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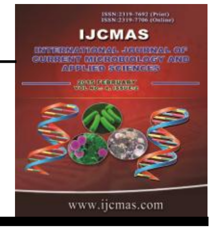

Original Research Article

Influence of Time Addition and Rates of Boron Foliar Application on Growth, Quality and Yield Traits of Sugar Beet

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A B S T R A C T

Keywords

Beta vulgaris, quality, Boron fertilization, Foliar application, Sugar yield

The aim of this work was to investigate the effect of foliar application of boron with different rates at two different times of foliar on growth, quality and yield traits of sugar beet, in El–Fayoum, Governorate, Egypt during 2011/2012 and 2012/2013 seasons. Results indicated that, foliar application of boron rates showed significant increase for all growth traits under study. The results cleared that the treated of plants by 0.25 g B/L, followed by treatment of 0.20 g B/L, they exerted the highest values of quality traits. Results showed that the B6 recorded the highest values of yield characters i.e. root, top and sugar yields as compared with other treatments. Moreover, the results concluded that foliar applications of boron at twice (80 and 110 day) after sowing showed significant differences for root, top and yield traits. Generally, it concluded that spraying plants of sugar beet by 0.25 g B/L, at 110 day after sowing produce the highest productivity and quality of sugar

Introduction

Sugar beet is considered the second source for sugar production in Egypt and in many countries all over the world. The Egyptian government encourages sugar beet growers to increase the cultivated area with sugar beet to increase sugar production and decrease the gap between sugar production and consumption. There are several advantages favoring sugar beet as a suitable crop in Egypt. The crop is annual grows during the winter season, with a relatively short duration period and allows for growing a summer crop during the same year. Proper plant nutrition is an important factor for improving productivity and quality of agricultural production. Root fresh weight, sucrose %, root and top yields significantly increased by increasing boron levels (Jaszczolt, 1998).

Mirvat and Mekki (2005) stated that, application of boron fertilizer of sugar beet cultivars significantly increase the root yield and yield components and also increased recoverable sugar percent and sugar yield.

The optimum fertilization with minor elements such as boron is importance for sugar beet plants grown in saline soil (El-Hawary, 1994). Boron is by far the most important of the trace elements needed sugar beet because, without an adequate supply, the yield and quality of roots is very depressed (Cooke and Scott; 1993).

Therefore, the present investigation is to study the effect of foliar application of boron with different doses at two different times of foliar application on growth, quality and yield traits

Materials and Methods

The experiment trials were conducted throughout two successive seasons 2011/2012 and 2012/2013at the experimental farm of the Etsa region at El Fayoum Governorate, Egypt, to study the effect of foliar application of boron element and different time addition on sugar beet plants. Boron was used in form of boric acid. Sugar beet variety used in this study was Top. Chemical analyses of the soil were carried out before planting as showed in Table 1 according to methods described by Jackson (1973). Planting dates were on 20^{th} October in the two seasons. The two variables investigated in this study were; time of foliar application of boron, foliar spray of boron, one at 80 day after sowing and twice at both 80 and 110 days after sowing. Concentration of boron; B1, 0.00g/L (control); B2, 0.05g B/L; B3, 0.10 g B/L; B4, 0.15 g B/L; B5, 0.20 g B/L and B6, 0.25g B/L.

At the harvest, a random sample of four guarded plants in each sub-plot was taken. Samples were carried immediately to laboratory where roots washed to remove the soil particles. The following growth characters were determined at harvest: root length (cm), root diameter (cm), root fresh weight per plant (g) and top fresh weight per plant (g). For determining root and top dry weights per plant (g), such parts (tops and roots) were cut into small pieces, and a representative sample were taken from each treatment weighed and dried quickly in an oven at 105 °C till constant weight was reached.

The juice of another representative samples from fresh roots was extracted to determine the following characters: sucrose percentage was determined by using Sacharometer on a lead acetate extract of fresh macerated root according to the procedure of the El-Fayoum Sugar Company (Le-Docte,1972).

Sucrose percentage, sodium (mEq/ 100 gm of beet), potassium (mEq/ 100 gm of beet) and alpha amino nitrogen (mEq/ 100 gm of beet) were determined by using Analyzer – HG in reception laboratory in El –Fayoum Company.

Sugar loss to molasses percentage=0.343(Na +K) -0.094(alpha- amino -N) -0.31, according to (Reinfeld *et al.*, 1974).

Recoverable sugar percentage (RS%) =Pol% -0.029 – 0.343(Na+ K) – 0.094 (alpha – amino-N). According to Reinfeld *et al.* (1974), Where: Pol% = sucrose %, K, Na and amino –N in Milliequivalent /100 gm in beet

At harvest, plants of all ridges from each subplot were harvested, cleaned, topped and weighed in plus weight of four plant sample and then it was converted to estimate root and top yields (ton/fed.). Apparent or gross sugar yield per feddan = (root yield ton/fed x sucrose %).

Statistical analysis

Data collected were statistically analyzed according to technique of analysis of variance "M STAT- C." Treatments were arranged in a split-plot design with four replications. Time of foliar application of boron was allotted to the main plots and different rates of boron to the sub-plots. The differences among treatment means were detected by LSD test at 5% level of probability (Gomez and Gomez, 1984).

Result and Discussion

Growth traits

Combined data analysis showed that significant difference between boron treatments for all growth traits under study, while not significant difference ($P \leq 0.05$) between two times of foliar boron application for growth traits except for, root diameter and top fresh weight traits were significant. The interaction between two variables concentrations of boron (B) x time of foliar application (A) had no significance for all growth traits. However, Data in Table 2 showed that, the rate of 0.25g B/L give higher values of root length as compared with 0.00 g B/L. The averages were39.31 and 41.47 cm for the treatment of 0.25 g B/L in the first and second time of addition of foliar application, respectively. The increase in root length accompanying higher concentration of foliar application of boron might have been due to its role in enzymes activity which facilitate carbohydrate transportation as well as protein synthesis Osman *et al.* (2003), Azzazy (2004), Enan (2004), Aly (2005), Saad (2005) and Abido (2012) clarified that increasing the concentration of boron significantly increased root length.

Regarding of root diameter, the averages of root diameter were 12.91 and 13.50 cm for treatment of B6 in the first and second dates of foliar applications, respectively, corresponding to values were 11.66 and 11.66cm as compared to the control. These values of root diameter were 12.31 and 12.74cm for the two times of applications (at 80 day from sowing one spray and twice spray at 80 & 110 day from sowing), respectively (Table 2). Such effect of boron might be attributed to the increase in activities of certain enzymes essential for cell division and the regulation of potassium/calcium ratio in plant. Osman *et al*. (2004), Saad (2005), Ibrahim (2006) and Abido (2012) clarified that increasing the concentration of boron significantly increased root diameter. Moreover, Aly (2005) reported that dates of spraying were significantly different in root diameter (cm).

Analysis of combined data over the two seasons indicated significant differences were observed among boron treatments applied on root fresh weight and top fresh weight traits. While, not significant differences were observed between two times of foliar application on root fresh weight and significantly on top fresh weight over two seasons. The interaction between concentrations of boron and time of foliar application had no significance.

In this concern, the positive effect of the boron element on the top fresh weight of sugar beet could be explained because of its essential role for the activity of enzymes involved in photosynthesis and respiration systems also this element is essential for the formation of new leaves. Moreover it has an active role in translation of assimilation product. Similar results were reported by Abido (2012) who found that the positive effect of boron may be due to the boron role in cell elongation where, in case of boron deficiency, plant leaves were smaller, stiff and thick.

Statistical analysis showed that significant differences were observed among boron treatments applied on root dry weight and top dry weight over both seasons. But, not significant differences were observed between two times of foliar application on root fresh weight and significantly on top fresh weight Table 2. Supporting results were obtained by Saif (1991) clarified that increasing the concentration of boron significantly increased root dry weight. In the meantime, Armin and Asgharipour (2012) found that increasing the dose of boron significantly increased top dry weight.

Quality traits

Data in Table 3 exhibited that the overall results of quality traits showed significant differences at the 5% level among different concentrations of boron applied on sodium, potassium and alpha-amino nitrogen contents. Moreover, significant differences were observed between two times of foliar application on sodium and alpha-amino nitrogen contents. On the contrary, data in Table 3 revealed that increasing doses of boron fertilization from 0.00 to 0.25 g B\L in form boric acid gave the lowest sodium content in the combined analysis. These results were in line with those findings by Saad (2005), Ibrahim (2006), El -Kammash (2007) and Armin and Asgharipour (2012) stated that increasing the concentration of boron significantly decreased sodium content.

Regarding of potassium contents, increased of boron fertilization from 0.00 to 0.25 g B\L in form boric acid gave the highest potassium content as compared with the control. The results found in this study are inconsistent with those of Kristek *et al* (2006) who reported that boron application had no impact on potassium content in sugar beetroot. While, Armin and Asgharipour (2012) found that the effect of different rates of boron application was significant at different concentration of boric acid, also Hussein (2002) reported that boron fertilization and increasing levels from 0 to 0.6% significantly affected potassium concentration. Moreover, Narayan *et al.* (1989) reported that B application increased juice quality by decreasing K content.

Results in Table 3 indicate that, the differences among different concentrations of boron as well as two times of foliar application on sucrose, sugar loss and recoverable sugar percentages were significant at the 5% level over both seasons. The interaction between concentrations of boron and time of foliar application had no significance. The present findings are in harmony with those obtained by Piszczek (2001) and Kristek *et al.* (2003) who reported that boron application increased sugar content. On the other hand, Hussein (2002) and Ciecko *et al.* (2004) reported that boron application did not affect root sugar content. Meanwhile, Abd El-Gawad *et al.* (2004) found that application of B at highest level (1 kg/fed.) insignificantly increased sucrose percentage.

Root, top and sugar yields

The obtained results cleared that significant differences were observed among boron treatments applied on root, top and sugar yields over two seasons. Moreover, the data indicated that significant differences for the two traits of root and top yield. While, not significant differences were observed for sugar yield trait in the two times of foliar application Table 4. Increasing of the concentrations of boron fertilization from 0.00 to 0.25 g B\L gave the highest root yield per feddan52.73 tones in second time of foliar boron element of the combined analysis as compared with the control. The increase in root yield accompanying boron foliar application might have been due to the increase in root length, root diameter and mean root weight as mentioned before. These results are in harmony with those obtained by Kristek *et al.* (2003) and Abido (2012).

Table.1 Chemical analysis of experimental soils in both seasons (average values)

Item	pH	EC (dsm^{-1})	O.M.	$CaCo_3$ %	P	K	B	Na^+	Ca^+	Mg^{++}	K^+
Value	7.92	2.29	2.10	11.60	Available nutrients (mg/kg soil)			Cations (meg/L)			
					29.70	217	0.46	19.70	2.20	0.60	0.40

Table.2 Mean values of growth traits of sugar beet as affected by boron concentrations and time addition of foliar application during 2011/2012 and 2012/2013 seasons (Combined data)

Concentration of Boron (B)		Time of Foliar Application (A)											
		Root length (cm)		Root diameter (cm)		Root fresh weight (g)		Top fresh weight (g)		Root dry weight (g)		Top dry weight (g)	
		A1	A2	A1	A2	A1	A2	A1	A2	A1	A2	A1	A2
B1		34.69	34.69	11.66	11.66	1098.43	1098.43	335.00	335.94	365.14	366.14	57.50	57.43
B2		35.91	37.66	11.82	12.31	1121.87	1217.18	343.75	460.94	373.95	405.66	70.83	73.75
B3		36.41	36.78	12.04	12.69	1207.87	1415.62	425.81	523.44	402.61	471.87	71.97	77.71
B4		37.97	38.81	12.56	12.93	1262.50	1514.06	439.06	533.62	420.83	504.76	80.20	82.29
B5		38.50	39.72	12.86	13.35	1304.68	1557.81	429.69	507.81	434.89	419.27	83.20	87.70
B6		39.31	41.47	12.91	13.50	1381.25	1742.18	492.19	585.94	460.48	580.73	83.12	92.08
Mean		**37.13**	**38.19**	**12.31**	**12.74**	**1229.43**	**1424.21**	**411.07**	**491.28**	**409.82**	**458.07**	**74.47**	**78.49**
LSD 0.05	**A**	**N.S**		**0.34**		**N.S**		**35.43**		**N.S**		**N.s**	
	B	**2.80**		**0.61**		**147.93**		**63.55**		**65.97**		**4.45**	
	A x B	**N.S**		**N.S**		**N.S**		**N.S**		**N.S**		**N.S**	

Table.3 Mean values of quality traits of sugar beet as affected by boron concentrations and time addition of foliar application during 2011/2012 and 2012/2013 seasons (Combined data)

Concentration of Boron (B)		Time of Foliar Application (A)											
		Sodium (mEq/100 gm of beet)		Potassium (mEq/100 gm of beet)		Alpha-amino nitrogen (mEq/100 gm of beet)		Sucrose (%)		Sugar molasses loss (%)		Recoverable sugar (%)	
		A1	A2	A1	A2	A1	A2	A1	A2	A1	A2	A1	A2
B1		2.50	2.53	5.35	5.33	0.49	0.47	16.65	16.50	2.43	2.43	13.68	13.70
B2		2.40	2.21	4.77	4.71	0.40	0.26	16.80	16.99	2.14	2.06	14.06	14.30
B3		2.06	1.98	4.41	4.31	0.35	0.19	17.10	17.34	2.03	1.86	14.38	14.87
B4		2.04	1.71	4.47	4.14	0.28	0.17	17.34	18.22	1.90	1.75	14.83	15.86
B5		2.01	1.74	4.20	3.89	0.23	0.15	17.77	18.84	1.80	1.63	15.36	16.54
B6		1.84	1.55	4.08	3.41	0.16	0.10	18.39	17.79	1.74	1.43	16.05	15.78
Mean		**2.14**	**1.95**	**4.55**	**4.30**	**0.32**	**0.22**	**17.34**	**17.61**	**2.01**	**1.86**	**14.73**	**15.18**
LSD 0.05	**A**	**0.14**		**0.20**		**0.08**		**0.26**		**0.07**		**0.23**	
	B	**0.25**		**0.30**		**0.13**		**0.66**		**0.13**		**0.64**	
	A x B	**N.S**		**N.S**		**N.S**		**N.S**		**N.S**		**N.S**	

Table.4 Mean values of yield traits of sugar beet as affected by boron concentrations and time addition of foliar application during 2011/2012 and 2012/2013 seasons (Combined data)

Concentration of Boron (B)		Time of Foliar Application (A)					
		Root yield (ton/fed.)		Top yield (ton/fed.)		Sugar yield (ton/fed.)	
		A1	A2	A1	A2	A1	A2
B1		32.90	32.80	10.07	10.10	5.49	5.53
B2		33.65	36.51	10.31	13.83	5.66	6.20
B3		36.23	42.47	12.77	15.70	6.22	7.37
B4		37.87	45.42	13.17	16.01	6.53	8.25
B5		39.14	46.73	12.98	15.23	6.99	8.85
B6		41.44	52.73	14.76	17.23	7.63	9.30
Mean		**36.87**	**42.78**	**12.34**	**14.68**	**6.42**	**7.58**
LSD 0.05	**A**	**N.S**		**0.86**		**N.S**	
	B	**4.96**		**1.59**		**0.90**	
	A x B	**N.S**		**N.S**		**N.S**	

Concerning of sugar yield, the increasing the concentrations of boron fertilization from 0.00 to 0.25 g B\L gave the highest sugar yield per feddan9.30 tones in the second of time application as compared with the control. On the other hand, decrease the concentrations of boron to 0.00 g B\L resulted in the lowest mean values of sugar yield per feddan over both seasons. Such effect of high boron rate may attribute to the increase in sucrose and recover able sugar percentages as well as roots yield perfeddan. These results in general go inline with those obtained by some investigators among them Maghrabi (2006) and El-Kammash (2007) and Abido (2012). However, Gezgin *et al*., (2001) found that root and sugar yields were increased by increasing boron fertilizer up to 0.3 Kg/da. Supporting results about not significant differences of foliar application times on root yield and top yield were obtained by Narayan and Chandel (1994)) who reported that dates of spraying were not significantly different in top yield per feddan. Also, Armin and Asgharipour (2012) who reported that dates of spraying were not significantly different in root yield per feddan.

Judging from yield of sugar beet, the results of the present study clearly indicate that, treated plants of boron at the twice (80 and 110 day) from sowing, improvement growth, quality and yield traits of sugar beet. Based on the present results it concluded that, spraying of 0.20 g B/L and 0.25 g B/L treatments, at 110 days from sowing were favorable treatments for producing relatively high yield through improved growth and quality traits.

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