EFFECTS OF BORON APPLICATION ON YIELD AND QUALITY OF BITTER GOURD

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Abstract

Boron (B) is a micronutrient which has remarkable role on flowering and fruiting of crops. This element deficiency (B) arises in Bangladesh soils and is prominent in dryland crops. With this idea the effect of boron (B) application on yield and quality of bitter gourd *(Momordica charantia)* was studied through an experiment at the research field of Soil Science Division of Bangladesh Agricultural Research Institute (BARI), Gazipur (AEZ-28) during kharif-I 2023 season (mid of March to mid of July). The main objective was to determine the optimum level of B for maximizing the yield and quality of bitter gourd (cv. BARI Karola-4). Five treatments with and without B were imposed: T_1: Control, T_2: Recommended Dose of Fertilizers (RDF), T_3: 1 kg B ha^{-1} + RDF, T_4: 1.5 kg B ha^{-1} + RDF and T_5: 2 kg B ha^{-1} + RDF. The source of B was boric acid (H_3BO_3) having 17% B. The common fertilizers were applied at a rate of 102-20-42-10-0.5 kg $ha^{-1}$of N-P-K-S-Zn in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively. Design of the experiment was randomized complete block design (RCBD) with three replications of each treatment. The yield and yield contributing characters of bitter gourd were significantly and positively influenced by B application. All yield parameters showed higher results in T_4 treatment (1.5 kg B ha^{-1}+ RDF) except flower shedding which was rather positive as this treatment resulted in the lowest flower shedding. The highest fruit yield (23.4 t ha^{-1}) was observed in the same treatment i.e. T_4 and it was significantly higher than in control plots. The concentration as well as uptake of nutrients in bitter gourd was also influenced by boron fertilization. Except K uptake, all other nutrient uptake was the maximum in the same T_4 treatment. Hence, it was concluded that application of boron at 1.5 kg B ha^{-1} found effective for reducing flower shedding and obtaining better yield and quality of bitter gourd.

Keywords: Boric acid, Flower shedding, Nutrient uptake, Fruit quality, Fruit yield

1. Introduction

Bitter gourd *(Momordica charantia)* is used as vegetables. This fruit ranks first among the cucurbits in respect of iron and ascorbic acid (vit. C). It also contains proteins, fats,

minerals, carotein, thiamine, riboflavins and very rich in phytonutrients like anti-oxidants. The alkaloid momordicasoides imparts the bitter taste to the fruit. Bitter gourd has a high nutrient requirement such as nitrogen, phosphorus, potash, zinc and boron. Bitter gourd fruit yield has been set aside by the deficiency of micronutrients, which leads to certain physiological disorders. Bitter gourd is a monoecious crop, where male and female flowers borne on the same plant. The production of staminate flower is normally much more than pistillate flowers ultimately only pistillate flowers contribute to the yield (Vala and Savaliya, 2014). During the plant growth period, micronutrients play various roles in physiological and biochemical processes and among those nutrients, B is a vital element which is involved in flowering and fruiting of the plant. So, this element deficiency causes floral deformities inducing male bareness (Nonnecke, 1989). Boron deficiency affects the growing points of roots and youngest leaves and it functions in the growth of cells in newly emerging shoots and roots while in some plants it is crucial for boll formation, flowering, pollination, seed development and sugar transport (Takano *et al.,* 2008; Miwa *et al.,* 2008). Boron deficiency plays a significant role in yield reduction of many vegetables, including bitter gourd due to premature flower, square or boll shedding.

Bitter gourd is a very popular vegetable in Bangladesh and its yield maximization is a major concern of local farmers. Information of the effect of B on major crops is although available in Bangladesh, while work on vegetables like bitter gourd is scanty. Bitter gourd is an important vegetable, and balanced supply of B for its cultivation is a must. Therefore, this study was planned to determine the effect of B on flower set and yield of bitter gourd, and to find out the optimum dose of B application for maximizing the yield and quality of bitter gourd.

2. Materials and Methods

2.1 Experimental site and soil characteristics

A field experiment was conducted at the experimental field of Soil Science Division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during 2023 kharif-I season. The experimental site falls under the agro-ecological zone Madhupur Tract (AEZ-28). Initial soil samples were collected from 0-15 cm depth and analyzed prior to application of different fertilizers. Texturally the soil was sandy clay loam, having 6.7 pH (1:2.5 soil-water ratio), 1.46% organic matter, 0.08% total N, 11 ppm Olsen-P, 0.11 me% NH_4OAc extractable (exchangeable) K, 15 ppm CaCl2 extractable S and 3.2 ppm DTPA extractable Zn. The status of hot water-soluble soil B was low, 0.18 ppm. Chemical analysis of soil was done following the method and procedure as outlined by Page *et al.* (1982).

2.2 Treatments and design

Treatments combinations were T_1: Control, T_2: recommended dose of fertilizers (RDF), T_3: 1 kg B ha^{-1} + RDF, T_4: 1.5 kg B ha^{-1} + RDF and T_5: 2 kg B ha^{-1} + RDF. The experiment was laid out in a RCB design, with three replications of each treatment. The unit plot was 2m × 1.5m in size. The common fertilizers were applied at the rate of 102-20-42-10-0.5 kg ha^{-1} of N-P-K-S-Zn in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively. Boron was applied as boric acid (H_3BO_3) containing 17% B. Basal application was made with 5 t ha^{-1} cowdung. The entire amount of cowdung and all P, K, S, Zn and B were applied at the time of sowing as basal dose. N was applied around the plant as side dressing in six splits (1st split was applied during transplanting, while 2nd, 3rd, 4th, 5th and 6th splits were applied with irrigation when necessary).

2.3 Experiment set up

BARI Karola-4 variety was used in the experiment. Before sowing the seeds were soaked in water for 24 hours to enhance germination. Then water was taken off and seed mass was covered with a wet cloth until seed is cracked. Then the seeds were placed into polybags after the seed cover cracked. When the seedlings were 8-10 cm long, seedlings were planted in the pit. Seeds were sown on 26 January 2023 in polybag. Seedlings were transplanted on 20 February, 2023 with a spacing of 1.5m from row to row and 2m from plant to plant. When the seedlings became 15-20 cm long, bamboo sticks were put into the ground. Irrigation was done during the growing period to keep the soil moist. Pheromone traps were used after the 1st week of transplanting in the field and it was changed after 50-60 days. Intercultural operations were done as and when required. Fruits were harvested at maturity stage. Harvested fruits were selected from each plot for recording necessary yield and yield component data. The data included number of flower sheds, fruit length (cm), fruit weight (g), fruit diameter (cm), and fruit yield (t ha^{-1}) and also vit. C and TSS.

Fruit N, P, K & B was determined by acid digestion, H_2SO_4 for N and HNO_3-$HClO_4$ (3:1) for P, K & B. Vit. C and TSS were also determined by standard methods. Total soluble solid (TSS) was measured with a digital hand refractometer and reported as Brix. Vitamin C was determined by classical titration method using 2, 6- dichlorophenol indophenols solution and expressed as 100 mg g^{-1} of fresh weight (Ranganna, 1995).

2.4 Statistical analysis

Data were analyzed by STATISTIX-10 program and means were compared by multiple comparison test using LSD (Statistix for Windows, 1998).

3. Results and Discussion

3.1 Effects of boron on the flowering of bitter gourd

Significant variation was observed among the treatments showing higher number of female flowering and decreased flower shedding (Table 1). The maximum number of female flowers was recorded in T_4 treatment containing 1.5 kg B ha^{-1} + NPKS fertilizers (70.9 $plant^{-1}$) which was identical with T_5 (69.6 $plant^{-1}$), followed by T_3 (64.9 $plant^{-1}$) and T_2 (60.6 $plant^{-1}$). The lowest number of female flowers was noted in control (45.2. $plant^{-1}$) treatment. Increased number of female flowers in bitter gourd with added B was also reported by Fozia *et al.* (2018) and Karthick *et al.* (2018). The number of flower shedding $plant^{-1}$ also significantly differed with the treatments. The minimum number of flower shedding (38.9) was found in T_4 treatment while the maximum number was observed in T_1 (79.2 $plant^{-1}$) treatment. The highest decrease in flower shedding was recorded in T_4 (50.9%) treatment leading to higher number of flower set. The percent decrease in flower shedding due to B treatment was the maximum in the study of Sultana *et al.* (2017).

Table 1. Effects of B on the flowering of bitter gourd

Treatments	No. of female flowers $plant^{-1}$	No. of flower sheds $plant^{-1}$	Decrease in flower shedding (%)
T_1: Control	45.2c	79.2a	-
T_2: RDF	60.6b	63.9b	19.3
T_3: 1.0 kg B ha^{-1} + RDF	64.9ab	53.9c	32.0
T_4: 1.5 kg B ha^{-1} + RDF	70.9a	38.9d	50.9
T_5: 2.0 kg B ha^{-1} + RDF	69.6a	40.9d	48.4
CV (%)	5.80	5.79	

Values of a column followed by the same letters are not significantly different at 5% level of significance. RDF = Recommended dose of fertilizers (NPKS)

3.2 Effects of boron on the yield components and yield of bitter gourd

Influence of boron treatment on the yield components and yield of bitter gourd were shown in Table 2. The number of fruits $plant^{-1}$ ranged 42.9 - 68.9, the maximum value was observed in T_4 treatment having 1.5 kg B ha^{-1} along with usual NPKS dose which however was identical with T_5 (67.2), followed by T_3 (63.2) and T_2 (60.9) treatment. The longest fruit was documented in T_4 (17.5 cm) followed by T_5 (16.2 cm), T_3 (15.6 cm) and T_2 (13.5 cm) treatment. Fruit diameter ranged from 4.05 cm to 4.61 cm, the maximum diameter being in

T_4 (4.61 cm) and followed by T_5 (4.51 cm), T_3 (4.44 cm) and T_2 (4.27 cm) treatment. Bharati et al. (2018) noticed increased fruit length, girth and weight in their studies. Significant variations were also observed in case of individual fruit weight. The maximum value was found in T_4 (104 g) which was identical with T_5 (103 g) and followed by T_3 (99 g), T_2 (94.2 g) treatment. The lowest value was noted in control treatment (89.2 g). Fruit weight (kg plant^{-1}) ranged from 2.87 kg to 6.26 kg, the maximum value being observed in T_4 which was followed by T_5 (5.98 kg), T_3 (5.35 kg) and T_2 (4.81 kg) treatment. Significant variation was also found in total yield (t ha^{-1}) of bitter gourd. The highest yield was obtained in T_4 (23.4 t ha^{-1}) which was followed by T_5 (22.5 t ha^{-1}), T_3 (20.4 t ha^{-1}) and T_2 (18.6 t ha^{-1}) treatment. The lowest yield was identified in T_1 (12.1 t ha^{-1}). It was clearly noticed that T_4 was the best treatment that was the combination of 1.5 kg B ha^{-1} + NPKSZn. Added boron compared to control increased yield that was mentioned by several researchers (Fozia *et al.,* 2018; Ashraf *et al.,* 2020; Bharati *et al.,* 2018).

Table 2. Effects of B on the yield components and yield of bitter gourd

Treatments	No. of fruits plant^{-1}	Length of fruit (cm)	Fruit dia. (cm) fruit wt.	Individual Fruit wt./ (g)	Fruit wt./plant (kg)	Fruit yield (t ha^{-1})
T_1: Control	42.9c	11.4c	4.05b	89.2c	2.87d	12.1d
T_2: RDF	60.9b	13.5bc	4.27ab	94.2bc	4.81c	18.6c
T_3: 1.0 kg B ha^{-1} + RDF	63.2ab	15.6ab	4.44ab	99.0ab	5.35bc	20.4bc
T_4: 1.5 kg B ha^{-1} + RDF	68.9a	17.5a	4.61a	104.0a	6.26a	23.4a
T_5: 2.0 kg B ha^{-1} + RDF	67.2a	16.2ab	4.51ab	102.5a	5.98ab	22.5ab
CV (%)	5.10	11.8	6.46	4.06	7.11	6.17

Values of a column followed by the same letters are not significantly different at 5% level of significance. RDF = Recommended dose of fertilizers (NPKS)

Fruit dry yield, nutrient content and uptake of N, P, K, Zn and B, were presented in Tables 3 and 4. Significant differences were observed in those plant parameters. The highest dry yield was recorded in T_4 (2228 kg ha^{-1}) which was followed by T_5 (2144 kg ha^{-1}), T_3 (1953 kg ha^{-1}) and T_2 (1790 kg ha^{-1}), and the lowest value was noted in T_1 i.e. Control (1202 kg ha^{-1}) treatment. The B concentration of fruit 44-58 ppm that together with fruit yield resulted in the maximum B uptake (1255 kg ha^{-1}) in T_4 treatment which was similar with T_5 (1244 kg ha^{-1}). The Zn concentration of fruit increased by the application of B to a certain level then its concentration decreased with higher rate of B application. Zn concentration varied from 46

to 56 ppm that also resulted in the maximum Zn uptake for the T_4 treatment (0.125 kg ha^{-1}). The lowest Zn uptake was recorded as 0.056 kg ha^{-1}.

The effect of B on the concentration of N, P, and K showed that added B increased the concentration of P and K in bitter gourd fruit, but the increment was not significant. The minimum N (3.46%) and P concentrations (0.41%) were found in control treatment while the maximum N concentration (3.71%) was found in T_5 and the maximum P (0.473%) was found in T_4 treatment. The N uptake by fruit was reached to the peak in T_4 (82.3 kg ha^{-1}) treatment which was identical with T_5 (79.6 kg ha^{-1}). The P conc. (%) was found to lie in between 0.410% and 0.473% that also reflected in P uptake by fruit kg ha^{-1} limiting between 4.91 kg ha^{-1} and 10.55 kg ha^{-1}. The K conc. (%) was the highest in T_5 (2.90%) and there was no significant difference between the treatments. The K uptake by fruit was the top in T_5 treatment (62.2 kg ha^{-1}) which however was identical with T_4 (61.6 kg ha^{-1}), T_3 and T_2 treatments. The present findings indicated that up to a certain level of B application to soil, plant N P, K, Zn and B content showed synergistic relationship.

Table 3. N, P and K content and uptake in bitter gourd fruit

Treatments	N conc. (%)	P conc. (%)	K conc. (%)	N uptake by fruit (kg ha^{-1})	P uptake by fruit (kg ha^{-1})	K uptake by fruit (kg ha^{-1})
T_1: Control	3.46b	0.410	2.48	41.6d	4.91d	29.8b
T_2: RDF	3.58ab	0.433	2.63	64.1c	7.77c	47.2a
T_3: 1.0 kg B ha^{-1} + RDF	3.65ab	0.440	2.78	71.3bc	8.55bc	53.8a
T_4: 1.5 kg B ha^{-1} + RDF	3.69ab	0.473	2.75	82.3a	10.55a	61.6a
T_5: 2.0 kg B ha^{-1} + RDF	3.710a	0.450	2.90	79.56ab	9.64ab	62.21a
CV (%)	4.45	8.66	7.87	7.33	8.37	9.21

Values of a column followed by the same letters are not significantly different at 5% level of significance. RDF = Recommended dose of fertilizers (NPKS)

Table 4. Nutrient content and uptake of Zn and B in bitter gourd fruit

Treatments	Fruit dry yield (kg ha^{-1})	Zn conc. (ppm)	B conc. (ppm)	B uptake by fruit (g ha^{-1})	Zn uptake by fruit (g ha^{-1})
T_1: Control	1202d	46c	44c	53.0d	56d
T_2: RDF	1790c	50bc	48bc	86.0c	90c
T_3: 1.0 kg B ha^{-1} + RDF	1953bc	52ab	52ab	101.9b	100bc
T_4: 1.5 kg B ha^{-1} + RDF	2228a	56a	56a	125.5a	125a
T_5: 2.0 kg B ha^{-1} + RDF	2144ab	53ab	58a	124.3a	114ab
CV (%)	5.84	4.77	7.44	7.37	7.70

Values of a column followed by the same letters are not significantly different at 5% level of significance. RDF = Recommended dose of fertilizers (NPKS)

The minimum Zn content was observed in control while the maximum Zn content was found with higher dose of B in the study of Sultana *et al.* (2017) which also indicated that at certain level of B in soil, Zn and B showed synergism. They also observed that B application increased the concentration of N and P in bitter gourd insignificantly. They again cited that relationship between B and K was synergistic having coinciding role in physiological approaches.

3.3 TSS and vitamin C content of bitter gourd

Quality characters such as Vit. C and TSS (0Brix) of bitter gourd have been depicted in Table 5. Vit. C ranged from 62.1 mg 100g^{-1} to 71.3 mg 100g^{-1}, the maximum value recorded in T_4 which was identical with T_5 (70.2 mg 100g^{-1}) which was followed by T_3 (68.3 mg 100g^{-1}), T_2 (65.7 mg 100g^{-1}) and T_1 (62.1 mg 100g^{-1}) treatment but they were statistically similar (Table 5). The maximum TSS was recorded in T_4 (3.97), followed by T_5 (3.70), T_3 (3.40) and T_2 (3.27) treatments. Vit. C and TSS were found to increase with B application in the study of Bharati *et al.* (2018). Ashraf *et al.* (2020) reported the maximum amount of TSS with B treatment. The highest TSS content in fruit was obtained with all micronutrients which might be due to higher conc. of N, P, K and micronutrient in leaves and fruits, which might have boosted the accumulation of assimilates resulting in better quality for bitter gourd (Meenakshi *et al.,* 2007).

Table 5. Quality characters of bitter gourd fruit as influenced by different B levels

Treatments	Vit. C (mg/100g)	TSS (0Brix)
T_1: Control	62.05b	3.10c
T_2: RDF	65.74ab	3.27bc
T_3: 1.0 kg B ha^{-1} + RDF	68.29ab	3.40bc
T_4: 1.5 kg B ha^{-1} + RDF	71.28a	3.97a
T_5: 2.0 kg B ha^{-1} + RDF	70.19a	3.70ab
CV (%)	5.90	7.11

Values of a column followed by the same letters are not significantly different at 5% level of significance. RDF = Recommended dose of fertilizers (NPKS)

4. Conclusions

Application of B enhanced fruit length (cm), fruit weight (g), fruit diameter (cm), fruit yield (t ha^{-1}), vit. C and TSS, and decreased flower shedding in bitter gourd. The highest yield (23.4 t ha^{-1}) was observed in T_4 (1.5 kg B ha^{-1} + RDF) and it was significantly higher than control plants. The maximum lowering of flower shedding (50.9%) was also observed in the same treatment. Nutrient concentration and uptake in bitter gourd were also influenced by B treatment. It was, therefore, concluded that 1.5 kg B ha^{-1} + NPKSZn (RDF) application could be used to obtain higher yield and quality of bitter gourd.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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