
<b>S X B (Interactions)</b>	<b>S</b>	<b>NS</b>	<b>S</b>

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

Treatments	Yield (kg ha <sup>-1</sup> )	
	Seed Yield	Stover Yield
S <sub>0</sub> : 0 kg ha <sup>-1</sup>	1008.48	1258.81
S <sub>1</sub> : 30 kg ha <sup>-1</sup>	1154.00	1443.43
S <sub>2</sub> : 40 kg ha <sup>-1</sup>	1326.32	1551.17
<b>S.E. (m)±</b>	<b>10.09</b>	<b>4.04</b>
<b>C.D. (5%)</b>	<b>30.51</b>	<b>12.22</b>
B <sub>0</sub> : Control	1129.47	1387.20
B <sub>1</sub> : 1 Spray (2 ppm)	1157.84	1434.62
B <sub>2</sub> : 2 Spray (2 ppm)	1201.48	1431.59
<b>S.E. (m) ±</b>	<b>10.09</b>	<b>4.04</b>
<b>C.D. (5%)</b>	<b>30.51</b>	<b>12.22</b>
<b>S X B (Interactions)</b>	<b>52.85</b>	<b>7.00</b>

## Conclusion

Based on the findings of the current investigation, it can be said that application of sulphur @ 40 kg ha<sup>-1</sup> 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<sup>-1</sup> and two spray of boron (2 ppm) 40 DAS along with recommended dose of fertilizers (N:P:K 60:20:20).

## References

- Ahmad, W., Zia, M.H., Malhi, S. S., Niaz, A., & Saifullah (2012).** Boron deficiency in soils and crops: A Review. Crop Plant, Aakash Goyal (Ed.), Intech Open, DOI: 10.5772/36702.
- Aulakh, M.S., & Pasricha, N.S. (1988).** Sulphur fertilization of oilseeds for yield and quality. In: *Sulphur in Indian Agriculture*, Chapter II.3, 1-14.
- Awal, M. A., Rashid, M. H. O., & Rahman, M. M. (2020).** Effect of agronomic biofortification of sulphur and boron on the growth and yield of mustard (*Brassica campestris* L.) Crop. Asian Soil Research Journal 3(4): 1-8, 2020; Article no.ASRJ.57886 ISSN: 2582-3973
- Chandel SRS (1998).** Advance agriculture statics, 2nd Edition, Kalyani Publication, New Delhi 1998.
- DAC&FW. (2020).** Agricultural Statistics at a glance 2019. Department of Agriculture, Cooperation and Farmer Welfare. Government of India. 45-92.
- Dhruw, S. S., Swaroop, N., Swamy, A., & Upadhayay, Y. (2017).** Effects of different levels of NPK and sulphur on growth and yield attributes of Mustard (*Brassica juncea* L.) Cv. Varuna. *International Journal of Current Microbiology and Applied Sciences*, 6(8), 1089-1098.
- DRMR. (2019).** Directorate of Rapeseed-Mustard Research. <https://www.drmr.res.in/>
- Gupta, R. D., & Gupta, S. K. (2016).** Strategies for increasing the production of oilseed on a sustainable basis. *Breeding Oilseed Crops for Sustainable Production*, Elsevier Inc. 1-18, doi:10.1016/b978-0-12-801309-0.00001-x.
- Havlin, J.L., Tisdale, S.L., Nelson, W.L., & Beaton. J.D. (2013).** *Soil Fertility and Fertilizers: An Introduction to Nutrient Management* (Eighth Edition). Pearson India Education Services Pvt. Ltd.

- Jamal, A., Moon, Y. S., & Zainul Abidin, M. (2010).** Sulphur-a general overview and interaction with nitrogen. *Australian Journal of Crop Science*, 4(7), 523-529.
- Kumar, A., & Chauhan, J.S. (2005).** Status and future thrust areas of rapeseed-mustard research in India. *Indian Journal of Agricultural Sciences*, 75(10), 621-635.
- Masum, M. A., Miah, M. N. H., Islam, M. N., Hossain, M. S., Mandal, P., & Chowdhury, A. P. (2019).** Effect of boron fertilization on yield and yield attributes of mustard var. BARI Sarisha-14. *Journal of Bioscience and Agriculture Research*, 20(02), 1717-1723.
- Nath, S., Kannaujiya, S. K., Kumar, S., Sonkar, S. P., Gautam, A. D., & Singh, A. (2018).** Effect of sulphur fertilization on yield, sulphur uptake and oil content in Indian mustard under sandy loam soil of eastern Uttar Pradesh. *J Krishi Vigyan*, 6, 81-83.
- Negi, A., Pareek, N., Raverkar, K. P., & Chandra, R. (2017).** Effect of two sulphur sources on growth, yield and nutrient use efficiency of Brassica. *International Journal of Science, Environment and Technology*, 6(1), 236-247.
- Öztürk, Ö. (2010).** Effects of source and rate of nitrogen fertilizer on yield, yield components and quality of winter rapeseed (*Brassica napus* L.). *Chilean journal of agricultural research*, 70(1), 132-141.
- Rajput, R. K., Singh, S., Varma, J., Rajput, P., Singh, M., & Nath, S. (2018).** Effect of different levels of nitrogen and sulphur on growth and yield of Indian mustard (*Brassica juncea* (L.) Czern and Coss.) in salt affected soil. *Journal of Pharmacognosy and Phytochemistry*, 7(1), 1053-1055.
- Rana, K., Parihar, M., Singh, J. P., & Singh, R. K. (2020).** Effect of sulfur fertilization, varieties and irrigation scheduling on growth, yield, and heat utilization efficiency of Indian mustard (*Brassica Juncea* L.). *Communications in soil science and plant analysis*, 51(2), 265-275.
- Rathore, S. S., Shekhawat, K., Kandpal, B. K., Premi, O. P., Singh, S. P., Singh, G. C., & Singh, D. (2015).** Sulphur management for increased productivity of Indian mustard: A review. *Annals of Plant and Soil Research*, 17(1), 1-12.
- Ray, K., Sengupta, K., Pal, A. K., & Banerjee, H. (2015).** Effects of sulphur fertilization on yield, S uptake and quality of Indian mustard under varied irrigation regimes. *Plant, Soil and Environment*, 61(1), 6-10.
- Sachan, R., Thomas, T., Pandey, H. P., Tiwari, A., Kumar, A., Yadav, P., Yadav, A., & Kumar, M. (2022).** Effect of STCR-IPNS Based Nutrient Application on Soil Health, Yield, Nutrient Content and Uptake of Mustard (*Brassica juncea* L.) in Eastern Plain Zone of Uttar

Pradesh, India. *International Journal of Plant & Soil Science* 34(20): 248-258, 2022; Article no.IJPSS.88196 ISSN: 2320-7035

**Sahoo, G. C., Biswas, P. K., & Santra, G. H. (2017).** Effect of different sources of sulphur on growth, productivity and oil content of *Brassica campestris* var. toria in the red soil of Odisha. *International Journal of Agriculture, Environment and Biotechnology*, 10(6), 689-694.

**Shekhawat, K., Rathore, S. S., Premi, O. P., Kandpal, B. K., & Chauhan, J. S. (2012).** Advances in agronomic management of Indian mustard (*Brassica juncea* (L.) Czernj & Cosson): An Overview. *International Journal of Agronomy*, 2012, 1-14.

**Shireen, F., Nawaz, M. A., Chen, C., Zhang, Q., Zheng, Z., Sohail, H., Sun, Jingyu, S., Cao, H., Huang, Y., & Bie, Z. (2018).** Boron: Functions and approaches to enhance its availability in plants for sustainable agriculture. *International Journal of Molecular Science*, 19, 1856.

**Singh, V., Singh, A. K., Raghuvanshi, N., & Singh, R. A. (2016).** Effect of sulphur levels on growth and yield of mus tard (*Brassica juncea* L. Czern and Coss) varieties. *Progressive Research – An International Journal* Print ISSN: 0973-6417, Online ISSN: 2454-6003 Volume 11 (Special-II) : 845-848 (2016)

**Singh, S. B., & Thenua, O. V. S. (2016).** Effect of phosphorus and sulphur fertilization on yield and NPS uptake by mustard (*Brassica juncea* L.). *Progressive Research-An International Journal*, 11(1), 80-83.

**Singh, A. K., Meena, R. N., Kumar, A. K. S., Meena, R., & Singh, A. P. (2017).** Effect of land configuration methods and sulphur levels on growth, yield and economics of Indian mustard [*Brassica juncea* (L.)] under irrigated condition. *Journal of Oilseed Brassica*, 81(2), 151-157.

**Singh, M., Sridhar, K.B., Kumar, D., Tewari, R.K., Dev, I., Ram, A., Uthappa, A.R., Kumar, V., Singh, R., & Dwivedi, R.P. (2018).** Options and strategies for farmers' income enhancement in Bundelkhand region of central India. *Technical Bulletin No. 2/2018*. ICAR-Central Agroforestry Research Institute (CAFRI), 14-15.

**Singh, M. K., Sirothia, P., Singh, J., & Upadhyya, P. K. (2018).** Effect of sulphur levels on mustard crops. *Int. J. Curr. Microbiol. App. Sci*, 7(10), 481-490.

**Singh, H., Singh, R. P., Meena, B. P., Lal, B., Dotaniya, M. L., Shirale, A. O., & Kumar, K. (2018).** Effect of integrated nutrient management (INM) modules on late sown Indian mustard [*B. juncea* (L.) Cernj. Cosson] and soil properties. *Journal of Cereals and Oilseeds*, 9(4), 37-44.

- Solanki, R. L., & Sharma, M. A. H. E. N. D. R. A. (2016).** Effect of phosphorus, sulphur and PSB on growth and yield of mustard in Southern Rajasthan. *Annals of Plant and Soil Research*, 18(1), 66-69.
- Thomas, J., Kuruvilla, K. M., & Hirdeek T. K., (2004).** Mustard. In *Handbook of Herbs and Spices*, 2, 196–205.
- Thompson, J. F., Smith, I. K., & Madison, J. T. (1986).** Sulfur Metabolism in Plants. *Sulfur in Agriculture*, M.A. Tabatabai (Ed.). 57-121.
- Upadhyay, P. K., Singh, D. P., Singh, M. P., & Srivastava, A. (2018).** Effect of phosphorus and sulphur levels on plant growth and dry matter production of mustard (*Brassica juncea* L.). *Int. J App. Biosci*, 6(6), 751-757.
- USDA. (2020).** World Agricultural Production. *Circular Series, WAP 7-20*, 29-34.
- Yadav, S. N., Singh, S. K., & Kumar, O. (2016).** Effect of boron on yield attributes, seed yield and oil content of mustard (*Brassica juncea* L.) on an Inceptisol. *Journal of the Indian Society of Soil Science*, 64(3), 291-296.
- Yadav, K. G., Kushwaha, C., Singh, P. K., Kumar, M., & Yadav Nishant, S. K. (2017).** Effect of nutrient management on yield and nutrient uptake by Indian mustard (*Brassica juncea* L.). *Journal of Pharmacognosy and Phytochemistry*, 1, 556-559.