INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 26, No. 1, p. 62-73, 2025

RESEARCH PAPER OPEN ACCESS

Effect of Boron Levels on Growth and Yield of Vegetable Crops in Bangladesh

B.M. Mahmudul Hasan[*1], Md. Nurul Alam[1], Md. Hanjala Pipil[1], Marufa Yeasmin[2], C.M Aditta Alam Protham[2], Md Rezoanul Islam[2]

[1]*Department of Biochemistry and Molecular Biology, Trust University, Barishal, Bangladesh*

[1]*Department of Crop Science and Engineering, University of Rajshahi, Bangladesh*

[2]*Department of Biochemistry and Molecular Biology, Trust University, Barishal, Bangladesh*

[2]*Department of Biochemistry and Molecular Biology, Bangabandhu Sheikh Mujibur Rahman Science and Technology University, Gopalganj, Bangladesh*

Key words: Boron, Vegetable crops, Toxicity, Environment

http://dx.doi.org/10.12692/ijb/26.1.62-73 Article published on January 04, 2025

Abstract

The experiments were conducted to investigate the effect of B levels on growth and yield of cabbage, cauliflower, carrot, potato and radish. The soil was medium fertility with low B content. The experiments were laid out in RCBD with 3 replications. There were seven levels of B viz. 0, 1, 2, 3, 4, 5 & 6 kg /ha. The B was used as boric acid. The results revealed that the application of B in deferent levels significantly influenced the growth and yield of vegetable crops. The yield of cabbage, cauliflower, potato and radish responded significantly to added B up to 3 kg/ha. The yield advantages due to B application are cabbage (68.32 %), cauliflower (70.84 %), potato (47.74 %) and radish (49.07 %) over control. Whereas, application of 2 kg B/ha produced the maximum root yield of carrot (40.47 %) yield over control also. The yield of vegetables was reduced without appropriate rate of B application. It is concluded that the suitable range of B application is 2-3 kg/ha for maximum vegetable crop production in upland soils of Bangladesh. The rate of 2 kg B/ha is applicable for relatively low biomass yielded vegetable crops and 3 kg B/ha for higher yielded vegetable crops, respectively. Interestingly, it can be also stated that the B application 5 kg/ha or above will be harmful and stunted or may be toxic their vegetative growth of vegetables.

* **Corresponding Author:** B.M. Mahmudul Hasan ✉ jewelgono @gmail.com

Introduction

Boron is an essential micronutrient requirement for normal growth and development. It is a very sensitive element and plants differ widely in their requirements but the ranges of deficiency and toxicity are narrow. The B concentration in soils varied widely with soil types and environment. The B requirements are common on upland crops in humid regions and also in calcareous soil. Boron deficiencies are widespread in humid regions by leaching losses (Thoeh *et al.*, 1993). It is wide spread and often incipient that B deficiency seems to exist in Bangladesh soils (Protch and Islam, 1984). Zinc and Boron normally becomes less available to plants with increasing soil pH. When Ca availability is high, there is a greater requirement of B for plant growth and yield (Tisdale *et al.*, 1995). Many researchers observed that B application increased growth and yield of upland crops like- wheat, pulses, oil seeds, potato, carrot, radish and papaya. Boron @ 3.0 kg/ha produced the highest grain yield of wheat, which was statistically similar to that produced by 2.0 kg B/ ha (Hafiz Akter *et al.*, 2001). Pregno and Arour (1992) also reported that the highest potato tuber yield was found when 2 kg B/ ha was applied to the soil followed by 4 kg B / ha. The highest yield of carrot was obtained when B was applied with a basal NPK (Nelyubora *et al.*, 1972). Maurya and Singh (1985) found that borax 10 kg/ha gave the highest radish yield increase viz. 41% over the control and the best protein and ascorbic acid content. Khanam *et al.* (2000) observed that the application of Mg and B is necessary for improving yield potentialities of chickpea and lentil at BAU farm soil of Bangladesh. Application of different levels of B influenced the growth and yield of crops reported by Maurya and Singh (1985) in carrot, Quaggio and Ranos (1986) in potato, Efkar *et al.* (1995) in potato, Porter *et al.* (1986) in potato, Ali *et al.* (2001) in papaya and Hafiz Akter *et al.* (2001) in wheat. The requirements of B fertilizer in vegetables are generally more than other corps. Rasp (1985) mentioned that the effect of added trace elements in 12 years of crop rotation in which potatoes and cereals were grown in alternate years. It was found that only B tended to increase potato yield. High Ganges River Floodplain soil (AEZ-11) is one of the most important calcareous soils of Bangladesh. The soils have large content of $CaCO_3$, as well as high concentration of available Ca^{++} present in that soil. The pH is generally ranging from 7.0-8.5 but in most of the upland soils ranges from 7.5-8.5. In fact, information regarding B requirements for vegetable should be meager in Calcareous and Baind soils of Bangladesh. Therefore, an attempt was made to study the effect of B levels on growth and yield of vegetable crops in Bangladesh.

Materials and methods

The experiments were conducted in calcareous soil during the period from October 2009 to February 2010 and also in Barind soil during the period from October 2010 to March 2011 to determine the effect of B levels on growth and yield of cabbage, cauliflower & carrot and potato & radish, respectively. The soil samples (0-15 cm) were collected and analyzed soil texture by Hydrometer method and other parameters by Hunter (1984) method. The experimental calcareous soil was low in fertility having pH 7.8 and silty clay loam texture, organic matter 1.12%, total N 0.07%, available P 19.6 mg/kg, exchangeable K 0.28 me/100g, available S 1.9 mg/kg, exchangeable Ca 17.66 me/100g, exchangeable Mg 0.79 me/100g, available Fe 67.6 mg/kg, available Mn 26.8 mg/kg, available Cu 1.68 mg/kg, available Zn 0.68 mg/kg and available B 0.22 mg/kg and also Barind soil was low in fertility having pH 5.6 and silt loam texture, organic matter 0.96%, total N 0.07%, available P 149.6 mg/kg, exchangeable K 0.23 me/100g, available S 2.3 mg/kg, exchangeable Ca 6.35 me/100g, exchangeable Mg 0.49 me/100g, available Fe 65.6 mg/kg, available Mn 32.3 mg/kg, available Cu 1.84 mg/kg, available Zn 0.48 mg/kg and available B 0.18 mg/kg.

There were 7 levels of B *viz.* 0, 1, 2, 3, 4, 5 and 6 kg/ha in the treatments as boric acid. The experiment was laid out in a RCBD with three replications. Other nutrients like N, P, K, S and Zn were applied at the rate of 150-50-100-20-3 kg/ha as basal dose during final land preparation and Mo was used as spray.

Urea, TSP, MP, gypsum, zinc sulphate and ammonium molybdate were applied as the sources of N, P, K, S, Zn and Mo respectively. All fertilizers except urea were applied during land preparation and Mo was applied at 45 days after planting/sowing. Urea was used in three splits i.e. at final land preparation, 30 and 55 days after planting (DAP).

There was no organic used in the field because organic matter has large content of boron. The size of each plot was 5m×5m, spacing 50cm×50cm for cabbage and cauliflower, spacing 25cm×20cm for Potato and 18cm×15cm for radish. The intercultural operation, weeding, pest management and irrigation were done as and when required. Data were recorded in randomly from 10 plants per plot. After collection of data, it was tabulated in proper form and subjected to the statistical analysis with the help of computer package MSTAT-C and means were separated by DMRT at 5% LSD values (Russell, 1996).

Results and discussion

Effect of boron levels on growth and yield of cabbage in calcareous soil

Plant height

Application of different levels of B showed significant effects on plant height at different days after transplanting of cabbage. At 30 DAT, the maximum plant height (23.39 cm) was recorded in treatment B_3 and the second but statistically similar in B_4. At both 45 and 60 DAT, the maximum plant heights were also found in B_3.

Table 1. Effect of B levels on plant height and plant spread of cabbage.

Treatments	Plant height (cm)			Plant spread (cm)		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
B_0 = Control	18.14	25.19	27.50	28.58	39.45	47.66
B_1 = 1 kg B/ha	19.47	28.33	32.22	32.56	51.54	57.52
B_2 = 2 kg B/ha	21.24	32.01	37.43	36.00	57.35	61.74
B_3 = 3 kg B/ha	23.39	33.23	39.55	36.17	63.80	66.37
B_4 = 4 kg B/ha	23.06	30.46	36.37	35.20	59.61	65.45
B_5 = 5 kg B/ha	19.32	26.60	32.80	32.36	53.45	59.02
B_6 = 6 kg B/ha	18.11	24.52	29.52	30.43	48.26	57.70
LSD at 5%	0.83	1.17	2.11	1.87	2.68	3.20
CV (%)	3.68	7.94	5.89	6.46	5.92	8.18

In a column, figure(s) having common letter(s) do not differ significantly by DMRT at 5% level, DAT = Days after transplant.

The lowest plant heights were observed in B_6 and B_0 (control)). Alam (2007) suggested that the growth and yield contributing parameters of cabbage increased up to 4.0 kg B/ha and decreased gradually with the increases of B levels (>4.0 kg B/ha).

Porter *et al.* (1986) showed that plants were stunted and yields reduced at application of grater than 4.5 kg B/ ha. Pregno and Arour (1992) mentioned that the highest tuber yield was found when 2 kg B/ha was applied and followed by 4 kg B/ha. The plant height was not increased by low rates of B but was reduced by 8 and 12 kg B/ha compared with no B.

Plant spread

Statistically significant difference was observed in plant spread affected by B levels in cabbage. The plant spread at different stages of growth (at 30, 45, and 60 DAT) was ranged from 28.58-36.17 cm, 39.45-63.80 cm and 47.66-66.37 cm respectively (Table 1). At all the growth stages (30, 45 and 60 DAT) the widest canopy spreads were recorded in the plot treated with 3 kg B/ha. On the other hand, the lowest plant spread was observed in B_0 and B_6 at all DAT. Alam (2007) reported that plant spread was significantly influenced by applied boron levels and maximum value was found for 3.0 kg B/ha.

Number of leaves per plant

Application of different doses of B exerted a significant influence on the number of leaves per plant in cabbage. The number of leaves increased with increasing B levels up to 4 kg B/ha. At all DAT, the highest number of leaves was found at 4 kg B/ha, which was statistically similar with 3 kg B/ha. The lowest number of leaves was found in the plot treated with control and 6 kg B/ha. Alam (2007) reported that leaf number was significantly influenced by B levels and maximum leaf number was found for 3.0 kg B/ha.

Table 2. Effect of B levels on number and length of leaves of cabbage.

Treatments	Number of leaves per plant			Length of largest leaf (cm)		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
B_0 = Control	10.86	13.92	15.31	17.18	22.33	27.38
B_1 = 1 kg B/ha	12.83	18.11	19.16	19.44	26.42	32.51
B_2 = 2 kg B/ha	13.75	17.38	18.36	22.13	27.90	33.48
B_3 = 3 kg B/ha	13.93	18.20	18.81	24.39	30.37	35.43
B_4 = 4 kg B/ha	14.17	18.22	19.34	25.28	31.78	35.72
B_5 = 5 kg B/ha	13.50	17.50	19.03	24.40	30.44	32.56
B_6 = 6 kg B/ha	11.83	17.33	18.17	21.90	29.61	30.83
LSD at 5%	1.13	1.22	1.30	1.27	1.44	1.36
CV (%)	3.65	7.50	2.56	3.42	3.94	6.12

In a column, figure(s) having common letter(s) do not differ significantly by DMRT at 5% level.

Length of largest leaf

The length of leaf influenced by B levels was found to be significant in growth period (Table 2). The largest leaf was recorded in the plot treated with B_4 and followed by B_3 but both are statistically similar in all stages. Ahmmad *et al.* (2009) showed that the length of largest leaf of cauliflower was significantly increased by the application of B at 3 kg/ha with Zn at 3 kg/ha. The results are in agreement with the findings of Alam (2007).

Table 3. Effect of B levels on leaf breadth and stem length of cabbage.

Treatments	Breadth of largest leaf (cm)			Length of stem (cm)		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
B_0 = Control	10.13	17.73	19.65	4.37	5.09	6.37
B_1 = 1 kg B/ha	11.48	19.28	21.36	4.40	6.57	6.65
B_2 = 2 kg B/ha	12.03	19.84	22.16	4.48	6.93	6.21
B_3 = 3 kg B/ha	12.57	21.35	23.30	4.96	7.57	6.93
B_4 = 4 kg B/ha	11.72	20.61	23.10	5.35	7.90	7.04
B_5 = 5 kg B/ha	11.36	20.05	22.22	4.50	6.11	6.23
B_6 = 6 kg B/ha	10.50	18.46	20.52	4.32	6.30	6.63
LSD at 5%	0.51	0.93	0.76	0.55	0.88	0.67
CV (%)	5.24	2.59	2.87	4.90	3.28	4.39

In a column, figure(s) having common letter(s) do not differ significantly by DMRT at 5% level.

Breadth of largest leaf

Application of different levels of B caused significant effects on the breadth of leaves at different DAT (Table 3). The highest breadth of leaf was found by B_3 and the second highest in B_4, and the minimum in control. The results are in partial agreement with Alam (2007) in cabbage, Ahmmad *et al.* (2009) in cauliflower and Ahmmad (2009) in cabbage.

Length of stem

Significant effects of micronutrient combination are observed on the length of cabbage. The results on length of stem influenced by B levels have been presented in Table 3. The stem length increases with increases of B levels up to 4 kg/ha and decreases gradually. The maximum stem length was found in B4 and the minimum in control in growth stages.

Table 4. Effect of B levels on growth and yield of cabbage at harvest.

Treatments	Days to head formation	Fresh weight of plant (g)	Diameter of head (cm)	Thickness of head (cm)	Marketable head weight (g)	Marketable head yield (t/ha)	% Yield increase over control
B_0 = Control	59.30	1052	12.83	9.73	908	28.11	-
B_1 = 1 kg B/ha	54.75	1317	15.37	11.30	1123	38.60	37.32
B_2 = 2 kg B/ha	52.22	1420	17.90	11.70	1254	43.19	53.65
B_3 = 3 kg B/ha	49.50	1680	20.45	12.80	1465	47.33	68.37
B_4 = 4 kg B/ha	48.16	1737	19.83	12.43	1395	46.95	67.02
B_5 = 5 kg B/ha	48.36	1473	16.80	11.15	1163	42.12	49.84
B_6 = 6 kg B/ha	49.65	1290	14.03	10.93	1016	35.87	27.61
LSD at 5%	2.06	112	1.02	0.43	137	2.11	-
CV (%)	3.54	10.56	2.56	3.85	8.33	6.19	-

In a column, figure(s) having common letter(s) do not differ significantly by DMRT at 5% level.

Days to head formation

The number of days required for head formation was significantly influenced by the treatments. The number of days required for head formation ranged from 48.16 to 59.30 (Table 4). The maximum number of days required for head formation (59.30 days) was observed in control plot. The minimum days to started the head was (48.16 days) in B_4 followed by B_5. It is indicated that B is required for early head formation or leaf folding of cabbage. The results are strongly supported by Alam (2006).

Fresh weight of plant

Fresh weight of plant along with root was found to be affected by B levels. The fresh weight of plant was ranges between 1052 g to 1737 g (Table 4). The maximum fresh weight of plant was observed in the plot treated with B_3 followed by B_4 but both are statically similar. However the minimum fresh weight of plant was found in control. The findings are in agreement with Alam (2007).

Diameter of head

The head diameter of cabbage significantly affected due to the addition of increasing rates of boron fertilizer (Table 4). The head diameter ranged from 12.83 to 20.45 cm. The maximum head diameter (20.45 cm) was found in B_3 but B_3 is similar with B_4 (19.83 cm). Application of above 3 kg B/ha decreased the head diameter of cabbage. The lowest head diameter was also found in control (B_0). Alam (2007) reported that the maximum head diameter was observed at 4 kg B/ha followed by 3 kg B/ha but both are statically similar.

Table 5. Effect of B levels on growth and yield components of cauliflower.

Treatments	Plant spread (cm)	Plant height (cm)	Largest leaf length (cm)	Largest leaf breadth (cm)	No. of leaves /plant
B_0 = Control	52.40	42.23	40.43	18.70	16.93
B_1 = 1 kg B/ha	58.76	47.63	44.30	20.93	17.06
B_2 = 2 kg B/ha	61.66	49.40	46.23	22.33	19.36
B_3 = 3 kg B/ha	65.63	52.23	48.83	23.70	19.73
B_4 = 4 kg B/ha	64.53	53.46	49.13	22.93	20.80
B_5 = 5 kg B/ha	59.86	49.63	45.30	20.93	19.06
B_6 = 6 kg B/ha	57.56	47.40	42.23	19.33	18.36
LSD at 5%	3.05	3.11	2.83	1.96	2.06
CV (%)	7.18	3.12	5.43	5.53	4.84

In a column, figures having same letter(s) do not differ significantly by DMRT at the 5 % level.

Thickness of head

The thickness of head was influenced significantly by the application of B levels (Table 4). The head thickness ranged from 9.73 to 12.80 cm. The highest head thickness (12.80 cm) was recorded in B_3 but B_3 and B_4 are statistically similar. The lowest head thickness was also found in control (B_0). The head thickness increased gradually up to 3 kg B/ha and above this level, it was decreased gradually. The results are partially supported by Alam (2007).

Table 6. Effect of B levels on growth and yield components of cauliflower.

Treatments	Wt. of leaves (g)/plant	Wt. of curd (g)/plant	Diameter of curd (cm)	Height of curd (cm)	Gross yield (t/ha)	Curd yield (t/ha)	% Yield increase over control
B_0 = Control	328.33	617.83	15.66	12.83	46.47	22.36	-
B_1 = 1 kg B/ha	474.38	721.43	17.43	14.60	56.73	29.80	33.27
B_2 = 2 kg B/ha	542.73	888.53	18.86	15.06	63.43	35.40	58.31
B_3 = 3 kg B/ha	619.51	965.53	21.23	17.05	67.50	38.20	70.84
B_4 = 4 kg B/ha	577.53	894.30	20.46	16.73	65.46	37.16	66.18
B_5 = 5 kg B/ha	482.36	686.85	19.90	15.39	58.43	32.66	46.04
B_6 = 6 kg B/ha	395.96	512.56	17.76	13.63	50.53	28.34	26.74
LSD at 5%	72.29	55.70	1.63	0.88	3.83	1.73	-
CV (%)	8.13	6.20	5.46	4.36	8.05	6.11	-

In a column, figures having same letter(s) do not differ significantly by DMRT at the 5 % level.

Head weight

The head weight was influenced significantly due to the effects of boron levels (Table 4). The head weight ranged from 908 to1465 g. The highest head weight (1465 g) was obtained by the application of B_3 and the second highest in B_4 (1395 g) followed by B_2 (1254 g) but they are statistically similar. The lowest head weight of cabbage was found control plot. Application of above 3 kg B/ha gradually decreased the head weight of cabbage. Similar type of results was found by Alam (2007). He stated that the highest head weight was obtained by the application of 4 kg B/ha, followed by 3 kg B/ha but they are statistically similar.

Table 7. Effect of B levels on growth and yield components of carrot.

Treatments	Plant height (cm)	No. of leaves / plant	Wt. of shoot (g)	Length of root (cm)	Diameter of root (cm)	Wt. of root (g)
B_0 = Control	45.43	7.23	55.76	15.26	3.23	54.16
B_1 = 1 kg B/ha	49.23	7.86	58.26	17.70	3.96	62.66
B_2 = 2 kg B/ha	50.53	7.63	75.27	18.26	4.64	67.63
B_3 = 3 kg B/ha	51.46	8.83	75.83	19.10	4.85	68.30
B_4 = 4 kg B/ha	52.13	8.96	74.93	19.46	3.83	67.56
B_5 = 5 kg B/ha	48.23	8.15	63.76	16.30	3.70	59.30
B_6 = 6 kg B/ha	46.43	8.03	58.33	15.90	3.48	57.33
LSD at 5%	1.78	1.27	3.25	1.19	0.51	4.38
CV (%)	4.93	5.55	7.13	6.62	3.24	6.15

In a column, figures having same letter(s) do not differ significantly by DMRT at the 5% level.

Marketable head yield

Marketable head yield (t/ha) were frond to be significantly influenced by the application of B levels. The head yield ranged from 28.11 to 47.33 (t/ha). The maximum yield (47.33 t/ha) was recorded in the treatment B_3 and it is similar with B_4 (46.95 t/ha), while the minimum yield (28.11 t/ha) was observed in T_1 (control). The head yield was gradually increased with the increase of B levels up to 3 kg/ha and then decreases. Application of 1, 2 and 3 kg B/ha increased

the head yield by 37.32, 53.65 and 68.37 % respectively and maximum at 3 kg B/ha. The requirements of B fertilizer in vegetables are generally more than other corps. Rasp (1985) mentioned that the effect of added trace elements in 12 years of crop rotation in which potatoes and cereals were grown in alternate years. It was found that only B tended to increase potato yield. Porter *et al.* (1986) reported that the band application of B in a complete fertilizer was the most efficient technique and the tuber yield was not affected by application of less than 2.2 kg B/ha. They also showed that plants were stunted and yields reduced at application of grater than 4.5 kg B/ ha.

Effect of boron levels on growth and yield of cauliflower in calcareous soil

Plant spread

The plant spread of cauliflower was increased with the increases of B levels up to 3 kg B/ha.

Table 8. Effect of B levels on growth and yield components of carrot.

Treatments	Shoot yield (t/ha)	Root yield (t/ha)	% Yield increase over control
B_0 = Control	13.18	20.26	-
B_1 = 1 kg B/ha	15.38	24.13	19.10
B_2 = 2 kg B/ha	18.56	28.48	40.47
B_3 = 3 kg B/ha	18.40	28.66	41.46
B_4 = 4 kg B/ha	17.85	27.31	34.79
B_5 = 5 kg B/ha	16.21	25.63	26.50
B_6 = 6 kg B/ha	15.17	23.17	14.36
LSD at 5%	2.06	1.78	-
CV (%)	9.16	7.63	-

In a column, figures having same letter(s) do not differ significantly by DMRT at the 5% level.

The highest plant spread 65.63 cm was found at 3 kg B/ha and lowest in control. But the rate 3 and 4 kg are statistically similar.

Plant spread

The plant height of cauliflower was increased with the increases of B levels up to 4 kg B/ha. The highest plant height was found at 4 kg B/ha and lowest in control.

Leaf size

The largest leaf size like leaf length and breadth was significantly influenced by B levels. The biggest leaf size was found in B_4 and small size in control (B_0).

Leaves per plant

The number of leaves was increased gradually with B levels and maximum at 4 kg B/ha.

Leaves weight

The leaves weight of cauliflower was highest at 3 kg B/ha and lowest in control or 6 kg B/ha. Data showed that the vegetative growth of cauliflower was maximum by the application of 3-4 kg B/ha.

Curd weight

The edible curd weight per plant was recorded at harvest. Application of 3 kg B/ha gave the maximum curd weight per plant and the lowest weight in 6 kg B/ha.

Curd size

The curd size was measured at harvesting time. The biggest size of curd was observed when 3 kg B/ha as boric acid was applied and smallest in control plot.

Gross and curd yield

Gross yield or curd yield was measured in a unit plot and converted to kg/ha. The yield was gradually increased with the increase of B levels up to 3 kg/ha and then decreases. Application of 1, 2 and 3 kg B/ha increased the curd yield by 33.27, 58.31 and 70.84 % respectively over control (no B fertilizer). In table-6 showed that curd yields of cauliflower were

significantly reduced without B application in calcareous soils. The results are in agreement with the findings of Alam (2007). Alam *et al* (2010) showed that application of 3 kg B/ha increased (27.74 %) the bulb yield of onion over control.

Effect of boron levels on growth and yield of carrot in calcareous soil

Plant height

Application of B levels exhibited a significant influence on growth of plant height. The plant height was increased gradually up to 4 kg B/ha and then decreases gradually with B levels.

The maximum plant height (52.13 cm) was recorded at 4 kg B/ha followed by 3 kg B/ha (51.46 cm) but both are statistically similar and lowest in control.

Leaves per plant

Application of 4 kg B/ha produced the maximum number of leaves of carrot but B levels 0, 1 and 2 kg/ha are statistically apart.

Shoot weight

Application of 3 kg B/ha produced the maximum weight of shoot of carrot but 2, 3 and 4 kg B/ha are statistically similar.

Root length

The root length was significantly influenced by B levels. The maximum root length was found at 4 kg B/ha but 2, 3 and 4 kg B/ha is statistically atpar and lowest in control.

Root diameter

Maximum root diameter of carrot was found in 3 kg B/ha but 2 and 3 kg B/ha are statistically similar and lowest in 6 kg B/ha or control.

Root weight

Application of B levels exhibited a significant influence on root weight of carrot. The maximum root weight was found at 3 kg B/ha but 2, 3 and 4 kg B/ha are statistically similar and lowest in control.

Shoot yield

Application of B increased the dry matter content in carrot plants. The fresh shoot yield was significantly influenced by the application of different doses of B.

The maximum shoot yield 18.56 t/ha was obtained by 2 kg B/ha followed (18.40 t/ha) by 3 kg B/ha but both are statistically similar. The results are is partial agreement with the findings of Porter *et al.* (1986), Alam (2006), Alam (2007) and Alam *et al.* (2010).

Table 9. Effect of B levels on growth and yield components of potato.

Treatments	Plant height (cm)	No. of main stem /hill	Wt. of haulm (G/hill)	No. of tubers/hill	Shoot yield (t/ha)	Tuber yield (t/ha)	% Yield increase over control
B_0 = Control	39.96	2.90	43.00	6.13	3.33	19.33	-
B_1 = 1 kg B/ha	42.73	3.07	46.36	7.56	4.65	22.36	15.67
B_2 = 2 kg B/ha	44.83	3.46	49.33	8.46	4.93	24.33	25.86
B_3 = 3 kg B/ha	49.76	3.63	56.33	8.57	5.18	28.56	47.74
B_4 = 4 kg B/ha	50.66	3.66	57.96	8.69	5.33	29.19	51.00
B_5 = 5 kg B/ha	48.90	3.23	53.67	7.43	4.63	26.23	35.69
B_6 = 6 kg B/ha	46.33	2.83	45.33	7.19	3.36	24.46	26.56
LSD at 5%	1.18	0.21	2.35	0.51	0.36	1.72	-
CV (%)	6.33	3.35	5.24	2.06	1.20	7.12	=

In a column, figures having same letter(s) do not differ significantly by DMRT at the 5% level.

Root yield

Application of different doses of B influenced the yield of carrot. The root yield of carrot responded significantly to added boron up to 3.0 kg/ha, this dose gave an additional root yield of 41.46 % over control and decreased gradually with the increases of B level (>3.0 kg B/ha). The second highest but statistically similar root yield was found by the application of 2.0 kg/ha. The lowest yield (20.26 t/ha) was found when B was not applied. The finding are strongly supported by Hafiz Akter *et al.* (2001) and Pregno and Arour (1992).

Table 10. Effect of B levels on growth and yield components of radish**.**

Treatments	Plant height (cm)	No. of leaves/plant	Length of largest leaf (cm)	Breadth of largest leaf (cm)	Length of root (cm)	Diameter of root (cm)
B_0 = Control	39.16	16.23	36.65	9.36	23.56	9.26
B_1 = 1 kg B/ha	44.63	19.09	38.25	10.46	26.52	10.61
B_2 = 2 kg B/ha	48.25	23.36	41.33	10.97	28.87	11.27
B_3 = 3 kg B/ha	51.23	23.63	42.43	11.39	30.61	12.53
B_4 = 4 kg B/ha	51.46	24.13	42.14	11.33	29.40	13.02
B_5 = 5 kg B/ha	49.86	23.04	40.06	9.88	27.93	12.17
B_6 = 6 kg B/ha	46.51	22.75	38.11	9.23	26.11	11.64
LSD at 5%	2.03	1.34	0.92	0.40	1.31	0.67
CV (%)	6.75	5.37	8.34	1.39	6.16	4.35

In a column, figures having same letter(s) do not differ significantly by DMRT at the 5% level.

The results suggested that 2-3 kg B/ha (as boric acid) are applicable for carrot cultivation in calcareous or any upland soils of Bangladesh.

Effect of boron levels on growth and yield of potato in barind soil

Plant height

The plant height of potato responded significantly with B levels. The highest plant height was recorded at 4 kg B/ha but 3 and 4 kg B/ha showed statistically similar plant height.

Main stem per hill

The maximum and similar plant height was found by 1, 2, 3, 4 and 5 kg B/ha. Application of 5 kg B/ha decreased the plant than control.

Weight of haulm

The maximum weight of haulm per hill of potato by 4 kg B/ha but 3 and 4 kg B/ha are statistically similar.

Tubers per hill

The number of tubers per hill influenced significantly by B levels. It is maximum in 3 Kg B/ha and the lowest in control.

Shoot yield

The shoot yield was increased up to 4 kg B/ha and then decreases gradually with B rate. Application of 5 kg B/ha significantly decreased the shoot yield than 4 kg B/ha. It indicates the stunted growth or toxicity of potato plants.

Tuber yield

Application of B levels exhibited a significant influence on tuber yield of potato. The maximum tuber yield (29.19 t/ha) was observed by 4 kg B/ha followed by 3 kg B/ha but both are statistically similar.

This result is directly supported by Alam (2007). Application of 1, 2, 3, 4, 5 and 6 kg B/ha increased the tuber yield by 15.67, 25.86, 47.74, 51.00, 35.69 and 26.56 % respectively than control.

Effect of boron levels on growth and yield of radish in barind soil

Plant height

The plant height was significantly influenced to B levels. Application of B increased the plant height and maximum (51.46 cm) at 4 kg B/ha followed by 3 kg B/ha (51.23 cm) both are statistically similar.

Leaves per plant

The number of leaves was increased by application of B fertilizer. The highest number (24.13) of leaves of radish was found at 4 kg B/ha but the rate 2-5 kg/ha responded similar number of leaves. The lowest number of leaves was found in control.

Leaf size

The leaf area was measured at harvesting time. The largest leaf size like leaf length and breadth was influenced significantly by B levels. The biggest leafsize was found at 3 kg B/ha.

Table 11. Effect of B levels on growth and yield components of radish in Barind soil.

Treatments	Fresh Wt. of Leaves (g)/plant	Fresh Wt. of root (g)/plant	Root Yield (t/ha)	Root Yield (t/ha)
B_0 = Control	244.6	413.6	44.24	-
B_1 = 1 kg B/ha	300.3	518.7	50.57	14.31
B_2 = 2 kg B/ha	330.5	674.8	56.84	28.48
B_3 = 3 kg B/ha	351.2	697.3	65.95	49.07
B_4 = 4 kg B/ha	356.2	703.5	67.16	51.80
B_5 = 5 kg B/ha	281.6	662.4	56.05	26.69
B_6 = 6 kg B/ha	260.3	555.0	50.23	13.53
LSD at 5%	36.8	62.4	3.14	-
CV (%)	8.11	10.27	11.21	-

In a column, figures having same letter(s) do not differ significantly by DMRT at the 5% level.

Root length

The root length was significantly influenced by B levels. The maximum root length was found at 3 kg B/ha but 2, 3 and 4 kg B/ha are statistically at par and lowest in control.

Root diameter

Maximum root diameter was found in 4 kg B/ha but 2, 3 and 4 kg are statistically similar.

Leaves weight

The weight of leaves was increased up to 4 kg B/ha and then decreases gradually with B rate. Application of 5 kg B/ha significantly decreased the leaves weight than 4 kg B/ha. It indicates that the stunted growth or toxicity of plants is also found.

Root weight

Application of B levels exhibited a significant influence on root weight of radish. The maximum root weight was obtained at 4 kg B/ha but 2-4 kg B/ha is statistically similar.

Root yield

Application of B levels exhibited a significant influence on root yield of radish. Boron was highly influenced on root yield. The maximum yield (67.16 t/ha) was observed by 4 kg B/ha followed by 3 kg B/ha (65.95 t/ha) but both are statistically similar. Application of 1, 2, 3, 4, 5 and 6 kg B/ha increased the additional root yield than control. The results suggested that 3 kg B/ha (as boric acid) are applicable for radish cultivation in Barind or any upland soils of Bangladesh. The results are directly agreed with Alam (2007) and partial supported by Hafiz Akter *et al.* (2001) and Pregno and Arour (1992).

Conclusion

The application of boron fertilizer significantly enhanced the growth and yield of various vegetable crops. The findings reveal that the appropriate level of boron application, particularly 3 kg B/ha, resulted in substantial yield increases over the control. The highest yield advantages were observed in cabbage (68.32%), cauliflower (70.84%), potato (47.74%), and radish (49.07%). For carrot, the maximum root yield was achieved at 2 kg B/ha, with a notable increase of 40.47% over the control.

These results underscore the critical role of boron in maximizing vegetable crop production in upland soils of Bangladesh. The data indicate that a boron application rate of 2 kg B/ha is optimal for low-yielding crops, while 3 kg B/ha is recommended for high-yielding vegetables. The study also highlights the negative impact of excessive boron application, with rates exceeding 5 kg/ha leading to reduced growth and potential toxicity.

Overall, the findings emphasize the need for precise boron management to achieve sustainable and enhanced crop productivity, offering valuable insights

for agricultural practices in regions with similar soil and environmental conditions.

References

Alam MN. 2007. Effect of boron levels on growth and yield of cabbage in calcareous soils of Bangladesh. Research journal of agriculture and biological sciences **3(6),** 858-865 p.

Alam MN. 2006. Effect of vermicompost and some chemical fertilizers on yield and yield components of selective vegetable crops. Ph.D. Thesis, Faculty of Agriculture, University of Rajshahi, Bangladesh. 122-176 p.

Alam MN, Abedin MJ, Azad MAK. 2010. Effect of micronutrients on growth and yield of onion under calcareous soil environment. International Research Journal of Plant Science **1(3),** 56-61 p.

Alam MS, Latif MA, Shahidullah SM, Ashrafuzzman M. 1999. Effect of Sulphar, Zinc, Boron and Molybdenum on yield, yield components and protein content of wheat. Progressive Agriculture **10(1&2)**, 83-86 p.

Ali MA, Islam Malik MF, Karim MA, Monir MA, Karim MR. 2001. Effect of added boron on the yield of papaya in High Ganges River Floodplain soil. Bangladesh Journal of Agricultural Science **28(2),** 205-208 p.

Azad AK. 2000. Effects of plant spacing, source of nutrients and mulching or growth and yield of Cabbage. An M.S. Thesis. Dept. of Hort., Bangladesh Agril. Univ. Mymensingh. 15-40 p.

Efkar A, Jan N, Kharttak SG, khattak MJ, Ahmad E. 1995. Potato yield as affected by boron fertilizer mixing with and without farm yard manure. Sarhad Journal of Agriculture **11(6),** 725-728 p.

FAO (Food and Agriculture Organization). 1988. Land resources appraisal of Bangladesh for Agricultural Department. Rep. 2. Agro-ecological regions of Bangladesh. UNDP, FAO, Rome, p 116.

Hafiz Akter AKM, Mamun AA, Altaf Hossain SM, Moula MG, Biswas M. 2001. Effect of sowing date and Boron fertilization on the performance of wheat. Bangladesh Journal of Agricultural Science **28(2),** 317-322 p.

Hossain SMF, Sattar MA, Rahman MH, Islam MR. 1999. Effect of fertilizers and manures on yield ecology and managment of wheat at old Brahmaputra floodplain soil. Bangladesh Journal of Environmental Science **(5),** 179-185 p.

Hunter AH. 1984. Soil fertility and analytical services in Bangladesh. Agricultural Research Project Phase II. BARC, Dhaka.

Islam MS, Alam MS, Alam MN, Rahman MA. Ali MK. 2009. Effect of boron on the yield performance of wheat varieties. Journal of the Bangladesh Society for Agricultural Science and Technology **3(3 & 4),** 165-170 p.

Kadir MA. 2002. Effect of different nutrients on growth and yield of broccoli. M. S. Thesis. Dept of Hort. BAU, Mymensingh. 25-35 p.

Khanam R, Arefin MS, Haque MA, Jahiruddin M. 2000. Effect of Mg, B and Mo on the growth, yield and protein content of chickpea and Lentil. Progressive Agriculturists **11(1&2),** 77-80 p.

Maurya KR, Singh BK. 1985. Effect of boron on growth, yield, protein and ascorbic acid content of Radish. Indian Journal of Horticulture **42(3 & 4),** 201-203 p.

Mishra HP. 1992. Effect of nitrogen its time of application and boron on cauliflower seed production in calcareous soil, Indian Journal of Horticulture **(49),** 83-86.

Nelyubova GL, Mukha NA, Mazepova KV. 1972. The sensitivity of carrots to boron under different levels of nitrogen nutrition **(169),** 89-94 p.

Noor S, Farid ATM, Shil NC, Hossain AKM. 2002. Integrated nutrient management for cauliflower. Bangladesh Journal of Environmental Science **(8),** 25-30 p.

Panigrahi UC, Phauhan NB, Das C. 1990. A note on the effect of micro-nutrient on yield cauliflower seeds in acid red soil of Orissa. The Orissa Journal Of Horticulture **18(1-2),** 62-64 p.

Porter GA, Morrow LS, Murphy HJ. 1986. Boron fertilization of Katahdin potatoes under acid soil conditions. American Journal of Potato Research **63(8),** 448 p.

Pregro LM Arour AJD. 1992. Boron deficiency and toxicity in potato cv. Sevago on an oxisol of the Atherton, North Queensland. Australian Journal of Experimental Agriculture **32(2),** 251-253 p.

Protch S, Islam MS. 1984. Nutrient status of some of the more important Agricultural soils of Bangladesh. In: Proc. Int. Cong. Mtg. Common. IV, International Union of Soil Sciences 97-105 p.

Quaggio JA, Ramos VJ. 1986. Potato response to lime and boron application. Revista Brasileira De Ciencia Dosolo. **10(3),** 247 p.

Russel DF. 1996. MSTAT-C. Package Programme. Dept. of Crop and Soil Sci. Michigan State Univ, USA.

Sarker MY, Begum F, Hasan MK, Raquibullah SM, Kader MA. 2003. Effect of different source of Nutrients and Mulching on growth and yield contributing characters of cabbage. Asian Journal of Plant Sciences **2(2),** 175-179 p.

Sarker NI, Zaman S, Islam MS, Islam MB, Mannaf MA. 1996. Effect of fertilizers alone and in combination with cowdung on the growth and yield of potato. Bangladesh Journal of AgricultureScience **21(1),** 275-282 p.

Singh A, Singh BB, Patel CS. 1992. Response of vegetable pea (*Pisum Sativum*) to Zn, B and Mo in an acid Alfisol of Meghalaya. Indian Journal of Agronomy **37(3),** 615-616 p.

Singh KP, Sinha H. 1975. Fixation of Boron in relation to certain soil properties. Journal of the Indian Society of Soil Science **(23),** 227-230 p.

Sohel MM, Islam MA, Das AC, Mondal MF. 2006. Effects of potassium and boron on the growth and yield of broccoli. Journal of the Bangladesh Society for Agricultural Science and Technology **3(3&4),** 49-52 p.

Szmit B. 1980. Principles of fertilizing Nantes carrots, grown stecklings and seed, with major and minor elements. VI. Fertilization with boron. Biuletyn warzywniczy. **24,** 205-522, Cited from Hort Abst. **53(11),** 777 p.

Talukder ASMHM, Nabi SM, Shaheed MMA, Karim MR, Goffar MA. 2000. Influence of S, B, and Mo on cauliflower in grey terrace soils. Bangladesh journal of Agricultural Research **25(3),** 541-546 p.

Talukder ASMHM, Nabi SM, Anwar MN, Shaheed MMA, Ara MA. 2001. Influence of Zn, B, and Mo on papaya in grey terrace soil. Bangladesh journal of Agricultural Research **26(4),** 471-478 p.

Thakur OP, Sharma PP, Singh KK. 1991. Effect of N and P with and without B on curd yield and stalk rot incidence of cauliflower. Vegetable Science **18(2),** 115-121 p.

Tisdale SL, Nelson WL, Beaton JD, Havlin JL. 1995. Soil Fertility and Fertilizers (5th Ed.). Printice Hall of India Pr. Ltd., **32,** 301-342 p.

Troeh HR, Thompson LM, 1993. Soils and soil Fertility (5th Ed.). Oxford University Press. 271-273 p.

Wang-Xiude D, Wang FT, Liao ZX, Yung J. Mao P. 1996. Study on formula selection and rational application amount of organic, inorganic granular fertilizer for some vegetable species. Acta Agriculture Shanghai 12**(1),** 61-65 p.