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Salinity tolerance in 280 genotypes of two-rows Barley

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Abstract

In order to study salt tolerance of barley (*Hordeum vulgare* L.) genotypes in germination and field growth stages, laboratory and field experiments were carried out at the Agricultural Experimental Research Farm of Faculty of Agriculture, Sohag University, in 2005/2006, 2006/2007 and 2007/2008 seasons. This work aims to screen and evaluate barley genotypes under salinity conditions. Two hundred and eighty genotypes of barley were screened by germination under salinity with different levels of NaCl in the laboratory. The best twenty selected genotypes under the highest level of salinity of NaCl and the two check cultivars Giza 127 and Giza 128 in laboratory test were evaluated in the next seasons under salinity affected soil in a field experiment. The results indicated that seven out of the twenty genotypes were tolerant to salinity stress. These genotypes were No. 1, 5, 7, 10, 13, 17 and 19. These seven genotypes had salinity susceptibility index (SSI) less than unity. The results revealed that the average of grain yield (ardab/fed) for the highest genotype No.10 was 9.44 ardab/fed, which was significantly higher than that the lowest genotype (No. 1) by 1.39 ardab/fed. It was also significantly higher than the check cultivars G.127 and G.128 (No. 21 and 22) by 1.04 and 1.59 ardab/fed, respectively. The decrease percentages of grain yield (ardab/fed) for the highest genotype No. 10, the lowest one, No.1 and the two check varieties (No. 21 and 22) due to salinity increase, were 22.11, 21.71, 18.57 and 24.08% , respectively. Salinity susceptibility index (SSI) for grain yield (ardab/fed) ranged from 0.51 for genotype No.7 to 0.99 for genotype No. 5.

Keywords: ***Barley, Hordeum vulgare, Salt-tolerance, Germination, Salinity susceptibility*.**

INTRODUCTION

The cultivation of barley crop is of great importance for its multy purposes, human consumption and also for animal feeding. Barley is a major source of food today for a large number of people living in the salinity affected and semi arid areas of the world, where wheat and other cereals are less adapted. The total production of barley in Egypt was 108,495 thousands metric tons resulted from 82.504 thousands hectares (FAO 2012). In addition, barley is considered as more tolerant to adverse environmental conditions such as drought and salinity than any other cereals. Thus, this crop is cultivated in Egypt mainly under the conditions which are not suitable for wheat growth. Salinity and water deficit stresses reduce the shoot growth, leaf photosynthetic pigments, K^+ contents and provoke oxidative stress in leaves confirmed by considerable changes in soluble carbohydrate, proline, malondialdehyde (MDA), total phenolic compounds, antioxidant activity and Na^+ contents. Leaf soluble protein of salt and water deficit treated plants was unaffected (Fayez and Bazaid 2014). Salinity reduced biomass yield and grain yield by 35% and 55% respectively, particularly at the highest level of 14 dS $m^{-1.}$ However, some entries maintained 7-9.5 and 2-2.6 t/ha of biomass yield and grain yield, respectively (Al-Dakheel *et al* 2012). Barley production under salinity stress is often variable because the actual cultivars used are not sufficiently tolerant (Steven 2011). Improved salinity tolerance permits the conservation of fresh water and its use for higher value purposes, providing both ecological and economic benefits essential for sustainable agriculture in dry lands (Keating *et al* 2010). Barley appeared to be the most tolerant crop to salinity with regard to seed germination and early growth of the plants (Mer *et al* 2000). Germination and seedling growth under saline environment are the screening criteria which are widely used to select salt tolerant genotype (Khan *et al* 1993)

A biotic stresses such as drought and salinity are serious threats to agriculture and cause deterioration of the environment. Salinity is particularly widespread in many regions and may cause serious salinization of more than 50% of all arable lands by the year 2050, moreover, leads to morphological, physiological and biochemical changes that adversely affect plant growth and productivity (Wang *et al* 2001). Salinity stress is primary cause of crop loss worldwide reducing average yields for most major crop plants by more than 50 % founded by (Bray *et al* 2000). Leaf area, dry weight of shoot, dry weight of root, shoots length; fresh weight of stem and fresh weight of root were decreased in all 12 barley varieties with increasing in salinity level, however varieties of Sina, Gorgan and Dasht showed the best response at all salinity levels (Taghipour and Salehi 2008).

Salinity stress is often interconnected and may induce similar cellular damage. For example, salintization is manifested primarily as osmotic stress, resulting in the disruption of homeostasis and ion distribution in cell (Zhu 2001).

Egypt is one of the countries that suffer from severe salinity problems. For example, 33% of the cultivated land which comprises only 4% of total land area in Egypt , is already salinized due to low precipitation (<25mm annual rainfall) and irrigation with saline water (El-Hendawy *et al* 2004 and Abdel-Latef 2005).

Salinity is the main limiting factor in crop production. Breeding for salinity tolerance needs many steps i.e., searching for genetic tolerant materials, selection between genotypes and evaluation under salinity stress conditions. The objectives of the present investigation are mainly: 1) screening barley genotypes under salinity stress conditions and 2) evaluation of the selected barley genotypes for their tolerance to salinity stress and for grain yield and its components.

MATERIALS AND METHODS

Laboratory and field experiments were carried out at the Agricultural Experimental Research Farm of the Faculty of Agriculture, Sohag University,Egypt in seasons of 2005/2006, 2006/2007 and 2007/2008.The genetic materials used in this study were obtained from crossing the German barley variety, Scarlett (*Hordeum vulgare* ssp. *vulgare*) with ISR42-S (*Hordeum vulgare* ssp. *spontaneum*) and then backcrossed with Scarlett, the observed Scarlett population (280 BC_2DH lines). Doubled haploid lines of a backcross population between a wild barley accession from the Middle East (ISR 42-S) and a German barley cultivar were examined on their tolerance in relation to salinity. Scarlett is a high yielding cultivar with has high quality characteristics; however, ISR 42-8 is a wild barley accession from the Middle East.

1- Preliminary laboratory studies

1-1-Germination under salinity conditions

In the first season, 2005/2006, a preliminary experiment was carried out using 280 doubled haploid lines to screen them for the germination under salinity with NaCl in the laboratory. The best 20 genotypes from the above mentioned experiment were evaluated in the next seasons for salinity tolerance under field conditions .Seed germination was tested under different levels of salinity using NaCl. The 280 sown in three replications under different levels of NaCl, namely, 0 (distilled water), 10, 15, 20 dSm^{-1}. Seventy- five grains were set to germinate on filter paper in 9cm Petri-dishes; 25 grains in each dish. For all concentrations, grains were watered with 6 ml for each treatment followed by 4 ml after 3 days, and were incubated at 20 ± 1 ^{o}C for 10 days. Germination tests were performed according to the techniques specified by the International Seed Testing Association; I.S.T.A. (1993). Number of germinated seeds was recorded on the 3^{th}, 6^{th} and 10^{th} day after sowing and germination percentage was calculated from the following formula:

$$\text{Germination}\,\% = \frac{No\ of\ \text{germinated}\ grains}{Total\ number\ of\ grains} x\,100$$

1-2- Field evaluation under salinity conditions

The twenty selected genotypes for high seed germination percentage under the highest level of salinity in season 2005/2006 plus two check cultivars, namely Giza 127 and Giza 128 were grown at two locations . The first location (S1) (old farm, Agricultural Experimental Research Farm of the Faculty of Agriculture, Sohag University, Egypt) has 0.69 (dS/m^{-1}) soil salinity, while the second (S2) (farm number 93 , Agricultural Experimental Research Farm of the Faculty of Agriculture, Sohag University, Egypt) has 10.97 (dS/m^{-1}) using normal irrigation every 10 days. Normal and saline soil analysis are shown in Table (1). The experiments of the two seasons 2006/2007 and 2007/2008 at the two locations were laid out in a randomized complete block design (RCBD) with three replications. Each plot was represented by six rows; 3 m long; 20 cm apart, 10 cm between; with a plot area was of 3.5 m^2. The agricultural practices recommended for barley production were applied throughout the growing seasons.

The studied characters in the evaluation experiment included days to heading, flag leaf area (cm^2), plant height (cm) , spike length (cm) , number of spikes /m^2, number of kernels/spike, 1000-kernel weight (g) , grain yield (ardab/fed) and straw yield (ton /fed) .

Table 1. Mechanical and chemical properties of soil*.

Soil properties	1st location (old farm) Salinity level (0.69 dS/m^{-1})		2nd location (farm number, 93) Salinity level (10.97 dS/m^{-1})	
	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008
Sand (%)	55.02	53.98	70.41	68.90
Silt (%)	19.11	20.01	10.40	12.30
Clay (%)	25.87	26.01	18.80	19.19
Soil texture	Sandy clay			
Organic mater (%)	0.80	0.90	0.97	1.20
Total N (%)	0.73	0.88	0.95	0. 100
EC(ds/m) (1:1)	0.69	0.64	10.97	10.77
PH(1:1)	7.60	7.50	7.55	7.30

*According to A.O.A.C. (1995).

Statistical analysis

The separate as well as combined analysis of variance for different characters was done on plot mean basis after testing the homogeneity of errors according to Gomez and Gomez (1984). Revised L.S.D at 5% level was used to compare the means according to Waller and Duncan (1969).

Salinity susceptibility index (SSI) was calculated for each genotype according to the method of Fischer and Maurer (1978) as follows:

$$SSI = \left(1-\left(\frac{Yd}{Yw}\right)\right) / D$$

Where;

(Yd) = mean yield for a genotype in stress environment.

(Yw) =mean yield for a genotype in normal environment.

D =environmental stress intensity, which was calculated as:

= mean of all genotypes in stress.

= mean of all genotypes in normal environment.

Genotypes with "SSI" value of 1.0 or more than one are susceptible to salinity, while those with values less than 1.0 are less susceptible (tolerant to salinity).

RESULTS AND DISCUSSION

The preliminary and evaluation results will be tabulated and discussed as follows:

1. Preliminary laboratory studies

1.1. Germination under salinity conditions

The 280 barley genotypes were screened under different levels of NaCl on the basis of germination percentage. The best 20 barley genotypes selected under the highest level of salinity (20dS/m^{-1} NaCl) are shown in Table (2). The results showed that the average of germination percentage under 20 ds/m NaCl, ranged from 30.33% for genotypes No. 9 and 11 to 53.00 %for genotype No.13 with an average of 37.94 %. Mer *et al* (2000) reported that the germination was decreased in soils with salinity above 8 mmhos cm^{-1}. These results were in accordance with those of El-Madidi *et al* (2004), Othman *et al* (2006), El-ardiry (2007) and Silva *et al* (2007).

Table 2. Mean of germination percentage of the best twenty barley genotypes selected under the highest level of salinity (20 dS/m^{-1} NaCl) from the preliminary studies.

No. Genotype	Germination% under salinity	No. Genotype	Germination% under salinity	No. Genotype	Germination% under salinity
1	37.00	9	30.33	17	51.33
2	33.33	10	45.66	18	44.00
3	34.70	11	30.33	19	43.66
4	32.00	12	30.66	20	30.70
5	44.00	13	53.00	G.127	42.66
6	31.00	14	32.33	G.128	38.70
7	42.66	19	37.33	Means	37.94
8	33.33	16	36.00		

2. Evaluation experiment

The combined analysis of variance revealed that all studied traits were highly significantly affected by soil salinity and genotypes. Furthermore, the mean squares due to genotypes x soil salinity and genotypes x soil salinity x year interactions were highly significant for all traits, except for straw yield which were insignificant (Table3).

2.1. Morphological characteristics

2.1.1. Flag leaf area (cm^2)

Under saline soil (10.97 dS/m^{-1}), the average of flag leaf area for the highest genotype (No. 13) had value of 4.35 cm^2 which was significantly higher than the lowest one (No. 9), by about 2.83 cm^2 under saline soil. Salinity susceptibility index (SSI) based on flag leaf area indicated that ten genotypes had (SSI) less than unity and were relatively tolerant to salinity stress. Moreover, the genotypes No. 4, 2 and 13 were the most sensitive, which had values of 0.72, 0.88 and 0.93, respectively Table (4). Ashraf (2002) reported that, the reduction in leaf area by salt stress may be due to reduction in leaf expansion, probably due to the effect of NaCl on cell division and / or cell expansion. These results are in agreement with those reported by El-Sayed *et al* (2002), Hamdy *et al* (2005), Oraby *et al* (2005) and Katerji *et al* (2006).

2.1.2. Days to heading

Number of days to heading for the earliest genotype (No.3) was 63.66 days which was significantly less than the latest one (No. 2) by about 13.33 days under saline soil (Table 4). Salinity susceptibility index (SSI) based on days to heading indicated that genotypes No. 2, 15 and 14 were the most tolerant to salinity, which had values of 0.54, 0.57 and 0.62, respectively. Ibrahim *et al* (2007) stated that early heading is one of the mechanisms that plants use to escape the damage effects caused by salinity stress. Mean number of days to heading decreased as salinity level increased (Oraby *et al* 2005). Similar results were reported by Katerji *et al* (2006).

2.1.3. Plant height (cm)

The tallest genotype (No. 19) 78.66 cm was significantly taller than the shortest one (No. 5), by about 37.66 cm under saline soil. Regarding SSI, eleven genotypes had values less than unity and were relatively tolerant to salinity stress; the genotypes No. 16, 6 and 4 were the most sensitive. Their SSI values were 0.72, 0.78 and 0.83, respectively (Table 4). Ibrahim *et al* (2007) reported that salinity level (500 mg/l Na Cl) caused a significant reduction by 6.50 % in plant height of barley. El-Zanaty *et al* (2006) found that plant growth and productivity may be adversely affected by salinity induced nutritional disorders. Zeng *et al* (2002) showed that in general, cereal plants are the most sensitive to salinity during the vegetative and early reproductive stages. These results are in line with those reported by Ahmed *et al* (2002) and Pakniyat *et al* (2003).

Table 3. Combined analysis of variance across the two levels of salinity and across two seasons for the studied traits of barley.

S.O.V	d.f	Mean squares (M.S.)								
		Days to Heading	Flag leaf Area (cm^2)	Plant Height (cm)	Spike Length (cm)	No. spikes /M^2	No. of kernels /spike	1000- kernel weight (g)	Grain yield (ardab/fed)	Straw yield (ton/fed)
Year (Y)	1	290.64**	2.80	8568.24**	96.82**	175667.04**	677.76**	1927.31**	96.08**	5.31
Rep/Y	4	4.78	0.442	6.10	1.28	75.22	3.80	1.94	3.18	0.45
Salinity soil (S)	1	10805.76**	3005.91**	96600.37**	621.67**	477700.37**	5176.36**	2158.55**	379.36**	89.85**
Y×S	1	2.36	9.78*	3490.90**	13.15**	105520.01**	24.85**	39.30**	25.10**	1.93
Error (a)	4	2.62	1.00	1.00	0.022	25.22	0.564	0.869	0.377	0.831
Genotypes (G)	21	57.74**	15.10**	906.52**	7.43**	10992.11**	44.86**	46.38**	5.94**	2.51 **
G×Y	21	18.77**	1.70**	115.05**	1.45**	1519.03**	10.05**	15.89**	0.869 **	0.231
G×S	21	35.07**	6.46**	127.71**	1.30**	1691.56**	13.02**	5.44**	1.08**	0.584
G×Y×S	21	16.91**	1.83**	105.62**	1.32**	1459.18**	13.25**	22.34**	0.712 **	0.499
Error (b)	168	2.15	0.264	1.20	0.138	13.20	0.717	0.916	0.200	0.477
Total	263									

*, **Significant and highly significant at 0.05 and 0.01 probability levels, respectively.

Table 4. Mean performance and salinity susceptibility index (SSI) of flag leaf area, days to heading and plant height of barley genotypes as affected by salinity levels combined over two seasons.

Genotypes	Combined means Level of salinity Flag leaf area , (cm^2)			Salinity susceptibility index (SSI)	Combined means Level of salinity No. days to heading			Salinity susceptibility index (SSI)	Combined means Level of salinity Plant height , cm			Salinity susceptibility index (SSI)
	S_1 (0.69)	S_2 (10.97)	Mean		S_1 (0.69)	S_2 (10.97)	Mean		S_1 (0.69)	S_2 (10.97)	Mean	
1	9.90	2.15	6.02	1.09	86.16	70.50	78.33	1.21	85.33	45.83	65.58	1.17
2	7.28	2.70	4.99	0.88	83.83	77.00	80.41	0.54	93.33	53.16	73.25	1.08
3	6.61	2.10	4.35	0.95	81.50	63.66	72.58	1.46	94.00	47.33	70.66	1.25
4	6.28	3.03	4.65	0.72	83.66	74.83	79.25	0.70	89.66	60.00	74.83	0.83
5	8.78	2.38	5.58	1.02	83.33	70.33	76.83	1.04	88.50	41.00	64.75	1.35
6	11.10	2.60	6.85	1.07	85.33	75.16	80.25	0.80	88.83	61.16	75.00	0.78
7	9.76	2.30	6.03	1.07	84.33	71.16	77.75	1.04	95.83	52.00	73.91	1.15
8	7.96	2.40	5.18	0.98	91.50	73.83	82.66	1.29	99.66	64.33	82.00	0.89
9	9.56	1.52	5.54	1.18	87.00	72.33	79.66	1.13	86.66	41.33	64.00	1.32
10	10.51	3.40	6.95	0.95	84.16	71.00	77.58	1.04	99.00	50.00	74.50	1.25
11	9.45	2.70	6.07	1.00	91.00	76.00	83.50	1.10	95.50	55.66	75.58	1.05
12	10.11	1.96	6.03	1.13	85.66	67.83	76.75	1.39	91.50	58.50	75.00	0.91
13	12.86	4.35	8.60	0.93	83.00	74.16	78.58	0.71	98.00	61.33	79.66	0.94
14	11.78	3.80	7.79	0.95	83.00	75.33	79.16	0.62	100.83	60.00	80.41	1.02
15	9.50	2.81	6.15	0.98	83.83	76.66	80.25	0.57	88.66	59.16	73.91	0.84
16	8.91	2.73	5.82	0.97	87.33	71.50	79.41	1.21	88.16	62.83	75.50	0.72
17	9.70	3.11	6.40	0.95	87.33	73.00	80.16	1.10	115.00	72.00	93.50	0.94
18	6.35	1.65	4.00	1.04	85.00	72.66	78.83	0.97	100.33	64.16	82.25	0.91
19	8.78	2.13	5.45	1.06	88.00	74.00	81.00	1.06	120.00	78.66	99.33	0.87
20	11.81	3.11	7.46	1.03	85.16	72.83	79.00	0.97	96.00	61.66	78.83	0.90
G.127	9.83	2.76	6.30	1.01	83.66	73.16	78.41	0.84	111.16	70.83	91.00	0.91
G.128	10.90	3.60	7.25	0.94	85.50	70.83	78.16	1.15	94.66	58.00	76.33	0.98
Mean	9.44	2.69	6.07	1.00 ± 0.02	85.42	72.62	79.02	1.00 ± 0.05	96.39	58.13	77.26	1.00 ± 0.04
Rev. L.S.D 5% Level					Rev. L.S.D 5% Level				Rev. L.S.D 5% Level			
	Soil salinity		0.27		Soil salinity		0.44		Soil salinity		0.27	
	Genotype		0.36		Genotype		1.05		Genotype		0.77	
	Interaction		0.52		Interaction		1.54		Interaction		1.098	

S1 = old farm and S2 = farm number, 93,in Agricultural Experimental Research Farm of the Faculty of Agriculture, Sohag University, Egypt

2.1.4. Spike length (cm)

The longest genotype in spike length (No. 5) was (8.18 cm) had significantly longer spike than the shortest one (No. 12), by about 3.13 cm under saline soil (Table 5). Results of SSI based on spike length showed that genotypes No. 7, 13 and 11, were tolerant to salinity stress and had SSI values of 0.47, 0.73 and 0.84, respectively. Salinity caused a reduction in spike length of barley genotypes (Javed *et al* 2003). These results are in harmony with those reported by Pakniyat *et al* (2003) and Oraby *et al* (2005).

2.2. Yield and yield components

2.2.1. Number of spikes / m^2

The highest average number spikes /m^2 was 266.00 spikes for genotype No. 13, which was significantly higher than the lowest one No. 9, by about 90.33 spikes under saline soil (Table 5). Ten genotypes had SSI based on spikes /m^2 less than unity and were relatively tolerant to salinity stress. The most salt sensitive genotypes were No. 7, 13 and 11 which had SSI values of 0.58, 0.63 and 0.71, respectively. These results showed also that number of spikes/m^2 was depressed under saline soil. Mostfa and Mokable (1995) found that increasing salinity at the beginning of tillering caused a decrease in number of spikes /plant. These results go in line with these reported by El-Sayed and Khodier (2004).

2.2.2. Number of kernels/spike

The average number of kernels/spike for the highest genotype (No. 10) was 22.83 which was significantly higher than the lowest one (No. 2) by about 8.83 under saline soil (Table 5). Seven genotypes had SSI based on kernels/spike less than unity and were relatively tolerant to salinity stress. The genotypes No. 10, 15 and 17 were the most sensitive and had SSI values of 0.41, 0.74 and 0.80, respectively. These results are in line with those reported by El-Sayed *et al* (2002) and Javed *et al* (2003).

2.2.3. 1000-Kernel weight (g)

The average 1000-kernel weight for the highest genotype (No. 10) 42.52 g was significantly higher than the check varieties G.127 and G.128 by 1.90 and 1.17 g, respectively, under saline soil (Table 6). Ten genotypes had SSI less than unity and are relatively tolerant to salinity stress based on 100-kernels weight, such as, genotypes No. 20, 10 and 17 and had SSI values of 0.71, 0.71 and 0.76, respectively. The most susceptible genotypes were No. 4, 3 and 8. These results were in accordance with those of El-Sayed *et al* (2002) and Javed *et al* (2003).

2.2.4. Grain yield (ardab/fed)

The combined average for grain yield (ardab/fed) of the selected barley genotypes and the two check cultivars as affected by soil salinity are shown in (Table 3). Since the interaction between the genotypes and salinity levels was highly significant (Table 3), the importance should be given to the best treatment combination between the two factors. Under saline soil (10.97 dS/m^{-1}), the average grain yield for the highest genotype (No. 10) was 8.32 ardab/fed, which was significantly higher than the lowest genotype (No. 20) by about 3.01 ardab/fed (Table 6). It was also significantly higher than the check varieties, G.127 and G.128 (No.21 and 22) by 0.78 and 1.54 ardab/fed, respectively, (Table 6).

Table 5. Mean performance and salinity susceptibility index (SSI) of spike length, number of spikes / m^2 and number of kernels /spike of barley genotypes as affected by salinity levels combined across two seasons.

Genotypes	Combined means Level of salinity Spike length ,(cm)			Salinity susceptibility index (SSI)	Combined means Level of salinity Number of spikes / m^2			Salinity susceptibility index (SSI)	Combined means Level of salinity Number of kernels /spike			Salinity susceptibility index (SSI)
	S_1 (0.69)	S_2 (10.97)	Mean		S_1 (0.69)	S_2 (10.97)	Mean		S_1 (0.69)	S_2 (10.97)	Mean	
1	9.85	6.83	8.34	0.95	269.50	209.16	239.33	0.79	27.00	17.16	22.08	1.07
2	8.85	6.70	7.77	0.75	280.16	209.33	244.75	0.89	23.16	14.00	18.58	1.16
3	9.66	6.45	8.05	1.03	294.33	198.83	246.58	1.14	25.33	17.50	21.41	0.91
4	9.91	5.91	7.91	1.25	298.00	198.16	248.08	1.18	26.00	14.16	20.08	1.34
5	11.41	8.18	9.80	0.88	346.33	249.00	297.66	0.99	31.66	21.16	26.41	0.97
6	10.05	6.63	8.34	1.06	249.33	185.83	217.58	0.90	22.50	14.00	18.25	1.11
7	8.98	7.58	8.28	0.48	312.83	261.50	287.16	0.58	24.66	16.33	20.50	0.99
8	9.06	6.58	7.82	0.85	290.83	226.00	258.41	0.78	25.50	15.66	20.58	1.13
9	9.63	6.48	8.05	1.02	268.83	175.33	222.08	1.22	31.00	17.66	24.33	1.26
10	10.06	6.38	8.22	1.14	367.66	263.83	315.75	0.99	26.50	22.83	24.66	0.41
11	10.86	7.93	9.40	0.84	273.66	218.50	246.08	0.71	24.50	15.16	19.83	1.12
12	7.91	5.05	6.48	1.12	247.16	175.83	211.50	1.02	27.16	15.50	21.33	1.26
13	9.06	6.93	8.00	0.73	324.16	266.00	295.08	0.63	26.16	18.50	22.33	0.86
14	9.41	6.13	7.77	1.08	277.50	195.66	236.58	1.04	26.33	16.66	21.50	1.08
15	10.86	7.45	9.15	0.97	281.83	202.83	242.33	0.99	25.66	19.16	22.41	0.74
16	8.88	5.86	7.37	1.06	265.83	181.00	223.41	1.12	25.83	18.50	22.16	0.83
17	9.93	6.41	8.17	1.10	351.16	248.66	299.91	1.03	24.00	17.50	20.75	0.80
18	8.20	5.16	6.68	1.15	311.83	187.83	249.83	1.40	26.00	17.00	21.50	1.02
19	9.60	5.46	7.53	1.34	358.16	210.16	284.16	1.45	27.33	17.83	22.58	1.02
20	8.20	5.96	7.08	0.85	267.66	193.50	230.58	0.98	24.83	15.00	19.91	1.16
G.127	10.05	6.50	8.27	1.10	339.16	235.33	287.25	1.08	26.66	19.66	23.16	0.77
G.128	9.21	5.56	7.39	1.23	313.33	225.33	269.33	0.99	24.33	16.33	20.33	0.97
Mean	9.53	6.46	7.99	1.00 ± 0.04	299.51	214.43	256.97	1.00 ± 0.05	26.00	17.15	21.58	1.00 ± 0.04
Rev. L.S.D 5% Level					Rev. L.S.D 5% Level				Rev. L.S.D 5% Level			
Soil salinity			0.04		Soil salinity		1.38		Soil salinity		0. 20	
Genotype			0.026		Genotype		2.57		Genotype		0.59	
Interaction			0.39		Interaction		3.64		Interaction		0.89	

S1 = old farm and S2 = farm number, 93,in Agricultural Experimental Research Farm of the Faculty of Agriculture, Sohag University, Egypt

Table 6. Mean performance and salinity susceptibility index (SSI) of 1000 kernel weight, grain yield ardab /fed and straw yield ton/fed of barley genotypes as affected by salinity levels combined across two seasons.

Genotype	Combined means, Level of salinity, 1000 kernel weight, (g)			Salinity susceptibility index (SSI)	Combined means, Level of salinity, Grain yield (ardab /fed)			Decrease Percentage S_1- S_2/ S_1%	Salinity susceptibility index (SSI)	Combined means, Level of salinity, Straw yield ton/fed			Salinity susceptibility index (SSI)
	S_1 (0.69)	S_2 (10.97)	Mean		S_1 (0.69)	S_2 (10.97)	Mean			S_1 (0.69)	S_2 (10.97)	Mean	
1	41.68	37.03	39.36	0.86	9.03	7.07	8.05	21.71	0.84	2.21	1.43	1.82	0.79
2	43.76	37.51	40.64	1.10	8.51	5.55	7.03	34.78	1.34	2.66	1.00	1.83	1.39
3	44.41	36.14	40.27	1.43	8.82	6.67	7.74	24.38	0.94	1.51	1.10	1.31	0.61
4	41.88	33.96	37.92	1.45	8.57	5.60	7.09	34.66	1.34	2.33	1.20	1.77	1.08
5	44.35	39.76	42.05	0.80	10.54	7.84	9.19	25.62	0.99	3.05	2.12	2.59	0.68
6	40.89	36.83	38.86	0.76	9.57	6.12	7.84	36.05	1.39	2.75	0.85	1.80	1.54
7	45.53	40.48	43.00	0.85	8.89	7.72	8.30	13.16	0.51	2.93	1.95	2.44	0.75
8	45.43	37.67	41.55	1.31	9.15	6.79	7.97	25.79	0.99	2.81	1.19	2.00	1.29
9	45.85	38.64	42.24	1.21	10.39	6.61	8.50	36.38	1.40	2.98	1.06	2.02	1.44
10	46.87	42.52	44.70	0.71	10.56	8.32	9.44	22.11	0.88	3.67	2.51	3.09	0.71
11	44.18	37.85	41.01	1.10	8.86	6.60	7.73	25.51	0.98	2.47	1.09	1.78	1.25
12	41.51	36.18	38.85	0.99	8.83	7.14	7.98	19.14	0.74	2.58	1.32	1.95	1.09
13	46.10	40.68	43.39	0.90	9.87	7.48	8.67	24.21	0.93	2.59	2.07	2.33	0.45
14	45.37	37.79	41.58	1.28	9.25	6.83	8.04	26.16	1.01	2.83	1.31	2.07	1.20
15	41.55	35.54	38.55	1.11	8.53	5.99	7.26	29.78	1.15	2.16	1.21	1.68	0.98
16	43.06	37.51	40.29	0.99	9.26	6.61	7.93	28.62	1.10	2.59	0.84	1.71	1.51
17	46.44	41.87	44.15	0.76	10.32	8.12	9.22	19.48	0.76	3.40	2.60	3.00	0.52
18	42.55	36.32	39.43	1.12	9.21	6.48	7.84	29.64	1.14	1.85	0.90	1.37	1.15
19	42.93	37.19	40.06	1.03	9.13	7.53	8.33	17.52	0.68	2.34	1.63	1.98	0.68
20	41.55	37.72	39.64	0.71	7.95	5.31	6.63	33.21	1.28	2.22	0.91	1.56	1.32
G.127	44.66	40.62	42.64	0.70	9.26	7.54	8.40	18.57	0.72	3.01	1.61	2.31	1.04
G.128	46.41	41.35	43.88	0.84	8.93	6.78	7.85	24.08	0.93	2.48	1.81	2.14	0.60
Mean	43.95	38.23	41.09	1.00 ± 0.05	9.25	6.85	8.05	25.95±1.37	1.00±0.05	2.61	1.44	2.03	1.00 ± 0.07

Rev. L.S.D 5% level	1000 kernel weight	Rev. L.S.D 5% level	Grain yield	Rev. L.S.D 5% level	Straw yield
Soil salinity	0.25	Soil salinity	0.16	Soil salinity	0.25
Genotype	0.67	Genotype	0.31	Genotype	0.56
Interaction	1.05	Interaction	0.49	Interaction	1.61

S1 = old farm and S2 = farm number, 93,in Agricultural Experimental Research Farm of the Faculty of Agriculture, Sohag University, Egypt

The decrease percentage of grain yield for the highest yielding genotype (No. 10), the lowest one (No.20) and the two check varieties (No. 21 and 22) due to salinity increase was 22.11, 33.21, 18.57 and 24.08 %, respectively, (Table 6),with a general mean of 25.95 ardap/fed.

The salinity susceptibility index (SSI) based on grain yield (ardab/fed) (Table 6) ranged from 0.51 for genotype No.7 to 1.40 for genotype No. 9. The results showed that eleven genotypes had SSI values based on grain yield less than unity and were relatively tolerant to salinity stress. The genotypes No. 7, 19 and 12 were the most salt tolerant and had grain yield means of 7.72, 7.53 and 7.14 ardab/fed, which had SSI values of 0.51, 0.68 and 0.76, respectively. While, nine genotypes were relatively sensitive. The most sensitive genotypes were No.9, 6 and 4 had grain yield means of 6.61, 6.12 and 5.60 ardab/fed, respectively.

2.2.5. Straw yield (ton /fed)

Increasing salinity level decreased straw yield of barley genotypes. Furthermore, the highest reduction was noticed in straw yield from 10.97 ds/m^{-1} level as compared with control. Genotypes No.10, 17 and 5, were the most tolerant, which recorded 3.09, 3.00 and 2.59 ton /fed, respectively (Table 6). Nine genotypes had SSI based on straw yield less than unity and were relatively tolerant to salinity stress. On the other hand, genotypes No. 13, 17, 3 and 5 were the most sensitive and had SSI values of 0.45, 0.52, 0.61 and 0.68, respectively. The results indicated that straw yield was reduced by increasing salinity stress. Bhadauria and Afria (2005) found that saline irrigation at EC12 dSm^{-1} decreased straw yield compared to the control. These results go in line with these reported by Hagag *et al* (1999).

CONCLUSION

Overall, it can be concluded that substantial variation in salt tolerance among barley genotypes at the seedling stage was found in this study. Days to heading, flag leaf area, plant height, spike length, number of spikes /m^2, number of kernels/spike, 1000-kernel weight, grain yield and straw yield confirmed that it is important to use these parameters as useful selection criteria for screening the salt tolerance in terms of grain yield among genotypes at early vegetative growth stage, most importantly, both parameters can be considered for screening barley genotypes at high salinity concentrations. Barley is a grain crop that has shown moderate salt tolerance. In conclusion, the results indicated that seven genotypes No. 1, 5, 7, 10, 13, 17, 19 were tolerant to salinity stress and had SSI less than unity.

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تحمل الملوحة فى الشعير

فراج فرغل برعى ابوالليل[1] ، خلف على همام[1] ، كمال عبده خير الله[2]، 2مسعد زكى الحفنى[2].
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من أجل دراسة تحمل الملوحة فى بعض التراكيب الوراثية من الشعير (الثنائى المغطى) تحت ظروف الإنبات فى المعمل و مراحل النمو فى الحقل ، أجريت تجارب معملية وحقلية في مزرعة البحوث الزراعية فى كلية الزراعة ، جامعة سوهاج، في مواسم 2005 / 2006، 2007/2006 و 2008/2007 . ويهدف هذا العمل إلى حصروتقييم مائتين و ثمانين تركيب وراثى من الشعير تحت ظروف الملوحة من حيث الإنبات تحت الملحية مع مستويات مختلفة من كلوريد الصوديوم في المعمل. تم إنتخاب أفضل عشرين من التراكيب الوراثية تحت أعلى مستوى ملحية من كلوريد الصوديوم وتم تقييم التراكيب الوراثية المنتخبة مع صنفين للمقارنة في الموسمين التاليين تحت التربة الملحية والعادية في الحقل . أشارت نتائج الفحص أن سبعة تراكيب وراثية من أصل عشرين تركيب وراثي كانت متحملة للإجهاد الملحى. وكانت هذه التراكيب الوراثية هى رقم (1، 5، 7، 10، 13، 17 و 19) حيث كان لهذه التراكيب السبعة حساسية للملحية أقل من الوحدة . كشفت النتائج في ظل المتوسط العام ، كان متوسط محصول الحبوب أردب / فدان لأعلى تركيب وراثي رقم (10) هو 9.44 اردب / فدان ، والذي كان أعلى بكثير من أدنى تركيب وراثي رقم (1) بـ 1.39 اردب / فدان . وكان أيضا أعلى بكثير من أصناف المقارنة جيزة 127 وجيزة 128 (رقم 21 و 22) بـ 1.04 و 1.59 اردب / فدان ، على التوالي . نسبة نقص محصول الحبوب (أردب / فدان) لأعلى تركيب وراثي (رقم 10) وهو أدنى مستوى واقل من الواحد ، واقل من التركيب الوراثى رقم (1) و أيضا أقل من أصناف المقارنة ، رقم 21 و 22 ، وذلك تحت زيادة الملحية وكانت نسبة النقص هى 22.11 ، 21.71 ، 18.57 و 24.08% على التوالي. معدل تحمل الملحية (SSI) فى محصول الحبوب (أردب / فدان) ، تراوح بين 0.51 للتركيب الوراثى (رقم 7) إلى 0.99 للتركيب الوراثى (رقم 5).