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OBIAL AND ENZYMATIC ACTIVITIES OF SOYBEAN EFFECT OF PLANT SPACING AND FOLIAR APPLICATION WITH BORON ON YIELD AND QUALITY OF TWO SUGAR BEET (*Beta vulgaris,* L.) VARITIES

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ABSTRACT

Two field Experiment swore carried out at the Experimental Farm, Village of Tahnsha at Minia Governorate, Egypt , during 2014/2015 and 2015/2016 seasons, to study the effect of three plant spacings (15, 20 and 25 cm between hills) and foliar application of boron at three levels (control, 50 and 100 ppm) on yield and quality of two sugar beet varieties (Kawemira and Oscar poly). A randomize completed block design in split–split plot arrangement with three replications was used in the two seasons. Sugar beet varieties were assigned to the main plots, plant spacings were randomly distributed in the sub plots and boron levels were located in the sub –sub plots. The obtained results revealed that sugar beet varieties exhibited significant differences in root diameter (cm), top and root yields (ton /fad.) in both seasons, while root fresh weight (g/ plant), sugar yield (ton/fad.) and total soluble solids percentage (TSS%) in the first season only and sucrose percentage in the second season only . Root length (cm) wos not significant in both seasons. Plants of Kawemira variety were superior to Oscar poly variety in root diameter (cm), top, root and sugar yields /fad., total soluble solids percentage (TSS %) and sucrose percentage (%) in both seasons and root fresh weight/ plant in the first season only. Increasing plant spacing from 15 to 20 and 25 cm between hills resulted in a significant increase in root length (cm), root diameter (cm), root fresh weight/ plant, top, root and sugar yields /fad., total soluble solids percentage (TSS%) and sucrose percentage (%) in both seasons. Foliar application with boron significantly increased root length (cm), root diameter (cm), root fresh weight (g/ plant), top and root yields /fad. and total soluble solids percentage (TSS %) in both seasons, sugar yield/fad. in the first season only, and sucrose percentage in the second only. Boron level at 100 ppm gave the highest values for all studied parameters in the first and second seasons. In general, the highest of yield and quality were obtained from sowing sugar beet Kawemira variety af plant spacing 25 cm between hills and boron foliar application of 100 ppm under Minia Governorate conditions.

INTRODUCTION

Total sugar production in Egypt (from sugar cane and sugar beet) is about 2.25 million tons which provide 69.63% self-sufficiency. The annual raw sugar imports are about 986 thousand tons which cost approximately 481 million dollars. On the contrary, the annual raw sugar exports are about 360 thousand tons which generate approximately 168.5 million dollars (FAO, 2018). So, increasing the productivity of sugar in Egypt is a must.

Sugar beet (*Beta vulgaris*, L.*)* became one of the important sugar crops; its roots are processed into white sugar, pulp and molasses for food, feed or industrial applications and are rarely used as a raw commodity. Sugar beet plays a prominent role for sugar production, about 58.9% of local sugar production, (CCSC, 2013). Saif, Laila (2000) found that sugar beet root length and root diameter were insignificantly affected by the studied varieties. Fresh weight of root / plant for sugar beet plants significantly responded to the differences between the studied varieties. The values of sucrose % and purity percentage were affected by the studied varieties. Abo El-Ghait and Mohamed (2005) showed that sugar beet varieties varied significantly for root fresh weight/plant, root and sugar yields in the first season only. However, they did not differ significantly for root length and root diameter as well as sucrose and purity percentages in both seasons. El- Sayed (2005) showed that variety Gloria surpassed variety Toro in root length, root fresh weight, top and root yields in the first season only. El- Hawary *et al.* (2013) showed that sugar beet varieties significantly differed in root yield/fad., sugar yield/fad., TSS% and sucrose percentage in both seasons. Sugar beet variety Farida gave the highest value of root yield/fad., sugar yield/fad., TSS% and sucrose % as compared with the other two sugar beet varieties in both seasons. Yasin (2017) found that Pleno variety surpassed the other two investigated varieties in root length, root diameter, root fresh weight/plant, root and recoverable sugar yields (ton/fad.). Teama *et al.* (2018) indicated that Kawemira sugar beet variety gave the highest mean values of root length, root diameter, single root weight, root yield (ton/fad.), sugar recovery percentage and recoverable sugar yields (ton/fad.) in both seasons.

Plant spacing also plays an important role on sugar beet growth and yield. Plants with a more extensive and well-distributed root system could exploit a larger soil volume, thereby making more effective use of soil water and nutrients. Nawar and Saleh (2003) showed that plant spacing significantly affected root diameter, root weight as well as root and sugar yields/fad. The highest diameter and root weight values were obtained by growing sugar beet at 30 cm between hills, while the maximum root and sugar yields were obtained at 15 cm between hills. Ouda, (2005) reported that root length and diameter, sucrose %, T.S.S. % and sugar, top and root yields were significantly increased by increasing plant population up to 46000 plants/fad. Shalaby *et al*. (2011) revealed that increasing plant spacing from 15 to 25 cm increased significantly root length and diameter, fresh weight, sucrose %, root and sugar yields/fad. in both seasons. Abdel Aziz *et al*. (2014) found that hill spacing had significant effect on root fresh weight, root and sugar yields/fad., sucrose % and total soluble solids % in both seasons. El-Geddawy, Dalia and Makhlouf (2015) showed that root diameter, root fresh weight and yield of root and tops were significantly increased with increasing hill spacing from 15 to 25 cm. The highest significant values of sucrose and sugar yield were obtained with 20 cm spouts between hills; meanwhile, the purity percentage was recorded with 15 cm between hills, in both seasons. Yasin (2017) found that planting density affected all traits (root length, root diameter, root fresh weight/plant, root yield top yield sugar yield and sucrose and purity percentages in both seasons, Increasing planting density up to 42000 plants/fad. significantly decreased root length, root diameter and fresh top and root weights/plant. On the other sucrose %, purity %, extractable sugar %, top, root and recoverable sugar yields were significantly and gradually increased.

Boron is one of the essential micronutrients required for plant growth and productivity. It plays an important role in cell wall synthesis, RNA metabolism and root elongation as well as phenol metabolism. Also, boron is involved in pollen and tube growth (Marschner, 1995; Srivastava and Gupta,1996) and Ahmed (2005) reported that boron fertilizer , as boric acid , at the rate of 0.9 kg H_3BO_3/ fed significantly increased top fresh weight plant, top dry weight plant, root fresh weight plant, root dry weight plant, root length, root diameter, root/top ratio, root fresh yield, root dry matter yield , purity% and T.S.S%, in sugar beet roots. Moustafa and Omran (2006) pointed out that foliar spray with Barron significantly increased sugar and total soluble sugars, juice quality (sucrose % and purity %), growth traits (average root diameter, root length, fresh weights of roots and tops, yields of roots, tops and sugar). Vince Lawson (2008) found that boron fertilizer treatments increased average root weights, root yield and percent sugar content of roots. Taha *et al*. (2013) indicated that boron fertilizer treatments had significant effect on root length, root diameter, top yield, root yield and sugar yield in both seasons. El-Geddawy, Dalia and Makhlouf (2015) reported that increasing boron levels up to 210 ppm significantly increased root length, root diameter and root fresh weight, sucrose and purity percentages, as well as yield of root, top and sugar and boron concentration in root, in both seasons. Nemeat Alla *et al*. (2016) indicated that addition of boron as foliage spraying at rate of 1.5 kg/fad. significantly increased the values of most characters under study i.e. root dimension, yields of root, top and sugar per fad , in addition to quality traits sucrose and sugar losses percentages. On the other hand, purity and extractability percentage had the highest values with control treatment, in both seasons.

The objective of the present work was to study the response of two sugar beet varieties, Kawemira and Oscar poly, to three plant spacings and application of three levels of boron under Minia Governorate conditions.

MATERIALS AND METHODS

Two field Experiments were carried out at the Experimental Farm Village of Tahnsha at Minia Governorate, Egypt during 2014/2015 and 2015/2016 seasons, to study the effect of three plant spacings (15, 20 and 25 cm between hills) and foliar application of three levels of boron (control, 50 and 100 ppm) on yield and quality of two sugar beet (*Beta vulgaris*, L.) varieties (Kawemira and Oscar poly) under Minia Governorate conditions. Boron was applied as boric acid (H_3Bo_3 17% boron) and applied as foliar application at 30 and 60 days after sowing. Spraying was applied in early morning. The experimental unit comprised af five ridges, each 3.5m long and 0.6 m wide (or 10.5 m^2 in area = 1/400 /fad.). Seeds were sown on October 17th and 21st in 2014/2015 and 2015/2016 seasons, respectively. The preceding summer crop was maize in both seasons. All other practices were uniformly applied as recommended for sugar beet production in the region.

Experimental design:

A randomized complete block design in split–split plot arrangement with three replicates. Sugar beet varieties were assigned to the main plots, plant spacings were randomly distributed in the sub plots and boron levels were located in the sub –sub plots.

Soil analysis: -

Mechanical and chemical properties of the soil at the experimental site (Table 1) were analyzed according to the methods described by Black (1965) for available nitrogen**,** Jackson (1973) for pH, organic matter and EC and Olsen and Sommers (1982) for available phosphorus.

Studied attributes:

A- Yield components: -

At harvest (180 days from sowing), five plants were randomly taken from the outer ridges of each sub-sub plot to determine yield components characters as follows:

1 - Root length (cm).

2 - Root diameter (cm).

3- Root fresh weight (g/ plant).

B - Yield attributes: -

At harvest time, sugar beet plants from the two inner ridges of each sub-sub plot were collected, roots and tops were separated and weighed (in kg), then converted to determine: -

1- Top yield (ton/fad.).

2- Root yield (ton/fad.).

3- Sugar yield (ton/fad.). it was computed according to the following formula:

$$\text{Sugar yield} = \frac{\text{Recovery sugar x root yield}}{100}$$

Table (1): The mechanical and chemical analyses of soil field experiments.

Soil properties	2014/2015 season	2015/2016 season
Mechanical analysis		
Sand (%)	25.90	24.40
Silt (%)	37.60	39.30
Clay (%)	36.50	36.30
Soil texture	Clay loam	Clay loam
Chemical analysis		
Organic matter (%)	0.94	1.05
Available N (ppm)	63.50	70.20
Available P (ppm)	9.14	10.20
Available K (ppm)	348.30	355.00
PH (s.p. 65)	7.80	8.02
E.C (ds. m^{-1})	1.15	1.16
Total Ca Co_3 (%)	2.80	2.50

C - Quality traits:

1- Total soluble solids percentage (TSS %) of roots, was measured in juice of fresh root using hand refractometer.

2- Sucrose percentage (%) was determined according to Le-Decote (1927).

Statistical analysis:

The results were statistically analyzed according to Gomez and Gomez (1984), using the computer MSTAT-C statistical analysis package by Freed *et al.* (1989). The least significant differences (LSD) test at probability level of 0.05 was manually calculated to compare the differences among means.

RESULTS AND DISCUSSION

B - Yield components: -

1- Root length (cm):

It was quite clear from the presented results in Table (2) that root length (cm) was not differences between both varieties in 2014/2015 and 2015/2016 seasons. These results agree with these obtained by Abo El-Ghait and Mohamed (2005).

The results presented in Table (2) revealed that the root length was significantly affected by plant spacing in both seasons. The highest values (36.92 and 36.01 cm) were obtained at plant spacing 25 cm between hills in both seasons respectively. On the other hand, the smuaest plant spacing

(15 cm between hills) recorded the lowest means of root length in both seasons. This increase may be due to the high competition between plants for plants growth resources. In those connection Ouda, Sohier (2005), Shalaby *et al*. (2011) and Yasin (2017) reported that root length was increased by increasing plant spacing.

The application of boron to sugr beet plants exerted a significant influence on root length (cm) in the first and second seasons. In general, root length (cm) was high at rate of 100 pm was applied to sugr beet plants compared to the control in both seasons. The pronounced effect of boron on root length may be due to its effect on the growth which in turn affect root length of sugar beet. The results of boron on root length obtained in the study are in agreement with those obtained by Ahmed (2005), Moustafa and Omran (2006), Taha *et al*. (2013) and Nemeat Alla *et al*. (2016).

The presented results (Table,2) show that root length (cm) was significantly affected by the interaction bet wees varieties and plant spacing in the second season, only, where the highest value 36.23 cm was obtained from Oscar poly variety when plant spacing 25 cm between hills was applied. Also, it was significantly affected by the interaction between varieties and boron in the second season, only where the highest value (36.37 cm) was obtained from Kawemira variety when boron at 100 ppm was applied. The interaction between plant spacing and boron was significant in both seasons, where the highest values 37.22 and 36.65 cm were obtained from plant spacing 25 cm between hills and 100 ppm in the first and the second seasons, respectively. The second order interaction exerted a significant influence on root length in the second season only, where the highest value (36.88 cm**)** of root length obtained from Kawemira variety at the received highest plant spacing (25 cm**)** and 100 ppm boron.

2- Root diameter (cm):

The results in Table (3) illustrated that the varieties were significantly differed in root diameter cm in the first and second seasons. However, Kawemira variety surpassed Oscar poly variety in root diameter in both seasons. These results may be attributed to genetic factors as well as their interactions with the environmental conditions. The results of varieties in root diameter obtained in the paest study are in agreement with those obtained by Yasin (2017) and Teama *et al*. (2018).

The presented data showed that root diameter (cm) was significantly affected by plant spacing in both seasons. Increasing plant spacing from 15 to 20 and 25 cm between hills increased root diameter in the two seasons. This finding may be due to that the wider distance between hills decreased the competition between plants which allowed better conditions for the plant grown and in turn was reflected on root growth. The results of plant spacing in root diameter obtained in the present study are in agreement with those obtained by Nawar and Saleh (2003), Ouda,Sohier

(2005), Shalaby *et al*. (2011), El-Geddawy, Dalia and Makhlouf (2015) and Yasin (2017).

The application of boron to sugar beet plants had a significant influence on root diameter cm in 2014/2015 and 2015/2016 seasons. The highest values (13.67 and 12.72 cm) were obtained when applied boron at a level 100 ppm in the first and the second seasons, respectively. The relative advantage of boron element on root thickness may be due to the distinct role on photosynthates translocation process. In those connection Ahmed (2005), Moustafa and Omran (2006), Taha *et al*. (2013) and Nemeat Alla *et al*. (2016). they reported that root diameter increased by increasing boron levels.

The results presented in Table (3) showed that all possible interactions had no significant influence on root diameter in both seasons.

3- Root fresh weight (g/plant):

Data in Table (4) show that root fresh weights (g/plant) were significantly affected by varieties in the first season, only. The highest value of root fresh weight was recorded from Kawemira variety that had higher root fresh weight than Oscar poly variety. The significant differences between sugar beet varieties in root fresh weight may be due to the interaction between gentic make – up and environmental condition. It could be mentioned that the results of the varieties differences in root fresh weight, herein in agreement with those obtained by Saif,Laila (2000), Abo El-Ghait and Mohamed (2005), El- Sayed (2005), Yasin (2017) and Teama *et al*. (2018).

The data presented in Table (4) showed that root fresh weight (g/plant) was significantly affected by plant spacing in both seasons. Increasing plant spacing from 15 to 20 and 25 cm between hills increased root fresh weight in the two seasons. This finding may be due to that the wider hills space allowed plants to grow better than the narrower space which was reflected on the plant growth and consequently root fresh weight. These results agreed with those of Nawar and Saleh (2003), Abdel Aziz *et al*. (2014), El-Geddawy, Dalia and Makhlouf (2015) and Yasin (2017).

The presented data showed that a gradual increase in root fresh weight (g/plant) as the growing progressive and increasing levels of boron concentrations (0, 50 and 100 ppm) the root fresh weight was significantly affacted in 2014/2015 and 2015/216 seasons. The highest values (944.07 and 807.74 g/plant) were obtained when boron was applied at level 100 ppm in the first and second seasons, respectively. This observation is due to the important role of boron on dry matter translocation which in turn was reflected on the final root fresh weight. These results are in accordance with those of Ahmed (2005), Moustafa and Omran (2006) and Vince Lawson (2008). they reported that root fresh weight was significantly affected by boron.

Also, the results showed that root fresh weight was significantly affected by the interaction between varieties and plant spacing in the first and second seasons, where the highest values 1067.95 and 903.22 g/plant were obtained from Kawemira variety when plant spacing was 25 cm between hills in the first and second seasons, respectively. Also, it was significantly affected by the interaction between varieties x boron in the second season, only where the highest value (819.63 g/plant) was obtained from Oscar poly variety when 100 ppm borrows applied. Root fresh weight was significantly affected by the interaction betake plant spacing x boron Cancemtratwn in the two seasons, where the highest values 1033.05 and 920.52 g/plant were obtained from plant spacing 25 cm between hills and 100 ppm in the first and the second seasons, respectively. The second order interaction was significantly affected The same parameter in both seasons, where the highest values (1081.30 and 923.11g/plant**)** of root fresh weight were obtained from Kawemira variety at The highest plant spacing 25 cm between hills and received 100 ppm boron in the first season and Oscar poly variety en at the highest plant spacing 25 cm between hills and received 100 ppm boron in the second season, respectively.

C- Yield attributes: -

1- Top yield (ton/fad.):

The presented results in Table (5) showed that the differences between sugar beet varieties were significant for top yield (ton/fad.) in 2014/2015 and 2015/2016 seasons. Furthermore, results clearly showed that Kawemira variety surpassed in top yield (ton/fad.) than Oscar poly variety in the two seasons. The differences between sugar beet varieties in the production efficiency may be due to the differences in partitioning and migration of photosynthetic between sugar beet varieties. These results are in harmony with this found by El- Sayed (2005).

That results presented in Table (5) revealed that top yield (ton/fad.) was significantly affected by plant spacing in both seasons. The highest values (13.93 and 14.19 ton/fad.) were obtained at plant spacing 25 cm between hills in the first and the second seasons, respectively. This finding may be due to under the wider hill spaces the competition between plants grown was decreased arrd in turn was reflected on the values of tops yield. These results agreed with those of Ouda,Sohier (2005), El-Geddawy, Dalia and Makhlouf (2015) and Yasin (2017).

The application of boron folia to sugr beet plants exerted a significant influence on top yield ton/fad. in the first and second seasons. In general, top yield was high at rate of 100 pm was applied to sugr beet plants compared to the control in both seasons. This finding may be due to the healthy role of boron on the plant grown which directly affected growth vigor of the plants. This result is in harmony with those obtained by Ahmed (2005), Moustafa and Omran (2006), Taha *et al*. (2013) and Nemeat Alla *et al.* (2016). reported that top yield was significantly affected by boron.

Table (2): Effect of plant spacing, foliar with boron and their interactions on root length (cm) of two sugar beet varieties in 2014/2015 and 2015/2016 seasons.

Seasons		2014/2015				2015/2016			
Varieties	Plant spacing (cm)	Foliar with boron (ppm)			Mean	Foliar with boron (ppm)			Mean
		Cont.	50	100		Cont.	50	100	
Kawemira	15	34.34	34.95	36.62	35.30	33.24	35.94	36.31	35.16
	20	36.53	37.01	36.92	36.82	35.33	35.16	35.92	35.47
	25	36.75	37.24	37.19	37.06	34.73	35.79	36.88	35.80
Mean		35.87	36.40	36.91	36.39	34.43	35.63	36.37	35.48
Oscar poly	15	33.46	35.03	37.25	35.24	33.14	33.88	35.75	34.25
	20	35.66	36.78	37.21	36.55	35.42	35.31	35.72	35.48
	25	36.16	36.91	37.26	36.77	35.99	36.28	36.42	36.23
Mean		35.09	36.24	37.24	36.19	34.85	35.15	35.96	35.32
Mean for plant spacing	15	33.90	34.99	36.93	35.27	33.19	34.91	36.03	34.71
	20	36.09	36.89	37.06	36.68	35.37	35.23	35.82	35.47
	25	36.45	37.08	37.22	36.92	35.36	36.03	36.65	36.01
Mean		35.48	36.32	37.07		34.64	35.39	36.16	

L.S.D. at 5% for	2014/2015	2015/2016
Varieties (V)	N.S	N.S
Plant spacing (S)	0.75	0.24
Boron (B)	0.48	0.33
V X S	N.S	0.34
V X B	N.S	0.47
S X B	0.83	0.59
V X S X B	N.S	0.83

Table (3): Effect of plant spacing, foliar with boron and their interactions on root diameter (cm) of two sugar beet varieties in 2014/2015 and 2015/2016 seasons.

Seasons		2014/2015				2015/2016			
Varieties	Plant spacing (cm)	Foliar with boron (ppm)			Mean	Foliar with boron (ppm)			Mean
		Cont.	50	100		Cont.	50	100	
Kawemira	15	11.41	13.01	13.62	12.68	10.79	11.80	12.53	11.70
	20	12.03	13.42	14.31	13.25	11.49	12.39	13.09	12.32
	25	12.72	13.83	13.83	13.46	11.51	13.09	13.59	12.73
Mean		12.05	13.42	13.92	13.13	11.26	12.43	13.07	12.25
Oscar poly	15	11.05	12.28	12.87	12.06	10.14	10.49	11.55	10.73
	20	11.44	12.96	13.28	12.56	10.52	11.66	12.30	11.49
	25	12.52	13.54	14.12	13.39	11.61	12.77	13.28	12.55
Mean		11.67	12.93	13.42	12.67	10.76	11.64	12.37	11.59
Mean for plant spacing	15	11.23	12.65	13.24	12.37	10.46	11.15	12.04	11.21
	20	11.73	13.19	13.79	12.90	11.01	12.02	12.69	11.91
	25	12.62	13.69	13.98	13.43	11.56	12.93	13.43	12.64
Mean		11.86	13.17	13.67		11.01	12.03	12.72	

L.S.D. at 5% for	2014/2015	2015/2016
Varieties (V)	Sig.	Sig.
Plant spacing (S)	0.36	0.35
Boron (B)	0.42	0.27
V X S	N.S	N.S
V X B	N.S	N.S
S X B	N.S	N.S
V X S X B	N.S	N.S

Table (4): Effect of plant spacing, foliar with boron and their interactions on root fresh weight (g/plant) of two sugar beet varieties in 2014/2015 and 2015/2016 seasons.

Seasons		2014/2015				2015/2016			
Varieties	Plant spacing (cm)	Foliar with boron (ppm)			Mean	Foliar with boron (ppm)			Mean
		Cont.	50	100		Cont.	50	100	
Kawemira	15	776.50	813.88	878.23	822.87	651.69	682.03	698.86	677.52
	20	855.82	889.63	915.47	886.97	738.54	748.09	770.76	752.46
	25	1048.33	1074.23	1081.30	1067.95	887.98	903.75	917.93	903.22
Mean		893.55	925.91	958.33	925.93	759.40	777.96	795.85	777.73
Oscar poly	15	738.80	773.72	818.72	777.08	623.89	668.23	676.94	656.35
	20	903.26	927.67	985.92	938.95	788.42	801.25	858.83	816.16
	25	959.52	978.34	984.81	974.22	888.76	835.76	923.11	882.54
Mean		867.19	893.24	929.81	896.75	767.02	768.41	819.63	785.02
Mean for plant spacing	15	757.65	793.80	848.47	799.97	637.79	675.13	687.90	666.94
	20	879.54	908.65	950.69	912.96	763.48	774.67	814.79	784.31
	25	1003.93	1026.29	1033.05	1021.09	888.37	869.75	920.52	892.88
Mean		880.37	909.58	944.07		763.21	773.18	807.74	

L.S.D. at 5% for	2014/2015	2015/2016
Varieties (V)	Sig.	N.S
Plant spacing (S)	9.54	13.04
Boron (B)	4.41	11.43
V X S	13.51	18.44
V X B	N.S	16.16
S X B	7.63	19.80
V X S X B	10.80	28.00

The presented in results in Table (5) show that top yield (ton/fad.) was significantly affected by the interactions of varieties x plant spacing in both seasons, where the highest values 14.71 and 14.77 ton/fad. were obtained from Kawemira variety at plant spacing 25 cm between hills in the first and second seasons, respectively. The interaction between plant spacing x boron was significantl in both seasons, where the highest values 14.71 and 14.93 ton/fad. were obtained from plant spacing 25 cm between hills and 100 ppm in first and the second seasons, respectively. The second order interaction was significantl in both seasons, where the highest values (15.26 and 14.96 ton/fad.) of top yield were obtained from Kawemira variety at the highest plant spacing 25 cm between hills and received 100 ppm boron in the first season and Oscar poly variety at the highest plant spacing 25 cm between hills and received 100 ppm boron in the second season, respectively.

2- Root yield (ton/fad.):

Results illustrated in Table (6) obviously showed that sugar beet varieties significantly differed in root yield (ton/fad.) in both seasons. Where, Kawemira variety was assenter for this character than Oscar poly variety in both seasons. This may be due to the differences in genetic make up between varieties. Such varieties differences in root yield (ton/fad.) were previously reported by Abo El-Ghait and Mohamed (2005), El- Sayed (2005), El- Hawary *et al*. (2013), Yasin (2017) and Teama *et al*. (2018).

The presented data showed that root yield (ton/fad.) was significantly affected by plant spacing in both seasons. Increasing plant spacing from 15 to 20 and 25 cm beween hills increased root yield in the two seasons.The pronounced effect of the wider hill may be spaces due to the distinct effect of the wider hill spaces on growth criteria i.e root diameter and root fresh weight (Tables 3 and 4) and the assimilator organs in terms tops yield, the wider the hills space, the heavier, the individual root fresh weight, the heavier the root yield. This result is in harmony with those obtained by Nawar and Saleh (2003), Ouda,Sohier (2005), Shalaby *et al*. (2011), Abdel Aziz *et al*. (2014) and Yasin (2017) they reported that root yield was significantly affected by plant spacing.

The application of boron foliar to sugar beet plants had a significant influence on root yield (ton/fad.) in 2014/2015 and 2015/2016 seasons. The highest root yield values (26.49 and 26.58 ton/fad.) were obtained at a level 100 ppm in the first and second seasons, respectively. The increase in value of root yield as a result to the increase in boron lewef application could be due to the favorable effect of boron element on growth criteria in af root diameter and root fresh weight (Tables 3 and 4). These results agreed with those of Ahmed (2005), Moustafa and Omran (2006), Vince Lawson (2008); Taha *et al*. (2013) and Nemeat Alla *et al*. (2016).

The presented results show ed that root yield (ton/fad.) was significantly affected by the interactions of varieties x plant spacing in both seasons, where the highest values (28.21 and 28.67 ton/fad). were obtained from Kawemira variety at plant spacing 25 cm between hills in the first season and second season, respectively. Also, it was significantly affected by the interaction between varieties x boron level in the two seasons, where the highest values (27.28 and 27.09 ton/fad.) were obtained from Kawemira variety when received 100 ppm borone foliar in the first season and second season, respectively. The results of the interaction between plant spacing x boron were significant in both seasons, where the highest values (27.69 and 27.80 ton/fad). were obtained from plant spacing 25 cm between hills and 100 ppm in the first and second seasons, respectively. The second order interaction was exerted a significant influence on root yield (ton/fad.) in the second season only, where the highest value (28.70 ton/fad.**)** was obtained from Kawemira variety at the highest plant spacing 25 cm between hills and received 100 ppm boron.

3- Sugar yield (ton/fad.):

The presented results in Table (7) showed that the differences between sugar beet varieties were significant for sugar yield (ton/fad.) in the first season, only. Furthermore, results clearly showed that Kawemira was superror in sugar yield (ton/fad.) than Oscar poly variety. The differences between sugar beet varieties in the production efficiency may be due to the differences in partitioning and migration of photosynthetic between sugar beet varieties, also, may be due to its highest cotent of leaves fresh weight (g/plant) and leaf area in both seasons. These results are in harmony with those found by Abo El-Ghait and Mohamed (2005), El- Hawary *et al*. (2013), Yasin (2017) and Teama *et al*. (2018).

The results presented in Table (7) revealed that sugar yield (ton/fad.) was significantly affected by plant spacing in both seasons. The highest values (4.82 and 4.87 ton/fad.) were obtained at plant spacing 25 cm between hills in the first and second seasons, respectively. This distinct effect of hill space of 25 cm could be due its pronounced influence on the values of sucrose percentage (Table 9) which in turn was reflected on the average of sugar yield. These results are completely in agreement with those found by Nawar and Saleh (2003), Ouda,Sohier (2005), Shalaby *et al*. (2011), Abdel Aziz *et al*. (2014) and Yasin (2017)

The application of boron to sugar beet plants exerted a significant influence on sugar yield (ton/fad.) in the first season, only. In general, sugar yield (ton/fad.) was high at rate of 100 pm applied to sugar beet plants compared to the control. This result was valid, and is mainly due to the essential role of boron on storage process of sugar in the root which consequently was reflected on sugar yield. These results are in harmony with those obtained by Ahmed (2005), Moustafa and Omran (2006), Taha *et al*. (2013) and Nemeat Alla *et al*. (2016).

Sugar yields (ton/fad.) were significantly affected by the interaction between varieties x plant spacing in the first season only, where the highest value (4.94 ton/fad). was obtained from Kawemira variety at spacing 25 cm between hills. Also, sugar yield was significantly affected by the interaction between varieties and boron in the first season only, where the highest value (4.60 ton/fad). was obtained from Kawemira variety when 100 ppm borone was applied. The interaction between plant spacing x boron and the second order interaction were not significant in the first and second seasons.

c- Quality traits:

1- Total soluble solids percentage (TSS %):

The presented data in Table (8) show ed that total soluble solids percentage (TSS%) was significantly affected by varieties in the first season, only. Kawemira variety had higher total soluble solids (19.45 %) than Oscar poly variety. The difference between varieties of total soluble solids percentage could be due to the variation in the gene make-up and their response to the environmental conditions. These results are in agreement with tho se obtained by El- Hawary *et al*. (2013) who reported that total soluble solids percentage was significantly affected by varieties

The presented data showed that total soluble solids percentage (TSS%) was significantly affected by plant spacing in both seasons. Increasing plant spacing from 15 to 20 and 25 cm between hills increased total soluble solids percentage in the two seasons. Such effect may be due to the fact that under the highest plant spacing appreciable imcreese in top and root weights was recorded which was reflected in the increase of root total soluble solids percentage. These results are completely in agreement with those found by Ouda,Sohier (2005) and Abdel Aziz *et al*. (2014).
The presented results in Table (8) observe that the differences between levels of boron had insignificant effrct this parametr in both seasons.

The presented results showed that total soluble solids percentage (TSS%) were significantly affected by the interactions of varieties x plant spacing in both seasons, where the highest values (20.36 and 20.53 %) were obtained from Oscar poly variety at plant spacing 25 cm between hills in the first season and second season, respectively. Also, it was significantly affected by the interaction between varieties x boron in the two seasons. The interaction between plant spacing x boron was significantl in both seasons. The second order interaction exerted a significant influence on total soluble solids percentage in the second season only, where the highest value (20.90 %**)** was obtained from Kawemira variety when at plant spacing 20 cm between hills and 100 ppm boron.

2- Sucrose percentage (%):

The presented results in Table (9) show ed that sucrose percentage (%) was significantly affected by varieties in the second season, only. Kawemira variety had higher sucrose percentage (16.96 %) than Oscar poly

(16.59%) variety. The differences in this trait are mainly due to gene make-up effect. These results are agreed with those obtained by Saif,Laila (2000) and El- Hawary *et al.* (2013) who reported that sucrose percentage was significantly affected by varieties. Results in Table (9) revealed that sucrose percentage **(%)** was significantly affected by plant spacing in both seasons. The highest values (17.70 and 17.64 %) were obtained at plant spacing 25 cm between hills in the first and second seasons, respectively. Such effect may be due to the fact that under the widest plant spacing appreciable increase in root weight was recorded which was reflected in the increase of root sucrose content. These results are in harmony with those obtained by Ouda,Sohier (2005), Shalaby *et al*. (2011), Abdel Aziz *et al*. (2014) and Yasin (2017).

Also, the presented data showed that agradual increase in sucrose percentage (%) was dotained the growth progressed and increasing the levels of boron concentrations (0, 50 and 100 ppm)-the sucrose percentage was significantly affacted in the second season, only. The highest value (16.95%) were obtained when boron was applied at level 100 ppm.

The distinct effect of boron fertilization on this trait could be due to the essential role of boron in sugar translocation and, in turn, sugar storage in root. It could be concluded that the presnt results are in harmony with those obtained by Ahmed (2005), Moustafa and Omran (2006), Vince Lawson (2008) and Nemeat Alla *et al*. (2016).

Sucrose percentage was significantly affected by the interaction between varieties x plant spacing in the two seasons, where the highest values (17.88 and 17.74 %) were obtained from Oscar poly variety at plant spacing 25 cm between hills in first and the second seasons, respectively.

The interactions between varieties x boron, plant spacing x boron and the second order interaction were not significant in first and the second seasons.

Table (5): Effect of plant spacing, foliar with boron and their interactions on top yield (ton/fad.) of two sugar beet varieties in 2014/2015 and 2015/2016 seasons.

Seasons		2014/2015				2015/2016			
Varieties	Plant spacing (cm)	Foliar with boron (ppm)			Mean	Foliar with boron (ppm)			Mean
		Cont.	50	100		Cont.	50	100	
Kawemira	15	7.80	8.81	10.05	8.89	7.38	8.45	9.44	8.43
	20	9.74	10.67	11.38	10.59	9.78	10.64	11.31	10.58
	25	14.16	14.72	15.26	14.71	14.96	14.44	14.91	14.77
Mean		10.57	11.40	12.23	11.40	10.71	11.17	11.89	11.26
Oscar poly	15	6.70	7.81	8.51	7.67	7.33	7.44	8.21	7.66
	20	8.61	9.50	10.33	9.48	10.39	10.09	9.85	10.11
	25	12.44	12.82	14.16	13.14	11.93	13.99	14.96	13.62
Mean		9.25	10.04	11.00	10.10	9.88	10.51	11.01	10.46
Mean for plant spacing	15	7.25	8.31	9.28	8.28	7.36	7.95	8.83	8.04
	20	9.17	10.08	10.85	10.04	10.08	10.36	10.58	10.34
	25	13.30	13.77	14.71	13.93	13.44	14.21	14.93	14.19
Mean		9.91	10.72	11.61		10.29	10.84	11.45	

L.S.D. at 5% for	2014/2015	2015/2016
Varieties (V)	Sig.	Sig.
Plant spacing (S)	0.17	0.13
Boron (B)	0.12	1.76
V X S	0.24	0.23
V X B	N.S	N.S
S X B	0.20	0.25
V X S X B	0.29	0.43

Table (6): Effect of plant spacing, foliar with boron and their interactions on root yield (ton/fad.) of two sugar beet varieties in 2014/2015 and 2015/2016 seasons.

Seasons		2014/2015				2015/2016			
Varieties	Plant spacing (cm)	Foliar with boron (ppm)			Mean	Foliar with boron (ppm)			Mean
		Cont.	50	100		Cont.	50	100	
Kawemira	15	24.31	24.96	27.01	25.42	23.12	23.82	25.97	24.30
	20	26.44	25.85	26.52	26.27	26.72	26.15	26.62	26.50
	25	28.43	27.92	28.29	28.21	28.64	28.37	28.70	28.67
Mean		26.39	26.24	27.28	26.64	26.26	26.11	27.09	26.49
Oscar poly	15	22.50	23.68	24.62	23.60	22.67	23.66	24.81	23.71
	20	24.41	24.92	25.42	24.91	24.71	25.71	26.51	25.64
	25	25.35	26.62	27.08	26.35	25.63	27.09	26.91	26.54
Mean		24.08	25.07	25.71	24.95	24.34	25.48	26.07	25.30
Mean for plant spacing	15	23.40	24.32	25.82	24.51	22.89	23.74	25.39	24.01
	20	25.42	25.39	25.97	25.59	25.71	25.93	26.56	26.07
	25	26.89	27.27	27.69	27.28	27.29	27.73	27.80	27.60
Mean		25.24	25.66	26.49		25.30	25.80	26.58	

L.S.D. at 5% for	2014/2015	2015/2016
Varieties (V)	Sig.	Sig.
Plant spacing (S)	0.19	0.43
Boron (B)	0.32	0.37
V X S	0.27	0.61
V X B	0.45	0.52
S X B	0.55	0.63
V X S X B	N.S	0.89

Table (7): Effect of plant spacing, foliar with boron and their interactions on sugar yield (ton/fad.) of two sugar beet varieties in 2014/2015 and 2015/2016 seasons.

Seasons		2014/2015				2015/2016			
Varieties	Plant spacing (cm)	Foliar with boron (ppm)			Mean	Foliar with boron (ppm)			Mean
		Cont.	50	100		Cont.	50	100	
Kawemira	15	3.93	4.01	4.14	4.02	3.69	3.80	4.19	3.89
	20	4.60	4.44	4.73	4.59	4.57	4.59	4.69	4.62
	25	5.04	4.83	4.94	4.94	5.04	4.99	5.06	5.03
Mean		4.52	4.42	4.60	4.52	4.43	4.46	4.65	4.51
Oscar poly	15	3.48	3.63	3.87	3.66	4.53	3.72	3.96	4.07
	20	3.88	4.05	4.13	4.02	3.96	4.20	4.34	4.17
	25	4.50	4.75	4.88	4.71	4.50	4.79	4.83	4.71
Mean		3.95	4.14	4.29	4.13	4.33	4.24	4.38	4.31
Mean for plant spacing	15	3.71	3.82	4.00	3.84	4.11	3.76	4.07	3.98
	20	4.24	4.24	4.43	4.30	4.26	4.40	4.52	4.39
	25	4.77	4.79	4.91	4.82	4.77	4.89	4.95	4.87
Mean		4.24	4.28	4.45		4.38	4.35	4.51	

L.S.D. at 5% for	2014/2015	2015/2016
Varieties (V)	Sig.	N.S
Plant spacing (S)	0.10	3.04
Boron (B)	0.08	N.S
V X S	0.14	N.S
V X B	0.11	N.S
S X B	N.S	N.S
V X S X B	N.S	N.S

Table (8): Effect of plant spacing, foliar with boron and their interactions on T.S.S.% of two sugar beet varieties in 2014/2015 and 2015/2016 seasons.

Seasons		2014/2015				2015/2016			
Varieties	Plant spacing (cm)	Foliar with boron (ppm)			Mean	Foliar with boron (ppm)			Mean
		Cont.	50	100		Cont.	50	100	
Kawemira	15	18.45	18.16	17.97	18.19	18.92	18.36	17.86	18.38
	20	19.91	19.99	19.81	19.90	19.29	20.77	20.90	20.32
	25	20.44	20.18	20.14	20.25	21.23	20.13	20.02	20.46
Mean		19.60	19.44	19.31	19.45	19.81	19.75	19.59	19.72
Oscar poly	15	18.32	18.44	18.01	18.25	18.43	18.30	18.40	18.38
	20	18.03	19.05	19.33	18.80	18.47	19.84	19.38	19.23
	25	20.18	20.48	20.43	20.36	20.24	20.47	20.88	20.53
Mean		18.84	19.32	19.26	19.14	19.05	19.54	19.55	19.38
Mean for plant spacing	15	18.38	18.30	17.99	18.22	18.68	18.33	18.13	18.38
	20	18.97	19.52	19.57	19.35	18.88	20.30	20.14	19.77
	25	20.31	20.33	20.28	20.31	20.73	20.30	20.45	20.50
Mean		19.22	19.38	19.28		19.43	19.65	19.57	

L.S.D. at 5% for	2014/2015	2015/2016
Varieties (V)	Sig.	N.S
Plant spacing (S)	0.10	0.32
Boron (B)	N.S	N.S
V X S	0.14	0.46
V X B	0.24	0.41
S X B	0.29	0.49
V X S X B	N.S	0.71

Table (9): Effect of plant spacing, foliar with boron and their interactions on sucrose % of two sugar beet varieties in 2014/2015 and 2015/2016 seasons.

Seasons		2014/2015				2015/2016			
Varieties	Plant spacing (cm)	Foliar with boron (ppm)			Mean	Foliar with boron (ppm)			Mean
		Cont.	50	100		Cont.	50	100	
Kawemira	15	16.19	16.06	15.33	15.86	15.59	15.96	16.15	15.90
	20	17.39	17.16	17.85	17.47	17.13	17.55	17.62	17.43
	25	17.75	17.32	17.48	17.52	17.41	17.59	17.65	17.55
Mean		17.11	16.85	16.88	16.95	16.71	17.03	17.14	16.96
Oscar poly	15	15.48	15.34	15.70	15.50	15.64	15.75	15.95	15.78
	20	15.91	16.24	16.27	16.14	16.02	16.35	16.39	16.25
	25	17.77	17.85	18.03	17.88	17.55	17.70	17.97	17.74
Mean		16.39	16.47	16.66	16.51	16.40	16.60	16.77	16.59
Mean for plant spacing	15	15.83	15.70	15.51	15.68	15.61	15.85	16.05	15.84
	20	16.65	16.70	17.06	16.80	16.57	16.95	17.00	16.84
	25	17.76	17.59	17.75	17.70	17.48	17.65	17.81	17.64
Mean		16.75	16.66	16.77		16.55	16.82	16.95	

L.S.D. at 5% for	2014/2015	2015/2016
Varieties (V)	N.S	.
Plant spacing (S)	0.27	0.08
Boron (B)	N.S	0.13
V X S	0.38	0.12
V X B	N.S	N.S
S X B	N.S	N.S
V X S X B	N.S	N.S

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تأثير مسافات الزراعة والرش الورقي بالبورون على المحصول والجودة لصنفين من بنجر السكر

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أجريت تجربة حقلية خلال موسمي نمو متتالين (2015/2014 و2016/2015) بمزرعة قرية طهنشا بمحافظة المنيا بهدف دراسة تأثير ثلاث مسافات زراعة (15، 20 و25 سم بين الجور) والرش الورقي بالبورون بتركيز (كنترول، 50 و100 مليجرام) على صنفين من بنجر السكر (كاوميرا وأوسكار بولي) وأثر ذلك على المحصول ومكوناته وجودته تحت ظروف محافظة المنيا. وقد استخدم تصميم القطاعات الكاملة العشوائية في القطع المنشقة مرتين في ثلاث مكررات حيث وضعت الأصناف في القطع الرئيسية بينما وضعت مسافات الزراعة وتركيزات البورون في القطع المنشقة والمنشقة مرتين على الترتيب.

وقد أظهرت النتائج المتحصل عليها إختلافاً معنوياً بين أصناف بنجر السكر في قطر الجذر(سم) ومحصول الأوراق والجذور (طن/فدان) في كلا الموسمين، ووزن الجذر الطازج (جم /نبات) ومحصول السكر(طن/فدان) والنسبة المئوية للمواد الصلبة الذائبة الكلية % في الموسم الأول فقط، ونسبة السكروز % في الموسم الثاني فقط، أما بالنسبة لطول الجذر (سم) فكانت الفروق غير معنوية في الموسمين. وتفوقت نباتات الصنف كاوميرا على الصنف أوسكار بولي في قطر الجذر(سم) ومحصول الأوراق، الجذور والسكر (طن/فدان) والنسبة المئوية للمواد الصلبة الذائبة الكلية % ونسبة السكروز % في كلا الموسمين، ووزن الجذور الطازج (جم /نبات) في الموسم الأول فقط.

أدي زيادة مسافات زراعة من 15، 20 إلى 25 سم بين الجور إلي زيادة معنوية في كل الصفات تحت الدراسة في كلا الموسمين، حيث تحققت اعلي القيم عند الزراعة على مسافة 25 سم بين الجور.

أدت زيادة تركيزات البورون إلي زيادة معنوية في طول وقطر الجذر(سم) ووزن الجذر الطازج (جم /نبات) ومحصول الأوراق والجذور (طن/فدان) والنسبة المئوية للمواد الصلبة الذائبة الكلية % في كلا الموسمين، ومحصول السكر(طن/فدان) في الموسم الأول فقط، ونسبة السكروز % في الموسم الثاني فقط.

كان التفاعل بين الأصناف ومسافات الزراعة له تأثيراً معنوياً على طول الجذر في الموسم الثاني فقط، والوزن الطازج للجذر ومحصول الأوراق والجذور (طن/فدان) والنسبة المئوية للمواد الصلبة الذائبة الكلية ونسبة السكروز % في كلا الموسمين ومحصول السكر(طن/فدان) في الموسم الأول فقط.. بينما

التفاعل بين الأصناف والبورون كان لـه تأثيراً معنوياً علـى طـول الجـذر والـوزن الطـازج للجـذر فـي الموسم الثـاني فقـط ومحصـول الجـذور (طن/فـدان) والنسـبة المئويـة للمـواد الصـلبة الذائبـة الكليـة % فـي كـلا الموسـمين ومحصـول السـكر (طن/فدان) فـي الموسـم الأول فقـط. وكـان التفاعـل بـين مسـافات الزراعـة والبـورون لـه تـأثيراً معنوياً علـى طـول الجـذر (سم) والـوزن الطـازج للجـذر (جم /نبـات) ومحصـول الأوراق والجذور (طن/فدان) والنسبة المئويـة للمـواد الصـلبة الذائبـة الكليـة % فـي كـلا الموسـمين. التفاعـل الثلاثـي أظهر تأثيراً معنوياً على طول الجذر ومحصول الجذر (طن/فدان) والنسبة المئوية للمواد الصلبة الذائبة الكلية % في الموسم الثاني فقط والوزن الطازج للجذر ومحصول الأوراق (طن/فدان) في كلا الموسمين.
وبصفة عامة توصي الدراسة بزراعة الصنف كاوميرا مع الزراعة على مسافة 25 بين الجور والمعاملة والرش الورقي بالبورون بتركيز 100 مليجرام وذلك لتحقيق أعلي ناتج من نباتات بنجر السكر من حيث المحصول والجودة تحت ظروف منطقة الزراعة.