J. Agr. Sci. Tech. (2014) Vol. 16: 779-790

Seed Germination, Plant Establishment, and Yield of Sugar Beet Genotypes under Salinity Stress

S. Khayamim[1*], R. Tavakkol Afshari[2], S. Y.Sadeghian[3], K. Poustini[2], F. Rouzbeh[1], and Z. Abbasi[4]

ABSTRACT

It is well known that sugar beet is sensitive to salinity stress at the germination stage. Three separate experiments were conducted to study the effects of salinity on seed germination, plant establishment, and yield of sugar beet genotypes for screening purposes. These included: (a) A laboratory study using four water salinity levels (with EC values < 0.1 as the control, 16, 20, and 24 dS m^{-1}) with 20 sugar beet genotypes, which were evaluated in a factorial completely randomized design with four replications, and seedling characteristics were measured; (b) A greenhouse experiment where the same statistical design as the lab study was used for seed germination and establishment of 19 sugar beet materials, with irrigation water *EC*= 3 and 16 dS m^{-1}; and (c) A field experiment that was carried out to study the response of nine selected genotypes to irrigation waters with *EC*= 4 and *EC*= 16 dS m^{-1}, using a split plot design with three replications. Interaction effects of salinity and genotypes were statistically significant (α= 0.01) for percentage of germination, abnormal seedling, and root and hypocotyls lengths. Indeed, sugar beet germination decreased to 35% and dead seedlings increased to 80 % under salinity stress (EC= 16 dS m^{-1}) in the greenhouse. Genotypes were ranked from tolerant to susceptible. The results of field experiment were consistent with that obtained in the greenhouse. It can be concluded that salt stress decreased seed germination and, later on, crop establishment by increasing dead seedlings; consequently, sugar beet yield decreased. It seems that establishment is more susceptible to salinity than germination. Root length and abnormal seedling are good indexes for screening sugar beet genotypes for salinity tolerance at the primary growth stages.

Keywords: Abnormal seedlings, Crop establishment, Root length, Saline irrigation water.

INTRODUCTION

Sugar beet is one of the salt tolerant industrial crops that is sensitive to salinity at germination stage. The threshold of salt damage to sugar beet crop differs in various reports. Threshold of 50 percent damage ranged between 15 (Doorenbaos and Kassam, 1979) to 20 dS m^{-1} *EC* of saturated soil extract (Mesbah *et al.,* 1991; Ebrahimian and Ranji, 2004a, b), calculated by Abrol *et al.* (1988) equation. The threshold level has not been a constant value in different studies, but has always depended on the environmental conditions (Abrol *et al.,* 1988). In other studies, the germination percentage decreased in salinity with *EC* of 8 dS m^{-1} (Jafarzadeh and Aliasgharzadeh, 2007), whereas 12 dS m^{-1} salinity shortened root length without affecting seed germination significantly (Mohammadian *et al.,* 1995).

[1] Sugar Beet Seed Research Institute, Mahdasht ave, Karaj, Islamic Republic of Iran.
[*] Corresponding author; email: samar.khayam@gmail.com
[2] Department of Agronomy and Plant Breeding, Faculty of Agricultural Science and Engineering, College of Agriculture and Natural Resources, University of Tehran, Karaj, Islamic Republic of Iran.
[3] Seed and Plant Certification and Registration Institute, Karaj, Islamic Republic of Iran.
[4] Isfahan Agricultural Research and Natural Resources Institute, Isfahan, Islamic Republic of Iran.

[DOR: 20.1001.1.16807073.2014.16.4.6.6]

Germination is affected by genetics as well as environmental (place and time) and seed processing (seed treatment) factors (Apostolides and Goulas, 1998). It has been shown that sugar beet seed germination percentage and plant establishment are mostly controlled by genetic factors (Sadeghian and Khodaii, 1998).

Root and hypocotyls lengths of sugar beet (Sadat Noori and McNeilly, 2000), potential of germination, and number of normal seedlings (Habibi, 1993) and seed germination rate (Mohammadian *et al.,* 1995) were affected negatively by high salt levels in various laboratory experiments. Measurement of sugar beet root length in laboratory and under high osmotic pressure is suggested as a fast and proper method for evaluating tolerant genotypes to drought and salt stress (Habibi, 1993).

As the rate of root and hypocotyl emergence are delayed with salt stress (AboKassem, 2007), the increase in salinity was reported to decrease the hypocotyl length of sugar beet seedlings more than their root length (Shonjani, 2002).

Germination is one of the most important qualitative characteristics of sugar beet seed and high standard laboratory test can be used to assess correlation with establishment in the farm (Sadeghian and Yavari, 2004).

The goal of this study was to evaluate sugar beet genotypes for their germination and establishment indices under salinity stress in laboratory and greenhouse, in order to find the most salt tolerant and sensitive ones based, particularly, on their yields in the field.

MATERIALS AND METHODS

This research was conducted in three separate experiments under laboratory, green house, and field conditions as follows. In the first experiment, seeds were washed in order to remove germination inhibitors existing in the seed coats according to Sadeghian and Lexander (1993).

Laboratory Experiment

Seed germination of 20 sugar beet genotypes (Table 1) was measured using the procedure of

Table 1. List of the sugar beet genotypes.

No	Line and population		Genotype background
1	BP Mashhad	Poly germ	Population, Drought tolerant
2	BP Karaj	Poly germ	Population, Drought tolerant
3	7219 p. 69	Poly germ	Progeny line, Drought tolerant
4	9572 p. 12	Poly germ	Progeny line, Salt tolerant
5	*B. maritima*	Poly germ	Wild type
6	7112 Firuzkuh	Mono germ	Inbreed line, Salt sensitive
7	436	Mono germ	Inbreed line, Rather salt sensitive
8	436 Bigerm	Poly germ	Population,, Rather salt tolerant
9	9671 p.11	Mono germ	Progeny line, Salt Tolerant
10	Orbis	Mono germ	commercial variety, Salt tolerant
11	9597 p. 12	Mono germ	Progeny line, Rather salt sensitive
12	428 OT	Mono germ	Inbreed line, Drought tolerant
13	8150 p.9	Mono germ	Progeny line, Rather salt tolerant
14	7233 p.29	Poly germ	Progeny line, Rather Salt Tolerant
15	7233 p.12	Poly germ	Progeny line, Rather salt tolerant
16	261 OT	Mono germ	Inbreed line, Rather salt tolerant
17	452	Mono germ	Inbreed line, Drought sensitive
18	7221	Poly germ	Fodder type, Drought tolerant
19	191	Poly germ	Pollinator, Drought sensitive
20	7233p.29×MSC2[a]	Poly germ	Hybrid, Salt tolerant

[a]This genotype was not used in the greenhouse experiment.

[DOR: 20.1001.1.16807073.2014.16.4.6.6]

International Seed Testing Association (ISTA, 1985).

Seeds of 20 sugar beet genotypes (Table 1) with different background of drought and salinity tolerance, received from Sugar Beet Seed Research Institute (Iran), (Ebrahimian and Ranji, 2004a, b) were studied using distilled water (EC< 0.1) (normal), and three salinity levels including 16, 20, and 24 dS m^{-1} of NaCl in a factorial experiment based on a completely randomized design with four replications. 25 seeds in each replication were placed on 14.5 x 58 cm papers, which were then rolled and put in 3-liter pots. Germinated seeds (root length more than 5 mm) and abnormal seedlings (ISTA, 1985) were counted three times (on the 5^{th}, 10^{th}, and 15^{th} day) during 15 days. Hypocotyl and root lengths (Jamil, *et al.,* 2006; Habibi, 1993) were also measured for five plants in each treatment.

Greenhouse Experiment

20 genotypes, except entry no. 20 (Table 1), were compared in normal (EC= 3 dS m^{-1}) and NaCl salinity (EC= 16 dS m^{-1}) using a factorial experiment in a completely randomized design with three replications, in green house (200 µmol m^{-2} s^{-1} PAR; 25^0C/15 ^{0}C). Seeds were planted in alluvial sands in 6 L pots with 24 holes (one plant in each hole). Normal treatment was Hoagland nutrient solution, but NaCL was directly added to it for salt treatment from the second irrigation on, three days after sowing. Pots were weekly irrigated from the top and electrical conductivities of drainage water and sand medium were regularly controlled in order to apply the expected salt treatment carefully. The germinated seeds were measured, firstly, 14 days after sowing, and , later, four times during the two growing months. Finally, the percentage of germinated and dead plants were calculated.

Field Experiment

was conducted as a split plot experiment based on a completely randomized block design with three replications during 2007 and 2008. Main plots were allocated to two water salinity levels with *EC*= 4 dS m^{-1}, which was the normal water in the region, and *EC*= 16 dS m^{-1}. The sub plots were planted to the nine genotypes that had been selected from the laboratory and greenhouse experiments based on germination properties and establishment. The experiment was performed at the Rudasht_salinity research station located at 52° E, 32.5°N, 1,450 m elevation, in Esfahan province, Iran. The area has warm and dry weather with mean annual temperature of 14.6 ^{0}C. Seeds were planted at 50 cm row spacing and 20 cm within rows, with a plant density of 100,000 p ha^{-1}. Electrical conductivity of the soil saturation extract was about 8 dS m^{-1} (pH= 7.8, O.C= 0.47%, Na=14 meq l^{-1}, available P=18 ppm, K= 270 ppm) before planting. Plants were irrigated by the ordinary water (EC= 4 dS m^{-1}) and saline water (EC= 12 dS m^{-1}), which was applied after plant establishment (6-8 leaf stages). Final soil electrical conductivities at harvest time were 4 and 16 dS/m for the ordinary and salt treatments, respectively.

At harvest, agronomical and beet quality parameters such as root yield, shoot yield (including leaf and petiole), sugar content (Polarimetry), Na, and K (Flame photometry) and alpha amino nitrogen (Blue No.) were measured and molasses, sugar yield, white sugar content and white sugar yield were calculated based on the Abdollahian *et al.* (2005). During the second year of the experiment, only salinity stress trial was carried out due to the global drought stress in the region and the results were presented separately.

Data were transformed using arcsines and logarithmic transformations. Since the transformed data did not affect the results of analysis of variance as well as the experimental error, the raw (original) data were considered for statistical analysis. The square root transformation was used for abnormal seedlings obtained in the laboratory and the dead plants in the greenhouse study. Adjusted germination (germination percentage under each salinity level×100 /potential germination) was used

[DOR: 20.1001.1.16807073.2014.16.4.6.6]

for standard germination percentage and removed differences of seed potential germination (Sadeghian and Yavari, 2004; Shonjani, 2002; Sadat Noori and Mc Neilly, 2000). MSTATC, SPSS 10, and Excel softwares were applied for statistical analysis and producing charts. Means were compared by Duncan multiple range test at α= 0.05. Genotype clustering for germination percentage and root and hypocotyls lengths was done using Ward's method and dendogram graph was drawn.

RESULTS

Laboratory Experiment

Mean germination percentage was significantly (α =0.01) affected by salinity and was similar at *EC*= 16 and *EC*= 20 dS m^{-1} (Figure 1). Salt stress negatively affected germination percentage of all genotypes tested (Table 2). The mean of the lowest germination (about 28 %) was observed in genotypes 9671 p.11 and 452 (Table 2). Genotypes 7219 p.69, 7233 p.12, Bp Karaj, 7112-Firuzkuh, and 7233 p.29×MSC2 with a germination decrease of about five percent under salt stress treatment were categorized as salt tolerant genotypes at the germination stage (Table 2).

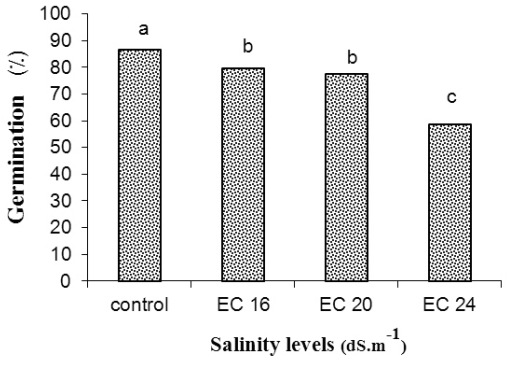

Figure 1. Comparison of sugar beet seed germination percentage in salt stress treatments and normal condition in laboratory (S_x= 1.07, α= 0.05).

In addition to the significant differences between the main effects, interaction effects of genotype and salinity levels were also significant (α= 0.01) for the percentage of abnormal seedlings, roots and hypocotyls lengths (data are not shown): salinity increased percentage of abnormal seedlings and decreased root and hypocotyls lengths in all of the tested genotypes. After slicing interaction effect on each level of salt stress for the traits (Radaee, 2009), it seemed that genotypes 7219 p.69, 7233 p. 29 7233 p. 12, and 7233 p.29×MSC2 were more tolerant than the others (Table 2). Genotypes 7112 Firuzkuh, 261 OT, and 7221 were more susceptible to salinity as evidenced by high reduction in root and hypocotyls length and higher percentage of abnormal seedlings compared with the other genotypes (Table 2). Although some genotypes (7221) germinated in higher salinity with only 14% germination reduction (Table 2), their seedlings were not normal and could not develop to perfect plants.

Greenhouse Experiment

Another experiment was conducted in greenhouse conditions to identify the threshold of salinity tolerance and know the proper electrical conductivity to differentiate between sugar beet genotypes, in which *EC*= 16 dS m^{-1} was selected as critical electrical conductivity (Khayamim, 2010).

Results of greenhouse experiment indicated that there were significant differences between genotypes for germination and seedling mortality in sand under salinity. Salinity (EC= 16 dS m^{-1}) decreased germination up to 35% and increased seedling mortality to 80% (Figure 2). It can be concluded that seeds with higher germination in soil will produce more healthy and strong seedlings under greenhouse condition (22^0C/16 h light) (Sadeghian and Khodaii, 1998). Sugar beet seed could germinate at high salinity level under laboratory and green house

[DOR: 20.1001.1.16807073.2014.16.4.6.6]

Table 2. Mean ranking of sugar beet genotypes for Relative reduction of germination, abnormal seedling percentage, and root and hypocotyls length after slicing at different salinity levels.[a]

		Germination reduction (%) [b]	Abnormal seedling (%)				Root length (mm)				Hypocotyls length (mm)			
			Control	EC (dS m^{-1})			Control	EC (dS m^{-1})			Control	EC (dS m^{-1})		
Sugar beet genotypes				16	20	24		16	20	24		16	20	24
1	BP Mashhad	7.31cd	14a	18bc	8a	13a-c	12a-e	9c-f	14e-h	7b-e	8b-e	16ab	15e-h	4abc
2	BP Karaj	3.75cd	7a	4ab	2a	18a-c	17cde	6abc	9b-g	9b-f	11d-g	13ab	10b-h	6a-d
3	7219 p. 69	4.88cd	6a	15abc	15a	6ab	4abc	5abc	4a-d	4abc	10c-g	2ab	1a	1a
4	9572 p. 12	11.81bcd	5a	14abc	14a	2a	3ab	4abc	3abc	3abc	6b-e	7ab	4a-d	15c-e
5	*B. maritima*	-	20a	20c	19a	20c	20f	20h	20i	20h	20h	20c	20i	20f
6	7112 Firuzkuh	1.13cd	1a	13abc	1a	17a-c	18de	16fg	15f-h	17fg	17g	14ab	19i	18de
7	436	14.81abcd	4a	12abc	10a	5ab	19e	14e-g	19h	19g	13d-g	6ab	8g	11b-e
8	436 Bigerm	13.06abcd	13a	11abc	4a	3a	8a-d	12d-g	17gh	13d-f	2b	10ab	14d-h	14c-e
9	9671 p.11	27.00ab	12a	19c	20a	16a-c	5abc	7a-d	7a-e	12d-f	4bcd	3ab	6b-f	8b-d
10	Orbis	18.00abcd	11a	2a	3a	12a-c	1a	3abc	2ab	1a	7b-e	12ab	18hi	19e
11	9597 p. 12	19.38abcd	10a	17bc	6a	11a-c	9a-d	11c-f	18gh	10c-f	3bc	1a	13c-h	7b-d
12	428 OT	11.38bcd	9a	3ab	9a	4a	14a-e	13e-g	11c-g	18fg	16g	9ab	5a-e	12b-e
13	8150 p.9	16.81abcd	19a	10abc	18a	9a-c	11a-e	10c-f	10b-g	11c-f	12d-g	4ab	17g-i	13b-e
14	7233 p.29	7.94cd	18a	9abc	13a	19a-c	2ab	2abc	1a	2ab	5b-f	17b	9b-g	9b-d
15	7233 p.12	3.63d	8a	7abc	17a	8a-c	6abc	1a	8a-f	5abc	19h	15ab	2ab	2ab
16	261 OT	22.19abc	17a	6abc	12a	1a	15b-e	19c	12d-h	14d-f	15fg	11ab	16f-i	16c-e
17	452	29.38a	16a	5abc	16a	14a-c	13a-e	17fg	16gh	16ef	14efg	18b	7b-g	10b-d
18	7221	13.63abcd	3a	1a	5a	7a-c	7a-d	15fg	6a-e	15d-f	9b-f	19b	12b-h	17c-e
19	191	7.06cd	2a	8abc	7a	10a-c	16cde	8b-e	13e-h	8b-e	18g	8ab	11b-h	5abc
20	7233p.29×MSC2	4.88cd	15a	16bc	11a	15a-c	10a-d	18fg	5a-e	6a-d	1a	5ab	3abc	3ab
	S_x	5.27	1.13	2.4	1.25	1.36	5.22	2.69	2.63		4.06	2.8	2.19	1.95

[a] Means in each column followed by similar letter (s) are not significantly different at 5% of probability level using Duncan's multiple range tests.
[b] Relative germination reduction of salt treatment (EC= 16, 20, 24 dSm^{-1}) compared with normal.

conditions, but could not survive in these salinity levels. Therefore, sugar beet genotypes should not only be insensitive to salinity at the germination stage, but also it should survive after germination to produce reliable establishment in the saline soil (Table 2, Figure 2).

Positive and significant (α= 0.01) correlation was found between hypocotyls length and seedlings death in the greenhouse (Table 3), indicating longer seedlings will damage more in sand medium than shorter ones.

Dendogram of cluster analysis showed that 19 genotypes were divided into four clusters regarding seed germination and root and hypocotyls lengths (Figure 3).

Population *B. maritima* was removed from cluster analysis, because of no germination, and fell in a separate cluster. BP Mashad, BP Karaj, 191, 428 OT, 7219 p.69, 7233 p.29, and 7233 p.29×MSC2 genotypes grouped as tolerant; 9572 p.72, Orbis, and 7233 p.12 as relatively tolerant; 436 Bigerm, 9597 p.12, 8150 p.9, 7221, 261 OT, and 436 as relatively sensitive; and 9671 p.11, 452, and 7112 Firuzkuh as sensitive.

Genotype 7233 was already identified as a tolerant diploid population in the previous studies (Yavari *et al,* 2005; Mohammadian *et al.,* 1995; Mesbah *et al.,* 1991). One of its progeny (7233 p.29) showed a significantly

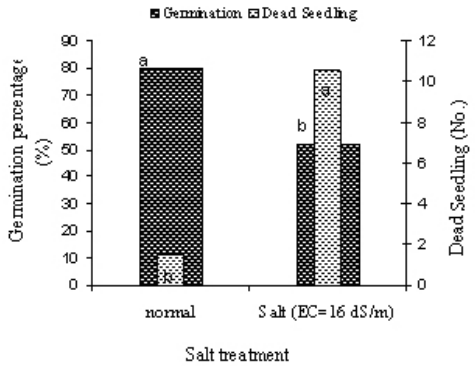

Figure 2. Seed germination percentage (%) and number of dead seedlings of sugar beet under normal and salinity (EC= 16 dS m^{-1}) conditions in greenhouse (S_x= 3.23, S_x= 0.07, α= 0.05).

Table 3. Laboratory, greenhouse, and field correlation results for sugar beet germination and yields characteristics.

	Lab germination	Lab abnormal germs	Root length	Hypocotyls length	Sand germination	Dead seedling in sand	Root yield	Sugar yield	White sugar yield
Lab germination%	1.00								
Lab abnormal seedlings%	-0.37**	1.00							
Root length	0.30*	-0.43**	1.00						
Hypocotyls length	-0.05	0.34*	-0.03	1.00					
Green house germination	0.06	-0.34*	0.30*	-0.41**	1.00				
unviable plants in sand	-0.37**	0.45**	-0.40**	0.55**	-0.21	1.00			
Root yield	0.31*	-0.35*	0.09	-0.46**	0.18	-0.35*	1.00		
Sugar yield	0.36*	-0.36*	0.13	-0.43**	0.18	-0.37*	0.96**	1.00	
White sugar yield	0.38**	-0.37**	0.16	-0.43**	0.19	-0.39**	0.93**	0.99**	1.00

*α= 0.05, ** α=0.01.

higher total dry matter and leaf area than other progenies such as 7233 p.12 and 7233 p.21 (Dadkhah and Grrifiths, 2006). Also, it was better than British check (Madison) (Dadkhah, 2011).Although it responded as a sensitive one in this study, one of its progeny hybrids (7233 p.29×MSC2) showed up tolerant to salinity (Figure 3). This result shows that salt tolerance properties of the genotype (7233) and subsequent selection program helped extracting new salt tolerant hybrids. Drought tolerant genotypes such as BP Mashhad, BP Karaj, and 7219 p.69 (Sadeghian and Yavari, 2004) also responded well to salinity stress (Figure 3), indicating that the physiological and genetic mechanisms of sugar beet tolerance to drought and salinity could be the same (Ashraf and Haris, 2004). Genotype 9597 p.12 that was sensitive to salinity in a previous study (Fotuhi *et al.,* 2006) remained relatively sensitive in this experiment (Figure 3). According to the results of this study, BP Karaj, 7219 p. 69, 436 Bigerm, 191, 7233 p 29×MSc2, 9597 p. 12, OT -428, 8150 p.9, and 452 could be selected for further physiological and breeding studies.

Field Experiment

Salinity stress decreased root yield, sugar yield, and white sugar yield about 20, 22, and 24%, respectively (Figure 4). Mean of sugar and white sugar yields of two genotypes BP Karaj and 7233 p.29*MSC2 were respectively 6.96 and 5.96 t ha-1 during 2007 and 7.19 and 5.48 t ha-1 during 2008. (Figure 5a and b), while genotype 7219 p.9 produced the highest sugar and white sugar yields in 2008 (Figure 5b). In terms of agronomic stability, these genotypes showed the best response as compared to the other genotypes. Genotypes 8150 p.9, 452, and 191 by displaying five and four t ha^{-1}, respectively, sugar and white sugar yields were the most sensitive genotypes in 2007 (Figure 5-a). Root yield (at α= 0.05) and white sugar yield (at α= 0.01) had significant and positive correlation with seed germination in the laboratory. Also, negative and significant correlations were observed between root yield and white sugar yield with abnormal seedlings in the lab, hypocotyls length, and dead plants in sand (Table 3). It means that good seedling establishment is highly important for crop

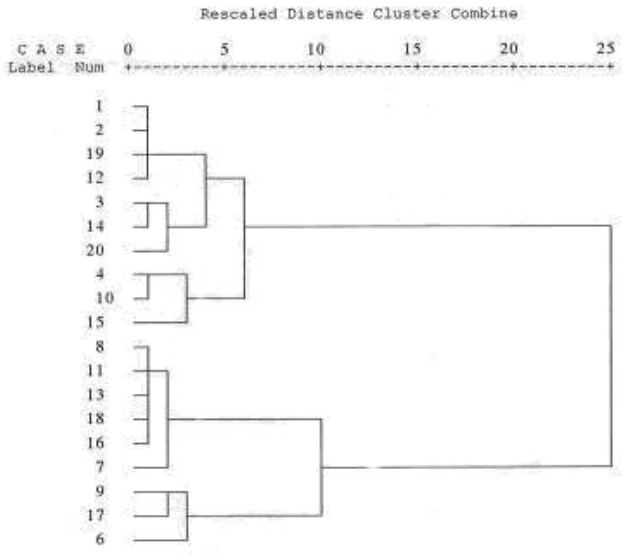

Figure 3. Dendogram of sugar beet genotypes using Ward's method for seed germination and seedling root and hypocotyls length characteristics.

[DOR: 20.1001.1.16807073.2014.16.4.6.6]

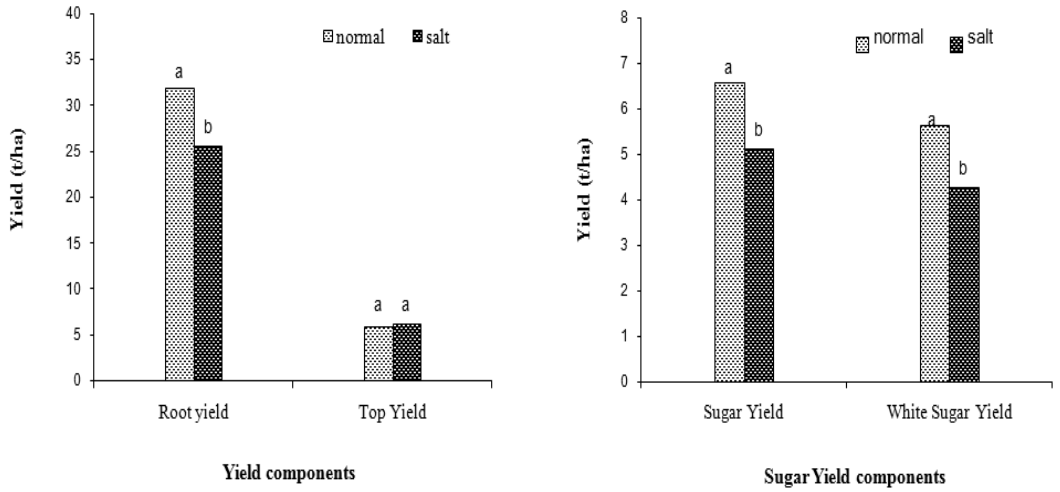

Figure 4. Sugar beet root and top yield (left) and sugar and white sugar yields (t/ha) (right) under normal and salt conditions at harvest time in 2007.

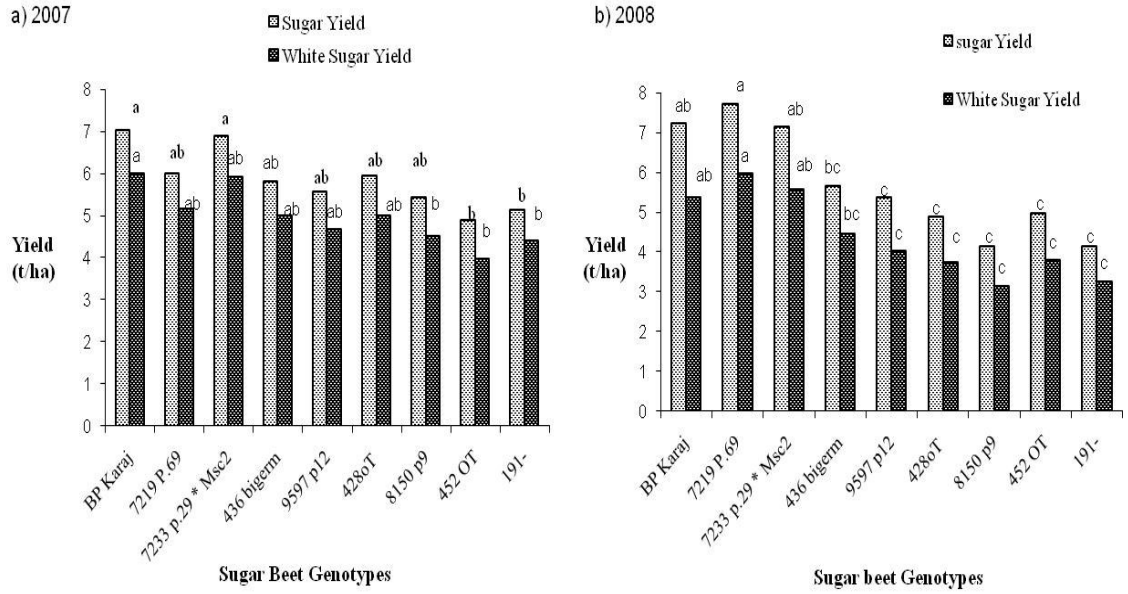

Figure 5. Sugar and white sugar yields (t ha^{-1}) of sugar beet genotypes at harvest time in 2007 (a) and 2008 (b).

yield at harvest.

DISCUSSION

The results of the study showed that sugar beet can germinate under high electrical conductivity (EC= 20 and 24 dS m^{-1}) of NaCl in the laboratory compared with greenhouse and field (EC= 16 dS m^{-1}) experiments, because salt compositions decreased sugar beet germination more than NaCl and, also, salt combination toxicity on plant germination was more than NaCl (Jafarzadeh and Aliasgharzadeh, 2007). Plants in the field have been damaged in less salinity than other conditions because of side effect provided by other soil ions (Duan *et al.,* 2004).

There was significant correlation between sugar beet seed germination and root and white sugar yields in the field, but no correlation was found between seed germination in laboratory and greenhouse germination, and genotypes with high germination percentage in the laboratory and greenhouse (for example, BP Karaj) had more white sugar yield and were more salt tolerant. This was also reported by Ebrahimian *et al.* (2008). A previous study showed that genotypes revealed more differentiation under environmental stress in the greenhouse than in the laboratory (Sadeghian and Yavari, 2004). Therefore, the difference of sugar beet germination percentage in paper and soil is found to be related to the interaction effects of genotype and environment for germination ability (Sadeghian and Khodaii, 1998).

Negative and significant correlation was observed between abnormal seedlings in the laboratory with greenhouse germination in sand and yield in the field (Table 3), therefore, percentage of abnormal seedlings could be a good characteristic for genotype screening for salinity stress at early growth stages. Selection of genotypes based on dead and alive plants and seedlings survival under salinity stress would be a reliable method beside seed germination and root length (Sadat Noori and McNeilly, 2000). Of course, abnormal germ determination is somewhat difficult and needs technical skill and precision.

Sugar beet seeds germinated under salinity stress in the greenhouse but seedlings were damaged by increasing salt stress. In this condition, salinity would affect plant establishment by influencing plant growth and size (Durrant *et al*., 1974). Salinity delayed seedling growth and development and, consequently, affected later seedlings establishment (Durrant *et al.,* 1974). Salinity had more effects on seedling growth reduction than germination percentage in millet (Al-Taisan, 2010) and chick pea (Okcu *et. al.,* 2005). Thus, not only a good germination of seeds is essential for seedling development, but an acceptable yield under saline condition depends on the survival of seedlings for a good plant establishment (Sadat Noori and McNeilly, 2000).

Research reports have indicated that salinity decreased hypocotyls length more than root (AboKassem, 2007; Ramoliya and Pandey, 2002). In the current study, similar to the results of Jafarzadeh, and Aliasgharzad (2007), it was the root length that was highly affected by salt stress.

Generally, salt tolerant genotypes had high root and hypocotyls length. The same conclusions were also published for other abiotic stresses like drought (Sadeghian and Yavari, 2004). Root is directly in contact with soil, therefore, it absorbs water and other nutrients from it. Saline soils decrease water absorbance and, consequently, cell development; therefore, effects of salt stress on root length are higher than on hypocotyls length (Jamil *et al*., 2006). As a result, root length would be decreased at the minimum levels of salinity (Jafarzadeh and Aliasgharzad. 2007). Seed germination factors and seedling properties could be considered as evaluation criteria in breeding programs when working with environmental stresses (Sadeghian and Yavari, 2004).

Seed characteristics such as germination percentage, seedlings establishment, and 1000 seed weight are mainly controlled genetically while germination rate and seedling vigor are usually affected by environment (Sadeghian and Khodaii, 1998).

It can be concluded that salt stress decreased seed germination and plantlet length at early growth stage and, later on, by producing abnormalities, decreased establishment and finally reduced yield of sugar beet. To obtain a proper crop yield under salinity stress, insuring sugar beet seed germination and suitable seedling establishment are necessary. Seed germination, abnormal seedlings, and root length would be reliable indices for sugar beet genotype screening for salinity stress at early growth stages.

[DOR: 20.1001.1.16807073.2014.16.4.6.6]

ACKNOWLEDGEMENTS

We thank Eng. Nasrin Yavari for her comments and English editing on manuscript. This research was supported by Sugar Beet Seed Research Institute.

REFERENCES

1. Abdollahian, N. M., Sheikholeslami, R. and Babaee B. 2005. Technological Quantitative and Qualitative Expression and Explanation of Sugar Beet. *Sugar Beet,* **21:** 101-104. (Persian with English Abstract)
2. AboKassem, E. ED. M. 2007. Effects of Salinity: Calcium Interaction on Growth and Nucleic Acid Metabolism in Five Spices of *Chenopodiaceae*. *Turk. J. Bot.,* **31:** 125-134.
3. Abrol, I. P., Yadav J. S. P. and Massoud F. I. 1988. Crops in Saline Soils. In: "Salt-Affected Soils and Their Management". *FAO Soils Bulletin,* **39**. [Online]. Available at: http://www.fao.org/docrep/x5871e/x5871e00.htm#Contents.
4. Al-Taisan, W. A. 2010. Comparative Effects of Drought and Salt Stresses on Germination and Seedling Growth of *Pennisetum divisum* (Gmel.) Henr. *Amer. J. Appl. Sci.,* **7(5):** 640-646.
5. Apostolides, G. and Goulas, C. 1998. Seed Crop Environment and Processing Effects on Sugar Beet (*Beta vulgaris* L.) Certified by Hybrid Variety Seed Quality. *Seed Sci.Tech.,* **26:** 223-235.
6. Ashraf, M. and Harris, P. J. C. 2004. Potential Biochemical Indicators of Salinity Tolerance in Plants. *Plant Sci.,* **166:** 3-16.
7. Dadkhah, A. 2011. Effect of Salinity on Growth and Leaf Photosynthesis of Two Sugar Beet (*Beta vulagaris* L.) Cultivars. *J. Agr. Sci. Tech.,* **13:** 1001-1012.
8. Dadkhah, A. and H. Grrifiths. 2006. The Effect of Salinity on Growth, Inorganic Ions and Dry Matter Partitioning in Sugar Beet Cultivars. *J. Agr. Sci. Tech.,* **8:** 199-210.
9. Doorenbaos, J. and Kassam, A. N. 1979. Yield Response to Water: Paper 33. FAO Irrigation and Drainage.
10. Duan, D., Liu, X., Ajmal Khan, M. and Gul, B. 2004. Effect of Salt and Water Stress on the Germination of *Chenopodium glaucum* L. *Seed. Pak. J. Bot.,* **36(4):** 793-800.
11. Durrant, M. J., Draycott, A. P. and Payne, P. A. 1974. Some Effect of Sodium Chloride on Germination and Seedling Growth of Sugar Beet. *Annal. Bot.,* **38:** 1045-1051.
12. Ebrahimian, H. R. and Ranji, Z. 2004 a. Preparing Tolerant Variety to Salt Stress with Diurnal Halfsib Selection: Final Report. Sugar Beet Seed Institute (SBSI), Karaj. (In Persian with English Abstract).
13. Ebrahimian, H. R. and Ranji, Z. 2004 b. Comparison of Salt Tolerant Variety 7233-29*MST with Current Variety Sown in Esfahan: Final Report. Sugar Beet Seed Institute (SBSI), Karaj. (In Persian with English Abstract)
14. Ebrahimian, H. R., Ranji, Z., Rezaee, M. A. and Abbasi, Z. 2008. Screening Sugar Beet Genotypes under Salinity Stress in the Green House and Field Conditions. *J. Sugar Beet,* **24(1):** 1-21. (in Persian with English Abstract)
15. Fotuhi, K., Mesbah, M., Sadeghian, S. Y., Ranji, Z. and Orazizadeh, M. R. 2006. Assessment Salt Tolerance in Sugar Beet Lines. *J. Sugar Beet,* **22(2):** 1-18. (in Persian with English Abstract)
16. Habibi, D. 1993. Selection of Sugar Beet Tolerant Progenies to Drought and Salt Stress in Germination Phase. MSc. Thesis, Science and Research Branch, Islamic Azad University. (in Persian with English Abstract)
17. International Seed Testing Association. 1985. International Rules for Seed Testing: Rules 1985. *Seed Sci. Tech.,* **13:** 299-355
18. Jafarzadeh, A. A. and Aliasgharzadeh, N. 2007. Salinity and Salt Composition Effects on Seed Germination and Root Length of Four Sugar Beet Cultivars. *Bio. Brati.*, 62(5): 562-564.
19. Jamil, M., Lee, D. B., Jung, K. Y., Ashraf, M. S., Lee, C. and Rha, E. S. 2006. Effect of Salt (NaCl) Stress on Germination and Early Seedling Growth of Four Vegetables Species. *J. Cent. Europ. Agric.,* **7(2):** 273-282.
20. Khayamim, S. 2010. Study of Physiological Parameters of Sugar Beet Lines in Salt Stress and Normal Conditions. PhD. Thesis, University of Tehran. (in Persian with English Abstract)
21. Mesbah, M., Yavari, N., Motahari, A. R., Arjmand, N. and Alimoradi, I. 1991. Results

[DOR: 20.1001.1.16807073.2014.16.4.6.6]

of Salt Tolerance Assessment in Different Sugar Beet Lines: Final Report. Sugar Beet Seed Institute (SBSI). (In Persian with English Abstract).
22. Mohammadian, R., Ghasemi Golozani, K., Moghaddam, M. and Sadeghian, S. Y. 1995. Effects of Seed Exhausted in Germination, Seedling and Establishment of Seven Sugar Beet Lines under Salt Stress. MSc. Thesis, Tabriz University. (in Persian with English Abstract)
23. Okcu, G., Kaya, M. D. and Atak, M. 2005. Effects of Salt and Drought Stresses on Germination and Seedling Growth of Pea (*Pisum sativum* L.). *Turk J. Agric. Fores.*, **29:** 237-242
24. Radaee, Z. 2009. Effects of Drought Stress in Farm and It's Relation with Stress in Poly Ethylene Glycole for Screening Sugar Beet Genotypes. MSc. Thesis, University of Tehran. (in Persian with English Abstract)
25. Ramoliya, P. J. and Pandey A. N. 2002. Effect of Increasing Salt Concentration on Emergence Growth and Survival of Seedling of *Salvadora oleoides*. *J. Arid Env.,* **51:** 121-132.
26. Sadat Noori, S. A. and McNeilly, T. 2000. Assessment of Variability in Salt Tolerance Based on Seedling Growth in *Triticum durum* Desf. Genet. *Resourc. Crop Evol*., **47:** 285-291.
27. Sadeghian, S. Y. and Khodaii, A. 1998. Diallel Cross Analysis of Seed Germination Traits in Sugar Beet. *Euphytica,* **103:** 259-263.
28. Sadeghian, S. Y. and Lexander, K. 1993. Fatty Acid Composition of Plasma Membrane in Relation to Bolting in Sugar Beet. *Flowering News,* **16:** 39-43
29. Sadeghian, S. Y. and Yavari, N. 2004. Effect of Water Deficit Stress on Germination and Early Seedling Growth in Sugar Beet. *J. Agron. Crop Sci.,* **190**: 138-144.
30. Shonjani, S. 2002. Salt Sensitivity of Rice, Maize, Sugar Beet and Cotton during Germination and Early Vegetative Growth. Inaugural Dissertation, Institute of Plant Nutrition, Justus Leibig University, 164 PP.
31. Yavari, N., Mesbah, M. and Ghaffari Jahromi, A. 2005. A Study on Advancing Treatment on Sugar Beet Embryo Culture in Salt Stress Conditions *In vitro*. *J. Sugar Beet,* **21(1):** 87-97. (in Persian with English Abstract).

جوانه‌زنی ، استقرار و عملکرد ژنوتیپ های چغندرقند تحت تنش شوری

س. خیامیم، ر. توکل افشاری، س. ی. صادقیان، ک. پوستینی ، ف. روزبه، و ز. عباسی

چکیده

چغندرقند به عنوان گیاهی که بیشتر در مرحله جوانه زنی به شوری حساس است شناخته می‌شود لذا به منظور بررسی اثر شوری بر جوانه‌زنی بذر ، استقرار گیاهچه و عملکرد ژنوتیپهای چغندرقند و غربال این ژنوتیپ‌ها در شرایط گلخانه و مزرعه این مطالعه در قالب سه آزمایش جداگانه انجام شد: در آزمایش اول اثر چهار سطح هدایت الکتریکی شاهد (هدایت الکتریکی کمتر از یک)، ۱۶، ۲۰ و ۲۴ دسی زیمنس بر متر از منبع کلرید سدیم بر ۲۰ ژنوتیپ به صورت آزمایش فاکتوریل در قالب طرح کاملا تصادفی با چهار تکرار انجام و خصوصیات گیاهچه بررسی گردید. آزمایش دوم با طرح آماری مشابه آزمایش اول به منظور بررسی جوانه زنی و استقرار ۱۹ ژنوتیپ چغندرقند تحت شرایط شاهد (EC=3) و شوری ۱۶ دسی زیمنس بر متر در گلخانه اجرا شد. آزمایش سوم به منظور بررسی واکنش نه ژنوتیپ

[DOR: 20.1001.1.16807073.2014.16.4.6.6]

انتخابی به تیمار شاهد (EC=4) و شوری ۱۶ دسی زیمنس برمتر با استفاده از آزمایش کرت خرد شده در قالب طرح بلوک‌های کامل تصادفی با سه تکرار در مزرعه انجام گردید. نتایج نشان داد که اثر متقابل شوری در ژنوتیپ برای صفات درصد جوانه زنی، جوانه های غیر طبیعی، طول ریشه‌چه و ساقه‌چه در سطح احتمال یک درصد معنی‌دار بود. در اثر تنش شوری ۱۶ دسی زیمنس بر متر جوانه زنی چغندرقند تا ۳۵ درصد کاهش و تعداد گیاهچه های از بین رفته تا ۸۰ درصد افزایش یافت. ژنوتیپ ها به گروههای متحمل تا حساس تقسیم شده و نتایج آزمایش مزرعه مطابق با گلخانه بود. نتایج نشان می دهد در مراحل ابتدای رشد شوری باعث کاهش جوانه‌زنی و طول گیاهچه می‌شود. در مرحله استقرار جوانه‌های غیر طبیعی افزایش و در نتیجه با افزایش شوری به تدریج گیاهچه های سبز شده از بین می روند لذا استقرار بوته‌های چغندرقند و درنتیجه عملکرد کاهش می یابد. بنابراین به نظر می رسد مرحله استقرار چغندرقند حساس تر از جوانه زنی نسبت به تنش شوری باشد. در نهایت طول ریشه‌چه، و تعداد جوانه‌های غیر طبیعی به عنوان شاخص مناسب برای غربال ژنوتیپ‌های چغندرقند جهت تحمل به شوری در مراحل اولیه رشد گیاه تشخیص داده شدند.

[DOR: 20.1001.1.16807073.2014.16.4.6.6]