Effect of boron and sulphur on growth, yield and nutrient uptake of mustard (*Brassica juncea* L.)

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**Abstract**

Field experiment was carried out to evaluate the effect of boron and sulphur on growth and yield attributes of mustard (*Brassica juncea* L.) during *Rabi* season of 2017-2018 at experimental farm of Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab. The experiment had nine treatments viz., T1- 100% RDF, T2- 100% RDF + 2 kg/ha B, T3- 100% RDF + 3 kg/ha B, T4- 100% RDF + 2 kg/ha B + 15 kg/ha S, T5- 100% RDF + 3 kg/ha B + 15 kg/ha S, T6- 100% RDF + 2 kg/ha B + 30 kg/ha S, T7- 100% RDF + 3 kg/ha B + 30 kg/ha S, T8- 100% RDF + 2 kg/ha B + 45 kg/ha S and T9- 100% RDF + 3 kg/ha B + 45 kg/ha S with three replications in randomized block design. The results revealed that the highest plant height, number of primary and secondary branches, dry matter accumulation, number of siliquae/plant, length of siliqua, number of seeds/siliqua, grain yield, stover yield and biological yield were recorded with the application of 100% RDF + 2 kg/ha B + 45 kg/ha S which was significantly at par with T5: 100% RDF + 3 kg/haB + 45 kg/haS and T6: 100% RDF + 2 kg/haB + 30 kg/haS and T8: 100% RDF + 3 kg/haB + 30 kg/haS. It was significantly superior over all treatments. While, harvest index was highest where 100% RDF applied.

**Keywords:** Siliqua, dry matter, yield

**Introduction**

Oilseeds have prestigious place in Indian agriculture next to cereals. Mustard occupies an important position among oilseed crops grown in India. Mustard (*Brassica* spp.) belongs to family Brassicaceae occupies about 23% area and 14.6% production in India (Kumar et al., 2016) [13]. India is the third largest mustard producer in the world after China and Canada with 12% of world total production. Mustard cultivation is carried out widely in 13 states of India. Rajasthan ranks first in total mustard production (48.6%) followed by Uttar Pradesh (13.4%) and Haryana (11.4%) (Anonymous, 2010). Mustard is the third important oilseed crop after soybean (*Glycine max*) and palm oil (*Elaeis Guineensis*). The crop can be raised well under both irrigated and rainfed conditions. Mustard is a *Rabi* crop that requires relatively low temperature. During growing season it requires fair supply of soil moisture and dry period during harvest (Rehman et al., 2013) [16]. Mustard seed contain 30-45% protein content and 37-49% oil content. All the major nutrient viz., nitrogen, phosphorus, sulphur and boron play an important role in increasing the yield and quality of mustard. Nitrogen is known to activate most of metabolic activities and transformation of energy. Phosphorus has essential role of cell division and meristic growth of tissue. Sulphur is essential for increasing oil content (%) and oil yield. Sulphur application greatly influenced chlorophyll synthesis, carbohydrate as well as protein metabolism. It is essential for synthesis of amino acids, proteins, oils and activates enzyme system in plant. Three amino acids viz., methionine (21% S), cysteine (26% S) and cystine (27% S) contain sulphur which are the building blocks of proteins. About 90% of sulphur is present in these amino acids. Sulphur is also involved in the formation of chlorophyll, glucosides and glucosinolates (mustard oils), activation of enzymes and sulphhydryl (SH) linkages that are the source of pungency in oilseeds. Sulphur levels significantly influenced the seed and stover yield of mustard (Sharma et al., 2009) [17].

Boron is one of the essential micronutrient required for normal growth of most of the plants. Boron plays an important role in cell differentiation and development, regulating membrane permeability, tissue differentiation, carbohydrates and protein metabolism.
It also helps in translocation of photosynthates and growth regulators from source to sink and growth of pollen grains thereby increase in seed yield of crops. Function of plant like cell wall formation, cell wall strength, cell division, fruit and seed development and sugar transport are related to boron.

Materials and Methods
The field experiment was carried out at Experimental Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab during Rabi season of 2017-2018. The site falls in the central plain regions of Punjab at an elevation of 247 m above the mean sea level. The site represents 30°-27° and 30°-46° N latitude and 76°-04° and 76°-38° E longitude. The experiment consisted of nine treatments viz. T₁- 100% RDF, T₂- 100% RDF + 2 kg/ha B, T₃- 100% RDF + 3 kg/ha B, T₄- 100% RDF + 2 kg/ha B + 15 kg/ha S, T₅- 100% RDF + 3 kg/ha B + 15 kg/ha S, T₆- 100% RDF + 2 kg/ha B + 30 kg/ha S, T₇- 100% RDF + 3 kg/ha B + 30 kg/ha S, T₈- 100% RDF + 2 kg/ha B + 45 kg/ha S and T₉- 100% RDF + 3 kg/ha B + 45 kg/ha S which were arranged in randomized block design with three replications. The soil of the experimental field was clay loam in texture with ph (8.18), electrical conductivity (0.72) and organic carbon (0.55%). It was moderately fertile with available nitrogen (298.34 kg/ha), available phosphorus (15.05 kg/ha), available potassium (198.56 kg/ha), sulphate sulphur (17.32 mg/kg) and available boron (2.42 mg/kg).

Mustard variety “super Jhilmi” was sown in rows 45 cm apart on 23rd November of 2017 and harvested on 3rd April of 2018. The recommended doses of fertilizer 60 kg/ha N, 40 kg/ha P₂O₅ and 0 kg/ha K₂O were applied for through urea and diammonium phosphate (DAP). Boron and sulphur was applied through di-sodium octa borate tetra hydrate and elemental sulphur. These fertilizers were applied as basal doses. The requisite quantity of seed applied at the rate of 5 kg/ha for mustard. Thinning and gap filling was done 20 DAS in order to keep healthy plant at a distance of 10 cm to maintain proper plant population. First irrigation was provided in the month of December and second was in January. For recording observations on growth parameters, five plants were randomly selected and labeled from each plot. Plant height, number of primary and secondary branches and dry matter accumulation were recorded at full maturity of crop i.e. at harvest. For recording the data regarding yield attributes five plants from each plot were randomly selected at the time of harvest and observations on number of siliquae/plant, length of siliqua, number of seeds/siliqua and test weight were recorded. After harvest, seed yield, stover yield, biological yield and harvest index were determined.

Result and Discussion

Growth attributes
Plant height, number primary and secondary branches, dry matter accumulation were significantly affected by the combination of sulphur and boron. The growth parameters significantly increased with the increasing level of sulphur but decreased at higher level of boron. It is due to the reduction of nutrient uptake and growth at higher rate of boron.

Plant height, number of primary and secondary branches, dry matter accumulation were significantly influenced due to different treatments are presented in Table. At 30 DAS application of boron and sulphur did not influenced significantly plant height and dry matter accumulation. The highest plant height and dry matter accumulation at 30 DAS obtained with T₉- 100% RDF + 2 kg/haB + 45 kg/haS which was closely followed by T₈- 100% RDF + 3 kg/haB + 45 kg/haS. At 60, 90 DAS and at harvest stage maximum plant height, number of primary and secondary branches and dry matter accumulation were observed in treatment T₈- 100% RDF + 2 kg/haB + 45 kg/haS which was significantly at par with T₉- 100% RDF + 3 kg/haB + 45 kg/haS, T₇- 100% RDF + 2 kg/haB + 30 kg/haS and T₉- 100% RDF + 3 kg/haB + 30 kg/haS whereas, lowest was noticed in treatment T₁- 100% RDF. Result is in agreement with the findings of Verma et al. (2012) [19]. The increase in plant height because sulphur increased activity of meristic tissue resulting in increase in plant height and cell elongation and boron also helps in cell elongation, photosynthesis and translocation of photosynthates. The availability of nutrient in adequate amount resulted in formation of photosynthates, which promote the metabolic activities, increased cell division, ultimately increase the number of primary and secondary branches. A similar finding was found by Yadav et al. (2016) [20]. In case of dry matter accumulation boron and sulphur helps in formation of deep green colour due to synthesis of chlorophyll which in turn provide the larger area for photosynthesis. This results in greater amount of dry matter accumulation in comparison to sulphur deficient plant (Kumar and Yadav, 2007) [10].

Yield attributes
Yield attributes are the resultant of vegetative development of plant and determines the yield. Yield attributes such as, number of siliquae/plant, length of siliqua, number of seeds/siliqua significantly affected by different doses of boron and sulphur.

Number of siliqua/plant, length of siliqua, number of seeds/siliqua was significantly influenced by different levels of sulphur and boron is presented in Table. Number of siliqua/plant, length of siliqua, number of seeds/siliqua observed highest in treatment T₈- 100% RDF + 2 kg/haB + 45 kg/haS which was significantly at par with T₉- 100% RDF + 3 kg/haB + 45 kg/haS, T₇- 100% RDF + 2 kg/haB + 30 kg/haS and T₉- 100% RDF + 3 kg/haB + 30 kg/haS and minimum were obtained from treatment T₁- 100% RDF. Whereas, test weight was found to be non-significant and did not significantly influenced by application of boron and sulphur.

Test weight was highest in T₈- 100% RDF + 2 kg/haB + 45 kg/haS closely followed by T₉- 100% RDF + 3 kg/haB + 45 kg/haS. Positive effect on number of siliquae/plant was also reported by Mojjiri and Arzani (2003) [14]. The positive response could be due to the increased absorption of sulphur and boron from the soil resulting in formation of reproductive structure. Similar results had also been reported by Budhar et al. (2003) [4] and Kumar et al. (2002) [12]. Increase in length of siliqua could be explain on the basis of balanced nutrient supply which enhance cell division, photosynthesis and later on converted into reproductive phases. Similar findings were also recorded by Kumar et al. (2000) [11] and Akter et al. (2007) [1]. Yasemin et al. (2013) had also reported positive effect of various levels of sulphur application on yield component of mustard. Optimum dose of boron significantly increased the number of seeds/siliqua. Nutrients requirement increases during initial stages to develop stages of grain filling in mustard. Thus application of boron and sulphur helps in photosynthesis and their translocation to sink. Kumar et al. (2000) [11] and Jat et al. (2008) [9] reported similar findings.
Table 1: Effect of boron and sulphur on growth parameters of mustard

| Treatments | Plant height (cm) | No. of primary branches | No. of secondary branches | Dry matter accumulation (g) |
|------------|------------------|-------------------------|---------------------------|----------------------------|
|            | 30 DAS | 60 DAS | 90 DAS | Harvest stage | 60 DAS | 90 DAS | Harvest stage | 60 DAS | 90 DAS | Harvest stage |
| T1- 100% RDF | 14.17 | 19.57 | 145.30 | 148.30 | 3.67 | 4.97 | 5.33 | 3.93 | 9.00 | 10.77 | 2.39 | 8.24 | 12.67 | 47.33 |
| T2- 100% RDF + 2 kg/ha B | 14.47 | 63.03 | 153.73 | 157.43 | 3.93 | 5.53 | 5.67 | 4.53 | 9.83 | 12.00 | 2.65 | 9.37 | 14.00 | 51.33 |
| T3- 100% RDF + 3 kg/haB | 14.23 | 61.03 | 150.30 | 154.77 | 3.87 | 5.37 | 5.50 | 4.20 | 9.53 | 11.23 | 2.51 | 8.70 | 13.33 | 50.00 |
| T4- 100% RDF + 2 kg/haB + 15 kg/haS | 15.37 | 67.97 | 156.00 | 159.36 | 4.23 | 6.13 | 6.23 | 4.73 | 10.55 | 12.67 | 2.97 | 10.09 | 17.00 | 56.67 |
| T5- 100% RDF + 3 kg/haB + 15 kg/haS | 15.23 | 65.00 | 155.87 | 158.67 | 4.07 | 5.73 | 5.83 | 4.57 | 10.23 | 12.47 | 2.83 | 9.63 | 15.00 | 53.33 |
| T6- 100% RDF + 2 kg/haB + 30 kg/haS | 15.80 | 71.56 | 165.97 | 171.63 | 4.60 | 6.70 | 6.93 | 5.00 | 11.40 | 13.53 | 3.38 | 10.51 | 14.00 | 63.00 |
| T7- 100% RDF + 3 kg/haB + 30 kg/haS | 15.73 | 70.36 | 162.83 | 163.10 | 4.40 | 6.50 | 6.77 | 4.87 | 11.26 | 13.27 | 3.10 | 10.42 | 12.67 | 61.67 |
| T8- 100% RDF + 2 kg/haB + 45 kg/haS | 16.10 | 75.53 | 173.70 | 178.00 | 4.77 | 7.11 | 7.33 | 5.30 | 11.77 | 14.30 | 3.97 | 11.54 | 16.67 | 67.00 |
| T9- 100% RDF + 3 kg/haB + 45 kg/haS | 16.10 | 73.53 | 168.53 | 174.43 | 4.70 | 7.10 | 7.23 | 5.13 | 11.63 | 13.80 | 3.48 | 11.05 | 15.00 | 65.00 |
| SEm± | 0.95 | 2.37 | 5.69 | 5.96 | 0.16 | 0.23 | 0.24 | 0.18 | 0.37 | 0.51 | 0.32 | 0.39 | 1.84 | 2.12 |
| CD @ 5% | NS | 7.11 | 17.05 | 17.86 | 0.49 | 0.70 | 0.71 | 0.54 | 1.12 | 1.53 | NS | 1.15 | 5.50 | 6.35 |

Table 2: Effect of boron and sulphur on yield and yield attributes of mustard

| Treatments | Number of siliquae/plant | Length of siliqua (cm) | Number of seeds/siliqua | Test weight (g) | Seed yield (q/ha) | Stover yield (q/ha) | Biological yield (q/ha) | HI (%) |
|------------|--------------------------|------------------------|-------------------------|----------------|------------------|---------------------|------------------------|--------|
| T1- 100% RDF | 250.20 | 4.33 | 10.83 | 8.10 | 22.16 | 59.40 | 73.06 | 31.03 |
| T2- 100% RDF + 2 kg/ha B | 265.53 | 4.79 | 11.63 | 5.00 | 22.66 | 59.40 | 73.06 | 31.03 |
| T3- 100% RDF + 3 kg/haB | 258.53 | 4.43 | 11.56 | 4.90 | 22.45 | 48.68 | 71.14 | 31.59 |
| T4- 100% RDF + 2 kg/haB + 15 kg/haS | 295.00 | 4.90 | 12.14 | 5.17 | 23.33 | 56.93 | 80.26 | 29.07 |
| T5- 100% RDF + 3 kg/haB + 15 kg/haS | 267.83 | 4.74 | 11.66 | 5.10 | 22.95 | 52.87 | 75.83 | 30.31 |
| T6- 100% RDF + 2 kg/haB + 30 kg/haS | 317.00 | 5.22 | 12.64 | 5.67 | 24.66 | 61.39 | 86.06 | 28.67 |
| T7- 100% RDF + 3 kg/haB + 30 kg/haS | 312.67 | 5.15 | 12.63 | 5.47 | 24.30 | 59.76 | 84.05 | 28.93 |
| T8- 100% RDF + 2 kg/haB + 45 kg/haS | 330.40 | 5.47 | 13.64 | 5.97 | 26.06 | 63.74 | 89.80 | 29.03 |
| T9- 100% RDF + 3 kg/haB + 45 kg/haS | 326.43 | 5.27 | 12.97 | 5.87 | 25.26 | 63.08 | 88.34 | 28.63 |
| SEm± | 10.68 | 0.17 | 0.44 | 0.28 | 0.86 | 1.99 | 2.01 | 1.14 |
| CD @ 5% | 32.02 | 0.51 | 1.32 | 1.32 | 2.58 | 5.97 | 6.01 | NS |

Crop yield
Yield is the resultant of growth and yield attributes as well as translocation of potential of photosynthates from source to sink. These all the attributes and process are governed very much by balanced supply of macro and micro nutrients application.

It is revealed from the Table that seed yield, stover yield and biological yield of mustard were influenced significantly by nutrient combination. Maximum increment in seed yield, stover yield and biological yield were observed under treatment T5- 100% RDF + 2 kg/haB + 45 kg/haS which was significantly at par with T9- 100% RDF + 3 kg/haB + 45 kg/haS, T1- 100% RDF + 2 kg/haB + 30 kg/haS and T7- 100% RDF + 3 kg/haB + 30 kg/haS and minimum were obtained from treatment T1- 100% RDF. Whereas, harvest index was found to be non significant. Highest harvest index was recorded with T1- 100% RDF and lowest with T1- 100% RDF + 3 kg/haB + 45 kg/haS. The increase in seed yield under adequate supply of boron and sulphur, mainly due to the combined effect of nutrients. As the growth of mustard in T5 increased, ultimately which result in increased yield of mustard. The enhancement of seed yield in mustard due to the application of sulphur had also been reported by Suresh et al. (2002) [18] and Raut et al. (2003). This improvement might be due to the translocation of photosynthates leading to improvement in higher seed yield and stover yield. Chatterjee et al. (1985) reported that application of borax increased seed

Table 3: Effect of boron and sulphur on total macro (NPK and S) and micro (B) nutrient uptake by mustard

| Treatments | Total uptake by crop |
|------------|----------------------|
|            | N (kg/ha) | P (kg/ha) | K (kg/ha) | S (kg/ha) | B (ppm) |
| T1- 100% RDF | 132.98 | 21.70 | 134.65 | 24.58 | 2984.32 |
| T2- 100% RDF + 2 kg/ha B | 144.77 | 24.85 | 151.31 | 28.40 | 3357.21 |
| T3- 100% RDF + 3 kg/haB | 139.87 | 23.61 | 146.13 | 27.00 | 3238.33 |

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Conclusion
On the basis of the experimental findings, it may be concluded that application of recommended doses of fertilizers with optimum doses of boron and sulphur increase the growth and yield of mustard. Boron and sulphur are important elements in sustaining growth and yield of mustard. This is reflected in terms of significant increase in growth, yield attributes, seed yield per plant yield as well as nutrient uptake by seed and stover. Maximum seed yield of mustard was recorded in 100% RDF + 2 kg/ha B + 45 kg/ha S application, thus the application of these elements in deficient areas is recommended to increase the growth and productivity of mustard in the region.

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