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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.*, T_1- 100% RDF, T_2- 100% RDF + 2 kg/ha B, T_3- 100% RDF + 3 kg/ha B, T_4- 100% RDF + 2 kg/ha B + 15 kg/ha S, T_5- 100% RDF + 3 kg/ha B + 15 kg/h S, T_6- 100%RDF + 2 kg/ha B + 30 kg/ha S, T_7- 100% RDF + 3 kg/ha B + 30 kg/ha S, T_8- 100% RDF + 2 kg/ha B + 45 kg/ha S and T_9- 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 withT_9- 100% RDF + 3 kg/haB + 45 kg/haS, T_6- 100% RDF + 2 kg/haB + 30 kg/haS and T_7- 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 Guineenisjacq*.). 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 meristematic 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 sulphydryl (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 30^0-27^0 and 30^0-46^0 N latitude and 76^0-04^0 and 76^0-38^0 E longitude. The experiment consisted of nine treatments *viz.*T_1- 100% RDF, T_2- 100% RDF + 2 kg/ha B, T_3- 100% RDF + 3 kg/ha B, T_4- 100% RDF + 2 kg/ha B + 15 kg/ha S, T_5- 100% RDF + 3 kg/ha B + 15 kg/h S, T_6- 100%RDF + 2 kg/ha B + 30 kg/ha S, T_7- 100% RDF + 3 kg/ha B + 30 kg/ha S, T_8- 100% RDF + 2 kg/ha B + 45 kg/ha S and T_9- 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 loan 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 Jhilmil” was sown in rows 45 cm apart on 23rdNovember of 2017 and harvested on 3rd April of 2018. The recommended doses of fertilizer 60 kg/ha N, 40 kg/ha P_2O_5 and 0 kg/ha K_2O 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 accumulationwerefound 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 T_8- 100% RDF + 2 kg/haB + 45 kg/haS which was closely followed by T_9- 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 T_8- 100% RDF + 2 kg/haB + 45 kg/haS which was significantly at par withT_9- 100% RDF + 3 kg/haB + 45 kg/haS, T_6- 100% RDF + 2 kg/haB + 30 kg/haS and T_7- 100% RDF + 3 kg/haB + 30 kg/haS. whereas, lowest was noticed in treatment T_{1-} 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 merismetic 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/palnt, length of siliqua, number of seeds/siliqua significantly affected by different doses of boron and sulphur.

Number of siliquae/plant, length of siliqua, number of seeds/siliqua was significantly influenced by different levels of sulphur and boron is presented in Table. Number of siliquae/plant, length of siliqua, number of seeds/siliqua observed highest in treatment T_8- 100% RDF + 2 kg/haB + 45 kg/haS which was significantly at par withT_9- 100% RDF + 3 kg/haB + 45 kg/haS, T_6- 100% RDF + 2 kg/haB + 30 kg/haS and T_7- 100% RDF + 3 kg/haB + 30 kg/haS and minimum were obtained from treatment T_1- 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 T_8- 100% RDF + 2 kg/haB + 45 kg/haS closely followed by T_9- 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 divison, 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]. Yeasmin *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 primarybranches			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	30 DAS	60 DAS	90 DAS	Harvest stage
T_1- 100% RDF	14.17	59.57	145.30	148.30	3.67	4.97	5.33	3.93	9.00	10.77	2.39	8.24	42.67	47.33
T_2- 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	44.00	51.33
T_3- 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	43.33	50.00
T_4- 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	47.00	56.67
T_5- 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	45.00	53.33
T_6- 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	54.00	63.00
T_7- 100% RDF + 3 kg/ha B + 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	52.67	61.67
T_8- 100% RDF + 2 kg/haB + 45 kg/haS	16.10	75.53	173.70	178.00	4.77	7.13	7.33	5.30	11.77	14.30	3.97	11.34	56.33	67.00
T_9- 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	11.10	55.00	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 (%)
T_1- 100% RDF	250.20	4.33	10.83	4.80	21.76	45.90	67.66	32.28
T_2- 100% RDF + 2 kg/ha B	265.53	4.79	11.63	5.00	22.66	50.40	73.06	31.03
T_3- 100% RDF + 3 kg/haB	258.53	4.43	11.56	4.90	22.45	48.68	71.14	31.59
T_4- 100% RDF + 2 kg/haB + 15 kg/haS	295.00	4.90	12.14	5.17	23.33	56.93	80.26	29.07
T_5- 100% RDF + 3 kg/haB + 15 kg/haS	267.83	4.74	11.66	5.10	22.95	52.87	75.83	30.31
T_6- 100% RDF + 2 kg/haB + 30 kg/haS	317.00	5.22	12.64	5.67	24.66	61.39	86.06	28.67
T_7- 100% RDF + 3 kg/ha B + 30 kg/haS	312.67	5.15	12.63	5.47	24.30	59.76	84.05	28.93
T_8- 100% RDF + 2 kg/haB + 45 kg/haS	330.40	5.47	13.64	5.97	26.06	63.74	89.80	29.03
T_9- 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	NS	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 T_8- 100% RDF + 2 kg/haB + 45 kg/haS which was significantly at par withT_9- 100% RDF + 3 kg/haB + 45 kg/haS, T_6- 100% RDF + 2 kg/haB + 30 kg/haS and T_7- 100% RDF + 3 kg/haB + 30 kg/haS and minimum were obtained from treatment T_1- 100% RDF. Whereas, harvest index was found to be non significant. Highest harvest index was recorded with T_1- 100% RDF and lowest with T_9- 100% RDF + 3 kg/haB + 45 kg/haS. The increased in seed yield under adequate supply of boron and sulphur, mainly due to the combined effect of nutrients. As the growth of mustard in T_8 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 yield of mustard over control. This may be due to the role of boron in fertility improvement and translocation of photosynthates to sink. These results are in close conformity to those of Chander *et al.* (2010). Stover yield also increases due to the increase in plant height and number of branches.

Total nutrient uptake

Total nutrient uptake *viz*., Nitrogen, phosphorus and sulphur was maximum in T_8- 100% RDF + 2 kg/haB + 45 kg/haSwhich was significantly at par withT_9- 100% RDF + 3 kg/haB + 45 kg/haS, T_6- 100% RDF + 2 kg/haB + 30 kg/haS and T_7- 100% RDF + 3 kg/haB + 30 kg/ha. Total uptake of potassium and boron also found maximum in T_8- 100% RDF + 2 kg/haB + 45 kg/haS but statistically at par with T_9- 100% RDF + 3 kg/haB + 45 kg/haS and T_6- 100% RDF + 2 kg/haB + 30 kg/haS. The reduction of total nutrient uptake at higher doses of boron might be attributed to the reduced enzymatic activity and toxic effects of boron in the roots which could reduce the nutrient uptake and plant growth (Arora, 2007) [3]. The results are in agreement with the findings of Hossain *et al*. (2011) and Jaiswal *et al*. (2015). The increase in nutrient uptake in T_8 mainly due to the better nutrition, which resulted in better growth and yield, ultimately in higher uptake of nutrients. The increased uptake of nutrients may also due to mutually competitive effect of adsorption sites and the resultant increase in nutrient concentration in soil solution.

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)
T_1- 100% RDF	132.98	21.70	134.65	24.58	2984.32
T_2- 100% RDF + 2 kg/ha B	144.77	24.85	151.31	28.40	3357.21
T_3- 100% RDF + 3 kg/haB	139.87	23.61	146.13	27.00	3238.33

T_4- 100% RDF + 2 kg/haB + 15 kg/haS	159.42	27.70	174.75	33.46	3733.04
T_5- 100% RDF + 3 kg/haB + 15 kg/haS	150.56	25.31	161.01	30.65	3534.76
T_6- 100% RDF + 2 kg/haB + 30 kg/haS	178.24	33.42	196.06	42.26	4211.37
T_7- 100% RDF + 3 kg/ha B + 30 kg/haS	171.54	31.39	186.67	37.88	4033.72
T_8- 100% RDF + 2 kg/haB + 45 kg/haS	198.60	39.08	230.51	51.33	4601.80
T_9- 100% RDF + 3 kg/haB + 45 kg/haS	189.18	36.70	212.21	45.89	4408.51
SEm±	6.31	29.31	7.63	3.26	113.30
CD @ 5%	18.90	6.10	22.87	9.78	339.67

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 stover yield as well as nutrient uptake by seed and stover. Maximum seed yield of mustard was recorded in 100% RDF + 2 kg/haB + 45 kg/haS 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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