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GROWTH TRAITS AND BEET WEIGHT OF TROPICAL SUGAR BEET RESPONSES TO FOLIAR APPLICATION OF BORON

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The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to assess the response of foliar application of boron on growth and beet weight. The experiment consisted of foliar application of boron at four concentrations *viz.* 0, 50, 100 and 150 ppm, and frequency of application thrice *viz.* once at 40 days after emergence (DAE), twice at 40 and 65 DAE and thrice at 40, 65 and 90 DAE. The experiment was laid out in a randomized complete block design with three replications. Growth traits and average beet weight were significantly influenced by boron concentration and frequency of application. At later stage of growth (at 140 days after sowing) the tallest plant, number of leaves/plant, shoot dry weight, root dry weight and root length were recorded in 150 ppm boron with three times foliar application at 40, 65 and 90 DAE. The highest average beet weight (1.04 kg/beet) was recorded in 150 ppm boron with foliar application thrice at 40, 65 and 90 DAE followed by 100 ppm boron with foliar application at 40, 65 and 90 DAE while the lowest one 0.28 kg/beet was found in control. So, from the result it can be concluded that 150 ppm boron with foliar application at 40, 65 and 90 DAE seems to be promising in terms of growth attributes and average beet weight/plant of tropical sugar beet.

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INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is a biennial root crop which develops leaf rosette and a beet in the first year and then flowers in the second year. Sugar reserves are stored in the sugar beet root during the first growing season for an energy source during overwintering. The roots are harvested for sugar at the end of the first growing season. Sugar beet is a crop of temperate region but now-a-days this crop is successfully grown in tropical and subtropical countries during the winter season. Sugar beet is one of the most important sugar crops worldwide which provides 30% of the world's sugar (Dom et al., 2014; Paul et al., 2018). According to FAO (2021), sugar beet covers 4.61 million ha and produced 278.50 million tons sugar in the world where production share of sugar beet by region are Europe (69.8%), Asia (14.9%), Americas (10.1%) and Africa (5.1%) in the year 2019. In Bangladesh, sugar beet is a newly introduced crop which has been successfully grown with some challenges (Bithy et al., 2020). Sugar beet seems to be an encouraging sugar crop due to its short duration, less requirement of water, higher yield and high sucrose content compared to sugarcane.

Boron participates in the carbohydrate metabolism, directly influencing plant development and indirectly affecting the efficiency of photosynthesis (Cakmak and Römheld, 1997). The main symptoms of B deficiency in sugar beet include death of the growing point and develop secondary buds in the root neck with development of a black rottenness at the heart (called heart disease) of the root (Blevins and Lukaszewski, 1998). Boron requirement of sugar beet is higher compared to other field crops (Tlili et al., 2018). Continuous supply of B for the plant development is required (Gupta, 1979). Production and translocation of sugars are linked to actively growing parts and developing roots of sugar beet (Barker and Pilbeama, 2007). Foliar application of boron lead to higher yield and better quality compared to the time using boric acid in soil. Bithy et al. (2020) reported that increased rate and frequency of foliar application of boron suppressed crown rot incidence and enhanced beet yield and juice quality. Spraying sugar beets with 0.5 kg B/ha increased the concentration of boron in leaves of sugar beet and led to higher yields (Dordas et al., 2007). Enan et al. (2016) observed that foliar application of 100 ppm boron increased beet weight/plant, beet and sugar yields, and boron contents in leaves and roots at harvest. Foliar application of boron @ 0.20 to 0.25 g L^{-1} increased beet yield and juice quality when applied twice at 80 and 110 days after planting (Abbas et al., 2014). The above results support that foliar application of boron influence the performance of sugar beet. Therefore, this study was undertaken to evaluate the effects of different concentrations and application times of boron on vegetative and quantitative aspects of sugar beet grown in Old Brahmaputra Floodplain soil of Bangladesh.

MATERIALS AND METHODS

Experimental Site and Experimentation

The research work was done at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, Bangladesh. The experimental site (24°75' N latitude and 90°50' E longitude at an elevation of 18 m above the sea level) belongs to the Old Brahmaputra Floodplain Agro-ecological Zone (AEZ-9) having non-calcareous dark gray floodplain soils (UNDP and FAO, 1988). The experimental plot is medium high land having silty-loam texture with pH 6.9, EC (electrical conductivity) 0.4 ds/m, OC (organic carbon) 1.00%, N 0.09%, P 1.60 ppm, K 0.10% meq/100g soil, Ca 8.30 meq/100 g soil, Mg 3.29 meq/100 g soil, S 2.98 ppm, Zn 0.21 ppm and B 0.23 ppm. The experimental area was under the sub-tropical climate with temperature 12.16°C to 31.69 °C, relative humidity 67.76 % to 83% and total rainfall 0.00 mm to 66.80 mm during experimentation. The experiment comprised four foliar application of boron concentrations viz. 0 ppm (B_0) 50 ppm (B_1), 100 ppm (B_2), 150 ppm (B_3) and three application times viz. once at 40 days after emergence (T_1), twice at 40 and 65 days after emergence (T_2) and thrice at 40, 65 and 90 days after emergence (T_3). The experiment was laid out in a factorial randomized complete block design with three replications. The size of the unit plot was 5.0 m^2 (2.5 m × 2.0 m). The distance between two adjacent plots was 0.5 m and plant to plant distances was 0.2 m.

Crop Husbandry

The land was fertilized with urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate @ of 260, 100, 225, 100 and 10 kg ha^{-1}, respectively. One third urea, total amount of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied at final land preparation and mixed well with soil. Two-third urea was applied in two equal splits at 40 and 70 days after sowing (DAS). Tropical sugar beet variety 'KWS Allayana' was used as test crop for the study. Seeds were sown on 23 November 2018 (after soaking in water) in rows on the ridge with 50 cm × 20 cm spacing @ two seeds $hill^{-1}$ for protecting the germination failure two seeds were placed in a hill on the ridge of the experimental plot. Some seeds were broadcasted separately by the side of the experimental field for necessary gap filling operation. Intercultural operations were done as and when necessary. Special precaution was taken during weeding in the early stage because in the early stage the seedlings were less vigorous, soft, and thin. Four hand weeding were done very carefully with "*niri*" at 15, 30, 45 and 60 DAS. The optimum plant population was maintained by thinning in each plot as two seeds were placed $hill^{-1}$. Thinning and earthing-up were done at 35 and 60 DAS, respectively. Plants were infected by *Sclerotium* root rot disease at seedling and later stages of growth which was controlled by spraying Amister top 0.5ml L^{-1} water + Provax 1g L^{-1} water at 15 days interval. At early stages of growth seedlings were infested by the caterpillar of cutworm (*Agrotis ipsilon*) while leaf eating caterpillar (*Spodoptera litura*) attacked in later stages. Sevin dust (500 g) was used with 5 kg wheat bran and *citagoor* 1 kg for cutworm, and Pheromone trap (commercial name: Spodo-Lure, generic name: (Z, E)-9, 11 Tetradecadien-1-yl acetate 97.52% w/w) was used to control the lepidopteran insect (leaf eater).

Data collection

Five plants (excluding border hills) were selected randomly from each plot and marked by bamboo stick to collect data on plant height and leaf number. The height was measured from the base of the plant to the tip of the tallest leaf and number of leaves was recorded at every 25 days interval beginning at 40 DAS up to 140 DAS. The mean values of 5 plants for each plot were determined. Two plants were uprooted carefully and measured their root length then the leaves and roots were separated and packed in labeled brown paper bags and dried in the oven at 85±5°C for 72 h until constant weight was reached. The samples were weighed carefully after oven drying to measure the dry weight of shoots and roots. The harvesting was done at full maturity of beets at 165 DAS. After harvesting, ten plants were selected randomly then washed and cleaned by removing dead and dried leaves and soil adhering to beets. The beets were weight and adapted to average beet weight (kg/beet).

Statistical Analysis

Data were analyzed using the analysis of variance (ANOVA) technique with the help of computer package program MSTAT-C and mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height

Plant height was significantly influenced by the interaction between boron concentration and time of application at all sampling dates (Table 1). The plant height progressively increased over time attaining the highest at final sampling date (140 DAS). At 40 DAS (before the first treatment application) the tallest plant (17.17 cm) was recorded in $B_1 \times T_1$ (50 ppm boron × foliar application once at 40 DAE) that was at par with $B_3 \times T_3$ (150 p pm boron × foliar application thrice at 40, 60 and 90 DAE) and $B_2 \times T_2$ (100 ppm boron × foliar application twice at 40 and 60 DAE) and the shortest plant (14.00 cm) was recorded in $B_0 \times T_3$ (0 ppm boron × foliar application thrice at 40, 60 and 90 DAE) that was at par with $B_3 \times T_2$ and $B_1 \times T_3$ while at 140 DAS the tallest plant (56.75 cm) was obtained in $B_3 \times T_3$ (150 ppm boron × foliar application thrice at 40, 60 and 90 DAE) and the smallest plant was obtained in $B_0 \times T_3$ (0 ppm boron × foliar application thrice at 40, 60 and 90 DAE) (Table 1). The increase in plant height by boron concentration and different application time could be attributed to the stimulating effect of boron on growth process as well as plant height. These result is in harmony with that of Abido (2012) who reported that the advantage of boron application could be the function of boron in increasing plant metabolism, development and growth.

Table 1. Interaction effects between boron concentration and frequency of application on plant height at different days after sowing of sugar beet

Interaction (Concentration of boron × frequency of application)	Plant height (cm)				
	Days after sowing (DAS)				
	40	**65**	**90**	**115**	**140**
$B_0 \times T_1$	15.00d	29.25cde	36.25f	37.46d	38.25d
$B_1 \times T_1$	17.17a	31.42abcd	42.00de	42.50c	45.83c
$B_2 \times T_1$	15.33cd	31.67abcd	42.42d	43.96bc	47.78c
$B_3 \times T_1$	16.17bc	30.50abcde	39.83e	46.92b	47.88c
$B_0 \times T_2$	15.25cd	25.42ef	33.00g	30.96e	38.04d
$B_1 \times T_2$	15.00d	28.67cdef	40.08e	44.17bc	46.04c
$B_2 \times T_2$	16.67ab	35.25a	47.67ab	50.79a	51.33b
$B_3 \times T_2$	14.42de	29.62bcde	45.75bc	50.67a	53.71b
$B_0 \times T_3$	14.00e	23.50f	29.83h	31.46e	33.29e
$B_1 \times T_3$	14.58de	27.17def	36.50f	45.17bc	51.34b
$B_2 \times T_3$	16.00bc	33.25abc	43.92cd	52.67a	52.84b
$B_3 \times T_3$	16.67ab	34.92ab	48.58a	53.58a	56.75a
$S\bar{x}$	0.293	1.65	0.730	1.12	1.02
Level of sig.	**	*	**	**	**
CV (%)	3.27	9.53	3.12	4.41	3.75

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT)

** =Significant at 1% level of probability NS= Not significant
B_0 = 0 ppm, B_1 = 50 ppm, B_2 = 100 ppm, B_3 = 150 ppm

T_1 = Once at 40 days after emergence
T_2 = Twice at 40 and 65 days after emergence
T_3 =Thrice at 40, 65 and 90 days after emergence

Number of leaves/plant

Interaction effects between boron concentration and application frequency had a significant effect on the leaf number of tropical sugar beet. The number of leaves plant^{-1} increased in course of time and the highest peak reached at 115 DAS and thereafter declined (Table 2). The highest leaf number at 115 DAS (31.83) was recorded in $B_2 \times T_3$ (100 ppm boron × foliar application thrice at 40, 60 and 90 DAE) while the lowest leaf number (19.08) was recorded in $B_0 \times T_3$ (0 ppm boron × foliar application thrice at 40, 60 and 90 DAE) (Table 2). These results may be due to role of boron element in cell elongation and subsequently its role for the formation of new leaves, where it was found that beet plants suffer from boron deficiency had smaller, stiff and thick leaves. Moreover, boron has an active role in translation of assimilation product of the leaves and roots. Similar results were reported by Kristek et al. (2006) and Abbas et al. (2014).

Table 2. Interaction effects between boron concentration and frequency of application on number of leaves plant^{-1} at different days after sowing of sugar beet

Interaction (Concentration of boron × frequency of application)	Number of leaves plant^{-1} Days after sowing (DAS)				
	40	65	90	115	140
$B_0 \times T_1$	6.75bc	10.50ef	14.42d	20.75e	15.67fg
$B_1 \times T_1$	6.91ab	11.25cd	18.08b	23.50d	18.58e
$B_2 \times T_1$	6.83ab	11.83bc	16.67c	30.50a	18.58e
$B_3 \times T_1$	6.33c	11.17de	19.08ab	22.83d	16.17fg
$B_0 \times T_2$	6.91ab	10.33f	14.00d	23.33d	15.17g
$B_1 \times T_2$	6.50bc	10.50ef	15.58c	23.17d	18.50e
$B_2 \times T_2$	6.91ab	12.50a	18.58b	26.33c	20.67d
$B_3 \times T_2$	6.50bc	10.67def	19.83a	27.08bc	22.25bc
$B_0 \times T_3$	6.33c	9.25g	10.00e	19.08f	16.50f
$B_1 \times T_3$	6.66bc	10.75def	14.00d	28.1b	21.42cd
$B_2 \times T_3$	7.25a	12.25ab	20.08a	31.83a	22.92b
$B_3 \times T_3$	6.67bc	11.08de	20.17a	28.08b	24.08a
$S\bar{x}$	0.132	0.215	0.393	0.498	0.389
Level of sig.	**	**	**	**	**
CV (%)	3.39	3.37	4.07	3.40	3.51

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT)

** =Significant at 1% level of probability NS= Not significant
B_0 = 0 ppm, B_1 = 50 ppm, B_2 = 100 ppm, B_3 = 150 ppm

T_1 = Once at 40 days after emergence
T_2 = Twice at 40 and 65 days after emergence
T_3 =Thrice at 40, 65 and 90 days after emergence

Shoot dry weight/plant

Shoot dry weight of tropical sugar beet was significantly influenced by the interaction between boron concentration and time of application at all sampling dates (Table 3). The shoot dry weight progressively increased over time attaining the highest at final sampling date (140 DAS). At 140 DAS, the highest shoot dry weight (133.50 g) was obtained in $B_2 \times T_3$ (100 ppm boron × foliar application thrice at 40, 65 and 90 DAE) which was at par with (132.60 g) $B_3 \times T_1$ (150 ppm boron × foliar application once at 40 DAE), $B_3 \times T_3$ (150 ppm boron × foliar application thrice at 40, 65 and 90 DAE), $B_1 \times T_2$ (50 ppm boron × foliar application twice at 40 and 65 DAE), $B_3 \times T_2$ (150 ppm boron × foliar application twice at 40 and 65 DAE) and the lowest shoot dry weight (84.93 g) was obtained in $B_0 \times T_3$ (0 ppm boron × foliar application thrice at 40, 65 and 90 DAE) (Table 3). Armin and Asgharipour (2012) found that increasing the dose of boron significantly increased top dry weight. Successive increment of boron increases the foliage yield of sugar beet was reported by Singh (2016).

Table 3. Interaction effects between boron concentration and frequency of application on shoot dry weight at different days after sowing of sugar beet

Interaction (Concentration of boron × frequency of application)	Shoot dry weight (g)				
	Days after sowing (DAS)				
	40	65	90	115	140
$B_0 \times T_1$	1.30f	2.60g	13.28f	23.69ef	100.20d
$B_1 \times T_1$	1.83d	4.80c	16.80de	30.56c	117.90c
$B_2 \times T_1$	1.60e	4.53cd	20.06c	24.03ef	126.30ab
$B_3 \times T_1$	1.27f	4.70c	12.14fg	43.20a	132.60a
$B_0 \times T_2$	1.90cd	3.16fg	10.99gh	27.95cd	106.20d
$B_1 \times T_2$	1.47e	3.96de	15.62e	22.63f	127.80a
$B_2 \times T_2$	2.13b	3.50ef	17.17d	35.78b	119.10bc
$B_3 \times T_2$	2.03bc	7.66a	17.75d	26.16de	125.50abc
$B_0 \times T_3$	1.60e	1.96h	10.11h	17.51g	84.93e
$B_1 \times T_3$	1.30f	4.76c	17.90d	35.00b	102.40d
$B_2 \times T_3$	1.27f	7.50a	24.29b	36.95b	133.50a
$B_3 \times T_3$	3.07a	5.60b	25.84a	34.35b	131.50a
$S\bar{x}$	0.045	0.207	0.501	0.956	2.62
Level of sig.	**	**	**	**	**
CV (%)	4.35	7.84	5.15	5.55	3.87

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT)
** =Significant at 1% level of probability
B_0 = 0 ppm, B_1 = 50 ppm, B_2 = 100 ppm, B_3 = 150 ppm

T_1 = Once at 40 days after emergence, T_2 = Twice at 40 and 65 days after emergence, T_3 =Thrice at 40, 65 and 90 days after emergence

Root dry weight/plant

Root dry weight was significantly influenced by the interaction between boron concentration and time of application at all days of sampling (Table 4). The root dry weight was progressively increased over time attaining the highest at final sampling date (140 DAS). At 140 DAS, the highest root dry weight (272.50 g) was obtained in $B_3 \times T_3$ (150 ppm boron × foliar application thrice at 40, 65 and 90 DAE) and the lowest root dry weight (136.70 g) was obtained in $B_0 \times T_3$ (0 ppm boron × foliar application thrice at 40, 65 and 90 DAE) (Table 4). Boron increase root weight and diameter enhance dry matter accumulation and improve quality of roots that increase sugar yield of sugar beet (Eweida et al., 1994). Similar trend was reported by Saif (1991) who noticed that the concentration of boron significantly increased root dry weight of sugar beet.

Table 4. Interaction effects between boron concentration and frequency of application on root dry weight at different days after sowing of sugar beet

Interaction (Concentration of boron × frequency of application)	Root dry weight (g)				
	Days after sowing (DAS)				
	40	65	90	115	140
$B_0 \times T_1$	0.70e	1.77h	81.76d	131.00ef	203.40fgh
$B_1 \times T_1$	0.90d	2.80f	108.80c	138.60cde	224.50cde
$B_2 \times T_1$	1.03bc	2.30g	92.43d	152.00bc	235.00cd
$B_3 \times T_1$	0.43f	2.80f	122.60b	145.80cd	197.20gh
$B_0 \times T_2$	1.10b	2.50fg	93.32d	129.40ef	213.80efg
$B_1 \times T_2$	0.67e	3.67d	116.50bc	134.20de	218.30def
$B_2 \times T_2$	0.87d	3.23e	146.00a	164.20ab	229.60cde
$B_3 \times T_2$	0.97cd	5.93b	141.40a	162.00ab	236.50c
$B_0 \times T_3$	0.47f	1.13i	92.57d	105.60g	136.70i
$B_1 \times T_3$	0.50f	5.37c	107.20c	119.80f	188.30h
$B_2 \times T_3$	0.70e	7.27a	143.80a	169.20a	256.00b
$B_3 \times T_3$	2.10a	3.50de	148.90a	172.70a	272.50a
$S\bar{x}$	0.041	0.102	4.06	4.54	5.50
Level of sig.	**	**	**	**	**
CV (%)	7.72	4.98	6.05	5.47	4.37

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT)

** =Significant at 1% level of probability NS= Not significant
B_0 = 0 ppm, B_1 = 50 ppm, B_2 = 100 ppm, B_3 = 150 ppm

T_1 = Once at 40 days after emergence, T_2 = Twice at 40 and 65 days after emergence, T_3 =Thrice at 40, 65 and 90 days after emergence

Root length

The response of interaction between boron concentration and application frequency on root length did not show a significant variation for all sampling date (Figure 1). The root length ranged from 8.17 cm to 9.67 cm at 65 DAS. Numerically, the lowest root length (8.17 cm) was recorded in $B_3 \times T_2$ (150 ppm boron × foliar application twice at 40 and 65 DAE) and the highest root length (9.67 cm) was recorded in $B_2 \times T_3$ **(**100 ppm boron × foliar application thrice at 40, 60 and 90 DAE). At 140 DAS, the maximum root length (20.83 cm) was observed in $B_3 \times T_3$ (150 ppm boron × foliar application thrice at 40, 65 and 90 DAE) which was as at par (19.67 cm) with $B_2 \times T_1$ (50 ppm boron × foliar application once at 40 DAE). The increase in root length accompanying higher concentration of foliar application of boron might have been due to its role in enzymes activity which facilitates carbohydrate transportation as well as protein synthesis. Similar observations were reported elsewhere (Osman et al., 2003, Enan, 2004, Aly, 2005, Saad, 2005 and Abido, 2012) who mentioned that increasing the concentration of boron significantly increased root length.

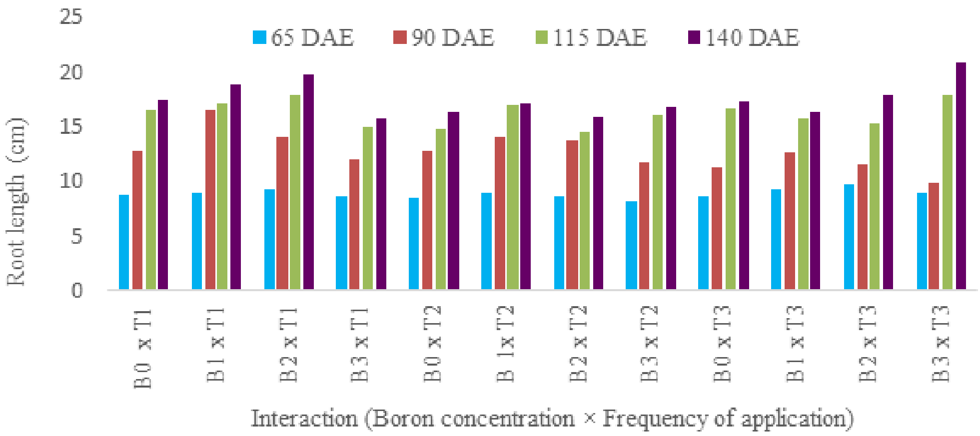

Figure 1. Effect of interaction between boron concentration and frequency of application on average beet length at different days after emergence. B_0 = 0 ppm, B_1 = 50 ppm, B_2 = 100 ppm, B_3 = 150 ppm, T_1 = Once at 40 days after emergence, T_2 = Twice at 40 and 65 days after emergence, T_3 = Thrice at 40, 65 and 90 days after emergence

Beet weight/plant

The individual beet weight of tropical sugar beet was significantly influenced by the interaction between boron concentration and time of application at harvest (165 days after sowing). Average beet weight gradually increased due to increasing concentration of boron along with its application frequency. The individual beet weight ranged from 0.28–1.04 kg (Figure 2). The highest individual beet weight (1.04 kg) was observed in $B_3 \times T_3$ (150 ppm boron × foliar application thrice at 40, 65 and 90 DAE) which was statistically identical (0.96 kg) with $B_2 \times T_3$ (100 ppm boron × foliar application thrice at 40, 65 and 90 DAE) while the minimum beet weight (0.28 kg) was obtained in $B_0 \times T_2$ (0 ppm boron × foliar application twice at 40 and 65 DAE) which was at par with (0.32 kg) in $B_0 \times T_3$ (0 ppm boron × foliar application thrice at 40, 65 and 90 DAE) and (0.35 kg) in $B_0 \times T_1$ (0 ppm boron × foliar application once at 40 DAE). This result is an agreement with those conducted by Nemeata Alla (2017) who noted that the interaction between boron fertilization level and its time of application had a significant influence on root fresh weight/plant, and elevated boron application to 100 and/or 150 ppm resulted higher beet weight/plant. Foliar application of boron from early to later growth stage might have increased boron absorption and compensated the boron requirement, and eventually increased average root weight/plant of tropical sugar beet. Higher values of beet fresh weight/plant and other quantitative and quality parameter were increased with increasing boron application up to 200 ppm (Enan, 2011).

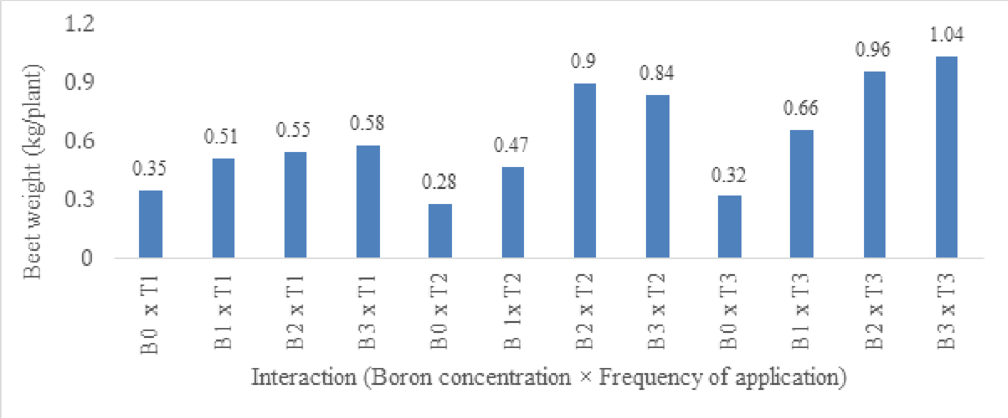

Figure 2. Effect of interaction between boron concentration and frequency of application on average beet weight. B_0 = 0 ppm, B_1 = 50 ppm, B_2 = 100 ppm, B_3 = 150 ppm, T_1 = Once at 40 days after emergence, T_2 = Twice at 40 and 65 days after emergence, T_3 = Thrice at 40, 65 and 90 days after emergence

Functional relationship between average beet weight at harvest and total dry matter production at 90 days after sowing

A positive relationship between yield and root dry weight of tropical sugar beet was observed, which indicated that the higher the total dry matter production, the higher the individual beet weight. The relationship of total dry matter production and beet yield was determined by using the respective interaction data between boron concentration and frequency of boron application. The response of total dry matter production to the average beet weight followed a linear positive relationship which could be adequately described by regression equation (Figure 3). The regression equation indicates that an increase in total dry matter production would lead to an increase in the average beet weight of tropical sugar beet. The functional relationship was significant at $p \leq 0.01$. It can be determined by the regression equation $Y = 0.009x - 0.578$ ($R^2 = 0.9107$). This relationship revealed that 91% of the variation in yield could be explained from the variation in root dry weight.

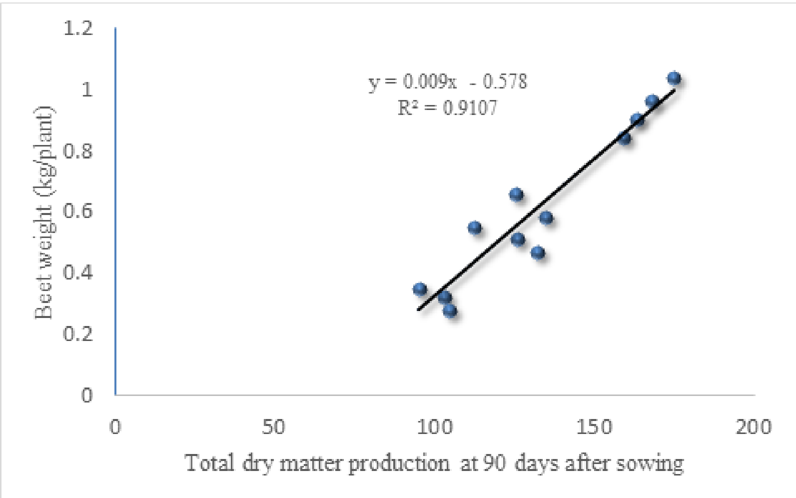

Figure 3. Functional relationship between average beet weight at harvest and total dry matter production at 90 days after sowing

CONCLUSION

It appears that the highest growth attributes such as plant height, number of leaves plant^{-1}, leaf dry weight, root dry weight, root length and average beet weight were obtained in 150 ppm boron with foliar application thrice at 40, 65 and 90 days after emergence. Therefore, 150 ppm boron applied thrice at 40, 65 and 90 days after emergence seems to be an advantageous practice in terms of growth performance and average beet weight of tropical sugar beet.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this paper

REFERENCES

1. Abbas MS, MDH Dewdar, ES Gaber and HAA El-Aleem, 2014. Impact of boron foliar application on quantity and quality traits of sugarbeet (*Beta vulgaris* L.) in Egypt. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 5(5): 143–151.
2. Abido WAE, 2012. Sugar beet productivity as affected by foliar spraying with methanol and Boron. International Journal of Agriculture Sciences, 4 (7): 287-292.
3. Armin M and M Asgharipour, 2012. Effect of time and concentration of boron foliar application on yield and quality of sugarbeet. American-Eurasian Journal of Agricultural and Environmental Sciences, 12: 444–448.
4. Aly MSM, 2005: Study of some factors affecting productivity of sugarbeet. PhD Thesis, Faculty of Agriculture, Al-Azhar University, Egypt.
5. Barker AV and DT Pilbeam, 2007. Handbook of Plant Nutrition (Books in Soils, Plants and the Environment). CRC Press, Boca Roton, Florida, United States. pp. 773.
6. Bithy S, SK Paul, MA Kader, SK Sarkar, CK Mahapatra and AKMR Islam, 2020. Foliar application of boron boosts the performance of tropical sugar beet. Journal of Bangladesh Agricultural University, 18(3): 537–544. https://doi.org/10.5455/JBAU.121026
7. Blevins DG and KM Lukaszewski, 1998. Boron in plant structure and function. Annual Review of Plant Physiology and Plant Molecular Biology, 49: 481-500.
8. Cakmak I and V Römheld, 1997. Boron deficiency-induced impairments of cellular functions in plants. Plant and Soil, 193:71-83. https://doi.org/10.1007/978-94-011-5580-9_6
9. Dom JC, AE Minochle, D Holtgrawe, GS Capella, F Zakrzewski, H Tafer, O Rupp, TR Sorensen, R Stracke, R Reinhardt, A Goesmann, T Kraft, B Schulz, PF Stadler, T Schmidt, T Gabaldon, H Lehrach, B Weisshaar and H Himmelbauer 2014. The genome of the recently domesticated crop plant sugarbeet (*Beta vulgaris*). Nature, 505(7484):546–549. https://doi.org/10.1038/nature12817
10. Dordas C, GE Apostolides and O Goundra, 2007. Boron application affects seed yield and seed quality of sugar beets. *Journal of Agricultural Science*, 145: 377–384.
11. Enan SAAM, 2011. Effect of transplanting and foliar fertilization with potassium and boron on yield and quality traits of sugar beet sown under saline conditions. Journal of Biology Chemistry and Environmental Science, 6(2):525– 546.
12. Enan SAM, 2004. Effect of transplanting and soil application of boron and zinc on yield and quality of sugar beet. Ph.D. Thesis, Fac. Agric. Al-Azhar Univ., Egypt.
13. Enan SAAM, AM El-Saady and AB El-Sayed, 2016. Impact of foliar feeding with alga extract and boron on yield and quality of sugar beet. Egyptian Journal *of* Agronomy*,* 38(2): 319-336.

14. Eweida MHT, AA El-Gharabawy, SY Besheit and Kh ElShenawy, 1994. Growth, quality and yield of sugar beet as affected by foliar applications of some micronutrients. Proc. 6 th Conf. Agron. Al-Azhar Univ., Cairo, Egypt, Sept. II: 859–869.
15. FAO, 2021. FAOSTAT Database. Food and Agriculture Organization of the United Nations. Available at: www.fao.org/faostat/ [accessed July 01, 2021].
16. Gomez KA and AA Gomez 1984, Statistical Procedures for Agricultural Research, Wiley and sons, New York.
17. Gupta UC, 1979. Boron nutrition of crops. Advances in Agronomy, 31: 273-307.
18. Kristek A, B Stojic and S Kristek, 2006. Effect of the foliar boron fertilization on sugarbeet root yield and quality. Agriculture, 12: 22–26.
19. Nemeata Alla HEA, 2017. Effect of boron level and time of application on yield and quality of sugar beet. Journal of Plant Production, Mansoura University, 8(11):1071–1075.
20. Osman AMH, GS El-Sayed, MSH Osman and KS El- Sogheir, 2003. Soil application of some microelements with relation to yield and quality of sugar beet varieties. Annals of Agricultural Science, 41(3): 1135–1152.
21. Paul SK, U Paul, MAR Sarkar and MS Hossain, 2018. Yield and quality of tropical sugarbeet as influenced by variety, spacing and fertilizer application. Sugar Tech, 20(2): 175–181. https://doi.org/10.1007/s12355-017-0545-3.
22. Saad NR, 2005. Effect of some agricultural practices on sugar beet under newly reclaimed land. M.Sc. Thesis, Fac. Agric. Minia Univ., Egypt.
23. Saif LMA, 1991. Yield and quality of sugar beet as affected by nitrogen sources and rate of some microelements in Kafr El-Sheikh University. Ph.D. Thesis, Fac. Agric. Ain Shams Univ., Egypt.
24. Singh J, 2016. Response of sugarbeet to soil applied boron in Loamy sand soil of Punjab. M.SC Thesis, Punjab Agricultural University, Ludhiana.
25. Tlili A, I Dridi, S Fatnassi, H Hamrouni, and M Gueddari, 2018. Effect of Boron distribution in sugarbeet crop yield in two soils of Dour Ismail irrigated perimeter. Advances in Science, Technology and Innovation. pp. 417–423. Doi.org/10.1007/978-3-319-70548-4_131.
26. UNDP and FAO. 1988. Land resources appraisal of Bangladesh for agricultural development, Report-2. BARC, Dhaka, pp. 212-221.