

# 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 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<sup>-1</sup> + 2.5 kg B ha<sup>-1</sup> 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) the results are added in numbers. Results showed that among the different fertility levels, application of 35 kg S ha<sup>-1</sup> + 2.5 kg B ha<sup>-1</sup> 40 DAS significantly enhanced productivity parameter i.e. seed yield (q ha<sup>-1</sup>) 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 fourth 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°14' N** latitude, **80°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.

### **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<sup>-1</sup>), medium in available P (16.00 kg ha<sup>-1</sup>), high in available K (308.90 kg ha<sup>-1</sup>) and high in available S (26.41 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:**

| <b>Levels of sulphur</b> | <b>Levels of boron</b> |
|--------------------------|------------------------|
|                          |                        |

|                |   |                        |                |   |                         |
|----------------|---|------------------------|----------------|---|-------------------------|
| S <sub>1</sub> | - | 0 kg ha <sup>-1</sup>  | B <sub>0</sub> | - | 0 kg ha <sup>-1</sup>   |
| S <sub>2</sub> | - | 15 kg ha <sup>-1</sup> | B <sub>1</sub> | - | 1.5 kg ha <sup>-1</sup> |
| S <sub>3</sub> | - | 25 kg ha <sup>-1</sup> | B <sub>2</sub> | - | 2.5 kg ha <sup>-1</sup> |
| S <sub>4</sub> | - | 35 kg ha <sup>-1</sup> |                |   |                         |

### **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 (80:40:40 kg ha<sup>-1</sup>) whereas Sulphur and Boron were applied through wettable powder (15, 25, 35 kg S ha<sup>-1</sup> and 1.5, 2.5 kg B ha<sup>-1</sup>)

### **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)**.

**It is very important to write down all the readings taken, how they were taken, and to write the reference such as: plant height, No. of branches**

## **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<sup>-1</sup> 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<sup>-1</sup> and 2.5 kg B ha<sup>-1</sup> at 30, 60, 90 DAS, respectively. The

interaction effect due to sulphur (control, 15 kg ha<sup>-1</sup>, 25 kg ha<sup>-1</sup> and 35 kg ha<sup>-1</sup>) and boron (control, 1.5 kg B ha<sup>-1</sup> and 2.5 kg B ha<sup>-1</sup>) 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) in the reference Solanki and Sharma 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 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<sup>-1</sup>, 25 kg ha<sup>-1</sup> and 35 kg ha<sup>-1</sup>) at 30, 60 and 90 DAS respectively. Number of leaves plant<sup>-1</sup> 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<sup>-1</sup> and 2.5 kg B ha<sup>-1</sup>) at 30, 60 and 90 DAS, respectively. The interaction effect due to sulphur and boron on number of leaves plant<sup>-1</sup> 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<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 1.93 to 2.76, 8.46 to 10.63 and 11.06 to 12.30 under different level of sulphur (control, 15 kg ha<sup>-1</sup>, 25 kg ha<sup>-1</sup> and 35 kg ha<sup>-1</sup>) at 30, 60 and 90 DAS, respectively. Number of branches plant<sup>-1</sup> 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<sup>-1</sup> and 2.5 kg B ha<sup>-1</sup>) at different observation stage of present study. The interaction effect due to sulphur and boron on number of branches plant<sup>-1</sup> 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<sup>-1</sup>**

An appraisal of the data given in Table-3 that number of siliquae plant<sup>-1</sup> mustard observed in the range of 304.43 to 321.06 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 siliquae plant<sup>-1</sup> was observed with application of 35 kg S ha<sup>-1</sup> (S<sub>2</sub>) which was significantly higher to 0, 15 and 25 kg S ha<sup>-1</sup> but statistically at par with 25 kg S ha<sup>-1</sup>. Number of siliquae plant<sup>-1</sup> mustard

observed in the range of 311.55-315.87 no. under different level of boron (control, 1.5 kg B ha<sup>-1</sup> and 2.5 kg B ha<sup>-1</sup>) at harvest stage. Application of 2.5 kg B ha<sup>-1</sup> resulted significantly higher number of siliquae plant<sup>-1</sup> as compared to control and 1.5 kg B ha<sup>-1</sup>. The interaction effect due to sulphur (control, 15 kg ha<sup>-1</sup>, 25 kg ha<sup>-1</sup> and 35 kg ha<sup>-1</sup>) and boron (control, 1.5 kg B ha<sup>-1</sup> and 2.5 kg B ha<sup>-1</sup>) on number of siliquae plant<sup>-1</sup> 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<sup>-1</sup>**

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<sup>-1</sup>, 25 kg ha<sup>-1</sup> and 35 kg ha<sup>-1</sup>). The increasing level of sulphur up to 35 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 10.45 to 10.90 under different level of boron (control, 1.5 kg B ha<sup>-1</sup> and 2.5 kg B ha<sup>-1</sup>) at harvest stage. The interaction effect due to sulphur (control, 15 kg ha<sup>-1</sup>, 25 kg ha<sup>-1</sup> and 35 kg ha<sup>-1</sup>) and boron (control, 1.5 kg B ha<sup>-1</sup> and 2.5 kg B ha<sup>-1</sup>) 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)** in the reverence **Yadav et al 2017**, **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<sup>-1</sup>, 25 kg ha<sup>-1</sup> and 35 kg ha<sup>-1</sup>). Maximum test weight (8.13 g ha<sup>-1</sup>) was observed with the application of 35 kg S ha<sup>-1</sup> (S<sub>1</sub>) which was significantly higher to 0, 15 and 25 kg S ha<sup>-1</sup>. 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<sup>-1</sup> 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, 15 kg ha<sup>-1</sup>, 25 kg ha<sup>-1</sup> and

35 kg ha<sup>-1</sup>) and boron (control, 1.5 kg B ha<sup>-1</sup> and 2.5 kg B ha<sup>-1</sup>) 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 9.90 to 11.30 q ha<sup>-1</sup> under different levels of sulphur (control, 15 kg ha<sup>-1</sup>, 25 kg ha<sup>-1</sup> and 35 kg ha<sup>-1</sup>). Increasing level of sulphur increase the mustard seed yield significantly up to 35 kg ha<sup>-1</sup>. Maximum yield (11.30 q ha<sup>-1</sup>) was observed with the application of 35 kg S ha<sup>-1</sup> (S<sub>2</sub>). Mustard Seed yield observed in the range of 10.42 to 10.74 q ha<sup>-1</sup> under different level of boron Control, 1 spray 2 ppm and 2 spray 2 ppm. Maximum yield (10.74 q ha<sup>-1</sup>) was observed with 2.5 kg B ha<sup>-1</sup>. The interaction effect due to sulphur (control, 15 kg ha<sup>-1</sup>, 25 kg ha<sup>-1</sup> and 35 kg ha<sup>-1</sup>) and boron (control, 1.5 kg B ha<sup>-1</sup> and 2.5 kg B ha<sup>-1</sup>) 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-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>1</sub> : 0 kg ha <sup>-1</sup>   | 304.43                              | 10.00                              | 7.30                 |
| S <sub>2</sub> : 15 kg ha <sup>-1</sup>  | 311.66                              | 10.50                              | 7.50                 |
| S <sub>3</sub> : 25 kg ha <sup>-1</sup>  | 318.00                              | 10.93                              | 7.86                 |
| S <sub>4</sub> : 35 kg ha <sup>-1</sup>  | 321.06                              | 11.26                              | 8.13                 |
| <b>S.E. (m)±</b>                         | 2.61                                | 0.10                               | 0.06                 |
| <b>C.D. (5%)</b>                         | 7.71                                | 0.31                               | 0.20                 |
| B <sub>0</sub> : 0 kg ha <sup>-1</sup>   | 311.55                              | 10.45                              | 7.55                 |
| B <sub>1</sub> : 1.5 kg ha <sup>-1</sup> | 313.95                              | 10.67                              | 7.70                 |
| B <sub>2</sub> : 2.5 kg ha <sup>-1</sup> | 315.87                              | 10.90                              | 7.85                 |
| <b>S.E. (m) ±</b>                        | 2.26                                | 0.09                               | 0.05                 |
| <b>C.D. (5%)</b>                         | 6.79                                | 0.28                               | 0.17                 |
| <b>S X B (Interactions)</b>              | S                                   | NS                                 | S                    |

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

| <b>Treatments</b>                        | <b>Yield (q ha<sup>-1</sup>)</b> |
|--|----------------------------------|
| S <sub>1</sub> : 0 kg ha <sup>-1</sup>   | 9.90                             |
| S <sub>2</sub> : 15 kg ha <sup>-1</sup>  | 10.43                            |
| S <sub>3</sub> : 25 kg ha <sup>-1</sup>  | 10.78                            |
| S <sub>4</sub> : 35 kg ha <sup>-1</sup>  | 11.30                            |
| <b>S.E. (m)±</b>                         | 0.10                             |
| <b>C.D. (5%)</b>                         | 0.31                             |
| B <sub>0</sub> : 0 kg ha <sup>-1</sup>   | 10.42                            |
| B <sub>1</sub> : 1.5 kg ha <sup>-1</sup> | 10.66                            |
| B <sub>2</sub> : 2.5 kg ha <sup>-1</sup> | 10.74                            |
| <b>S.E. (m) ±</b>                        | 0.09                             |
| <b>C.D. (5%)</b>                         | 0.28                             |
| <b>S X B (Interactions)</b>              | S                                |

## Conclusion

On the basis of result emanated from present investigation it can be concluded that application of sulphur @ 35 kg ha<sup>-1</sup> and 2.5 kg B ha<sup>-1</sup> 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 @ 35 kg ha<sup>-1</sup> and 2.5 kg B ha<sup>-1</sup> along with recommended dose of fertilizers (N:P:K 80:40:40).

## 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.
- Chandel SRS (1998).** Advance agriculture statics, 2nd Edition, Kalyani Publication, New Delhi 1998.
- Cooperation and Farmer Welfare. Government of India. 45-92.
- DAC&FW. (2020).** Agricultural Statistics at a glance 2019. Department of Agriculture,
- 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. **Don't found it in the paper**
- 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. **Don't found it in the paper**
- 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.
- 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, 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, 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.

**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, 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, 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. **In the paper Singh et al**

**Singh, V., Singh, A. K., Raghuvanshi, N., & Singh, R. A. (2016).** **EFFECT OF SULPHUR LEVELS ON GROWTH AND YIELD OF MUS TARD** **Only the first letter is capital** (*Brassica juncea* L. Czern and Coss) VA RI ETIES.

**Sinha, T., Mishra, A., Mishra, U. S., Sachan, R., & Singh, D., (2022).** 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. *International Journal of Plant & Soil Science*, 1329-1336.

**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. **In the paper Solanki et al**

**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. Biossci*, 6(6), 751-757.

**USDA. (2020).** World Agricultural Production. *Circular Series, WAP 7-20*, 29-34.

**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.

**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. **In the paper 2016 only**