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EVALUATION OF SOME SUGAR BEET GENOTYPES UNDER SALINITY STRESS CONDITION

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ABSTRACT

Evaluation of genotypes in arid and semi-arid regions comes in the first order for Sugar beet Breeding Program of Desert Research Center (DRC) due to its importance in determining this adaptation under stress conditions, especially after the success of flowering and seed production experiments of sugar beet under natural conditions of Saint Catherine. So, we need to optimize genotypes production by evaluation and adaptation under Egyptian conditions. A comparative study was conducted to assess the performance of twelve sugar beet genotypes in three salinity levels (L1, L2 and L3) in Ras Sudr station, South Sinai, DRC during 2016/2017-2017/2018 seasons. The experimental design was randomized complete block design with three replicates. The results indicated that the interaction between years, salinity and sugar beet genotypes mean squares were highly significant for all traits. This interaction between environmental conditions and sugar beet genotypes will have a significant impact on future breeding programs. HM16578 genotype gave the highest values of leaves weight per plant (205.8g, 200.4g and 111.7g) in L1, L2 and L3, respectively. DE 034-665 genotype recorded the highest values of root length; root diameter and root weigh per plant in L1and L2, while DE154-7682-118 genotype gave the highest values in L3. Primera genotype recorded the highest values of total soluble solids percentage (24.33, 26.00 and 27.67%) in L1, L2 and L3, respectively. Total soluble solids percentage showed a high significant negative correlation with each of leaves weight per plant, root length, root diameter and root weight per plant.

Key words: ***Evaluation, Sugar beet, Beta vulgaris L., Salinity levels, South Sinai.***

INTRODUCTION

The second sugar crop across the world is sugar beet. It is generally adapted to producing high yields under less favorable ecological conditions than that is required for sugar cane crop (El Refaey *et al*., 2012). In arid and semi-arid regions such as Ras Sudr, South Sinai. Irrigation is required to produce crops in arid and semi-arid regions. However, in such areas, water is generally salty, and it is therefore reasonable to consider salinity as a variable. Sugar beet is one of the major crops in these regions. Accumulation of excessive amounts of soluble salts in soil is a characteristic in arid and sub-arid regions, although not entirely limited to such areas. The ability of plants to tolerate excess salts in the rhizosphere is of considerable importance in arid and semi-arid regions where salinization of soil usually prevails (Abdel-Mawly and Zanouny 2004).

The sugar beet represents about 45% of the total sugar produced in the world, and is considered the main source of sugar in Europe. Sugar is one of the most important strategic commodities in Egypt, and sugar cane is the second source for the production of sugar in the country after the sugar beet. Data in Table (1) show that a significant evolution in the contribution of the sugar beet crop to the total production of sugar in Egypt, where its contribution was in 1982 about 2.5% and increased gradually to reach in 2015 about 55%.

Table 1. The contribution of sugar cane and sugar beet to sugar production in Egypt.

Sugar product*	Season 1982		Season 2000		Season 2015	
	Production	%	Production	%	Production	%
Sugar cane(tones)	681897	97.5%	1037664	74.5%	1024461	45%
Sugar beet(tones)	16937	2.5%	355769	25.5%	1273786	55%
Total	698834	100%	1393433	100%	2298247	100%

***Report of the Board of Sugar Crops; January 2015.**

Sugar beet which is considered to be the first source for sugar production in Egypt has the ability to grow in the new soils that usually suffer from salinity and poor quality of irrigation water. It tolerates soil salinity and soil water stress (Hills *et al* 1990). Recently, the use of salt tolerant crops has been recognized as a successful method to overcome salinity problem (Meiri and Plaut 1985). Roades and Loveday (1990) indicated that sugar yield of sugar beet was not affected by salinity up to an electrical conductivity value of soil paste extract (ECe) of $7dSm^{-1}$. Abdel-Mawly and Zanouny (2004) studied the effect of sugar beet to potassium application and irrigation with saline water. A combination of four potassium levels (0, 24, 48, and 72 kg K_2O/fed) with four levels of saline irrigation water (tap water, 2000, 4000 and 6000 ppm) on root yield and some chemical composition of sugar beet. They indicated that sugar beet plants could tolerate saline water up to 2000 ppm without impaired effects on growth yield and quality. Moreover, K application improved the quality of sugar beet roots irrigated with saline water and with tap water. Adbhai (2015) investigated the effect of saline stress on growth and yield of sugar beet, comprising of two variety of sugar beet *viz.*, PAC60008 and SZ35 and six levels of salinity applied as irrigation water *viz.*, BAW, EC 2dS m^{-1}, EC 4dS m^{-1}, EC 6dS m^{-1}, EC 8dS m^{-1}, EC 10dS m^{-1} and found that the interaction effect between the two varieties of sugar beet and the six salinity levels for all the parameters were significant. In Egypt, studies have focused on the analysis of results of agricultural activities under saline irrigation conditions for different crops. The studies included different treatments to reduce the negative effects of salinity, breeding for salt tolerance and application of different irrigation systems and water management to improve crop productivity under saline water conditions (Abou-Hadid 1998).

The main objective of plant breeding is the development of varieties with the maximum commercial yield at the lowest economic and environmental cost (Campbell 2005). Gross sugar yield is the most important trait for growers and it depends on the weight of the roots produced per unit area and on the sugar content, i.e., the percentage w/w of sucrose present in the roots. Varieties must also possess good yield stability across localities and years, which depend on a broad genetic base and on resistances against multiple biotic and abiotic stresses (Biancardi *et al* 2010). The development of high yielding varieties requires detailed knowledge of the genetic variability present in the germplasm of the crop, the association among yield components, input requirements and culture practices (Dutta *et al* 2013).

In that context, evaluation of genotypes in arid and semi-arid regions of Egypt comes in the first order for Sugar beet Breeding Program of Desert Research Center due to its importance in determining their adaptation under stress conditions, especially after the success of flowering and seed production experiments of sugar beet under natural conditions of Saint Catherine **(**Bayomi 2013). Thus, the objective of this study was evaluation and selection of sugar beet genotypes under three levels of irrigation water salinity in Ras Sudr, South Sinai.

MATERIALS AND METHODS

This study was executed at Ras-Sudr station, Desert Research Center (DRC), South Sinai, during 2016/2017-2017/2018 seasons. A list of sugar beet genotypes used in this study and the country of the origin are presented in Table (2).

Three levels of irrigation water salinity, level 1 (6.1dSm^{-1}), level 2 (9.15 dSm^{-1}) and level 3 (12.2 dSm^{-1}). Sugar beet genotypes were evaluated in a randomized complete blocks design with three replications of each level separately. Each plot size was 24 m^{2}, consisted of 12 rows, 4 meter long and 0.50 m width, spaced 20 cm between the plants in each row. Seed drilling was done in the 15th of September for two seasons. All plots were irrigated with level 1 (6.1dSm^{-1}), until sugar beet plants had 6- 8 leaves. Then the plots received irrigation water with different salinity levels.

Table 2. Genotypes used and their country of origin.

No.	Genotype	Seeds	Source
1	DE 034-665	Multigerm	Germany
2	HM 16578	Multigerm	Germany
3	HM16582	Multigerm	Germany
4	BEL 13-1339	Multigerm	Netherland
5	DE 154-7682-118	Multigerm	Germany
6	Primera	Multigerm	Italy
7	Cleopatra	Multigerm	France
8	Almas	Multigerm	Germany
9	Ras poly	Multigerm	France
10	Glorius	Multigerm	Germany
11	FC708	Monogerm	U.S.A
12	FC723	Monogerm	U.S.A

Agricultural practices were done recommended. Harvesting was occurred after 180 days. The data were recorded for leaves weight/plant (g), root length/plant (cm), root diameter/plant (cm), root weight/plant (g) and total soluble solids percentage (T.S.S.%). T.S.S.% was determined by using Hand Refractometer and expressed as percentage of the juice.

Statistical Analysis: Statistical analysis was performed using analysis of variance technique by means of "MSTAT" computer software package. The treatment means were compared using Duncan's multiple range test (Duncan 1955).

RESULTS AND DISCUSSION

Combined analysis of variance for each salinity level in the two seasons as well as the combined analysis of three salinity levels in the two seasons is presented in Table (3).Years mean squares were highly significant for all the studied traits, indicating that the genotypes behaved differently from year to another. Sugar beet genotypes mean squares were highly significant for all traits in the three levels of salinity as well as the combined data of three salinity levels in the two seasons. Differences among genotypes are necessary to continue to study the genetic behavior of these traits to improve them.

Salinity mean squares were highly significant for all traits. The interaction between years and sugar beet genotypes mean squares were highly significant for all traits in the three levels of salinity as well as the combined data. The interaction between salinity and sugar beet genotypes mean squares were highly significant for all traits.

Table 3. Combined analysis of variance (ANOVA) for leaves weight/plant (g), root length (cm), root diameter (cm), root weight/plant (g) and T.S.S% of twelve sugar beet genotypes under three salinity levels (6.1dSm^{-1}, 9.15 dSm^{-1} and 12.2 dSm^{-1}) in two seasons (Combined analysis of three salinity levels in two seasons).

SOV	df	Leaves weight/plant (g)	Root length (cm)	Root diameter (cm)	Root weight/plant (g)	T.S.S%
Salinity level 1 (6.1dSm^{-1})						
Year	1	2196.74**	0.180*	19.014**	316476.42**	39.013**
Y.× R.	4	100.292**	0.397**	0.026^{ns}	1409.76$^{n.s}$	1.472**
Genotype.	11	8507.901**	11.029**	5.959**	253102.532**	12.771**
Y.× G.	11	382.259**	0.945**	1.593**	7204.28**	2.105**
Error	44	19.599	0.042	0.045	1322.84	0.366
Salinity level 2 (9.15 dSm^{-1})						
Year	1	2191.22**	4.550**	32.00**	319200.50**	91.125**
Y.× R.	4	120.157*	0.139$^{n.s}$	0.093$^{n.s}$	385.818$^{n.s}$	0.444$^{n.s}$
Genotype.	11	9186.639**	12.194**	7.992**	253241.84**	13.589**
Y.× G.	11	361.590**	1.402**	0.744**	3652.357**	1.943**
Error	44	43.975	0.092	0.074	1057.069	0.354
Salinity level 3 (12.2 dSm^{-1}).						
Year	1	2158.245**	17.701**	43.40**	186060.167**	3.556**
Y.× R.	4	13.281$^{n.s}$	0.036$^{n.s}$	0.043$^{n.s}$	77.561$^{n.s}$	0.444$^{n.s}$
Genotype.	11	2826.069**	25.818**	7.714**	56337.486**	7.833**
Y.× G.	11	99.742**	0.725**	0.590**	3930.66**	0.707$^{n.s}$
Error	44	26.062	0.114	0.069	335.582	0.368
Combined analysis						
Year	1	6546.11**	15.25**	91.91**	810043.53**	104.16**
Salinity	2	94162.53**	252.14**	139.11**	3711711.62**	255.26**
Y.× S.×R.	12	77.91**	0.191*	0.054$^{n.s}$	624.38$^{n.s}$	0.787*
Genotype.	11	17922.43**	41.145**	19.962**	492455.04**	27.06**
Y.× G.	11	545.94**	2.325**	1.546**	8370.86**	3.07**
S.× G.	22	1299.09**	3.948**	0.852**	35113.41**	3.57**
Y.× S.× G.	22	148.83**	0.373**	0.691**	3208.22**	0.844**
Error	132	29.878	0.083	0.063	905.16	0.363

N.s, *, **: Insignificant, Significant and highly significant, respectively. Y. = Year R. =Replication G. =Genotype S. =Salinity

The second order interaction between years, salinity and sugar beet genotypes mean squares were highly significant for all traits. This interaction between environmental and sugar beet genotypes is expected to have a significant impact on future breeding programs. These results are in line with those obtained by Abdel-Mawly and Zanouny (2004) and Adbhai (2015).

The results presented in Table (4) indicate clearly that, there were significant differences between the different sugar beet in all studied traits at three levels of salinity, L1 (6.1dSm^{-1}), L2 (9.15dSm^{-1}) and L3 (12.2dSm^{-1}) in the combined analysis among the three salinity levels in the two seasons. HM16578 genotype gave the highest values of leaves weight per plant (205.8g, 200.4g, 111.7g, and 172.7g) in L1, L2, L3 and com., respectively. While FC723 genotype gave the lowest values of leaves weight per plant (82.8g, 69.1g, 42.9g and 65.1g) in L1, L2, L3 and com., respectively. DE 034-665 and Almas genotypes gave the highest values of root length per plant (17.3cm, 17.2cm, 16.6cm, and 16.3cm) in L1 and L2 respectively. Also, DE 154-7682-118 and DE 034-665 genotypes gave the highest values of root length per plant (14.5cm and 15.79cm) in L3 and com., respectively. While FC708 genotype gave the lowest values of root length per plant (12.6cm, 11.7cm, 6.9cm and 10.38cm) in L1, L2, L3 and com., respectively. In case of L1 (6.1dSm^{-1}), four genotypes, i.e., DE 034-665, HM16578, Ras poly and Glorius gave the highest values of root diameter per plant (10.4cm,10.3cm,10.3cm and 10.2cm) respectively. DE 034-665 and Ras poly genotypes gave the highest values of root diameter per plant (10.2cm and 9.9cm) respectively in L2 (9.15dSm^{-1}). While FC723 genotype gave the lowest values of root diameter per plant (7.4cm, 6.2cm, 4.6cm and 6.80cm) in L1, L2, L3 and com., respectively. DE 034-665 genotype gave the highest value of root weight per plant (1060.6g) in L1 (6.1dSm^{-1}). In case of L2 (9.15dSm^{-1}), three genotypes, i.e., DE 034-665, Ras poly and HM16578 gave the highest values of root weight per plant (946.8g, 922.9g and 911.2g) respectively. Also, DE 154-7682-118 genotype gave the highest values of root weight per plant (529.4g) in L3 (12.2dSm^{-1}). In case of the combined of the three experiments, three genotypes, i.e., DE 034-665, HM16578 and DE 154-7682-118 gave the highest values of root weight per plant (812.16g, 796.49g and 795.2g), respectively. While FC723 genotype gave the lowest values of root weight per plant (443.9g, 350.5g, 239.1g and 344.48g) in L1, L2, L3 and com., respectively. Primera genotype gave the highest values of total soluble solids percentage (24.33, 26.00, 27.67, and 25.72%) in L1, L2, L3 and com., respectively.

Table 4. Mean performance for leaves weight/plant(g), root length (cm), root diameter (cm), root weight/plant(g) and T.S.S% of twelve sugar beet genotypes under three salinity levels in two seasons (Combined analysis of three salinity levels in two seasons).

Genotypes	Leaves weight/plant(g)				Root length (cm)			
	Level 1	Level 2	Level 3	Com.	Level 1	Level 2	Level 3	Com.
DE 034-665	183.2 c	175.1 c	88.1 b	148.8 c	17.3 a	16.6 a	13.5 c	15.79 a
HM 16578	205.8 a	200.4 a	111.7 a	172.7 a	16.3 c	15.5 b	13.1 d	14.93cd
HM16582	147.8 e	142.6 e	107.5 a	133.1 d	15.2 e	14.4 d	14.1 b	14.56 e
BEL 13-1339	161.9 d	153.2 d	73.6 cd	129.5 e	15.2 e	14.5 d	13.1 cd	14.26 f
DE 154-7682-118	193.5 b	187.7 b	83.8 b	155.0 b	16.4 bc	15.7 b	14.5 a	15.51 b
Primera	120.4 h	112.3 h	65.6 e	99.4 h	14.3 f	13.3 e	10.9 g	12.83 g
Cleopatra	127.9 g	120.9fg	76.7 c	108.5 f	15.6 d	14.8 c	12.3 e	14.24 f
Almas	126.7 g	116.9gh	65.5 e	103.1 g	17.2 a	16.3 a	11.4 f	14.99 c
Ras poly	127.7 g	122.6fe	73.6 cd	107.9 f	16.2 c	15.6 b	12.3 e	14.69 e
Glorius	136.1 f	124.7 f	69.0 de	109.9 f	16.5 b	15.6 b	12.2 e	14.73de
FC708	96.2 i	88.6 i	48.7 f	77.8 i	12.6 g	11.7 f	6.9 i	10.38 i
FC723	82.8 j	69.1 j	42.9 g	65.1 j	14.4 f	13.3 e	10.1 h	12.56 h
Mean	142.5	134.49	76.2	117.75	15.6	14.76	12.02	14.12
CV%	3.11	4.93	6.69	4.64	1.32	2.06	2.81	2.04
LSD 0.05	5.51	7.72	5.94	3.604	0.24	0.364	0.393	0.19

Genotypes	Root diameter (cm)				Root weight/plant(g)			
	Level 1	Level 2	Level 3	Com.	Level 1	Level 2	Level 3	Com.
DE 034-665	10.4 a	10.2 a	7.2 bc	9.26 a	1060.6 a	946.8 a	429.1 de	812.16 a
HM 16578	10.3 ab	9.8 b	7.3 bc	9.12abc	1001.4 b	911.2 ab	476.8 c	796.49 ab
HM16582	9.7 d	9.4 c	8.0 a	9.02 cd	872.2 de	744.2 e	498.7 b	705 04 d
BEL 13-1339	9.4 e	8.9 de	6.5 d	8.28 f	889.9 d	797.6 d	422.3 e	703.26 d
DE 154-7682-118	9.9 c	9.2 cde	8.1 a	9.06bcd	952.5 c	903.8 b	529.4 a	795.20 ab
Primera	8.2 f	7.7 g	6.1 e	7.32 g	645.4 f	500.4 g	311.4 g	485.74 f
Cleopatra	10.1 bc	8.9 e	7.8 a	8.92 de	842.6 e	701.7 f	447.1 d	663.82 e
Almas	9.3 e	8.5 f	6.7 d	8.14 f	862.8 de	737.9 ef	398.9 f	666.56 e
Ras poly	10.3 ab	9.9 ab	7.5 b	9.22 ab	1017.7 b	922.9 ab	409.4 ef	783.32 b
Glorius	10.2abc	9.2 cd	7.1 c	8.82 e	981.0 bc	850.5 c	444.8 d	758.76 c
FC708	8.2 f	7.4 g	4.8 f	6.80 h	484.4 g	413.5 h	240.4 h	379.43 g
FC723	7.4 g	6.2 h	4.6 f	6.06 i	443.9 g	350.5 i	239.1 h	344.48 h
Mean	9.46	8.76	6.78	8.34	837.9	731.8	402.43	657.35
CV%	2.25	3.09	3.89	3.01	4.34	4.44	4.55	4.58
LSD 0.05	0.25	0.316	0.306	0.165	42.32	37.83	21.315	19.838

Table 4. Cont.

Genotypes	T.S.S%			
	Level 1	Level 2	Level 3	Com.
DE 034-665	20.50 de	22.17 ghi	24.83 e	22.50 g
HM 16578	20.17 e	21.67 i	23.33 f	21.72 h
HM16582	20.67 de	21.83 hi	24.83 e	22.44 g
BEL 13-1339	21.17 d	23.00 ef	25.50 de	23.22 ef
DE 154-7682-118	23.00 b	24.50 cd	25.17 de	24.22 c
Primera	24.33 a	26.00 a	27.67 a	25.72 a
Cleopatra	21.00 d	23.50 e	25.33 de	23.28 de
Almas	22.00 c	24.33 d	26.33 bc	24.22 c
Ras poly	20.83 de	22.83 efg	24.83 e	22.83 fg
Glorius	20.83 de	22.50 fgh	26.83 b	23.67 d
FC708	23.67 ab	25.17 bc	26.50 bc	25.11 b
FC723	23.67 ab	25.67 ab	25.83 cd	25.06 b
Mean	21.82	23.59	25.58	23.67
CV%	2.77	2.52	2.37	2.55
LSD 0.05	0.704	0.692	0.706	0.397

Level 1 = Salinity (6.1 dSm^{-1}), Level 2 = Salinity (9.15 dSm^{-1}), Level 3 = Salinity (12.2 dSm^{-1}).

While, HM16578 genotype gave the lowest values of total soluble solids percentage (20.17, 21.67, 23.33 and 21.50%) in L1, L2, L3 and com., respectively. Several investigators indicated that sugar beet has a fairly wide adaptability and is relatively resistant to cold, withstand drought, and are not overly sensitive to salinity (Ahmed *et al* 2012), however, productivity under unfavorable conditions is not high (Petkeviciene 2009). Moreover, other investigators indicated that the beet yield differed with different cultivars (Shalby *et al* 2011and Hassani *et al* 2018).

The results presented in Table (5) revealed the associations among five important traits of sugar beet genotypes under different salinity levels of irrigated water. In that context, leaves weight per plant had highly significant positive correlation with each of root length per plant, root diameter per plant and root weight per plant. In the contrary, high significant negative correlation was found between leaves weight per plant and total soluble solids percentage. Highly significant positive correlation was observed between root length per plant and each of root diameter per plant and root weight per plant. On the other hand, root length per plant showed a highly significant negative correlation with total soluble solids percentage.

Table 5. Pearson product moment correlation coefficients between five characters of sugar beet under three salinity levels in the two seasons (Combined analysis of the three salinity levels).

Characters	1	2	3	4	5
1-Leaves weight /plant(g)	1.000	0.768**	0.788**	0.870**	-0.636**
2- Root length (cm)		1.000	0.813**	0.853**	-0.638**
3- Root diameter (cm)			1.000	0.909**	-0.572**
4- Root weight /plant(g)				1.000	-0.659**
5- T.S.S %					1.000

Root diameter per plant had highly significant positive correlation with root weight per plant. Highly significant negative correlation was also found between root weight per plant and total soluble solids percentage.

CONCLUSIONS

An obvious variation of the performance of the twelve sugar beet genotypes under the three salinity levels was detected. In that respect, HM16578 genotype was better for leaves weight per plant, DE 034-665 genotype was better for root traits (length, diameter and root weight). On the other hand, Primera genotype was better for total soluble solids percentage. Therefore, when starting the breeding program, a large number of genotypes with good traits should be selected. Total soluble solids percentage showed a high significant negative correlation with all traits.

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تقييم بعض التراكيب الوراثية من بنجر السكر تحت ظروف الاجهاد الملحى

خالد السيد مجاهد بيومى و إيهاب سعودى عبدالحميد مصطفى

وحدة تربية النبات – قسم الاصول الوراثية – مركزبحوث الصحراء

تقييم التراكيب الوراثية بالمناطق الجافة وشبه الجافة من المهام الاولى لبرنامج تربية بنجر السكر بمركز بحوث الصحراء لتحديد التأقلم تحت ظروف الاجهاد ، خاصة بعد نجاح الازهار الطبيعى وإنتاج البذور لبنجر السكر تحت ظروف سانت كاترين. لذا نحتاج بإستمرار الى تحسين إنتاجية التراكيب الوراثية تحت الظروف المصرية المختلفة. تم إجراء هذه الدراسة لتقييم أداء اثنى عشر تركيباً وراثياً من بنجر السكر تحت ثلاث مستويات من ملوحة ماء الرى ($12.2\ dSm^{-1}$ – $9.15\ dSm^{-1}$ – $6.1dSm^{-1}$) بمحطة بحوث رأس سدر بجنوب سيناء مركز بحوث الصحراء خلال الموسمين ٢٠١٧/٢٠١٦ –٢٠١٨/٢٠١٧ ، فى تصميم القطاعات الكاملة العشوائية من ثلاث مكرارات والنتائج تشير الى أن التفاعل بين التراكيب الوراثية والملوحة والسنين كان عالى المعنوية وبالتالى يؤثر على برامج التربية فى المستقبل. التركيب HM16578 سجل أعلى المتوسطات لصفة وزن الاوراق للنبات (٢٠٥,٨ جم-٢٠٠,٤ جم- ١١١,٧ جم) للثلاث مستويات ملوحة على التوالى. التركيب DE034-665 سجل أعلى المتوسطات لصفات طول الجذر وقطر الجذر ووزن الجذر تحت مستوى الملوحة الاول والثانى بينما التركيب DE154-7682-118 كان الافضل للمستوى الثالث. التركيب Primera سجل أعلى قيم لنسبة المواد الصلبة الذائبة الكلية (٢٤,٣٣-٢٦,٠٠-٢٧,٧٦%) للثلاث مستويات من الملوحة على التوالى. وقد أظهرت النتائج وجود إرتباط سالب ومعنوى بين نسبة المواد الصلبة الذائبة الكلية و الصفات المدروسة.

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