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EFFECT OF BORON ON YIELD AND MINERAL NUTRITION OF MUSTARD (*Brassica napus*)

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Abstract

An experiment was conducted for three years from 2003-04 to 2005-06 to find out the optimum rate of B application for maximizing nutrient uptake and yield of mustard in calcareous soil of Jessore, Bangladesh. Boron was applied at 0, 1, and 2 kg/ha. The mustard variety BARI Sarisha-8, *(B. napus* group) was selected for the experiment. Effect of B was evaluated in terms of yield and mineral nutrients (N, P, K, S, Zn, and B) uptake. The mustard crop responded significantly to B application. The optimum rate of B was found to be 1 kg/ha There was no significant difference between 1 & 2 kg B/ha in all the years. Boron and N concentrations of grain and stover were significantly increased with increased rate of B application indicating that B had positive role on protein synthesis. In case of P, S, and Zn, the concentrations were significantly increased but in case of K, it remained unchanged in stover. The grain B concentration increased from 19.96 μg/g in B control to 45.99 μg/g and 51.29 μg/g due to application of 1 kg and 2 kg B/ha, respectively. Concerning the effect of B on the nutrient uptake, six elements followed the order K> N> S> P> B> Zn and these were significantly influenced by B application.

Keywords: Mustard, boron, yield, nutrient uptake.

Introduction

The essentiality of B for higher plants was first established by K. Warington in 1923 (Warington, 1923). Recent advances in B research have greatly improved an understanding for B uptake and transport processes (Brown *et al.,* 2002; Frommer and von Wiren, 2002; Takano *et al.,* 2002), and roles of B in cell wall formation (Matoh, 1997; O'Neill *et al.,* 2004), cellular membrane functions (Goldbach *et al.,* 2001), and anti-oxidative defense systems (Cakmak and Romheld, 1997). Boron deficiency is a worldwide problem for field crop production where significant crop losses occur both in yield and quality (Bell *et al*., 1990; Nyomora *et al.,* 1997; Wei *et al.,* 1998). Availability of B to plants is affected by a variety of soil factors including soil pH, texture, moisture, temperature, oxide content, carbonate content, organic matter content and clay mineralogy (Goldberg *et al.,* 2000).

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Boron is generally less available in clay soils and availability increases with increasing temperature (Fleming, 1980). Soil pH is regarded as a major factor regulating B availability in soils. Increasing pH favours its retention by soils or soil constituents (Mezuman and Karen, 1981; Bloesch *et al.,* 1987; Goldberg. 1997). Reproductive growth, especially flowering, fruit and seed set is more sensitive to B deficiency than vegetative growth (Dear and Lipsett. 1987; Noppakoonwong *et al.,* 1997).

Thus, B fertilization is necessary for improvement of crop yield as well as nutritional quality. Mustard as a *Brasmica* crop is very responsive to B application (Mengel and Kirkby, 1987). There are numerous reports on the positive response of mustard to B fertilization (Islam, 2005; Hossain *et al.,* 1995 and Saha *et al.,* 2003). Considering the facts above, the present study was undertaken to find out the optimum rate of B application for achieving the highest yield potential of mustard in this soil and to see the nutrient uptake pattern due to variation of rate of B application.

Materials and Method

The experiment was conducted in the calcareous soil of Regional Agricultural Research Station (RARS) farm, Jessore, Bangladesh for consecutive 3 years from 2003-2004 to 2005-2006. The land belongs to High Ganges River Floodplain agroecological zone (AEZ 11) and Gopalpur soil series (Soil taxonomy: Aquic Eutro-chrepts). The soil had high p^H value (8.1) and with low Ca (H_2P0_4) having B content of 0.18 mg/kg. The other soil properties were 1.65% organic matter, 10.1 mg/kg Olsen-P, 0.28 c mol/kg exchangeable K, 19 c mol/kg Ca, 1.75 c mol/kg Mg, 4.53 mg/kg $CaC1_2$-S and 0.89 mg/kg DTPA-Zn. Soil p^H was determined by glass electrode pH meter (1:2.5 soil-water ratio) and organic matter by wet oxidation method (Nelson and Sommers 1982). The K, Ca and Mg contents of soil were determined by 1M NH_4OAc (p^H 7.0) extraction method. The experiment was laid out in a randomized complete block design with three replications, each plot size being 4m x 3m. Boron was applied at 0, 1, and 2 kg/ha. This layout was kept undisturbed for the second and third years of the study. Boron was supplied as H_3Bo_3 (17% B). Every year, the mustard crop received 124 kg N, 30 kg P, 28 kg K, 35 kg S, and 2 kg Zn per hectare. The sources of nutrients were urea, TSP, MoP, gypsum, and zinc sulphate for N, P, K, S, and B, respectively. Intercultural operations viz., weeding, irrigation, and insecticide spray were done as and when required. Every year, the mustard (cv BARI Sarisha-8) were sown during first week of November and harvested in the second week of February. Data on the yield and yield contributing characters from all plots were recorded.

The yield data were expressed as kg/ha on 12% moisture basis. The grain and stover samples from each plot for every year were chemically analyzed for N, P,

K, S, Zn, and B concentration. Microkjeldahl method (H_2S0_4, digestion) was followed for N determination (Bremner and Mulvaney, l982) and the HNO_3 - $HC1O_4$ (5:1) digestion was made for P, K, S, Zn, and B determinations (Yoshida *et al.*, 1976). Nitrogen concentration was determined by titration method, the P and S concentration by colorimetric method, K concentration by flame photometer method, B concentration by azomethine-H method and the Zn concentration directly by flame-AAS (Modle UNICAM 969, England). The nutrients uptake was calculated from the crop yield and nutrients concentration data. The data were statistically analyzed following the principle of F- statistics and the mean values were separated by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Results and Discussion

Seed yield

The seed yield of mustard (cv. BARI Sarisha-8) increased markedly due to B application. The highest seed yield was obtained from the plots receiving 1 kg B/ha (Fig. 1) and the lowest yield from the B control plots. For all three years, the yield did not differ significantly between the two B levels (1 and 2 kg B/ha), however, both treatments differed significantly with control treatment. The 1 kg/ha B-treatment recorded the yield of 1995 kg/ha in 2003-04, 1716 kg/ha in 2004-05 and 1926 kg/ha in 2005-06, showing a 30-35% yield increase over control. Averaged over three years, the seed yield was found to vary from 1389 to 1879 kg/ha for 0, 1, and 2 kg/ha B treatments. Mengel and Kirkby (1987) stated that *Brassica* crop has high B requirement. Sinha *et al.* (1991) and Sen and Farid (2005) observed 1.5 kg B/ha as the optimum dose for mustard cultivation. Lu *et al.* (2000) found that B fertilizer contributed 611 kg/ha (48.5%) yield advantage of rapeseed. Positive effect of B application on mustard yield has been reported in Bangladesh by Hossain *et al.* (1995), Haque *et al.* (2000) and Islam (2005). As reported by Wang *et al.* (1996), both deficiency and excess level of B showed abnormal growth of rapeseed plants, and use of borax fertilizer did not cause B toxicity when it was used 4 to 8 times higher than the recommendation (Wang *et al.*, 1999).

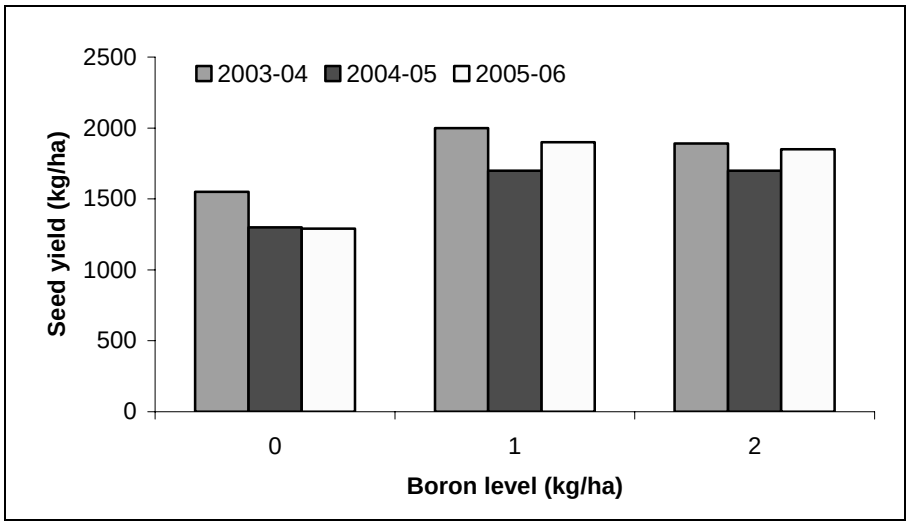

Fig. 1. Effect of B application on the seed yield of mustard.

Stover yield

The effect of B application on the stover yield of mustard was not significant (Table 1). However, B control treatment produced the lowest stover yield and application of 1 kg B/ha got the highest. The stover yield ranged from 3744 to 4100 kg/ha in 2003-04, 3298 to 3471 kg/ha in 2004-05 and 3895 to 4278 kg/ha in 2005-06, across the B treatments. On three years' average, the stover yield varied from 3646 to 3950 kg/ha. Although not significant, B supply to soil resulted in a 7-8% stover yield increase over control. Dear and Lipsett (1987) stated that reproductive growth is more sensitive to B deficiency than vegetative growth. Saha *et al.* (2003) also reported that the use of B did not influence the stover yield of mustard.

Yield components

The yield contributing characters of mustard, such as number of pods/plant, seeds/pod, pod length, and 1000-seed weight increased significantly due to B application (Table 1 & 2). The highest number of pods/plant (117.0 in 2003-04, 109.2 in 2004-05 and 116.5 in 2005-06) was recorded from 1 kg B/ha treated plots, which was statistically identical with that recorded with 2 kg B/ha (110.9 in 2003-04, 106.3 in 2004-05 and 115.6 in 2005-06). Similarly, the highest number of seeds/pod (26.98 in 2003-04, 24.10 in 2004-05, and 27.24 in 2005-06) was observed with 1 kg B/ha treatment and an identical result was found with 2 kg B/ha. Pod length also showed significant difference among B treatments and it was 7.87 cm (average of 3 years) when B was applied at 1 kg/ha and 7.29 cm when B was not added (Table 1). The maximum weight of 1000-seed (3.67 g,

mean of 3 years) was achieved from 1 kg B/ha treatment, which was statistically at par with 2 kg B/ha treatment. The growth parameter, such as plant height was not influenced remarkably by B treatments, plant height being 101.0-107.3 cm, among the B treatments (Table 1).

Islam and Sarker (1993) reported that B application significantly increased the number of pods/plant, seeds/pod, and seed yield of mustard. Hu *et al.* (1994) reported that the rate of 0.1 mg B/kg soil was optimum, at which plant height, number of branches/plant, number of siliquae/plant, number of seeds/siliqua, seed yield/plant and oil yield/plant increased from 149.2 cm, 14.1, 302.3, 12.6, 14.51 g, and 5.63 g in the control to 158.0cm, 23.8, 400.2, 16.3, 20.93 g and 9.61 g, respectively.

Table 1. Effect of B on the stover yield, plant height, and pod length of mustard.

B level (kg/ha)	Stover yield (kg/ha)			Plant height (cm)			Pod length (cm)		
	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06
B_0	3744	3298	3895	102.1	99.0	102.1	7,52b	7.04b	7.31b
B_1	4100	3471	4278	106.1	103.6	112.3	8.18a	7.44a	7.98a
B_2	4041	3449	4212	105.8	102.4	111.6	8.07a	7.38a	*7,95a*
CV (%)	4.25	6.50	*3.56*	2.87	1.72	*5.05*	2.51	1.98	1.90
SE(±)	NS	NS	NS	NS	NS	NS	0.116	0.084	0.086

Means followed by same letters are not significantly different at 5% level by DMRT, NS= Non Significant.

Table 2. Effect of B on the pods/plant, seeds/pod and 1000- seed weight of mustard.

B level (kg/ha)	Pods/plant (no.)			Seeds/pods (no.)			1000- seed wt (g)		
	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06
B_0	91.0b	83.Ib	82.3b	23.50b	20.88b	21.94b	3.30b	3.06b	3.27b
B_1	117.0a	109.2a	116.5a	26.98a	24.10a	27.24a	3.78a	3.55a	3.69a
B_2	110.9a	106.3a	115.6a	26.80a	23.88a	26.80a	3.74a	3.50a	3.62a
CV (%)	7.12	6.68	5.56	1,36	3.81	2.22	1.50	3.34a	3.02
SE(±)	4.366	3.836	3.364	0.203	0.504	*0.325*	0.032	0.066	0.061

Means followed by same letters are not significantly different at *5%* level by DMRT.

Nutrient concentration

The N and B concentration of mustard grain and stover were markedly influenced by B treatment (Table 3 & 5). For P, S, and Zn concentration, there was no significant difference between 1 and 2 kg B/ha, but differed significantly from B control plot (Table 3, 4 & 5). Like P, S, and Zn concentration, grain K concentration in mustard was significantly influenced by B application but stover K was not. The grain and stover N concentration (average of 3 years) varied from 2.93 to 3.61% and 0.42 to 0.56%, P from 0.49 to 0.61% and 0.023 to 0.067%, K from 0.62 to 1.13% and 2.07 to 3.30%, S from 0.69 to 1.20% and 0.16 to 0.27%, Zn from 27.00 to 46.23 μg/g and 21.54 to 34.73 μg/g and B from 15.41 to 62.45 jig g' and 22.05 to 50.15 jig g1, respectively (Table 3, 4 & 5).

Table 3. Effects of B on Nitrogen and Phosphorus concentration of mustard.

B level (kg/ha)	Seed N (%)			Stover N (%)			Seed P (%)			Stover P (%		
	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06
B_0	3.17b	3.14b	2.93b	0.447b	0.450b	0.420c	0.563b	0.540b	0.487b	0.028b	0.030b	0.023b
B_1	3.50a	3.46a	3.30a	0.517a	0.547a	0.490b	0.607a	0.590a	0.560a	0.047ab	0.064a	0.048a
B_2	3.61a	3.47a	3.34a	0.523a	0.560a	0.513a	0.613a	0.593a	*0.567a*	0.051a	0.067a	0.048a
CV (%)	1.68	2.03	2.85	1.96	2.57	3.91	1.77	1.16	2.48	3.71	2.15	2.72
SE (±)	0.033	0.039	0.052	0.006	0.008	0.011	0.006	0.004	0.008	0.001	0.001	0.001

Means followed by same letter are not significantly different at 5% level by DMRT.

Table 4. Effects of B on Potassium and Sulphur concentration of mustard.

B level (kg/ha)	Seed K (%)			Stover K (%)			Seed S (%)			Stover S (%		
	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06
B_0	1.04b	0.837b	0.617b	3.24	2.38	2.07b	0.717b	1.02b	0.694b	0.207b	0.217b	0.163b
B_1	l.13a	0.923a	0.703a	3.25	2.43	2.36a	0.827a	1.19a	0.787a	0.243a	0.257a	0.213a
B_2	l.13a	0.937a	0.710a	3.30	2.46	2.38a	0.820a	1.20a	0.793a	0.243a	0.270a	0.217a
CV (%)	3.01	1.48	3.82	1.38	1.42	3.02	1.77	2.18	2.98	3.82	2.69	2.66
SE(±)	0.019	0.008	0.015	NS	NS	0.040	0.008	0.014	0.013	0.005	0.004	0.003

Means followed by same letters are not significantly different at 5% level by DMRT, NS Non Significant.

Table 5. Effects of B on Zinc and Boron concentration of mustard.

B level (kg/ha)	Seed Zn µg/g			Stover Zn µg/g			Seed B µg/g			Stover B µg/g		
	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06
B_0	27.00b	38.77b	39.07b	21.80b	25.32b	2l.54b	25.50b	l8.97c	15.41c	31.45b	22.22c	22.05c
B_1	27.20b	45.93a	42.20a	25.93a	33.75a	25.35a	41.83a	35.89b	60.25b	44.20a	29.44b	47.94b
B_2	29.20a	46.23a	42.20a	25.50a	34.73a	25.99a	50.15a	41.27a	62.45a	45.05a	32.30a	50.15a
CV (%)	2.20	2.72	2.42	1.21	2.53	2.74	3.63	1.66	1.78	3.66	2.99	1.52
SE (±)	0.353	0.686	0.576	0.171	0.457	0.385	0.820	0.307	0.474	0.850	0.483	0.352

Means followed by same letter are not significantly different at 5% level by DMRT.

Table 6. Effects of B on nutrient uptake (Seed + Stover) by mustard during 2003-04 to 2005-06.

B level (kg/ha)	Nutrient uptake (kg/ha)																	
	2003-04						2004-05						2005-06					
	N	P	K	S	Zn	B	N	P	K	S	Zn	B	N	P	K	S	Zn	B
B_0	66.41b	9.88b	137.7b	18.97c	0.124b	0.158b	55.88b	8.08b	8958b	20.47b	0.134b	0.098b	54.0lb	7.18b	88.44b	15.34b	0.134b	0.106b
B_1	90.99a	14.04a	155.9a	26.47a	0.161a	0.265a	78.42a	12.39a	100.3a	29.27a	0.196a	0.164a	84.41a	12.77a	114.45a	24.26a	0.190a	0.321a
B_2	88.86a	13.58a	154.6a	25.19b	0.158a	0.276a	78.36a	12.40a	100.8a	29.72a	0.198a	0.182a	83.41a	12.52a	113.15a	23.83a	0.188a	0.327a
CV(%)	2.37	3.49	3.17	2.23	1.53	2.75	0.94	0.79	0.91	2.3	2.02	1.94	1.55	4.13	1.54	2.25	2.96	2.49
SE (±)	1.123	0.252	2.74	0.303	0.0013	0.004	0.385	0.05	0.5 10	0.363	0.002	0.002	0.661	0.258	0.936	0.274	0.003	0.004

Means followed by same letter are not significantly different at *5%* level by DMRT.

Nutrient uptake

Total N uptake by mustard was significantly influenced by B application. The N uptake ranged from 66.41 to 90.99, *55.88* to 78.42 and 54.01 to 84.41 kg/ha in 2003-04, 2004-05, and 2005-06, respectively (Table 6). The highest N uptake for all three years were observed with 1 kg B/ha, which was significantly higher over B control but statistically identical with subsequent higher B dose (2 kg B/ha). Like N uptake, the P, K, S, Zn, and B uptake by the crop was positively influenced by B treatment. The variation of nutrient uptake was influenced by seed yield and nutrient concentration. As the yield of mustard optimized with 1 kg B/ha application, therefore, the nutrient uptake (N,P,K,S etc.) might be higher with that treatment. Similar result was obtained by Islam (2005). The magnitude of uptake for different nutrients followed the order: K> N> S> P> B and Zn. Total P uptake by mustard (seed + stover) depending on the B rates varied from 9.88 to 14.04, 8.08 to 12.40 and 7.18 to 12.77 kg/ha in 2003-04, 2004-05, and 2005-06, respectively.

The K uptake by the crop under different B treatments varied from 137.7 to 155.9 kg/ha in the first year, 89.58 to 100.8 kg/ha in the second year, and 88.44 to 114.5 kg/ha in the third year (Table 6). The plant uptake of S ranged from 18.97 to 26.47, 20.47 to 29.72, and 15.34 to 24.26 kg, ha in 2003-04, 2004-05, and 2005-06, respectively. The Zn uptake by mustard varied from 0.124 to 0.161, 0.134 to 0.198, and 0.134 to 0.190 kg h&1 in 2003-04, 2004-05 and 2005-06, respectively. Boron application increased Zn uptake significantly.

Positive interaction between B and Zn in mustard was also reported by Sinha *et al.* (2000). Total B uptake by mustard (seed + stover) was markedly influenced by B application (Table 6). The plant B uptake varied from 0.158 to 0.276, 0.098 to 0.182 and 0.106 to 0.324 kg/ha in 2003-04, 2004-05, and 2005-06, respectively. In all cases, the highest B uptake was recorded under 2 kg B/ha and the lowest in B control treatments but there was no significant difference in B uptake between application of 1 and 2 kg B/ha, as evidenced in the first and third year experiments. It is reported that increased level of boron application in mustard tissue B content (Dutta *et al.*, 1984; Yang *et al.*, 1989 and Yang *et al.*, 1998).

Conclusion

The seed yield of mustard (cv. BARI Sarisha-8) increased markedly due to B application in soil, showing a 30-35 % yield increase over control. Higher dose of B i.e. 2 kg B/ha did not exert any negative effect on the crop. There was no significant influence of B, on stover yield. Three years' study reveled that the application of 1 kg B/ha optimized the seed yield of mustard showing insignificant decline with subsequent higher dose (2 kg B/ha). So, the rate 1 kg B/ha was found optimum for higher seed yield of mustard.

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