



Response of Sugar Beet Genotypes under Salinity Stress in Central Areas of Iran

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ABSTRACT

To evaluate sugar beet genotypes in saline and non-saline conditions, 30 genotypes were selected from Iranian Sugar Beet Seed Institute Breeding Program and planted in two salinity levels. The experiment took one agricultural year to complete in 2017. A total number of 28 sugar beet genotypes, including five genotypes as Controls, were cultivated, and subjected to two salinity levels of irrigation water, 2dS.m⁻¹ and 14dS.m⁻¹, in five replications within the format of complete randomized block design. Upon the establishment of the plants, the number of the plants on the cultivation lines was counted and thinning was done. The entire cultivation plots were harvested in technological harvesting time and the roots were counted, weighed, and finally sent to Sugar Beet Technology Laboratory affiliated with Sugar beet Seed Institute-Iran to be used for pulp determination and eventually undergo qualitative analysis. Data analysis was carried out in SAS and the mean comparisons were carried out using Duncan test in a 5% probability level and the interaction effects were examined by taking advantage of slicing method. The experiment results indicated that salinity has a significant effect on such traits as root yield, fresh and dry shoot weight, sugar content and molasses sugar. Salinity treatment had no significant effect on number of plants per hectare and number of roots in the plot. The salt tolerant genotypes selected in this experiment include genotypes 17, 29, 3 and 24, which require further examination in terms of yield stability.

Key Words: Genotype, Root Yield, Sugar Beet, Salt Tolerance.

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INTRODUCTION

Today's salinity is one of the most important environmental stresses. According to the definition of saline soils, it refers to soils that contain high concentrations of salts, to the extent that they adversely affect plant growth [1]. At least 45 million ha of the irrigated land is salt affected or irrigated with saline waters in the world [2] and it is estimated that about 15% of the total land area of the world has been degraded by soil erosion and physical and chemical degradation, including soil salinization [3, 4] and it is expected to result in a 50% loss of arable lands by the middle of the 21st century [5].

Iran is one of the countries facing low rainfall in the last

30 years and then come through degradation of water supplies and this eventuated to increase salinity problems especially in arid and semiarid regions where evapotranspiration volume is greater than precipitation volume along the year. In most of these areas we are obligated to use brackish waters and salinization of soils becomes a serious agricultural concern.

Salt in the soil water inhibits plant growth in two phases. First decrease of the water uptake by roots due to osmotic effects of salts and second, excessive salts inside the plants will eventually injure cells in transpiring leaves [6]. The first phase of the growth reduction contributes to outside salts in the soil solution which reduces leaf and root growth by stomatal closing and limitation of water uptake and the salts taken up by the roots does not directly inhibit the growth of the new leaves. This phase

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is shorter than second one and the cell division and metabolic process involved are similar to water stress [6]. The second phase takes several weeks/months and more reduction of growth occurred which is due to ionic toxicity and disruption in photosynthesis [7]. In this phase, salts is causing injury of the photosynthetic leaves especially young leaves due to accumulation of Na^+ cations in cytosol with toxic levels and ionic imbalance [8]. Daoud et al. (2008) stated that salinity tolerance in two sugar beet species (*Beta vulgaris* ssp. *Martima* and *Beta vulgaris* ssp. *vulgaris*) depends on their ability to regulate osmotic through ionic regulation and water absorption from the growth medium [9]. The mechanisms used by these two species to prevent ionic toxicity include surrounding sodium and chloride ions in the shoot vacuoles and synthesizing the compatible soluble solutes in the cell cytoplasm. They stated that the reason for long-term survival under salt stress conditions and preservation of leaf turgidity in these two species was due to decreased stomatal conductance and reduced transpiration. Also, the high levels of photosynthesis in both species showed that the cause of growth loss under salt stress conditions was not due to decreased photosynthesis but due to ionic toxicity. Abbas et al. (2012) conducted an experiment on 10 sugar beet genotypes to assess their salinity tolerance [10]. In this study, Na^+ content was increased in leaves and roots of all genotypes under salt stress conditions. This increase in Na^+ content in leaves was higher than the root. On the other hand, K^+ content decreased in leaves and roots, and this decrease was lower in roots than leaves. In general, inorganic solutions (sodium and potassium) in leaves were more than roots. In this study, Kawimera genotype was the most tolerant and Tigris genotype was the most sensitive.

One of the most effective methods in exploiting soil and salt water is the improvement of salinity tolerant cultivars in order to increasing yield. The basis of most plant breeders to select a tolerant genotype is the difference in tolerance to salt stress among genotypes of one species. But due to the genetic and physiological complexity of salt tolerance, very few conventional programs have reached acceptable results.

Sugar beet, has halophytes ancestors [10]. Members of Chenopodiaceae family including sugar beet can tolerate salinity by having osmotic regulation system and accumulation of Na^+ and Cl^- in their vacuoles and cytoplasm [11, 12]. Sugar beet genotypes absorb Na^+ and accumulate it in their leaf tissue for regulation and adaptation of its osmotic potential with soil [13]. This may be the reason for considering sugar beet as a tolerant crop. Sugar beet is one of the salt tolerant glycophyte crops but it is classified as sensitive during germination and stablishing stages [14, 15] and farmers may have

inadequate stands under saline conditions. Base on Khayamim et al., (2017) who reviewed sugar beet salt stress studies, establishment stage is sensitive than germination [16]. High soil salinity affects the growth of crops and the salt tolerance level varies from one species to another so sugar beet threshold value is 7.0 dS.m^{-1} with slope of %5.9 [17].

Breeding of the new varieties and introducing of salt tolerance cultivars are of the most useful strategies against salinity problem and improving of agricultural section. Sugar beet genotypic diversity in salinity tolerance is vary that would be used for improving salt tolerant varieties. In this experiment, it has been tried to use the genetic diversity to select salt tolerant genotypes.

MATERIALS AND METHODS:

In the present study, 30 sugar beet genotypes, including five genotypes as controls, were cultivated and subjected to two salinity levels of irrigation water, 2 dS.m^{-1} and 14 dS.m^{-1} , in five replications within the format of complete randomized block design. At first, the farm was selected with a uniform salinity and two times irrigation before planting (with 2 and 8 dS.m^{-1} water for non-saline and saline plots, respectively) were carried out to instigate more uniform salinity of the soil. Following the tillage operation in fall, the intended land was again prepared in April and cultivation was conducted during 17-19 April. The cultivation was carried out in the form of furrow-irrigated raised bed system. The entire plots were irrigated with non-saline water for the first and second times [18]. After the plants were found well-established, the later irrigations were carried out based on the specified treatments. Soil samples were collected in all the experimental plots from various depths: 0-30, 30-60 and 60-90 centimeters, before sowing the seeds as well as during the growth season. This was done to determine the amount of salinity the plant is exposed to during the growth season, as well as for managing the later irrigations (determination of the amount of leaching fractions). Upon the leaves being found established (8-10 leaf stage), the number of the plants on the cultivation rows was counted following which some thinning was conducted. Diazinon sprays were undertaken seven times for pest extermination. The number of plants was counted after emergence and also following exposing the plants to salinity treatment so that the salt-sensitive and salt-tolerant genotypes can be identified during early vegetative growth stage. The entire cultivation plots were harvested in technological harvest time and small samples were taken from shoots to be subjected to dry weight determination. After the roots were counted, they were sent to the sugar technology laboratory to be weighed and

undergo pulp determination and qualitative analysis. The traits evaluated in the laboratory were root yield (RY), sugar content or purity (SC), white sugar content (WSC), sugar yield (SY), white sugar yield (WSY), sodium, potassium and nitrogen impurities, molasses sugar (MS), extraction coefficient of sugar (ECS), alkalinity coefficient (Alc), dry matter percentage of root (DM) and shoot yield. Sugar content was measured based on polarimetry method; harmful nitrogen content was determined based on chromatography using betalyzer device and sodium and potassium impurities were measured based on flame photometry [19, 20]. The dry matter percentage of root was measured through placing an amount of root paste in a 105°C oven and allowing it to reach a constant weight [21]. The amount of molasses sugar was estimated based on the amounts of potassium, sodium and harmful nitrogen. The rest of the parameters and indices were calculated using the following relations:

Equation (1): $WSC = SC - (MS + 0.6)$

Equation (2): $SY = SC \times RY$

Equation (3): $WSY = WSC \times RY$

Equation (4): $ECS = (WSC / SC) \times 100$

Equation (5): $Alc = (K + Na) / (\alpha - N)$

Equation (6): $Tol = Y_p - Y_s$

Equation (7): $MP = \frac{Y_p + Y_s}{2}$

Equation (8): $STI = \frac{Y_p \times Y_s}{Y_p^2}$

Y_p = yield in non-saline condition; Y_s = yield in stress condition; \bar{Y}_p = mean of the genotypes yield in non-saline condition

Experimental data analyses were conducted using SAS software and performing mean comparisons based on Duncan test in a 5% probability level and the group comparisons were carried out using orthogonal coefficients and the interactions effects were determined using slicing method [22].

RESULTS:

Root Number

In this experiment, in order to create the same plant density, it was tried to reduce soil salinity during planting to ensure uniform plant density in both saline and non-saline conditions. The consumption of saline water at 14 dS.m⁻¹ after emergence caused soil salinity to reach 14-16 dS.m⁻¹. (Fig. 1). Under these conditions, it can be ensured that reduced yield and reduced growth in saline

conditions are due to the effect of soil salinity, not due to the lower plant density.

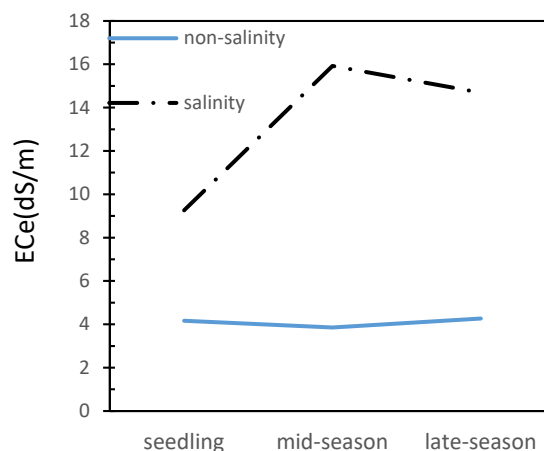


Figure 1: Soil salinity diagram during growing season for saline and non-saline conditions

According to table (1), the effect of salinity on the number of roots was non-significant, but on the total weight of root plots was significant at 5% probability level. The effect of genotype on each of these traits was significant at 1% probability level and the interaction effect of salinity × genotype on root number was meaningless and on total root weight at 1% level. Regarding the significance of interaction between salinity and genotype for total root weight of plot and its slicing, it was found that in half of the genotypes (14 genotypes), the difference in root weight was significant in saline conditions rather than non-saline conditions. This is a promising result for having salt tolerant genotypes that can be identified by evaluating other traits.

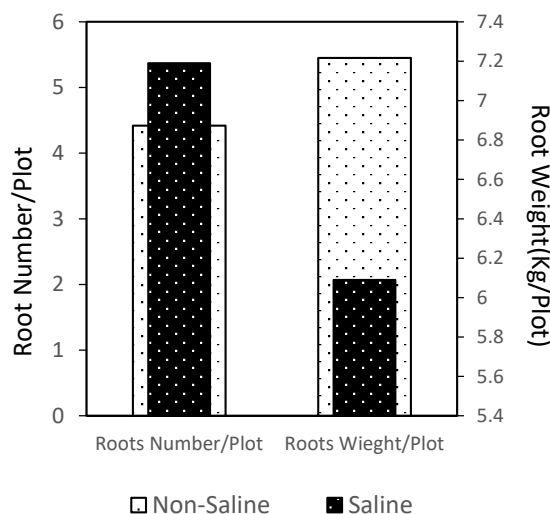


Figure 2: Number and weight of roots in plots in saline and non-saline conditions



Plant Number per hectare

The effect of salinity treatment on number of plants per hectare was not significant (Table 1). This issue is very important in assessing the effects of salinity, as it indicates that the decrease in growth and yield in saline conditions is not due to the low number of plants, but the salt stress in this regard. Regarding the fact that the sugar beet plant is very sensitive to salinity stress during plant establishment, and having enough plant to understand the effects of salinity stress it was necessary, so we used non-saline water for irrigation until plant establishing stage. However, plots in saline condition at the beginning of the growing season had a higher salinity, which was due to leaching with irrigation of 8 dS.m⁻¹ before planting (Fig. 1).

In this experiment, the effect of genotype on plant number per hectare was very significant (Table 1), and there is a great difference among the genotypes (Table 3). The highest number of plants per hectare observed in genotypes no. 4, 3, 24, 5 and 28, and the remaining genotypes except no. 25, 30, 18, 10 and 26 had no significant difference. This also suggests that if there is a difference among the genotypes in root growth and root yield is not due to plant density, and that five genotypes with low plant density removed in sieving process due to the sensitivity to salinity stress and low adaptation to the environment.

Fresh and dry shoot weight

In this study, the effect of salinity treatment on fresh and dry weight of shoot was significant at 5% probability level. The effect of genotype and the interaction effect of salinity × genotype was significant at 1% probability level (Table 2).

The fresh weight of shoots in saline conditions decreased by 43.4%, and the reduction was 29.6% for dry weight. Among the examined genotypes, there was a significant difference in terms of fresh and dry weight and these differences were significant (table 3). Based on the slicing of the interactions, it was observed that 16 genotypes had a significant difference in terms of fresh weight in saline and non-saline conditions. This number is less and includes 7 genotypes in terms of dry weight.

Root Yield (RY)

Results showed that, the effect of salinity on root yield was significant (5% probability level). The genotype effect and the interaction effect of salinity × genotype were also found to be statistically significant in a 1% probability level (table 1). Root yield in saline and non-saline conditions were 11.55 ton.ha⁻¹ and 22.78 ton.ha⁻¹, respectively (table 2). It means that a reduction by 49.3% was evidenced in sugar beet root yield subjected to salt stress. Based on the threshold of salinity tolerance of

sugar beet, the foresaid reduction in yield is obtained in salinity rates almost equal to 15.3dS.m⁻¹ [17].

Among the studied genotypes, very evident differences were scored in terms of root yield, white sugar content, extraction coefficient of sugar, sugar content, molasses sugar, alkalinity coefficient and harmful sodium, potassium and nitrogen impurities.

The highest root yield, 28.16 ton.ha⁻¹, was obtained in the genotype S1-930708 (no.8) and there was not found any significant difference among the foresaid genotype and the following ones in this regard: S1-930882 (no.24), DRI-HSF-14-P.35 (no.29), OT-110-25-90 (no.3), OT-111-17-90 (no.6), S1-940655 (no.17), S1-930770 (no.21), S1-930702 (no.7), OT-111-9-90 (no.4) and S1-940645 (no.13) (Table 3).

However, if genotypes were screened based on the stress tolerance index (STI) and yield under saline and non-saline conditions, genotypes S1-930882 (No. 24), OT-110-25-90 (No. 3), DR1-HSF-14-P .35 (No. 29) and S1-940655 (No. 17) will be selected (Fig. 3). The stress tolerance index in these genotypes were 1.37, 1.03, 1.00, and 0.85, which was more than half of the stress tolerance index in the studied genotypes (fig.3).

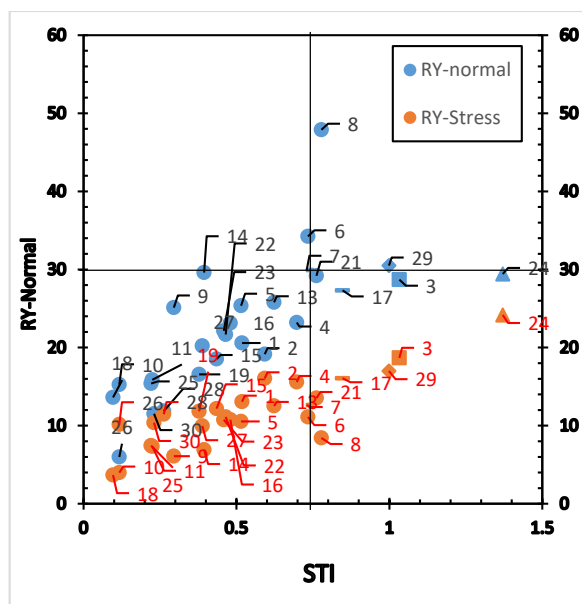


Figure 3. Bi-plot of stress tolerance index (STI) related to root yield under stress (yellow) and non-stress (blue) conditions. The right vertical axis: root yield in saline condition and left vertical axis: root yield under non-saline conditions. Symptoms of selected genotypes: Δ (S1-930882) No. 24; □ (OT-110-25-90) No. 3; ◇ (DRI-HSF-14-P.35) No. 29; — (S1-940655) No. 17 ; ⊥ (S1-930702) No. 7.

Based on this chart, genotypes in the upper and right quadrant have high STI and high root yield. Considering that no genotype is seen in this section, the closest

genotypes to this region are genotypes S1-930882 (No. 24), OT-110-25-90 (No. 3), DR1-HSF-14-P.35 (No. 29) and S1-940655 (No. 17). The genotype S1-930702 (No. 7) is also selected for high sugar yield and white sugar yield (see more results in: Pharmacophore. 9(2) 2018, pages: 60-71). These genotypes also have less differences in stress and non-stress conditions (less Tol. index) and higher mean productivity (high MP index). In addition, genotypes S1-930770 (No. 21) and OT-111-17-90 (No. 6) were in an acceptable range. To avoid the elimination of good genotypes, they can be used in supplementary experiments.

The highest root yield in this experiment was for genotype S1-930708 (No. 8), which due to its low yield in stress conditions, has low STI and high Tol. index and therefore is not suitable for salinity stress conditions.

Slicing of interaction of salinity \times Genotype showed that some genotypes had a significant difference in terms of root yield in saline conditions with non-saline conditions. Accordingly, the genotypes S1-940619 (No. 10); S1-940645 (No. 13); S1-940650 (No. 14); S1-940654 (No. 16); S1-940655 (No. 17); S1-940656 (No. 18); S1-930770 (No. 21); S1-930772 (No. 22); S1-930792 (No. 23); 7233-P.29 (No. 27); DR1-HSF-14-P.35 (No. 29); OT-111-25-90 (No. 3); OT-111-29-90 (No. 5); OT-111-17-90 (No. 6); S1-930702 (No. 7); S1-930708 (No. 8) and S1-940615 (No. 9) had significant difference in terms of root yield. The mean of these genotypes with other genotypes is shown in Table (4). As it is seen, the root yield difference (saline with non-saline conditions) in these genotypes is more than the rest.

Sugar Content (SC)

According to Table 1, the effect of salinity and genotype on sugar content (SC) was significant at 1% probability level and the interaction effect of salinity \times genotype was significant at 5% probability level. Sugar content in saline conditions was 41.16% and 35.15% in non-saline conditions (Table 2). The highest sugar content was obtained in Genotype No. 28, which was 17.76 (Table 3), and the two genotypes of No.30 and No.27 also had a very high sugar content.

According to the slicing of salinity \times genotype; genotypes that have a higher sugar content in saline conditions than non-saline conditions are: S1-940645 (No. 13), S1-940655 (No. 17), S1-940665 (No. 19), S1- S1-930772 (No. 22), S1-930882 (No. 24), S1-930962 (No. 25), DR1-HSF-14-P.35 (No. 29), OT-111-17- 90 (No. 6), S1-930702 (Fig. 7), S1-930708 (No. 8).

Molasses Sugar (MS)

Molasses sugar is actually the amount of non-extractable sugar from the root of sugar beet and the unit is: g. sugar/100 g. beet. The effect of salinity and genotype on molasses sugar was significant at 1% probability level but

their interaction was not significant (Table 1). The amount of molasses sugar in saline conditions was 4.67 grams of sugar per 100 grams of beet and in non-saline condition it dropped by 28 percent to 37.3 grams of sugar per 100 grams of beet (table2).

According to Table 3, the highest molasses sugar was observed in genotype No. 29 and genotypes 5, 19, 25, 23 and 11 with no significant difference.

White sugar content (WSC)

The recoverable sugar is actually the amount of sugar found in the root of sugar beet which can be extracted in the factory, which is also called white sugar or pure sugar, and its unit is 1 g. sugar in 100 g. of beet.

The effect of salinity stress on white sugar content was not significant, but the effect of genotype and interaction effect of salinity \times genotype were significant at 1% and 5% probability levels respectively (Table 1).

The percentage of extractable white sugar in non-saline condition was 11.37 grams of sugar per 100 grams of beet and its average in saline conditions was 11.15 (Table 2). The highest amount of extractable sugar in the genotypes under study was observed in Genotype No. 28 with amount of 13.84 and there was no significant difference with the genotypes no. 27 and 30 as controls. In addition, genotypes no. 1, 2 and 13 were also in the same top group (table 3).

The interaction effect of salinity \times Genotype on this trait was significant at 5% probability level. The result of slicing showed that there was a significant difference among the genotypes under both stress and non-stress conditions (Table 4). Also, differences of genotypes no. 10, 13, 24 and 28 were significant in saline condition with non-saline condition.

Extraction Coefficient of Sugar (ECS)

Extraction coefficient of sugar is actually the percentage of white sugar extracted from sucrose in the root of sugar beet, and it is also known as extraction efficiency, and is derived from the ratio of WSC to SC and expressed as a percentage.

In this experiment, the effects of salinity and genotype on ECS were significant at 5% and 1% level of probability, respectively and their interaction was significant at 5% probability level (table1).

Extraction coefficient of sugar in non-saline condition was 73.69 percent and it was 67.57 in saline condition. This reduction (6.12%) was significant at the 5% probability level (table 2).

The genotype no. 28 (as control) with the ECS of 77.76% was the highest record among the examined genotypes. According to Duncan multiple tests (Table 3), genotypes no. 1, 27, 13, 30, 2, 17, 3, 7, 15 and 26 had no significant difference with genotype no. 28.



Alkalinity Coefficient

The ratio of total sodium and potassium to nitrogen in the root of sugar beet is called the alkalinity coefficient. According to table (1), the effect of salinity and the interaction of salinity × genotype was not significant, but the effect of genotype was significant at 1% probability level. This coefficient was 3.19% in non-saline condition and 3.09% in saline condition with no significant difference (Table 2). Among the examined genotypes, the highest alkalinity coefficient was related to genotype no. 5 with a value of 4.20 and 10 other genotypes in table 3 were not significantly different with genotype no. 5.

Na⁺, K⁺ and N

In this experiment, the effect of salinity on sodium and nitrogen elements was significant and on potassium was not significant. But the effect of genotype on all three elements was very significant. The interaction effect of salinity × genotype was significant only on sodium and was not significant on potassium and nitrogen. The amount of sodium, potassium and nitrogen elements in saline conditions was higher than non-saline conditions (Fig. 4) but potassium, although high in saline conditions, was not significant compared to non-coding conditions. In Fig. 5, the concentration of sodium, potassium and nitrogen components of sugar beet root is shown in various genotypes. The difference among these genotypes is shown in Table 3 according to Duncan's test. Investigating the interaction of salinity × genotype in

these elements showed that this interaction was significant only in sodium. The slicing of this interaction showed that sodium content of all genotypes in saline conditions was significantly higher than non-saline conditions, except genotype 13 (data not shown).

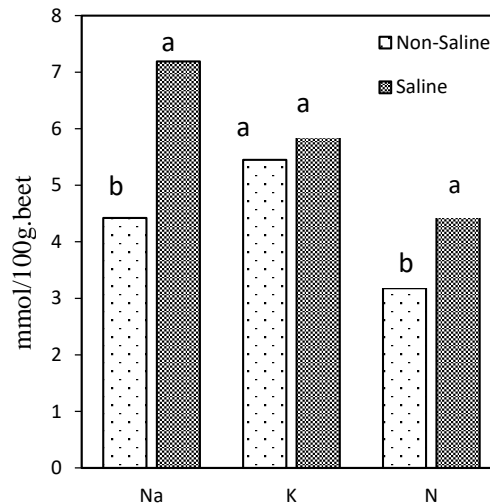


Figure 4: The amount of sodium, potassium and nitrogen in saline and non-saline conditions

The averages of each element are compared individually. The same letters in each element mean no significant difference.

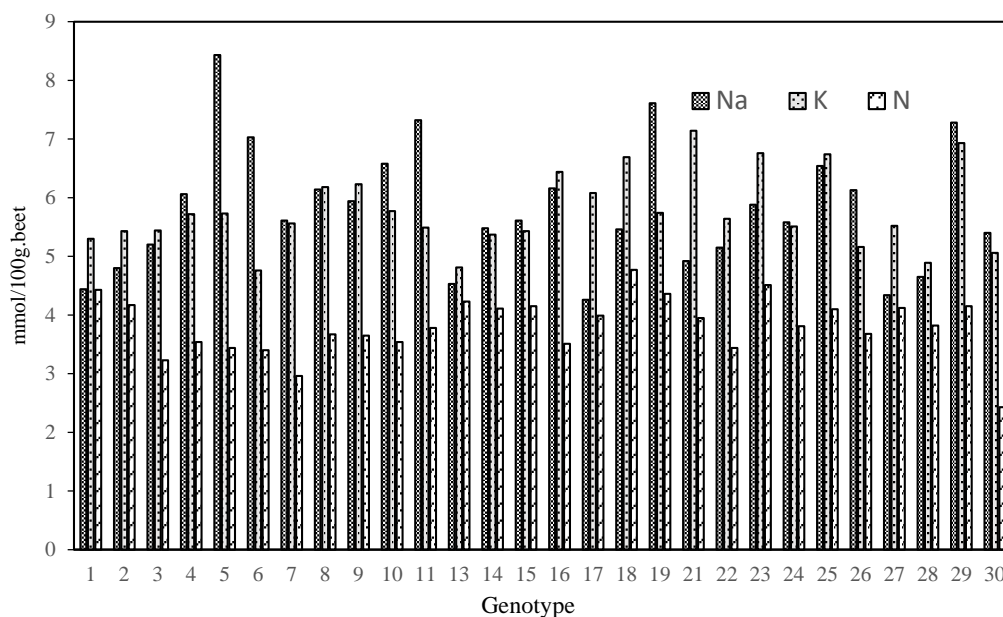


Figure 5: The concentration of sodium, potassium and nitrogen elements in the root of different genotypes of sugar beet

Table 1: Analysis of variance of studied traits

Source of Variation	Means of Squares									
	Plant number/ha	Root number/plot	Fresh shoot yield	Dry shoot yield	Root yield	Sugar content	Molasses sugar	White sugar content	Extraction coefficient of sugar	Alkalinity coefficient
Replication	15344.5	2447.9	1970	47.4	278.4	3.2	0.15	3.9	3.9	6.7
Salinity	1988.6 ^{ns}	323.1 ^{ns}	20444.8*	171.5*	5291.8*	47.9**	70.4**	2.2 ^{ns}	2.2 ^{ns}	0.4 ^{ns}
Error a	7776.7	1237.2	590.5	21.3	79.6	0.04	0.5	0.8	0.8	1.1
Genotype	2007.0**	320.0**	966.2**	18.0**	169.1**	6.6**	1.3**	11.8**	11.8**	1.4**
Salinity×genotype	1321.4 ^{ns}	211.7 ^{ns}	474.4**	8.5**	104.6**	1.5*	0.3 ^{ns}	2.0*	2.0*	0.3 ^{ns}
Error b	885.2	141.9	169.6	4.2	44.3	0.9	0.2	1.2	1.2	0.3
Coefficient variable (%)	34.9	34.9	32.7	35.4	38.8	5.9	10.5	9.6	9.6	18.9

Table 2: Comparison of means of studied traits in salt stress and non-stress conditions

treatment	Means									
	Plant number/ha	Root number	Fresh shoot yield (t/ha)	Dry shoot yield (t/ha)	Root yield (t/ha)	Sugar content (%)	Molasses sugar (g.sugar/100g.beet)	White sugar content (% in beet)	Extraction coefficient of sugar (% in sugar)	Alkalinity coefficient
Non-saline Con.	81786 a	32.71 a	50.86 a	6.83 a	22.78 a	15.35 b	3.37 b	11.37 a	73.69 a	3.19 a
Saline Con.	88667 a	35.49 a	28.80 b	4.81 b	11.55 b	16.41 a	4.67 a	11.15 a	67.57 b	3.09 a

Table 3: Comparison of mean of traits in the studied genotypes

Pedigree(#)	Means										
	Root yield (t/ha)	Plant number/ha	Root number	Fresh shoot yield (t/ha)	Dry shoot yield (t/ha)	Sugar content (%)	Molasses sugar (g.sugar/100 g.beet)	White sugar content (% in beet)	Extraction coefficient of sugar (% in sugar)	Alkalinity coefficient	
S1-930708(no.8)	28.16 a	95830 abc	38.33 abc	68.54 a	8.49 ab	14.66 jk	4.26 c-h	9.79 ij	66.87 ghi	3.46 a-d	
S1-930882(no.24)	26.79 ab	106670 a	42.67 a	59.02 ab	8.59 a	14.77 ijk	3.85 g-l	10.32 g-j	69.78 d-h	3.12 b-g	
DR1-HSF-14-P.35(no.29)	23.74 abc	87080 a-d	34.83 a-d	58.95 ab	8.47 ab	13.67 k	4.95 a	8.12 k	59.18 j	3.51 abc	
OT-110-25-90(no.3)	23.68 abc	111330 a	44.50 a	49.48 b-e	7.25 a-e	15.99 c-i	3.64 i-l	11.75 c-g	73.51 a-d	3.47 a-d	
OT-111-17-90(no.6)	22.68 a-d	86670 a-d	34.67 a-d	31.83 e-j	4.43 e-i	14.71 ijk	4.06 d-j	10.05 hij	68.47 fgh	3.52 abc	
S1-940655(no.17)	21.70 a-d	85420 a-e	34.17 a-e	46.62 b-f	7.50 a-d	16.53 a-f	3.61 jkl	12.32 b-e	74.56 abc	2.64 d-h	
S1-930770(no.21)	21.36 a-d	93330 abc	37.33 abc	42.67 b-h	6.33 a-g	14.85 ijk	4.20 c-i	10.05 hij	67.77 ghi	3.07 b-g	
S1-930702(no.7)	21.29 a-d	81670 a-e	32.67 a-e	50.43 bcd	6.82 a-f	16.46 b-g	3.80 g-l	12.05 b-f	73.41 a-e	3.80 ab	
OT-111-9-90(no.4)	19.39 a-e	112500 a	45.00 a	38.47 c-h	5.64 b-h	15.70 d-j	4.06 d-j	11.03 e-i	70.13 c-h	3.54 abc	
S1-940645(no.13)	19.16 a-e	93750 abc	37.50 abc	49.23 b-e	6.91 a-f	16.46 b-g	3.29 l	12.57 a-d	76.29 ab	2.24 h	
S1-940650(no.14)	18.25 b-f	85830 a-d	34.33 a-c	46.87 b-f	6.50 a-g	14.94 ij	3.80 g-l	10.54 g-j	70.60 c-g	2.67 d-h	
OT-111-29-90(no.5)	17.95 b-f	104580 a	41.83 a	36.81 c-i	5.52 c-h	14.92 ij	4.87 ab	9.45 ij	63.45 i	4.20 a	
8001-S1-18(no.2)	17.61 c-g	83330 a-e	33.33 a-e	48.02 b-f	7.51 a-d	16.98 abc	3.59 jkl	12.79 a-d	75.38 ab	2.51 e-h	
S1-940654(no.16)	16.95 c-h	100420 ab	40.17 ab	40.29 c-h	5.57 c-h	14.97 ij	4.34 b-g	10.03 hij	67.05 ghi	3.69 ab	
8001-S1-1(no.1)	16.83 c-h	77500 a-e	31.00 a-e	41.11 c-h	6.95 a-f	17.22 abc	3.45 kl	13.17 abc	76.50 ab	2.32 gh	
S1-930792(no.23)	16.44 c-h	94580 abc	37.83 abc	32.19 e-j	4.80 d-i	15.50 e-j	4.45 a-e	10.45 g-j	67.43 ghi	3.09 b-g	
S1-930772(no.22)	16.40 c-h	85420 c-h	34.17 a-e	32.82 d-i	4.77 d-i	15.70 d-j	3.71 h-l	11.39 d-h	72.61 b-f	3.16 b-f	
S1-940615(no.9)	15.61 c-h	73330 a-e	29.33 a-e	44.17 b-g	6.05 a-g	15.27 f-j	4.21 c-i	10.47 g-j	68.39 fgh	3.32 b-e	
S1-940653(no.15)	15.35 c-h	83920 a-e	33.67 a-e	33.86 d-i	5.66 b-h	16.65 a-e	3.86 f-l	12.19 b-e	73.28 a-e	2.77 c-h	
7233-P.29(no.27)	15.09 c-h	87920 a-d	35.17 a-d	54.15 abc	8.00 abc	17.56 ab	3.46 kl	13.50 ab	76.50 ab	2.43 fgh	
S1-940665(no.19)	14.20 d-h	101080 ab	40.50 ab	39.02 c-h	5.99 a-g	16.98 abc	4.68 abc	11.71 c-g	69.24 d-h	3.08 b-g	
191(no.28)	11.67 e-h	102920 a	41.17 a	30.47 f-j	4.65 d-i	17.76 a	3.32 kl	13.84 a	77.76 a	2.55 e-h	



S1-940622(no.11)	11.61 e-h	86670 a-d	34.67 a-d	27.52 g-j	3.74 ghi	15.22 g-j	4.44 a-f	10.19 hij	66.60 ghi	3.50 abc
S1-930962(no.25)	11.42 e-h	60420 b-e	24.17 b-e	31.51 e-j	4.36 f-i	15.11 hij	4.63 a-d	9.88 ij	65.45 hi	3.42 a-d
Ghazale(no.30)	10.94 e-h	57500 cde	23.00 cde	20.68 ij	3.12 hi	17.32 ab	3.60 jkl	13.12 abc	75.68 ab	3.29 b-e
S1-940619(no.10)	9.62 fgh	46920 de	18.83 de	20.47 ij	3.08 hi	15.61 d-j	4.26 c-h	10.75 f-j	68.80 e-h	3.66 ab
S1-940656(no.18)	8.65 gh	55000 cde	22.00 cde	24.95 hij	3.82 ghi	16.28 b-h	4.31 c-g	11.38 d-h	69.63 d-h	2.80 c-h
8001-bulk(no.26)	8.06 h	44750 e	18.00 e	15.14 j	2.40 i	16.88 a-d	3.91 e-k	12.37 b-d	73.22 a-e	3.15 b-f

Table 4: The mean of traits in salt stress and non-stress conditions for studied traits

Genotypes		RY		SC		MS		WSC		ECS		Alc	
No.	Pedigree	Stress	Non-Stress	Stress	Non-Stress	Stress	Non-Stress	Stress	Non-Stress	Stress	Non-Stress	Stress	Non-Stress
1	8001-S1-1	13.06	20.59	17.62	16.82	4.1	2.8	12.91	13.43	73.24	79.83	2.1	2.6
10	S1-940619	3.98	15.26	15.48	15.75	5.0	3.5	9.87	11.64	63.74	73.86	3.6	3.7
11	S1-940622	7.34	15.88	15.32	15.13	5.2	3.6	9.47	10.91	61.25	71.95	3.7	3.3
13	S1-940645	12.53	25.79	17.70	15.22	3.4	3.1	13.66	11.47	77.18	75.41	2.1	2.4
14	S1-940650	6.91	29.59	14.72	15.17	4.4	3.2	9.73	11.36	66.31	74.89	2.9	2.5
15	S1-940653	12.18	18.53	17.10	16.22	4.6	3.1	11.91	12.48	69.61	76.96	2.5	3.0
16	S1-940654	10.77	23.12	15.52	14.42	5.0	3.7	9.94	10.11	64.06	70.05	3.7	3.7
17	S1-940655	16.08	27.33	17.23	15.83	4.3	2.9	12.29	12.35	71.15	77.98	2.6	2.7
18	S1-940656	3.67	13.61	16.38	16.18	5.2	3.4	10.59	12.16	64.18	75.08	3.1	2.5
19	S1-940665	11.84	16.56	18.45	15.52	5.7	3.7	12.19	11.23	66.16	72.32	2.9	3.2
2	8001-S1-18	16.06	19.15	17.42	16.55	4.3	2.9	12.56	13.03	72.05	78.70	2.4	2.6
21	S1-930770	13.53	29.19	15.65	14.05	4.8	3.6	10.25	9.86	65.48	70.06	3.1	3.1
22	S1-930772	11.12	21.68	16.53	14.87	4.3	3.1	11.64	11.13	70.35	74.87	3.2	3.1
23	S1-930792	10.75	22.14	15.73	15.27	5.2	3.6	9.89	11.01	62.72	72.15	2.9	3.3
24	S1-930882	24.17	29.41	16.22	13.33	4.2	3.5	11.40	9.25	70.26	69.30	2.6	3.6
25	S1-930962	7.44	15.40	15.82	14.40	5.3	3.9	9.89	9.87	62.47	68.43	3.6	3.3
26	8001-bulk	10.14	5.99	16.83	16.93	4.8	3.0	11.46	13.29	68.07	78.36	3.0	3.3
27	7233-P.29	9.97	20.21	17.40	17.72	3.8	3.1	12.98	14.02	74.09	78.90	2.5	2.4
28	191	11.46	11.88	17.42	18.10	3.9	2.7	12.91	14.77	73.97	81.56	2.6	2.5
29	DR1-HSF-14-P.35	16.99	30.50	14.85	12.50	5.4	4.5	8.83	7.41	59.20	59.17	3.6	3.4
3	OT-110-25-90	18.67	28.70	16.45	15.53	4.2	3.1	11.68	11.82	71.01	76.01	3.1	3.8
30	Ghazale	10.37	11.52	17.88	16.77	3.8	3.4	13.48	12.76	75.39	75.97	2.7	3.8
4	OT-111-9-90	15.59	23.20	16.12	15.28	4.5	3.6	11.02	11.05	68.23	72.07	3.3	3.8
5	OT-111-29-90	10.54	25.35	15.42	14.43	5.9	3.9	8.95	9.95	58.00	68.91	4.0	4.4
6	OT-111-17-90	11.12	34.24	15.47	13.95	4.8	3.3	10.05	10.06	64.93	72.00	3.4	3.6
7	S1-930702	12.65	29.94	17.51	15.40	4.5	3.1	12.37	11.74	70.59	76.23	3.9	3.7
8	S1-930708	8.43	47.89	15.85	13.47	4.9	3.6	10.30	9.29	64.85	68.90	3.8	3.1
9	S1-940615	6.10	25.11	15.58	14.97	5.1	3.3	9.92	11.01	63.31	73.47	3.7	2.9

CONCLUSION

In this experiment root yield in salinity stress conditions decreased by 49.3%. Mas and Hoffman (1977) reported 15.3 dS.m⁻¹ of saturated extraction of soil as a 50 percent reduction in root sugar yield. In the salinity plots of this experiment, the salinity level of the soil saturation during the growing season (except beginning of the season) was between 14.7 until 15.9 dS.m⁻¹. At the beginning of the season, due to the susceptibility of sugar beet to salinity at the emergence stage [14, 23], it was necessary to reduce soil salinity to create appropriate plant density per unit area. This is necessary to separate the effects of salinity stress from the effects of plant density [18]. The sugar

yield and white sugar yield are a function of root yield [24] and there is a high correlation between these traits (corr: 0.96** and 0.98**). The reduction in sugar yield and white sugar yield in saline conditions were 0.44% and 47.8%, respectively (refer to: Pharmacophore, 9(2) 2018, pages: 60-71). Among the factors affecting these traits, other than root yield, are sugar content (SC) and white sugar content (WSC). Sugar content was 1.67% higher in saline conditions than non-saline condition, which is probably due to the smaller tubers in saline conditions. Although sugar content was higher in saline conditions, the white sugar content in both conditions was almost equal, due to the fact that the impurities of sodium, potassium and nitrogen in saline conditions were higher



than non-saline conditions. Due to the fact that molasses sugar is also calculated based on the amount of the above elements, the amount of molasses sugar in saline conditions is higher than non-saline conditions.

Regarding the differences among sugar beet genotypes to salinity tolerance and based on stress tolerance index (STI), several genotypes can be selected among examined genotypes with using the By Plot (Figures 1), which includes genotypes No. 24, 3, 29 and 17. Note that all these genotypes do not ultimately lead to the introduction and releasing of tolerant cultivars, and some of them will only be used as a salt tolerance trait in plant breeding processes. The traits that have a positive and high correlation with white sugar yield including root yield, fresh and dry weight of the shoot, sugar yield and extraction coefficient of sugar (ECS); and the traits which there is a negative and significant correlation with white sugar yield are the percentage of sodium, potassium and nitrogen impurities, alkalinity coefficient, molasses sugar and sugar content (Data not shown).

Based on the results of this experiment, salinity stress has a significant effect on root yield, and white sugar yield and examined genotypes showed different responses to salinity stress. Accordingly, there are acceptable genotypes for introducing farmers to cultivate in saline conditions, which requires further studies in this regard. Top Selected genotypes for salt tolerance in this experiment include the following genotypes: S1-930882 (No. 24), OT-110-25-90 (No. 3), DR1-HSF-14-P.35 (No. 29), and S1-940655 (No. 17). To avoid the removal of good genotypes that may be omitted due to experimental errors, another group was also selected to conduct further studies on them. These genotypes include S1-930702 (number 7), 8001-S1-1 (number 1), 8001-S1-18 (number 2), OT-111-9-90 (number 4) and S1-940645 (No. 13). The genotype S1-930708 (No. 8) is probably suitable for low salinity conditions, which has high potential in these areas, so this genotype can be used for supplementary studies for areas with low salinity problems. In the third priority, two other genotypes, including S1-930770 (number 21) and OT-111-17-90 (No. 6), are also selected due to root and gross sugar yield. In general, the screening of genotypes in real conditions and high salinity stress allows the researcher to achieve valuable results in selecting salinity tolerant genotypes. Using additional experiments, we can take more effective steps to introduce and release tolerant cultivars.

Other results from this study include sugar yield and white sugar yield, and other traits published in the *Pharmacophore*, 9(2) 2018, pages: 60-71.

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