Yield and Quality Parameters of Tropical Sugarbeet in Response to Foliar Applied Boron

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ABSTRACT

Sugarbeet consumes a higher amount of boron due to being a root crop of dicotyledonous nature. Boron enhances sugar transports, root yield and sucrose concentration; and reduces impurities in beet. A field experiment was conducted during 2013-14 cropping season at BSRI farm (AEZ-11) and Thakurgaon (AEZ-1) of Bangladesh to find out the effects of foliar applied boron on yield and quality parameters of tropical sugarbeet and determine the suitable concentration of boron for foliar application. The experiment was set up in randomized complete block design with three replications. There were five treatments viz. T_1–No boron, T_2–25 ppm boron, T_3–50 ppm boron, T_4–75 ppm boron and T_5–100 ppm boron. The foliar application of boron from boric acid was done at 50 and 80 days after sowing. From the results it is evident that foliar application of boron exerted positive effect on yield and quality parameters of sugarbeet. The boron concentration of 75 ppm was found suitable for its foliar application. It gave the maximum values in beet yield, brix and pol percentage and the minimum values in crown rot incidence at both locations. Therefore, foliar application of boron at 75 ppm may be practised for the better yield and quality performances of tropical sugarbeet.

Keywords: Tropical sugarbeet, foliar application, boron

INTRODUCTION

Most plants consume sugar for their own use but sugarbeet store it in the developing roots which act as warehouse. Sugarbeet is conventionally a native crop of the temperate region (Cooke and Scott, 1993) but its cultivation is now expanding from subtropical tracts to tropical world like India, Bangladesh, Pakistan etc. due to availability of tropical varieties. About 72% of the total sugar production in the world is obtained from sugarcane and 28% from sugarbeet. Global sugarbeet covers an area of 4.48 million hectare with annual production of 266.83 million ton and average yield of 59.60 t ha^{-1} (FAOSTAT, 2014). Sugarbeet quality is a combination of the entire chemical and physical aspects of the beet root which is by far the most important parameter affecting processing and yield of sugar or its by-products (Oldfield, 1974). The most important constituent of beet is certainly sucrose, while the various non-sucrose substances impair the sugar yield to different degrees.

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Boron is primarily associated with production and transport of sugars through membranes; protein synthesis, water consumption, uptake and efficient use of calcium, nitrogen, potassium and phosphorus; and development of young roots and shoots. Adequate supply of boron enhances the rate of transport of sugars to actively growing and developing roots of sugabeet (Barker and Pilbeam, 2007; and Katyal and Singh, 1983), augments the root yield and sucrose concentration (Cooke and Scott, 1993) and reduces the amount of impurities in beet root (Armin and Asgharipour, 2011). Boron is the second most widespread deficient and economically important micronutrient (Alloway, 2008) and unique among the trace elements because very small quantities are necessary for normal crop production. However, slightly high concentration may become toxic for the plant, as range between B deficiency and toxicity is very narrow (Gupta, 1993). Deficiency symptoms of boron appear on growing points and in meristematic tissues due to its relatively low mobility in plants. A severe lack of boron causes the breakdown of parenchymatous cell walls (Marschner, 1995; Katyal and Singh, 1983) which ultimately exhibits the well known symptoms on the sugarbeet plant. These are characterized by blackening of the centre of the crown, proliferation of small leaves, and heart and dry rot (Rowe, 1936; and Ulrich and Hills, 1969). Heart rot and dry rot of sugarbeet was thought to be a disease. Brandenburg (1931) first showed that boron deficiency was the cause of these rots. Heart rot is the term applied when the growing point blackens and dies while dry rot describes the symptoms on the tap root that usually appears after heart rot is observed. On the contrary, toxic symptoms of boron are noticeable on older leaves in a form of golden-yellow coloring leaf chlorosis and necrotic margins. Characteristic low mobility of boron within the plant creates a supplementary problem in the treatment of this deficiency which can be tackled by foliar application (Richter and H ivna, 2001). Foliar application of micronutrients that is functional to plant leaves (Romemheld and El-Fouly, 1999) has been effective (Savithri *et al.*, 1999) and especially significant in case of rapid absorption of the required nutrients (Kinaci and Gulmezoglu, 2007). It improves nutrient utilization and reduces the amount of fertilizers added to soil through quick response which ultimately reduces environmental pollution. Saqib *et al.* (2006) reported that foliar applied nutrients may actually promote root absorption of the same nutrient or other nutrients through improving root growth and increasing nutrients uptake. So keeping in view the above facts, this experiment was conducted to find out the effects of foliar applied boron on yield and quality parameters of tropical sugarbeet and determine the suitable concentration of boron for foliar application.

MATERIALS AND METHODS

The experiment was carried out during 2013-14 cropping season at BSRI farm (AEZ-11) and Thakurgaon (AEZ-1) of Bangladesh. The objectives of the experiment were to find out the effect of foliar applied boron on yield and quality parameters of tropical sugarbeet and determine the suitable concentration of boron for foliar application. The experimental design was a randomized complete block design (RCBD) with three replications. There were five treatments viz. T_1–No boron,

T_2–25 ppm boron, T_3–50 ppm boron, T_4–75 ppm boron and T_5–100 ppm boron. The recommended fertilizer dose was FYM-15 t ha^{-1}, urea-260 kg ha^{-1}, TSP-100 kg ha^{-1}, MoP-225 kg ha^{-1}, gypsum-100 kg ha^{-1} and zinc sulphate-10 kg ha^{-1}. Sugarbeet variety Shubhra was taken as test crop. The size of the plot was 6m 6m. The sugarbeet seeds were sown on 07 November 2013 at BSRI farm and 09 November 2013 at Thakurgaon maintaining 50cm 20cm row-row and plant-plant spacing. Well decomposed FYM was incorporated in the plots at 6 day before sowing seeds. Full amount of TSP, MoP, gypsum, zinc sulphate, and one half of urea were applied as basal and thoroughly mixed with soil. The rest half of the urea was applied at 30 days after sowing (DAS). The boron from boric acid was sprayed at 50 and 80 days after sowing. The cultural operations such as weeding, mulching, irrigation, gap filling, and thinning, insect control through hand picking, pheromone trap and insecticide spraying etc. were done as and when necessary. The data on leaf area, chlorophyll content and crown rot incidence were taken at 120 DAS. The leaf area was measured using Bioscience LI-3100C leaf area meter and chlorophyll content was measured using digital chlorophyll meter. The crop was harvested on 02 May 2014 at BSRI farm and 04 May 2014 in Thakurgaon. Data on beet length, beet diameter, beet yield, brix and pol percentage were recorded during harvesting of crop. All data were statistically analyzed to examine the treatment effects on the tropical sugarbeet.

RESULTS AND DISCUSSION

Yield parameters of tropical sugarbeet in response to foliar applied boron

Data presented in Table 1 indicate that foliar application of boron affected yield parameters of sugarbeet at both locations.

Chlorophyll content

Foliar application of boron increased the chlorophyll content in sugarbeet leaves. At BSRI the highest chlorophyll content of 47.5 SPAD was found from 75 ppm boron and the lowest chlorophyll content of 38.7 SPAD from no boron application. However in Thakurgaon, application of 75 ppm and 100 ppm boron showed statistically similar effect in producing chlorophyll but superior from other treatments.

Leaf area

The leaf area of sugarbeet increased with the increase in boron concentration up to 75 ppm and then decreased at both locations. The maximum leaf area (3374 and 3613 $cm^2 plant^{-1}$ at BSRI and Thakurgaon, respectively) was found from 75 ppm boron which was statistically superior from other treatments. However the minimum leaf area was obtained from no boron application.

Table 1. Yield parameters of tropical sugarbeet in response to foliar applied boron

Location	Treatment	Chlorophyll (SPAD)	Leaf area ($cm^2 plant^{-1}$)	Beet length (cm)	Beet diameter (cm)	Beet weight (g)	Beet yield ($t\ ha^{-1}$)
BSRI farm	T_1-Control	38.7d	1545d	25.7ab	14.9ab	779.2b	63.5c
	T_2-25 ppm	40.2cd	1994c	27.9a	16.0ab	808.3b	65.5c
	T_3-50 ppm	42.5bc	2251c	29.0a	16.7a	910.7a	75.0bc
	T_4-75 ppm	47.5a	3374a	29.7a	18.0a	958.3a	84.6a
	T_5-100 ppm	44.0b	2749b	29.3a	16.8a	918.3a	76.0ab
	LSD (0.05)	3.37	359.0	4.26	3.677	90.55	8.9069
Thakurgaon	T_1-Control	45.2c	2650c	25.1b	14.2c	751.6b	59.4c
	T_2-25 ppm	47.1bc	2808bc	27.7ab	15.3bc	765.6b	63.0c
	T_3-50 ppm	47.6bc	2907b	27.9ab	16.3ab	893.4ab	76.8b
	T_4-75 ppm	50.7a	3613a	28.7a	17.3 a	991.6a	85.0a
	T_5-100 ppm	49.1ab	2958b	28.0ab	16.6ab	916.5ab	81.5a
	LSD (0.05)	2.561	215.8	2.948	1.4	176.6	2.258

*Figures in a column having the same letter do not differ significantly as per DMRT

Beet length and diameter

Foliar application of boron did not show any significant effect in case of beet dimension. However the highest beet length (29.7 and 29.9 cm at BSRI and Thakurgaon, respectively) and beet diameter (18.0 and 17.3 cm at BSRI and Thakurgaon, respectively) was recorded from 75 ppm boron. The minimum values of beet dimension were recorded from no boron application.

Beet weight and yield

Beet yield is the cumulative contribution of length, diameter and weight of the individual beet. The beet weight due to foliar application of boron ranged from 779.2 to 958.3 g and 751.6 to 991.6 g at BSRI and Thakurgaon, respectively. Application of 75 ppm boron produced the beets of maximum weight which was statistically similar with 50 ppm and 100 ppm boron. The highest beet yield (84.6 and 85.0 t ha^{-1} at BSRI and Thakurgaon, respectively) was recorded from 75 ppm boron which was statistically at par with 100 ppm boron. However the minimum beet yield was recorded from no boron application. It is evident from the result that boron application increased beet yield with increasing concentration of boron up to 75 ppm and then decreased. The decreasing trend in beet yield by the application of 100 ppm boron might be due to its toxic effects. Armin and Asgharipour (2011) also reported the similar results. Kristek *et al.* (2006) obtained beet yield of 75.41, 79.03, 84.23 and 81.80 Mg ha^{-1}, by spraying 0.5, 1.0, 2.0 and 4.0 kg B ha^{-1}.

Quality parameters of sugarbeet in response to foliar applied boron

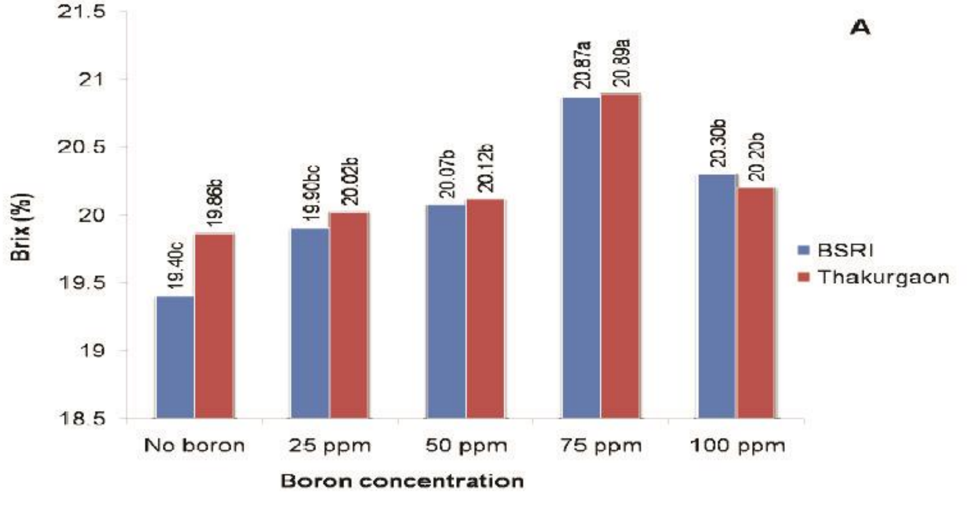
Figure 1 illustrates that the variation in quality parameters of sugarbeet was significant due to variation in concentrations of boron at both locations.

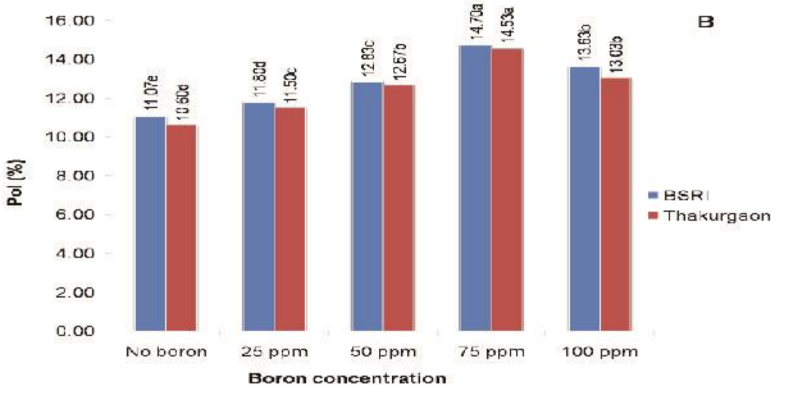
Brix and pol percentage

The foliar application of 75 ppm boron produced the beets of highest brix percentage (20.87 and 20.89 at BSRI farm and Thakurgaon, respectively) which was statistically superior to other treatments while the lowest brix percentage was obtained from no boron application. Similarly, the least pol% was observed from no boron application, increasing significantly along with the increase in boron concentrations up to 75 ppm then decreased.

Crown rot incidence (%)

The foliar application of boron reduced crown rot incidence significantly. The maximum crown rot incidence (23.8 and 17.0% at BSRI and Thakurgaon, respectively) was recorded from no boron application. On the contrary, the minimum crown rot incidence (3.0 and 1.8% at BSRI and Thakurgaon, respectively) was recorded from 75 ppm boron which led to produce beets of maximum weight with higher quality and sugar percentage. These results are in corroboration with Al-Mohmmad and Al-Geddawi (2001) who reported that boron consumption in sugar beet significantly reduced root rot, increasing the sugar yield due to increased glucose levels in roots and phloem sap.





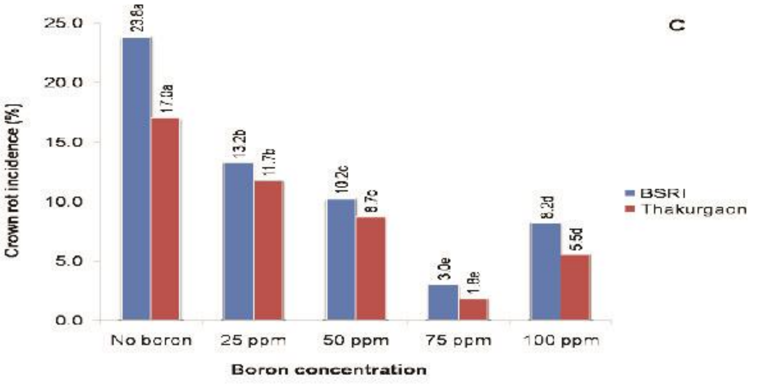


Figure 1. Quality parameters of tropical sugarbeet in response to foliar applied boron: A. Brix%, B. Pol%, C. Crown rot% of tropical sugarbeet.

From the overall results and discussions it is evident that foliar application of boron exerted positive effects on yield and quality attributes of tropical sugarbeet. The boron concentration of 75 ppm was found suitable for its foliar application. It gave the maximum values in beet yield, brix and pol percentage and the minimum values in crown rot incidence at both locations. Therefore, foliar application of boron at 75 ppm may be practised for the better yield and quality performances of tropical sugarbeet.

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