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Yield, quality and nutrient uptake of Indian mustard (*Brassica juncea*) under sulphur and boron nutrition

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ABSTRACT

A field experiment was conducted during the rabi season of 2011-13 to study the response of Indian mustard [Brassica juncea (L) Czemj of cosson] to different levels of sulphur and boron. The experiment was comprised of 16 treatments including all the combination of four sulphur levels (0, 20 and 60 kg ha^{-1}) and four levels of boron (0, 1, 2 and 3 kg ha^{-1}). Results revealed that the highest seed yield, protein and oil content of mustard were recorded with 60 kg S ha^{-1} which were statistically at par with 40 kg S ha^{-1} out significantly superior to other levels of sulphur. The seed yield of mustard at 40 kg S ha^{-1} was enhanced by 19.1% over control. The stover yield increased significantly up to 60 kg S ha^{-1} which was 51.1% higher than control. Application of 2 kg B ha^{-1} recorded the highest seed yield, which was significantly higher than lower levels of boron. The maximum S and boron uptake were recorded with 60 kg S ha^{-1} and 2 kg B ha^{-1}, respectively. The interaction between S and B had significantly effect on seed and stover yields of mustard and maximum yields were recorded under 60 kg S ha^{-1} and 2 kg B ha^{-1} which was statistically at par with 40 kg S ha^{-1}. and 2 kg B ha^{-1}. The uptake of N, P and K by mustard crop increased with graded levels of sulphur and boron up to 60 kg S ha^{-1} and 2 kg B ha^{-1}.

Keyword: Boron, mustard, oil content, sulphur, nutrient uptake, yield.

INTRODUCTION

Mustard is the second most important oil seed crop, contributing nearly 25-30% of the total oil seed production in the country. Optimum nutrition is required for getting maximum seed yield and good quality of the grain. Several abcotic and biotic factors have been found to effect mustard yields apart from major plant nutrients (N, P and K) sulphur and boron play an important role in the production phenology of oil seed crops and these crops respond well to applied sulphur and boron (KarthiKeyan and Shukla 2008). For oil seeds, sulphur and boron are most vital nutrients for the growth and development. Sulphur is considered to be the fourth important essential nutrient after nitrogen, phosphorus and potassium for the plant growth. Sulphur performs many physiological functions like synthesis of cystein, cystine, methionine chloroephyll and oil content of oil seed crops. It is also responsible for synthesis of certain vitamins (B, biotin and thiamine), metabolism of carbohydrates, proteins and oil formation of flavour compounds in crucifers. Brassica has the highest sulphur requirement owing to the presence of sulphur rich glucosinolates. Boron is an essential micronutrient for higher plants. The role of B within the plant includes cell-wall synthesis, sugar transport, cell-division and different actions in membrane functioning, root elongation, regulation of plant hormone levels and generative growth of plants. The quality of seeds deteriorated in decreased content of boron, starch, protein and oil along with stimulated concentrations of sugars and phenols. Application of B is essential for crops grown in soils with available B belon critical limit of 0.5 mg kg^{-1} (Ramana *et al.* 2016). However; studies investigating the impact of sulphur and boron application on yield of mustard remain scarce. Therefore, the present investigation was planned to study the effect of sulphur and boron on yield, nutrient uptake and quality of mustard.

MATERIALS AND METHODS

The field experiment was conducted during the winter (rabi) seasons of 2010-11 and 2011-12 at Bichpuri, Agra (UP) The soil was sandy loam, slightly above neutral in reaction (pH 7.8), low in organic carbon (2.9 g kg^{-1}), available N (145 kg ha^{-1}), available P (12.5 kg ha^{-1}) and medium in available potassium (120 kg

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ha^{-1}), low in sulphur (15.0 kg ha^{-1}) and boron (0.20 mg kg^{-1}). Treatments consisting of four level each of S (0, 20, 40 and 60 kg ha^{-1}) and B (0, 1, 2 and 3 kg ha^{-1}) which were replicated thrice in randomized block design. Sulphur and boron were applied as gypsum (16% s) and borox (11% B). A uniform dose of N, P and K (100 : 40 : 40 kg ha^{-1}) was applied at the time of sowing through urea, diammonium phosphate and muriate of potash, respectively. Mustard, Bio-902 was sown in second week of October using seed rate of 5 kg ha^{-1} with row spacing of 30cm and harvested in last week of March in both the years. Yield attributes were recorded at harvest to assess the contribution towards yield. The seed and stover yields were recorded at harvest. Seed and stover samples were digested with di-acid mixture of HNO_3 and $HClO_4$ in 9:1 ratio. Phosphorus was determined by vanado molybdo phosphoric acid yellow colour method (Jackson 1973). S by turbidimetric method (Chesnin and Yien 1951), K by flame photometer and B by carmine method (Hatcher and Wilcox 1950). Nitrogen in seed and stover was determined by modified micro-Kjeldahl method (Jackson 1973). Oil content in seeds of mustard was determined by employing non-destruction method of oil estimation using nuclear magnetic resonance spectroscope New port-analyzer model MK IHA. The nutrient uptake was calculated by multiplying the concentration values with the respective seed and stover yields. The data thus obtained were analysed statistically using analysis of variance technique for various parameters at 5% level of significance.

RESULTS AND DISCUSSION

Yield

A significant increase in seed yield was found with the addition of S over control (Table 1). The maximum seed yield of 20.44 q ha^{-1} was recorded in 60 kg S ha^{-1} over control. Stover yield of mustard increased significantly and the maximum of 64.75 q ha^{-1} was recorded with addition of 60 kg S ha^{-1}. Both the levels of S (40 and 60 kg ha^{-1}) were statistically at par in respect of yield of mustard seed.This increase in yield might be due to stimulatory effect of S on the synthesis of chloroplast and protein which in turn might have promoted greater photosynthesis and ultimately resulting in higher yield. The favourable effect of S on carbohydrate metabolism and increasing the plant growth by increasing the assimilatory surface area might have led to increased translocation of the photosynthates resulting in the formation of bold seeds. Jaiswal *et al.* (2015) found that the seed yield of mustard increased due to increasing levels of sulphur.

Table 1: Effect of sulphur and boron levels on yield and quality of mustard (mean of two years)

Treatments	Yield (t ha^{-1})		Protein in seed (%)	Protein yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
	Seed	Stover				
Sulphur (kg ha^{-1})						
0	14.18	42.84	19.25	273.0	39.4	558.6
20	16.00	49.04	19.62	314.0	39.9	638.4
40	19.89	61.42	19.87	395.2	41.2	819.5
60	20.44	64.75	20.06	410.0	41.8	854.4
SEm ±	0.48	0.79	0.07	8.24	0.06	9.32
CD (P=0.05)	1.41	2.30	0.21	23.81	0.19	26.92
Boron (kg ha^{-1})						
0	15.99	49.04	19.37	309.7	39.8	636.4
1.0	17.33	53.55	19.56	339.0	40.3	698.4
2.0	19.04	58.81	19.87	378.3	40.8	776.8
3.0	18.30	56.66	20.00	372.0	40.4	739.3
SEm±	0.48	0.79	0.07	8.24	0.06	9.32
CD (P=0.05)	1.41	2.30	0.21	23.81	0.19	26.92

Application of boron produced significantly higher seed and stover yield of mustard as compared to control (Table 1). The highest seed yield (19.04 q ha^{-1}) was recorded with 2 kg B ha^{-1}. Application of 2 kg B ha^{-1} had resulted in highest stover yield of 58.81 q ha^{-1} over control yield of 40.04 q ha^{-1}. Boron promotes the pollen producing capacity of anthers and hence might have produced higher number of seeds per siliqua. It also had a positive effect on the photosynthetic performance of plants by influencing phosphorylation process, reducing the quantity of assimilates consumed by respiration to obtain energy and accelerating the removal of products of photosynthesis. The increase in seed yield is largely a function of improvement in the yield attributes. These results are in agreement with the finding of Mathew and George (2013) in sesame.The positive influence of B in improving the seed yield of mustard was also reported by Jaiswal *et al.* (2015).

Interaction

The seed yield was significantly increased with the increase in sulphur level from 10 to 40 and 60 kg S ha^{-1} at all the levels of boron (Table 2). The increase in seed yield with boron levels only was recorded at 40 kg S ha^{-1}. It signifies the importance of boron application at 40 kg S ha^{-1}. The highest seed yield recorded with S_{40} $B_{2.0}$ was statistically at par with S_{60} $B_{1.0}$ and S_{40} B_2, treatments but was significantly higher than all other combinations of sulphur and boron.

Table 2: Interaction effect of sulphur and boron on seed and stover yield of mustard (mean of 2 years)

Sulphur (kg ha^{-1})	Boron (kg ha^{-1})			
	0	1	2	3
Seed yield (q ha^{-1})				
0	12.25	13.95	15.05	14.30
20	15.00	15.62	17.00	16.40
40	18.06	19.75	21.00	20.65
60	18.66	20.00	23.10	22.00
SEm ±		0.97		
CD (P=0.05)		2.82		
Stover yield (q ha^{-1})				
0	37.58	43.14	46.50	44.17
20	45.10	48.19	52.35	50.52
40	55.80	60.88	65.00	64.01
60	57.69	62.00	71.39	67.95
SEm ±		1.58		
CD (P=0.05)		4.60		

Quality

The protein content of mustard increased significantly over control with application of S (Table 1). The maximum protein content (20.06%) was recorded with 60 kg S ha^{-1} whereas the minimum was in control. Sulphur is an integral part of amino acids viz. cysteine, cystine and methonine, therefore, its application enhanced the amount of protein in mustard seed leading to highest protein. Oil content in seed increased significantly by application of sulphur in soil. The highest oil content (41.8 %) was in 60 kg S ha^{-1} which was 2.4 % higher over control (39.4%). Sulphur is a constituent of glucosinolate which play a vital role in synthesis of mustard oil. Application of S might have favoured the synthesis of Co A and lipoid acid resulting in increased oil content (Methew and George 2013). The protein content of mustard seed increased significantly with the highest level of B over control (Table 1). Highest content of protein in seed was 20.00% with the application of 3 kg B ha^{-1}. Boron plays an important role in protein synthesis in the meristematic tissues through the involvement in the synthesis of uracil, which is an essential compound of RNA. Synthesis of protein leads to disturbance in the development of meristematic tissue and to overcome the same regular supply of B is required.The protein yield exhibited to increase with increasing levels of sulphur up to 60 kg S ha^{-1} and at this level the protein yield was 410 kg ha^{-1}.The oil production increased significantly with every increase in level of S. Hence maximum oil yield (854.4 kg ha^{-1}) was in the treatment where 60 kg S ha^{-1} was applied. Similarly application of boron increased the oil yield from 636.4 kg ha^{-1} in the control to 776.8 kg ha^{-1} with 2 kg B ha^{-1}. Positive effect may be attributed to marked improvement in seed production with S and B application.

Table 3: Effect of sulphur and boron leels on uptake of N, P, S (kg ha^{-1}) and B (g ha^{-1}) by mustard crop and available S and B in soil (mean of 2 years)

Treatments	Nitrogen		Phosphorus		Sulphur		Boron		Available S (kg ha^{-1})	Available B (mg kg^{-1})
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover		
Sulphur (kg ha^{-1})										
0	43.6	29.5	9.6	12.0	9.8	9.8	23.4	83.1	14.5	0.22
20	50.2	34.3	11.2	14.5	11.4	11.7	28.5	103.0	20.6	0.24
40	63.2	43.6	14.1	17.8	14.5	16.0	39.4	137.5	25.5	0.26
60	65.6	46.0	14.5	19.4	15.3	17.5	43.5	158.0	30.7	0.27
SEm ±	1.03	0.79	0.40	0.42	0.56	0.33	1.16	6.43	0.58	0.04
CD (P=0.05)	2.97	2.28	1.18	1.20	1.40	1.03	3.36	18.59	1.68	0.11
Boron (kg ha^{-1})										
0	49.6	34.8	10.3	13.2	11.3	11.3	23.5	85.8	20.5	0.16
1	54.1	38.0	12.2	15.0	12.2	12.7	30.1	107.1	22.5	0.22
2	60.5	42.9	13.9	17.0	13.7	15.3	38.8	137.6	24.4	0.27
3	58.5	42.5	13.0	17.0	13.5	14.7	42.3	151.2	25.9	0.33
SEm ±	1.03	0.79	0.40	0.42	0.56	0.35	1.16	643	0.58	0.04
CD (P=0.05)	2.97	2.28	1.18	1.20	1.40	1.03	3.36	18.59	1.68	0.11

Nutrient uptake

A perusal of data (Table 3) revealed that N, P, S and B uptake increased significantly with B application over control. The highest uptake of N in seed (60.5 kg ha^{-1}) and straw (42.9 kg ha^{-1}) was associated with 2 kg B ha^{-1}. Significant increase in P uptake by seed (13.9 kg ha^{-1}) and stover (17.0 kg ha^{-1}) of mustard was also found with 2 kg B ha^{-1} as observed by Karthi Keyan and Shukla. The highest uptake of S by seed (13.7 kg ha^{-1}) and stover (15.3 kg ha^{-1}) was recorded with 2 kg ha^{-1}. The uptake of B by mustard crop increased along with rise in level of B up to 3 kg ha^{-1}. The increase in nutrient uptake may be due to increase in nutrient content and yield. Boron plays structural and regulatory roles in large number of enzymes and protein synthesis, which directly affects the nutrient absorption from the soil. A marked increase in N uptake by seed (65.6 kg ha^{-1}) and stover (46.0 kg ha^{-1}), P (14.5 and 19.4 kg ha^{-1}) S (15.3 and 17.5 kg ha^{-1}) was recorded with the application of 60 kg S ha^{-1}. The maximum uptake of B by seed (43.5 g ha^{-1}) and stover (158.0 g ha^{-1}) was recorded with 60 kg S ha^{-1}. Since, the nutrient uptake is a function of their contents in crop plants and yield of crop. The increase in these parameters due to application of S led to an increased uptake of nutrients are in conformity with Shekhawat and Shivay (2008) who reported increased uptake of nutrients by sunflower and Jaiswal *et al.* (2015) in mustard.

Available S and B in soil

Available S and B content in post harvest soil significantly increased with graded levels of their application, which varied from 14.5 to 30.7 kg ha^{-1} and 0.16 to 0.33 mg kg^{-1}, respectively (Table 3). The maximum values of available sulphur (30.7kg ha^{-1}) and boron (0.33 mg kg^{-1}) content in post harvest soil was recorded in 60 kg S ha^{-1} and 3 kg B ha^{-1} while the minimum of 14.5 kg ha^{-1} and 0.16 mg kg^{-1}, respectively being in control. This increase in content of available S and B in post harvest soil may be attributed to increased availability in soil as a result of their addition. Similar results were reported by Jaiswal *et al.* (2015) and Singh (2017). Sulphur and boron, the two inevitable nutrients in oil seed production has been proved to be playing a beneficial role in sustaining the productivity of mustard. This is reflected in terms of enhancement of yield and nutrient uptake by seed and stover as well in improving the availability of S and B in a sandy loam soil. Hence, application of these two elements would likely to improve the productivity of mustard.

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