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Influence of Boron Application on Yield and Juice Quality of Some Sugar Beet Cultivars Grown under Saline Soil Conditions

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Abstract: Boron fertilizer was added at different rates (0, 1.0, 1.5 and 2.0 Kg/acre) to some sugar beet cultivars (Ras Ploy, Kawemira and Top) grown in high saline soil (10.8 dSm^{-1}) at Abo Mady region, Belkas, El - Dakahlyia Governorate, Egypt during two winter seasons 2003/2004 and 2004 /2005. In general, three sugar beet cultivars were significantly different in root length and diameter (cm), root weight (Kg), root, top, sugar and recoverable sugar yields (ton/acre). Top cultivar showed more root, sugar and recoverable sugar yields than other two cultivars, while Ras Ploy cultivar showed more sucrose, recoverable sucrose, as well as, Juice purity percentages than Kawemira and Top cvs. This means that Ras Poly cultivar had the lowest Na, K and "- amino N in their root juice. Application of boron rates from zero up to 1.5 Kg/acre increased root length, diameter and root yield. The increase of root yield estimated by 4.00 and 5.76 ton/acre over the treatment received low or unfertilized by boron, respectively. However, increasing boron fertilizer up to 2.0 Kg/acre resulting in the highest sugar and recoverable sugar yields (6.611 and 5.559 ton/acre), respectively. Sucrose, recoverable sucrose and juice purity percentages were also increased by adding high level of boron rate. Such increases of sucrose, recoverable sucrose and juice purity percentages due to adding high level of boron might be attributed to decrease of Na and K uptake in root juice. Top cultivar showed the highest root weight, root and sugar yields when it received high level of boron rate (2.0 Kg/acre), while Kawemira cv. was very affected by absence of boron application, hence it had the lowest values of these traits. On the other hand, Ras Ploy cv. was also significantly affected by high boron level,it had more sucrose and recoverable sucrose % and also the highest juice purity that due to the decrease of Na and K contents in their root juice at same conditions of boron application.

Key words: Sugar beet cultivars, boron, root yield, quality

INTRODUCTION

Sugar beet (*Beta vulgaris L.*) is considered the second sugar crop for sugar production in Egypt after sugar cane. Recently, sugar beet crop has been an important position in Egyptian crop rotation as a winter crop not only in fertile soils, but also in poor, saline, alkaline and calcareous soils. It could be economically grown in newly reclaimed soils. The optimum fertilization with minor elements such as boron is importance for sugar beet plants grown in saline soil [1]. 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[2]. Soil application, as well as, a foliar spray of boron is equally effective, hence the root fresh weight, sucrose %, root and top yields significantly increased by increasing boron levels[3-5]. On contrast, El- Geddawy *et al*[6] indicated that application of boron at a rate of 1 Kg./acre did not significantly affect in root yield and quality of sugar beet.

Therefore, the objective of this work aims to investigate the effect of different boron rates as soil application on root yield and quality of some sugar beet cultivars grown under saline soil conditions in Egypt.

MATERIALS AND METHODS

During two winter seasons in Egypt, 2003/2004 and 2004/2005 a field trials were carried out at Abo Mady region, Belkas, El – Dakahlyia Governorate in order to investigate application of different boron rates on root yield and quality of some sugar beet cultivars grown under saline soil conditions. Mechanical and chemical properties of soil site are shown in Table 1. according to methods described by Jackson[7].

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The experimental design was split – plot in four replications and the plot area was 10.5 m^2 (3 x 3.5 m). Sugar beet cultivars were arranged in the main plots, while the boron rates were randomly distributed in sub – plots. Phosphorous and potassium fertilizers were added before sowing at a rate of 31.0 Kg. P_2O_5 as a form of super phosphate (15.5%) and 24.0 Kg.

Table 1: Physical and chemical properties of experimental soil site.

Soil properties	Value
Sand %	17.9
Silt %	38.3
Clay %	43.8
Texture	Clay
P^H	8.13
EC (dSm^{-1})	10.8
O.M %	0.74
Ca CO_3 %	2.13
Cations (meq/L)	
Na^+	4.33
K^+	1.14
Ca^{++}	13.10
Mg^{++}	16.60
Anions (meq/L)	
Cl^-	35.6
HCO_3^{-}	1.12
SO_3^{-}	0.98
Available N (ppm)	23.9
P	4.7
K	339.5
B	0.50

K_2O/acre as a form of potassium sulphate (48%), respectively. Nitrogen fertilizer was added at a rate of 80.0 Kg./ acre as a form of urea (46.0 % N) in two equal portions, the 1st half at 45 days from sowing and the 2nd after 2 weeks later. Seeds of three sugar beet cultivars mainly were obtained from Delta Company for Sugar, Belkas, El - Dakahylia Govornorate, Egypt were seeded in hills 20 cm between at October 3,5 in the two successive seasons. Thinning was done twice to leave one plant/hill till harvest. The treatments used as follows:

A-Sugar beet cultivars:

- Ras Ploy
- Kawemira
- Top

B-Boron rates were added as a form of sodium borate (11.0% B):

- Without
- 1.0 Kg.B/acre
- 1.5 Kg.B/acre
- 2.0 Kg.B/acre

At harvest time (190 days from sowing) a random sample of ten plants were taken from each plot to determine root length and diameter (cm), as well as, root weight (Kg.). Sucrose % was determine using Sacharimeter apparatus according to the method described by Le – Docte[8], total soluble solids (T.S.S %) by using Hand Fractometer, while Juice purity % was determined according to Carruthers and Oldfield [9] as a ratio between sucrose % and T.S.S %. Total impurities (Na, K and "- amino N) were determined according to the method of A.O.A.C[10].

Sugar Recoverable (SR) was determined according to the following equation:

SR = Pol – {0.343 (K + Na) + 0.094. "- amino N + 0.29}

Where: Pol = Sucrose %

Root and top yields (ton/acre) were also determined from the three middle rows for each plot, then the sugar yield was also calculated by multiplying root yield (ton /acre) x Sucrose %.

Data of two seasons were statistically analyzed according to Snedecor and Cochran[11] and the combined analysis was done according to Steel and Torrie[12], then the treatments means were compared using LSD test at 5% of probability.

RESULTS AND DISCUSSIONS

Root characters and root, top and sugar yields:

1. Effect of cultivars: Root length and diameter, as well as, root weight in sugar beet cultivars were significantly different (Table 2). Top cultivar had more root length, diameter and root weight than the other two cultivars, however the lowest were recorded with Kawemira cultivar. At the same time, the differences between Kawemira and Ras Ploy cultivars were not significant in these traits. Data also cleared that root and top yields, as well as, sugar and recoverable sugar yields were significantly different between three cultivars used. In general, Top

Table 2: Root characters and root, top and sugar yields of some sugar beet cultivars.

Cultivars	Root length cm	Root diameter cm	Root weight kg	Root yield (ton/acre)	Top yield (ton/acre)	Sugar yield (ton/acre)	Recoverable sugar yield (ton/acre)
Ras Ploy	37.76	14.22	1.131	31.861	13.703	6.067	5.052
Kawemira	36.69	13.74	1.084	30.774	12.164	5.596	4.588
Top	40.21	14.84	1.206	34.072	13.120	6.315	5.168
LSD 5%	2.12	0.51	0.049	0.727	0.660	0.247	0.143

Table 3: Root characters and root , top and sugar yields in response to boron fertilizer rates.

Boron (Kg/acre)	Root length cm	Root diameter cm	Root weight kg	Root yield (ton/acre)	Top yield (ton/acre)	Sugar yield (ton/acre)	Recoverable sugar yield (ton/acre)
0.0	33.76	12.19	0.944	28.972	11.164	4.148	4.163
1.0	37.25	14.09	1.056	30.733	12.225	5.620	4.589
1.5	41.90	16.12	1.279	34.733	14.127	5.591	5.435
2.0	39.98	14.66	1.284	34.471	14.467	6.611	5.559
LSD 5%	0.98	0.41	0.022	0.535	0.337	0.159	0.108

cultivar showed more roots, sugar and recoverable sugar yields than Ras Ploy or Kawemira cultivars, however Ras Ploy had the highest top yield and the lowest with Kawemira cv. The differences between cultivars used in these traits might be attributed to the differences in genetic constituents for each cultivar. These results are in line with those obtained by Shehata *et al* [13], while Ismail [14] reported that root length and diameter were not significantly different between sugar beet cultivars used, whereas root and sugar yields were significant.

2. Effect of boron fertilizers: Data in Table 3 show that application of boron at different rates resulting in a significant increase in root yield and other yield attributes especially when sugar beet plants grown under saline soil (Table 1). It is well known that salinity retards plant growth and yield, then the use of salt tolerance crop has been recognized as a successful method to overcome the salinity problem [15]. For this reason boron application is most important for sugar beet plants grown in saline soils. The presence of boron is essential to facilitate sugar transport within plant. Data in Table 3 indicated that root length, diameter, root weight and yield were significantly increased due to increasing boron rates from zero to 1.0 and/or 1.5 Kg /acre. El – Hawary[1] supporting this finding, however adding boron fertilizer at a rate of 2.0 Kg/acre resulting in a significant decrease in root length, diameter and increased root weight. Root and top yields were also significantly affected by boron application, the highest root and top yields were obtained by adding 1.5 or 2.0 Kg/acre, respectively. The increase in root yield estimated by 4.00 and 5.76 ton/acre in comparison to the treatments had low boron fertilizer or the treatment had no boron fertilizer, respectively. Increasing of boron rates from zero to 1.0,1.5 and 2.0 Kg/acre showed a gradually increase in top, sugar and recoverable sugar yields. The increase in top y ield estimated by 0.340, 2.242 and 3.303 ton/acre in comparison to untreated plants, respectively. Sugar and recoverable sugar yields were also increased at the same boron rates and the highest sugar and recoverable sugar yields (6.611 and 5.559 ton/acre) were obtained when plants received the high boron rate (2.0 Kg/acre), respectively. At the same time the differences between the treatments received 1.0 or 1.5 Kg B were not significant in sugar yield. These results were supported by other studies, Gobarah and Thalooth[16] reported that foliar spraying with different miconutrients significantly increased root length and diameter, as well as, fresh root weight, root, top, sugar and recoverable sugar yields. Also, El- Hawary[3] and Bondok[4] stated that sugar yield was increased due to boron application. On the other hand, El – Geddawy *et al*[6] indicated that application of boron at a rate of zero to 1.0 Kg/acre did not significantly affect in root length and diameter, root, top and sugar yields, whereas, Gezgin *et al*[17] found that root and sugar yields were increased by increasing boron fertilizer up to 0.3 Kg/da.

3. Effect of interaction: It is well established that sugar beet crop characterized by its suitability to grown well in saline soils. Moreover, yield of sugar beet and its technological properties is highly affected by micronutrients especially boron fertilizer. Data in Table 4 indicated that sugar beet cultivars is very affected by boron application at different rates. Root length and diameter, as well as, root weight were high when Top cultivar was treated by 1.5 or 2.0 Kg B/acre, whereas Kawemira cultivar had the lowest values of these traits at no boron fertilizer. Data also indicated that root yield was significantly affected by the interaction between sugar beet cultivars x boron rates, while top yield was

Table 4: Interaction between sugar beet cultivars and boron fertilizer rates on root characters and root, top and sugar yields.

Cultivars	Boron (Kg/acre)	Root length cm	Root diameter cm	Root weight kg	Root yield (ton/acre)	Top yield (ton/acre)	Sugar yield (ton/acre)	Recoverable sugar yield (ton/acre)
Ras Poly	B_0	33.63	11.90	0.955	29.012	11.581	5.241	4.310
	B_1	36.38	14.11	1.063	30.850	12.794	5.695	4.716
	B_2	42.20	15.96	1.298	34.738	14.856	6.750	5.639
	B_3	38.83	14.80	1.209	32.844	15.581	6.581	5.543
Kawemira	B_0	32.36	11.81	0.904	27.354	10.605	4.792	3.819
	B_1	35.63	13.45	0.966	29.131	11.431	5.311	4.295
	B_2	40.74	15.49	1.204	33.563	13.494	6.254	5.096
	B_3	38.04	14.20	1.264	33.050	13.125	6.026	5.143
Top	B_0	35.30	12.75	0.973	30.550	11.306	5.411	4.359
	B_1	39.74	14.71	1.138	32.338	12.450	5.854	4.755
	B_2	42.75	16.92	1.334	35.900	14.031	6.770	5.568
	B_3	40.05	14.99	1.380	37.519	14.694	7.225	5.990
LSD 5%		NS	NS	0.049	1.071	NS	0.247	0.143

B_0: without; B1: 1.0 Kg B/acre; B_2 : 1.5 Kg B/acre; B_3 : 2.0 Kg B/acre

Table 5: Juice quality and impurities content of some sugar beet cultivars.

Cultivars	Sucrose %	Recoverable sucrose %	T.S.S %	Juice purity %	Na	K	"- amino N
					Meq/100 g root		
Ras Poly	18.99	15.81	21.84	86.96	2.00	5.98	1.67
Kawemira	18.28	14.86	21.79	83.87	2.26	6.44	2.18
Top	18.45	15.11	21.68	85.10	2.11	6.33	1.99
LSD 5%	0.23	0.23	NS	1.12	0.09	0.21	0.08

insignificant. Moreover, application of boron fertilizer to Top cv. at a rate of 2.0 Kg/acre resulting in the highest root yield (37.519 ton / acre) and the lowest (27.354 ton/acre) was recorded when Kawemira cv. had no boron fertilizer. Top yield (ton/acre) was also increased in Ras Ploy cv. when it received high level of boron. Many workers had confirmed the importance of micronutrients to root yield[18,19]. Sugar yield, as well as, recoverable sugar yield was significantly affected by the interaction between sugar beet cvs. x boron fertilizer rates, especially when grown under high saline conditions. Roads and Loveday[20] pointed that sugar yield was not affected by salinity up to a soil paste conducting value of 7 dS m^{-1}. The results in Table 4 confirmed these findings, then increasing of boron rate up to 2.0 Kg/acre resulting in the highest sugar and recoverable sugar yields (7.225 and 5.990 ton/acre) in Top cv., respectively. These results were also supported by other studies[21,22].

Juice quality and impurities content:

1. Effect of cultivars: Root quality namely sucrose, recoverable sucrose, total soluble solids (T.S.S) and juice purity percentages, as well as, Na, K and "- amino N are shown in Table 5. In general, three cultivars used were significantly different in these traits, except T.S.S %was insignificant. Ras Poly cv. recorded the highest values of sucrose, recoverable sucrose and Juice purity percentages compared to other two cultivars, whereas Kawemira cultivar had the lowest recoverable sucrose and juice purity percentages. The increase in sucrose and juice purity contents in Ras Poly might be attributed to its ability for more tolerate when it grown under high salinity conditions (Table 1), this may be also due to the increase of total carbohydrates accumulation under high salinity. These findings are in line with those obtained by Munns and Termaat[23] and Mekki and El – Gazaar[24]. On the other hand, the decrease in juice purity in Kawemira cultivar mainly due to the increase of Na, K and "- amino N and consequently total impurities, however Ras Poly seem to be high juice purity due to the reduction of Na, K and "- amino N in root juice (Table 5). This means that under saline soils conditions, the uptake of Na and K was

Table 6: Juice purity and impurities conent in response to boron fertilizer rates.

Boron (Kg/acre)	Sucrose %	Recoverable sucrose %	T.S.S. %	Juice purity %	Na	K	"- amino N
					meq/100 g root		
0.0	17.76	14.36	21.72	81.78	2.19	6.41	1.73
1.0	18.18	14.91	21.56	84.28	2.13	6.29	1.86
1.5	18.97	15.64	21.79	87.06	2.10	6.22	2.02
2.0	19.39	16.14	22.01	88.11	2.07	6.08	2.17
LSD 5%	0.16	0.20	0.20	0.56	0.03	0.08	0.04

Table 7: Interaction between sugar beet cultivars and boron fertilizer rates on juice quality and impurities content.

Cultivars	Boron (Kg/acre)	Sucrose %	Recoverable sucrose %	T.S.S. %	Juice purity %	Na	K	"- amino N
						Meq/100 g root		
Ras poly	B_0	18.06	14.86	21.73	83.16	2.04	6.07	1.46
	B_1	18.46	15.29	21.56	85.62	1.98	6.00	1.55
	B_2	19.42	16.23	21.84	88.92	1.99	6.01	1.74
	B_3	20.04	16.88	22.24	90.14	2.00	5.83	1.92
Kawmira	B_0	17.51	13.96	21.72	80.65	2.38	6.61	1.94
	B_1	17.98	14.74	21.63	83.05	2.27	6.48	2.08
	B_2	18.64	15.18	21.83	85.35	2.21	6.39	2.26
	B_3	18.99	15.57	21.98	86.42	2.17	6.30	2.46
Top	B_0	17.71	14.26	21.72	81.53	2.16	6.54	1.80
	B_1	18.10	14.70	21.50	84.18	2.13	6.39	1.94
	B_2	18.86	15.51	21.70	86.90	2.09	6.26	2.07
	B_3	19.14	15.96	21.81	87.77	2.04	6.12	2.16
LSD 5%		NS	0.23	NS	NS	0.09	0.21	0.08

increased by Kawemira cultivar compared to Ras Poly, then the impurities in juice was increased and consequently reduced the quality. Such reduction in juice purity was undesirable for sugar processing. These results are in harmony with those obtained by Darwish *et al*[25].

2. **Effect of boron fertilizers:** In this concern, boron application at different rates resulting in a significant increases in sucrose, recoverable sucrose and also juice purity percentages (Table 6). Application of high level of boron fertilizer had the highest values of these traits and a gradually increase was noticed due to increasing boron rates from zero to 1.0, 1.5 and/or 2.0 kg /acre. On contrast Na and K contents were gradually decrease under the same conditions, while "- amino N showed the opposite trend compared to Na and K contents. Such reduction in Na and K contents at high boron fertilizer is reflected to the increase in juice purity at the same boron application. The increase in sucrose or recoverable sucrose % under high boron rate estimated by 1.63 and 1.78 % in comparison to untreated plants, respectively. Foliar spraying with different micrnutrients elements that led to a positive increase in sucrose, T.S.S and purity percentages are reported by Jaszczolt[5] and Khalifa and Header[19]. On the other hand, El – Geddawy *et al*[6] pointed that sucrose, purity and T.S.S % were not affected by adding boron fertilizer, while Genaidy [26] indicated that adding boron to sugar beet plants at a rate of 2.0 Kg/acre increased sugar and purity % by about 12.0 and 18.0 %, respectively.

3. Effect of interaction: Application of different boron rates to sugar beet cultivars did not significantly affect on sucrose, TSS and juice purity percentages (Table 7). However, recoverable sucrose %, as well as, Na, K and "- amino N were significantly affected by the interaction between cultivars x boron fertilizer rates. Data in Table 7 indicated that Ras Poly cultivar recorded the highest values of sucrose, recoverable sucrose and also juice purity % when it received the high level of boron (2.0 Kg/acre) and the lowest were noticed when Kawemira cultivar received unfertilized boron. In Kawemira and Top cvs increasing boron rates from zero up to 2.0 Kg/acre lead to a gradually decrease in Na and K contents, while it showed a gradually increase in "- amino N. Ras Poly seem to be the same trend, except in Na content it had approximately the same values with different boron rates. This means that increasing of boron rates up to high level lead to a decrease Na an K uptake by all cultivars used, especially when it grown in high saline soil, hence the total impurities in root juice were decreased and consequently lead to increase of recoverable sugar % in the factory process. These results are in harmony of those obtained by El – Maghraby *et al*[27]. On the other hand, Nemeat Alla and El – Geddawy[28] pointed that foliar spraying with micronutrients decreased TSS%, while sucrose and purity percentages were not significantly affected in all varieties used.

Finally we are concluding that application of boron fertilizer to sugar beet cultivars, especially when it grown in high saline soils is very important, which lead to increase the root yield and yield components and also increased recoverable sugar percent and sugar yield, decreased Na and K uptake in root juice, hence the impurities was decreased and consequently the Juice purity % was increased.

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