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Evaluation of wheat genotypes and some soil properties under saline water irrigation

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Abstract Sixteen genotypes of spring wheat (*Triticum aestivum* L.) from different countries were evaluated for salt stress tolerance in the greenhouse under saline water irrigation. Five treatments, (T_1) = tap water (control), (T_2) = 25 mM NaCl, (T_3) = 50 mM NaCl, (T_4) = 75 mM NaCl and (T_5) = 100 mM NaCl were applied for each genotype grown in two seasons. Soil properties were also evaluated under these levels of water salinity. The results indicated that Number of tillers/plant, number of leaves/plant, leaves area/plant at vegetative stage, biomass, days to heading, number of kernels/spike, 1000-kerenl weight, grain yield, K^+ concentration and K^+/Na^+ ratio were decreased under salinity treatments as compared with control, and hence Na^+ concentration was increased. Salinity levels, 25, 50, 75 and 100 mM NaCl reduced grain yield by 14.57%, 29.59%, 42.80% and 55.78%, respectively, as compared with the control treatment. After plant harvesting, soil pH decreased significantly in all soil treatments irrigated with saline water from 7.95 to 7.8. Soil electrical conductivity (EC) increased in all treatments from 3.28 to 6.22 dS/m. The irrigation with saline water caused increase in soluble cations and anions in all soil treatments. Available Mn, Zn and Cu increased in all treatments compared with control. This study suggests that wheat genotypes Shakha 93, HAAMA-14 and Shakha 8 can be selected to grow under salinity stress conditions.

Introduction

In Egypt, agriculture land depends on irrigation water from the River Nile. In the recent years, water recourses are decreased and limiting factors for cultivate land due to demand food production increased (Mohamed et al., 2007). Therefore it is necessary to search for another sources of water irrigation such as reclaimed waste water, recycle water by product, sea water, drainage water and ground water to develop the most suitable irrigation schedule and to get the optimum plant yield for different regions. The use of saline water may be a potential source for suitable irrigation for some crops especially wheat and barley particularly in the arid and semi-arid regions of the world. They are capable of tolerating certain levels of salinity, which vary with different species, varieties and ecotypes (D'Amico et al., 2004).

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Wheat is the most important and widely adapted food cereal in Egypt. Wheat has a good high productively under saline conditions (Ragab et al., 2008). Therefore, it is necessary to increase wheat production in Egypt by raising the wheat grain yield. However, a difference in the salt tolerance among genotypes may also occur at different growth stages. The varietal differences in salinity tolerance that exist among crop plants can be utilized through screening programs by exploiting appropriate traits for salt tolerance (Kingsbury et al., 1984). Grain yield is frequently used in crops such as wheat as the main criteria for salt tolerance (Jafari-Shabestari et al., 1995). Other agronomic traits such as number of tiller, fertile tillers with other indices have been used for the assessment of salt tolerance. These parameters are the main criteria for selecting other complex traits such as resistance to salinity are not satisfying (Flowers and Yeo, 1995). Salinity is one of the major factors reducing plant growth and productivity and also affects about 7% of the world's total land area (Flowers et al., 1997). Egypt is one of the countries that suffer from severe salinity problems. For example, 33% of the cultivated land is already salinized due to low precipitation (< 25 mM annual rainfall) and irrigation with saline water (Ghassemi et al., 1995). The effect of high salinity on plant can be observed at the whole plant level in terms of plant death and/or decrease in productivity due to increase NaCl concentration (Parida et al., 2004). However, it is believed that selection and breeding would be more successful in achieving maximum attainable tolerance, if it were based directly on the relevant agronomic and physiological mechanism(s) (Noble and Rogers, 1992). Salt stress results in a considerable decrease in the tap and dry weights of leaves, tillers and fertile tillers (Chartzoulakis and Klapaki, 2000). On the other hand, soil EC values increased with increasing saline water irrigation (Ragab et al., 2008). The plants tend to take up more Na and exclude K with increasing NaCl concentration (Werner and Finkelstein, 1995). The K^+/Na^+ ratio is decreased under salt stress (Tammam et al., 2008). The objectives of this study were: (i) to evaluate sixteen genotypes of wheat crops under different levels of saline water. (ii) to determine some soil properties and Na^+ and K^+ concentration in plant.

Materials and methods

Plant materials

Sixteen genotypes of spring wheat (*Triticum aestivum L.*) from different countries were evaluated for salt stress tolerance in the greenhouse under different levels of saline water. The entry name and the source providing of the sixteen genotypes used in this study were; line 210, line 1009 and line 103 obtained by Prof. Dr. Kamal A. Kheiralla, Agronomy Department, Faculty of Agriculture, Assiut University, Egypt. Sedes1, Giza 168, Sahel 1, Shakha 93, Shakha 69, Sedes12 and Shakha 8 from Egypt; (Triso) from IPK-gatersleben Genebank-Germany, (GOUMRIA-19, HAAMA-14, QAFZAH-18 and SEIF-4) from ICARDA-Syria (Table 1).

Table 1 Brief description of the name and the origin of sixteen genotypes.

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Genotypes	Sides1	Triso	Giza 168	Line 210	Sahel 1	GOUMRIA-19	Shakha 93	Shakha 69	line 1009	Line 103	HAAMA-14	QAFZAH-18	HAMAM-4	SEIF-4	Shakha 8	Sides12
Origin	Egypt	Germany	Egypt	Egypt	Egypt	ICARDA	Egypt	Egypt	Egypt	Egypt	ICARDA	ICARDA	ICARDA	ICARDA	Egypt	Egypt

Soil sampling

Surface Soil samples (0–30 cm) were collected from the Experimental Farm of Faculty of Agriculture, Sohag University, Sohag, Egypt. They were air dried, then sieved with 2-mm. The soil characters for various physico-chemical characteristics are shown in (Table 2).

Physical and chemical methods in soil analysis

Soil sample (40 g) was used for particle size distribution analysis by sieving and pipette methods (Richards, 1954). The soil pH was measured in 1:1 soil: water suspension (Orion model 410A) using pH meter (Jackson, 1967). The soil electrical conductivity (EC) of the soil past extract (ECe) was measured using electrical conductivity meter (Orion model 150) (Jackson, 1973). Soluble cations and anions were measured in the saturated soil paste extracted according to Jackson (1973). The organic matter content was determined by a modified Walkley and Black method (Walkley and Blacke, 1934). Calcium carbonate content was determined volumetrically using the calibrated collin's Calcimeter method (Jackson, 1973). Available metal content in the soil was determined by ICP mass Spectrometer (Icap6000 Series- Thermo Fisher Scientific Company) after using DTPA extractable micronutrients were extractable from the soil samples by 0.05 M DTPA at pH 7.3 according (Lindsay and Norvel, 1978).

Greenhouse experiment and salinity treatments

The experimental location was at greenhouse at the Experimental Farm of Faculty of Agriculture, Sohag University, Sohag, Egypt. The experimental design was a split- plot arrangement of treatment with three replicates in a randomized complete block design. The salinity treatments were assigned to the main plot and genotypes assigned randomly to the sub-plot. The air dried soil samples were filled in boxes wood. Each box dimensions were (100 cm × 120 cm × 30 cm) (width × length × height). Wheat genotypes were sown in the wood box covered inside by black polyethylene on middle November (favorable), during winter season of 2010/2011 and 2011/2012. Each genotype was sown in a one row 120 cm length, 20 cm width and 2400 cm^2 area. Soil moisture was maintained at 70% of WHC with tap water. After 20 days from planting all boxes irrigated by five treatments, tap water as control (T_1), 25(T_2), 50(T_3), 75(T_4) and 100(T_5) mM NaCl salinity levels were applied for each genotype grown on two seasons.

Traits measurement and analysis of plant and soil

The data were recorded on row basis for each genotype and each replicates to measure the following traits: Number of tillers/plant, number of leaves/plant, leaves area/plant (cm), biomass (g) for one row length 120 cm, days to heading, number of kernels/spike, 1000-kernel weight (g) and grain yield (g) for one row length 120 cm. After harvest plant samples were wet digested in 5 mL 14 M HNO_3, 2 mL H_2O_2 and 1 mL distilled water at 180 °C in PFA (perfluoroalkoxy copolymer resin) tubes under microwaves (MarXpress, CEM). Mineral

Table 2 Physico-chemical characteristics of the investigated soil before cropping.

Parameter	Soil particles (%)			Texture grad	pH (1:1susp.)	ECe (dS/m)	Organic matter%	Total $CaCO_3$ (%)	Soluble cations (meq/l)				Soluble anions (meq/l)			Micronutrients (available) ppm		
	Sand	Silt	Clay						Ca^{2+}	Mg^{2+}	Na^+	K^+	HCO_3	Cl^-	SO_4	Mn	Cu	Zn
Value	70	19	11	Sandy loam	8.1	3	0.4	0.9	18	12	1.4	0.2	4.2	20	6.5	27	0.4	0.8

Table 3 Mean squares (MS) of the analysis of variance of all studied traits under salinity levels over two years.

Traits	M.S.					
	Years (Y)	Genotypes (G)	Salinity treatments (T)	Y * G	Y * T	T * G
d.f.	1	15	4	15	4	60
Tillers number/plant	1.34**	29.23**	51.46**	0.006**	0.011**	1.41**
Leaves number/plant	21.67**	279.05**	678.34**	0.074**	0.18**	7.39**
Leaves area/plant (cm)	3166.01**	12246.25**	44257.65**	4.71**	17.02**	780.17**
Biomass (g)	1264.63**	13545.56**	122407.5**	4.23**	38.26**	1214.2**
Days to heading	524.85**	398.77**	7363.05**	0.19**	3.56**	47.39**
Number of kernels/spike	331.88**	851.12**	7978.7**	0.377**	3.53**	108.81**
1000-kerenl weight (g)	208.81**	938.29**	3964.28**	0.49**	2.09**	7.97**
Grain yield (g)	151.53**	556.68**	5996.35**	0.27**	2.9**	15.2**
K^+ (ppm)	8943.44*	389.19**	5127.69**	1.4**	18.45**	264.43**
Na^+ (ppm)	2595.82**	600.89**	35093.43**	2.16**	126.34**	398.53**
K^+/Na^+ ratio	11.13**	7.48**	213.72**	0.026$^{n.s.}$	0.77**	4.13**

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

composition in the plant digests (Na and K) was determined by Flame photometer (Page et al., 1982). The soil samples were taken from all boxes experiment to measure some soil properties (Jackson, 1967).

The stress susceptibility index and salt tolerance index

According to Fernandez (1992), genotypes can be divided into four groups based on their yield response to stress conditions: (1) genotypes producing high yield under both salinity stress and non-stress conditions (group A), (2) genotypes producing high yield under non-stress (group B) (3) genotypes producing high yield under stress conditions (group C) and (4) genotypes with poor performance under both stress and non-stress conditions (group D).

Salinity resistance indices were calculated using the following relationships:

(1) Stress susceptibility index $SSI = 1 - (Y_S/Y_P)/1 - (\overline{Y}_S/\overline{Y}_P)$ (Fischer and Maurer, 1978) where Y_S is the yield of genotype under stress, Y_P the yield of genotype under control, $\overline{Y}_S$ and $\overline{Y}_P$ are the mean yields of all genotypes under stress and non-stress conditions, respectively, and $1 - (\overline{Y}_S/\overline{Y}_P)$ is the stress intensity. (2) Mean productivity $MP = (Y_P + Y_S)/2$ (Hossain et al., 1990). (3) Tolerance $TOL = Y_P - Y_S$ (Hossain et al., 1990). (4) Stress tolerance index $STI = (Y_P + Y_S)/\overline{Y}_P^2$ (Fernandez, 1992). (5) Geometric mean productivity $GMP = (Y_P * Y_S)^{0.5}$ (Fernandez, 1992). (6) Yield index $YI = Y_S/\overline{Y}_S$ (Gavuzzi et al., 1997). (7) Yield stability index $YSI = Y_S/Y_P$ (Bouslama and Schapaugh, 1984).

Statistical analysis

The data of season 2010/2011 and 2011/2012 were subjected to statistical analysis performed by the SAS software (SAS Institute, 1999).

Results and discussion

Analysis of variance

Mean squares were highly significant for number of tillers/plant, leaves number/plant, leaves area/plant at vegetative stage, biomass, days to heading, number of kernels/spike, 1000-kerenl weight, grain yield, concentrations of K^+, Na^+ and K^+/Na^+ ratio as presented in Table 3. The differences between years, genotypes and salinity levels were highly significant for the measured traits. The interaction between (years * salinity levels), (years * genotypes) and (salinity levels * genotypes) was highly significant for all parameters, except the interaction between (years * genotypes) for K^+/Na^+ ratio was not significant (Table 3).

Tillers number/plant after 45 days

The results in Table 4 show that 25, 50, 75 and 100 mM NaCl treatments reduced tiller number by 20.24%, 28.43%, 33.72% and 40.49% as compared with the control treatment (Table 9). Under T_1 treatment the genotype Nos. 10, 4, 15 and 9 had the highest number of tiller/plant with an average 5.48, 5.58, 5.68 and 5.79 tillers respectively over two years. While under T_2 treatment the genotype Nos. 3, 9, 11, 4 and 15 gave highest number of tiller/plant with an average 4.47, 4.87, 4.97, 5.14 and 5.18 tillers respectively. On the other hand under T_3 treatment the highest number of tiller/plant was genotype Nos. 3, 9, 11, 4 and 15 with average 4.16, 4.67, 4.67, 4.69 and 4.87 tillers respectively. The result obtained under T_4 treatment the highest number of tiller/plant was genotype Nos. 3, 11, 9, 4 and 15 with an average 3.86, 4.16, 4.57, 4.58 and 4.77 tillers over two years respectively. While under T_5 the genotype Nos. 3, 11, 9, 4 and 15 gave highest number of tiller/plant with an average 3.55, 3.86, 4.26, 4.53 and 4.67 tillers respectively. Tillers per plant that are main components of the final grain yield of wheat are initiated at germination and early vegetative growth stages, respectively (Naseer et al., 2001). Vegetative growth of wheat plants is characterized by the tillering, leaf appearance and growth on the tillers. The values of the tiller number in our results by increasing salinity were reduced. However, salt sensitive genotypes showed a greater reduction in tiller number (e.g. by about 80.00% for Triso genotype) than tolerant ones (e.g. by about 17.86% for Shakha 8 genotype) (Table 4). When salinity levels are greater than 50 mM NaCl, most of the secondary tillers of moderately tolerant genotypes were eliminated, and the number of primary tillers for salt sensitive wheat genotypes was greatly reduced (Eugene et al., 1994). Tiller number can again be used as a

Table 4 Genotypes means under different salinity levels for tillers number/plant, leaves number/plant, leaves area/plant and total biomass over two years.

G	Tillers number/plant after 45 days					Mean	Leaves number/plant after 45 days (cm)					Mean
	T1	T2	T3	T4	T5		T1	T2	T3	T4	T5	
1	3.65	1.83	1.52	1.42	1.32	1.95	11.18	8.44	6.61	6.20	5.49	7.58
2	5.08	3.55	2.54	1.62	1.02	2.76	16.67	14.23	11.18	8.54	6.10	11.34
3	4.67	4.47	4.16	3.86	3.55	4.14	16.26	14.84	14.43	14.03	13.32	14.58
4	5.58	5.14	4.69	4.58	4.53	4.90	21.35	18.50	16.67	15.55	14.84	17.38
5	4.67	3.35	2.94	2.84	2.54	3.27	18.30	16.26	13.32	12.20	10.57	14.13
6	4.87	3.65	2.44	2.33	1.22	2.90	16.26	14.23	13.21	9.15	7.62	12.10
7	3.76	3.65	3.55	3.35	3.05	3.47	16.06	13.42	12.91	12.30	11.59	13.26
8	3.86	3.65	3.45	3.25	3.05	3.45	18.30	16.47	14.64	12.91	11.69	14.80
9	5.79	4.87	4.67	4.57	4.26	4.83	17.28	16.26	14.23	13.21	12.20	14.64
10	5.48	3.86	3.76	3.55	3.45	4.02	20.13	17.28	15.25	13.21	12.20	15.61
11	5.28	4.97	4.67	4.16	3.86	4.59	17.08	16.37	15.65	14.84	14.43	15.67
12	3.65	1.83	1.62	1.42	1.12	1.93	11.18	9.15	7.12	5.08	3.05	7.12
13	5.28	2.64	2.13	1.83	1.22	2.62	18.30	17.38	12.40	10.16	8.13	13.28
14	3.86	3.65	3.35	3.15	3.05	3.41	11.18	10.16	8.54	7.42	7.12	8.88
15	5.68	5.18	4.87	4.77	4.67	5.03	21.35	18.30	16.26	14.23	12.20	16.47
16	4.36	4.16	3.86	3.55	3.25	3.84	15.25	14.23	13.21	11.18	9.15	12.60
Mean	4.72	3.78	3.39	3.14	2.82	3.57	16.63	14.72	12.85	11.26	9.98	13.09
		LSD 0.05			LSD 0.01			LSD 0.05		LSD 0.01		
Genotypes (G)			0.22			0.29			0.49		0.66	
Salinity levels (T)			0.12			0.16			0.28		0.37	

G	Leaves area/plant at day 45 (cm)					Mean	Total biomass/one row at day 75 (g)					Mean
	T1	T2	T3	T4	T5		T1	T2	T3	T4	T5	
1	138.72	114.24	104.04	97.92	85.68	108.12	165.43	156.47	116.66	116.26	60.06	122.97
2	150.96	137.70	122.40	93.84	71.40	115.26	107.91	93.86	67.29	59.04	24.94	70.61
3	155.04	144.84	140.76	134.64	127.50	140.56	193.83	123.18	80.83	65.05	54.16	103.41
4	171.36	163.20	154.02	149.94	147.90	157.28	138.24	99.56	86.84	72.18	45.81	88.53
5	173.40	147.90	134.64	112.20	81.60	129.95	149.65	116.05	112.69	64.54	27.79	94.14
6	153.00	137.70	120.36	104.04	91.80	121.38	79.51	72.89	41.03	33.80	32.37	51.92
7	142.80	132.60	127.50	122.40	117.30	128.52	176.93	161.05	148.42	128.27	88.06	140.55
8	153.00	147.90	141.78	133.62	128.52	140.96	118.09	117.27	106.89	82.36	60.06	96.93
9	183.60	181.56	142.80	112.20	91.80	142.39	125.42	118.19	102.21	57.21	52.43	91.09
10	173.40	168.30	132.60	127.50	122.40	144.84	111.27	105.57	102.11	71.16	57.01	89.42
11	168.30	162.18	155.04	148.92	143.82	155.65	154.74	138.19	76.54	60.57	33.09	92.63
12	142.80	127.50	107.10	95.88	71.40	108.94	173.47	112.18	103.63	71.97	55.18	103.29
13	158.10	142.80	117.30	81.60	71.40	114.24	108.11	89.18	85.11	62.91	29.22	74.90
14	112.20	99.96	84.66	75.48	70.38	88.54	111.27	80.63	59.04	53.24	15.68	63.97
15	183.60	168.30	153.00	147.90	142.80	159.12	154.02	116.56	84.49	76.25	40.21	94.31
16	173.40	147.90	138.72	127.50	112.20	139.94	125.42	113.30	102.21	57.21	52.43	90.11
Mean	158.35	145.29	129.79	116.60	104.87	130.98	137.08	113.38	92.25	70.75	45.53	91.80
		LSD 0.05			LSD 0.01			LSD 0.05		LSD 0.01		
Genotypes (G)			5.13			6.76			6.40		8.43	
Salinity levels (T)			2.87			3.78			3.58		4.71	

simple and non-destructive measurement to evaluate large number of wheat genotypes in breeding programs; especially the parameter can be determined at early growth stages.

Number of leaves/plant after 45 days

The results in Table 4 show variations in number of leaves due to salinity levels and genotypes. At 25, 50, 75 and 100 mM NaCl treatments, for number of leaves/plant was reduced by 11.80%, 23.26%, 32.99% and 40.87% as compared with the control treatment (Table 9). Under T_1 treatment the genotype Nos. 8, 5, 10, 15 and 4 gave an average of 18.30, 18.30, 20.13, 21.35 and 21.35 leaves respectively over two years. While under T_2 treatment the genotype Nos. 8, 10, 13, 15 and 4 gave highest leaves number/plant with an average 16.47, 17.28, 17.38, 18.30 and 18.50 leaves, respectively. On the other hand under T_3 treatment the genotype Nos. 8, 10, 11, 15 and 4 gave an average of 14.64, 15.25, 15.65, 16.26 and 16.67 leaves respectively. The result reported under T_4 treatment the highest leaves number/plant was genotype Nos. 9, 10, 3, 15, 11 and 4 with an average 13.21, 13.21, 14.03, 14.23, 14.84 and 15.55 leaves respectively over two years. While under T_5 treatment the highest genotype Nos. 9, 10, 15, 3, 11 and 4 gave highest leaves number/plant with an average 12.20, 12.20, 12.20, 13.32, 14.43 and 14.84 leaves respectively. Vegetative growth stage is known to be more sensitive to salt stress compared with later growth stages in wheat (Bhutta and Hanif, 2010 and Khayatnezhad and Gholamin, 2010). On the early

developmental traits it would appear that main-stem apical primordium development and growth are not sufficiently affected by salt treatment in time to reduce number of leaves and tiller appearance (Ellis et al., 2004). The values of the leaves number/plant in our results by increasing salinity were reduced. However, salt sensitive genotypes showed a greater reduction in leaves number/plant (e.g. by about 72.73% for QAFZAH-18 genotype) than tolerant ones (e.g. by about 15.48% for HAAMA-14 genotype) (Table 4).

Leaves area/plant after 45 days

The average of leaves area/plant under T_1, T_2, T_3, T_4 and T_5 treatments was 158.35, 145.29, 129.79, 116.60 and 104.87 cm^2 respectively. Leaves area/plant decreased 8.44%, 18.16%, 26.49% and 33.92% by 25, 50, 75 and 100 mM NaCl treatments as compared with the control treatment respectively (Table 9). The data in Table 4 showed that, T_1 treatment the highest leaves area values were of genotype Nos. 16, 10, 5, 15 and 9 with an average 173.40, 173.40, 173.40, 183.60 and 183.60 cm^2 respectively over two years, while under T_2 treatment the genotype Nos. 11, 4, 10, 15 and 9 gave highest leaves area with an average 162.18, 163.20, 168.30, 168.30 and 181.56 cm^2 respectively. On the other hand the highest leaves values area were produced from genotype Nos. 8, 9, 15, 4 and 11 with an average 141.78, 142.80, 153.00, 154.02 and 155.04 cm^2 under T_3 treatment respectively. However, under T_4 treatment the genotype Nos. 8, 3, 15, 11 and 4 gave highest leaves area with an average 133.62, 134.64, 147.90, 148.92 and 149.94 cm^2 respectively over two years. While the highest leaves area values were produced from genotype Nos. 3, 8, 15, 11 and 4 with an average 127.50, 128.52, 142.80, 143.82 and 147.90 cm^2 under T_5 treatment, respectively. The study found salinity caused a significant reduction of the leaves area and decrease of biomass accumulation. Leaves area reduction was the main salinity avoidance strategy in some genotypes. However, salt sensitive genotypes showed a greater reduction in leaves area (e.g. by about 54.84% for HAMAM-4 genotype) than tolerant ones (e.g. by about 14.55% for HAAMA-14 genotype) (Table 4). Under salinity stress, loss of leaves and reduced expansion of younger leaves caused a decrease in the leaves area ratio in the stressed plants (El-Hendawy et al., 2005). Genotypes, which exhibited salt tolerance at early stage, but did not at late stage, can be exploited in breeding programs (Sabir and Ashraf, 2008).

Total biomass (g)

At 25, 50, 75 and 100 mM NaCl treatments, total biomass was reduced by 16.20%, 31.92%, 48.12% and 66.52% respectively, as compared with the control treatment (Table 9). The result in Table 4 shows that with application of T_1 treatment, the heaviest biomass was produced from genotype Nos. 11, 1, 12, 7 and 3 with an average 154.74, 165.43, 173.47, 176.93 and 193.82 g respectively over two years. While under T_2 treatment the genotype Nos. 9, 3, 11, 1 and 7 gave heaviest biomass with an average 118.19, 123.18, 138.19, 156.47 and 161.05 g respectively. On the other hand T_3 treatment the heaviest biomass was genotype Nos. 12, 8, 5, 1 and 7 with an average 103.63, 106.89, 112.69, 116.66 and 148.42 g respectively. While under T_4 treatment the genotype Nos. 4, 15, 8, 1 and 7 gave heaviest biomass with an average 72.18, 76.25, 82.36, 116.26 and 128.27 g respectively over two years. However under T_5 treatment the heaviest biomass was genotype Nos. 12, 10, 1, 8 and 7 with an average 55.18, 57.01, 60.06, 60.06 and 88.06 g respectively. Biomass was affected by leaves area, plant growth and environments. When the developmental pattern of genotypes is so different between growth stages, assessment of the actual salt tolerance of the genotypes may be determined by comparisons with their biomass production over a long growth period (Munns et al., 2000 and El-Hendawy et al., 2005), which therefore serve as another criterion to evaluate the salt tolerance. The results in this study indicate that the different among genotypes for salt tolerance based on the biomass at different salinity levels was close to that based on agronomic parameters at the vegetative stage. However, salt sensitive genotypes showed a greater reduction in biomass (e.g. by about 85.91% for SEIF-4 genotype) than tolerant ones (e.g. by about 49.14% for Shakha 69 genotype) (Table 4). This indicates that the reduction in biomass was closely related to those in tiller and leaves number and leaves area (Hu et al., 1997). Bhadauria and Afria (2005) found that saline irrigation decreased biomass compared to the control treatment.

Days to heading

Heading under the salinity stress treatments was earlier by about seven to twenty two days compared to control treatment. The average of number of days to heading at salinity levels was reduced by 12.25%, 21.39%, 29.27% and 37.78% denote 7.41, 12.75, 17.45 and 22.56 days, at 25, 50, 75 and 100 mM NaCl treatments, respectively, as compared with the control treatment (Table 9). The data in Table 5 showed that under T_1 control treatment, the genotype Nos. 15, 2, 13, 10 and 11 followed by 57.26, 56.24, 56.24, 54.19 and 53.17 days were the earliest under both treatments. The earliness in heading reached 49.08, 49.08, 49.08, 49.08 and 48.06 days under T_2 as compared to control treatment for genotype Nos. 11, 6, 15, 8 and 5. Under T_3 treatment the genotype Nos. 5, 10, 11, 15 and 6 gave the earliest heading date with an average 46.01, 43.94, 42.94, 40.90 and 37.83 days respectively over two years, while under T_4 treatment genotype Nos. 2, 8, 11, 15 and 6 gave the earliest heading date with an average of 37.83, 37.83, 37.83, 36.81 and 35.79 days respectively. On the other hand, under T_5 treatment the genotype Nos. 1, 14, 5, 2 and 8 gave the earliest heading date with an average of 33.74, 32.72, 32.72, 31.70 and 30.67 days respectively. Bajji et al. (2004) showed that early heading is one of the mechanisms that plants use to escape the damage effects caused by salinity stress. Means of days to heading decreased as salinity level increased (Oraby et al., 2005). However, salt sensitive genotypes showed a greater reduction in days to heading (e.g. by about 29.65 days for SEIF-4 genotype) than tolerant ones (e.g. by about 9.21 days for HAMAM-4 genotype) (Table 5). Katerji et al. (2006) showed large differences in day number to heading were decreased by increasing salinity levels.

Number of kernels/spike

Number of kernels/spike showed variations under salinity stress treatments (Table 5). At 25, 50, 75 and 100 mM NaCl treatments, number of kernels/spike was reduced by 10.31%,

Table 5 Genotypes means under different salinity levels for days to heading, 1000-kernel weight and grain yield over two years.

G	Days to heading					Mean	Number of kernels/spike					Mean
	T1	T2	T3	T4	T5		T1	T2	T3	T4	T5	
1	61.35	51.12	48.06	43.97	33.74	47.65	51.08	40.86	37.80	33.71	23.49	37.39
2	56.24	50.10	48.06	37.83	31.70	44.79	44.95	39.84	37.80	21.45	11.24	31.05
3	63.39	59.30	51.12	40.90	38.85	50.72	53.12	49.03	40.86	30.65	28.60	40.45
4	61.35	52.15	46.01	39.88	37.83	47.44	51.08	41.88	35.75	29.62	27.58	37.18
5	58.28	48.06	46.01	41.92	32.72	45.40	41.88	37.80	35.75	31.67	22.47	33.91
6	58.28	49.08	37.83	35.79	35.79	43.35	38.82	34.73	32.69	27.58	25.54	31.87
7	61.35	58.28	52.15	51.12	48.06	54.19	55.16	52.10	48.01	46.99	37.80	48.01
8	59.30	49.08	47.03	37.83	30.67	44.79	49.03	46.99	43.92	37.80	20.43	39.63
9	60.33	51.12	47.03	38.85	36.81	46.83	51.08	50.05	38.82	36.77	26.56	40.66
10	54.19	53.17	43.97	42.94	34.76	45.81	43.92	42.90	40.86	34.73	32.69	39.02
11	53.17	49.08	42.94	37.83	35.79	43.76	46.99	44.95	42.90	27.58	25.54	37.59
12	70.55	56.24	54.19	53.17	43.97	55.62	60.27	45.97	43.92	42.90	33.71	45.35
13	56.24	53.17	49.08	47.03	47.03	50.51	48.01	43.92	41.88	39.84	36.77	42.09
14	62.37	50.10	46.01	43.97	32.72	47.03	64.35	56.18	52.10	28.60	22.47	44.74
15	57.26	49.08	40.90	36.81	34.76	43.76	46.99	38.82	33.71	28.60	24.52	34.53
16	59.30	55.21	48.06	43.97	36.81	48.67	59.25	55.16	48.01	43.92	36.77	48.62
Mean	59.56	52.15	46.78	42.11	37.00	47.52	50.37	45.07	40.92	33.90	27.26	39.51
		LSD 0.05		LSD 0.01				LSD 0.05		LSD 0.01		
Genotypes (G)			1.27		1.67				1.92		2.52	
Salinity levels (T)			0.71		0.93				1.10		1.41	

G	1000-kernel weight (g)					Mean	Grain yield (g)					Mean
	T1	T2	T3	T4	T5		T1	T2	T3	T4	T5	
1	35.54	31.62	26.03	22.85	21.22	10.14	36.39	30.98	24.74	23.21	21.88	27.44
2	32.43	28.59	25.03	20.45	17.40	9.74	30.26	28.01	21.67	18.30	12.06	22.06
3	32.14	27.42	23.01	19.90	18.30	11.16	38.34	32.71	27.40	22.39	16.15	27.40
4	30.28	25.82	21.42	18.72	17.01	11.16	32.71	27.30	23.41	16.77	14.11	22.86
5	38.19	34.64	29.80	24.82	20.46	9.62	38.13	32.61	26.07	19.42	16.25	26.50
6	31.73	28.33	24.05	19.95	16.50	11.77	24.13	20.34	13.60	11.86	8.38	15.66
7	37.69	32.80	28.66	24.91	21.11	9.73	39.15	33.02	28.22	23.92	20.04	28.87
8	42.37	38.27	35.63	30.59	25.59	10.75	39.15	33.63	28.52	22.18	17.79	28.26
9	40.86	35.77	31.34	28.24	25.04	11.16	38.44	31.69	26.58	23.10	18.30	27.62
10	36.77	26.17	25.15	21.69	12.07	11.57	36.70	31.79	27.30	21.16	18.50	27.09
11	47.97	42.15	39.83	33.89	29.88	9.18	44.16	39.77	32.51	26.38	20.45	32.65
12	31.25	26.80	23.37	18.80	15.86	9.13	31.59	25.15	20.96	17.07	14.01	21.75
13	30.55	26.28	21.71	17.98	14.21	7.91	27.30	22.18	18.61	14.72	11.65	18.89
14	36.40	33.93	30.64	25.77	21.44	7.71	36.19	30.46	24.13	18.91	12.47	24.43
15	47.40	42.94	39.02	34.80	30.43	9.54	40.69	35.07	29.24	22.49	16.56	28.81
16	42.42	38.14	34.23	29.94	25.70	6.31	38.44	33.74	29.65	25.15	14.21	28.24
Mean	37.12	32.48	28.68	24.58	20.76	9.79	35.74	30.53	25.16	20.44	15.80	25.53
		LSD 0.05		LSD 0.01				LSD 0.05		LSD 0.01		
Genotypes (G)			0.53		0.69				0.72		0.95	
Salinity levels (T)			0.29		0.39				0.40		0.53	

18.42%, 32.39% and 45.57%, respectively, as compared with the control treatment (Table 9). Under T_1 treatment the highest number of kernels/spike genotype Nos. 3, 7, 16, 12 and 14 gave an average 53.12, 55.16, 59.25, 60.27 and 64.35 kernels respectively over two years. While under T_2 treatment the genotype Nos. 3, 9, 7, 16 and 14 gave highest number of kernels/spike with an average 49.03, 50.05, 52.10, 55.16 and 56.18 kernels respectively. On the other hand under T_3 treatment the highest No. 12, 8, 7, 16 and 14 gave an average 43.92, 43.92, 48.01, 48.01 and 52.10 kernels respectively. The result reported under T_4 treatment the highest number of kernels/spike was genotype Nos. 8, 13, 12, 16 and 7 with an average 37.80, 39.84, 42.90, 43.92 and 46.99 kernels respectively over two years. While under T_5 treatment the highest genotype Nos. 10, 12, 13, 16 and 7 gave highest number of kernels/spike with an average 32.69, 33.71, 36.77, 36.77 and 37.80 kernels respectively. Oraby et al. (2005) showed that the highest salinity level (200 mM NaCl) caused a significant decrease number of kernels/panicle. In addition, Guasmi et al. (2007) showed that salinity had significant effect reduced number of kernels per spike.

Thousand kernel weight (g)

The results of 1000- kernel weight in Table 5 indicate large variations in the response to salinity stress. At 25, 50, 75 and 100 mM NaCl treatments, 1000-kernel weight was reduced by 12.68%, 23.26%, 34.39% and 44.64%, respectively, as

compared with the control treatment (Table 9). Under T_1 treatment the heaver kernel weight resulted in genotype Nos. 9, 8, 16, 15 and 11 with an average 40.86, 42.37, 42.42, 47.40 and 47.97 g respectively over two years. While under T_2 treatment the genotype Nos. 9, 16, 8, 11 and 15 gave highest 1000-kernel weight with an average 35.77, 38.14, 38.27, 42.15 and 42.94 g respectively. On the other hand under T_3 treatment the highest 1000- kernel weight were genotype Nos. 9, 16, 8, 15 and 11 with an average 31.34, 34.23, 35.63, 39.02 and 39.83 g respectively. However adding T_4 treatment the highest genotype Nos. 9,16, 8,11 and 15 gave highest 1000-kernel weight with an average 28.24, 29.94, 30.59, 33.89 and 34.80 g respectively over two years. While under T_5 treatment the highest 1000-kernel weight were genotype Nos. 9, 8, 16, 11 and 15 with an average 25.04, 25.59, 25.70, 29.88 and 30.43 g respectively. This may be due to the irrigation with salinity water affecting the grain maturity which resulted in shrunken kernels. Our results showed that high reduction in kernel weight was found under irrigation with salinity water; it could be fully accounted by the reduction in grain filling period. The various yield components showed different responses to salinity. Jones et al. (1996) found that physiological stress expressed by salinity during kernel filling period reduces the storage capacity of cereal kernels and decreased the number of endosperm cells and/or the number of amyloplasts initiated, therefore, caused the reduction in grain weight.

Grain yield/row (g)

The effects of salinity levels on the wheat grain yield/one row are presented in Table 5. At 25, 50, 75 and 100 mM NaCl treatments, grain yield was reduced by 14.71%, 30.02%, 43.12% and 56.08%, respectively, as compared with the control treatment (Table 9). The results indicated large variations between salinity stress; under T_1 treatment the highest yield was genotype Nos. 16, 7, 8, 15 and 11 with an average of 38.44, 39.15, 39.15, 40.69 and 44.16 g respectively over two years. While under T_2 treatment the genotype Nos. 7, 8, 16, 15 and 11 gave highest yield with an average of 33.02, 33.63, 33.74, 35.07 and 39.77 g respectively. On the other hand under T_3 treatment the highest yield was genotype Nos. 7, 8, 15, 16 and 11 with an average of 28.22, 28.52, 29.24, 29.65 and 32.51 g respectively. The result showed under T_4 treatment the genotype Nos. 9, 1, 7, 16 and 11 gave the highest yield with an average of 23.10, 23.21, 23.92, 25.15 and 26.38 g respectively over two years. While under T_5 treatment the highest yield was genotype Nos. 9, 10, 7, 11 and 1 with an average of 18.30, 18.50, 20.04, 20.45 and 21.88 g respectively. The irrigation with salinity water was attributed to grains could be affected by high salinity. Reducing leaves area and kernel weight caused a great reduction in grain yield. When the strategy of breeding program is to improve yield in a small stress or non-stress environment, it may be possible to explain local adaptation to increase grains from selection conducted directly in that environment (Hohls, 2001). The estimation of potential yield losses by individual abiotic stresses is estimated at 17% by drought, 20% by salinity, 40% by high temperature, 15% by low temperature, and 8% by other factors (Ashraf and Harris, 2005). Improving the grain yield of wheat is always the main target in plant breeding. Therefore, the evaluation of final grain yield and growth parameters determining grain yield is a critical aspect of breeding programs. The effect of salinity on tiller number and number kernels/spike, which both initiate during early growth stages, has a greater influence on final grain yield than on yield components in the later stages (El-Hendawy et al., 2005).

Concentration of Na^+, K^+ and K^+/Na^+ ratio

The treatments, tap water as control (T_1), 25 (T_2), 50 (T_3), 75 (T_4) and 100 (T_5) mM NaCl levels had significant effects on Na^+, K^+ and K^+/Na^+ ratio of the wheat genotypes (Table 6). Na concentration increased with increasing saline water salinity levels in all soil treatments. While K content decreased with increasing saline water salinity levels in all soil treatments. K^+/Na^+ ratio indicates that a decreased under highly salinity levels. In this study "Shakha 8" (a salt tolerant cultivar) had the lowest Na^+ content and the highest K^+/Na^+ ratio, while "Triso" (a salt sensitive cultivar) had the lowest K^+/Na^+ ratio. Genotypes "Sides 1", "Giza 168","Shakha 93", "Shakha 69", "line 1009", "line 103""HAAMA-14" and "Sides 12", having higher K^+/Na^+ ratio which may be considered as salt tolerant genotypes. Our results are consistent with the finding of Chhipa and Lal (1995), who suggested that wheat, genotypes with higher K^+/Na^+ ratio could be considered as salt tolerant ones grown under saline conditions. The genotypes "Triso", "GOUMRIA-19", "QAFZAH-18" "HAMAM-4" and "SEIF-4" with higher Na^+ content and lower K^+/Na^+ ratio which may be considered as non-tolerant cultivars (Table 6). Our results are degree with the finding of (Goudarzi and Pakniyat, 2008; Ragab et al., 2008 and Tammam et al., 2008). They suggested that wheat crops with lowest K^+/Na^+ ratio could be considered as nontolerant cultivars under saline conditions.

Effect of salinity levels irrigation on some soil properties

Data in Table 7 showed that soil pH decreased in all soil treatments irrigated with saline water from 7.95 to 7.8 with increasing water salinity. Decreases in soil pH in all soil treatments could be due to displacement of protons by Na of saline irrigation water (Ghallab and Usman, 2007). Saline levels of irrigation water increased soil electrical conductivity (EC) in all treatments from 3.28 to 6.22 dS/m. The highest value of EC was T_5 treatment and the lowest one was T_1 control treatment. These results were agreements with obtained by (Ragab et al., 2008) they reported that values of EC for irrigated soil increased with increasing salinity water used. On the other hand, the irrigation with saline water caused an increase in soluble cations Ca, Mg, Na and K in all soil treatments. Soluble sodium content in all soil treatments is increased by increasing NaCl levels (Ghallab and Usman, 2007). Increasing saline levels water irrigation indicated that the contents of anions ions such as HCO_3, Cl^- and SO_4 increased in all treatments compared with control treatment. Several studies indicated that the distribution and concentration of most cations and anions were increased with increasing saline level water irrigation (Ghallab and Usman, 2007 and Ragab et al., 2008). In addition, Soluble Mn, Zn and Cu increased in all soil treatments by increasing saline water irrigation compared with control treatment. The increases in the soluble Mn and Zn

Table 6 Effect of different consternations of K^+, Na^+ and K^+/Na^+ ratio parameters in wheat genotypes under different salinity levels.

G	K^+ (ppm)					Mean	G	Na^+ (ppm)					Mean
	T1	T2	T3	T4	T5			T1	T2	T3	T4	T5	
1	82.00	66.00	81.00	63.00	64.00	71.20	1	24.00	21.00	30.00	55.00	65.00	39.00
2	71.00	81.00	66.00	74.00	61.00	70.60	2	23.00	31.00	38.00	60.00	64.00	43.20
3	84.00	70.00	73.00	58.00	61.00	69.20	3	25.00	20.00	27.00	56.00	81.00	41.80
4	84.00	70.00	73.00	58.00	58.00	68.60	4	19.00	23.00	38.00	70.00	70.00	44.00
5	72.00	81.00	60.00	66.00	63.00	68.40	5	17.00	27.00	63.00	67.00	54.00	45.60
6	79.00	70.00	75.00	74.00	57.00	71.00	6	29.00	26.00	34.00	54.00	53.00	39.20
7	85.00	88.00	80.00	73.00	59.00	77.00	7	12.00	18.00	22.00	58.00	52.00	32.40
8	89.00	79.00	81.00	73.00	62.00	76.80	8	15.00	19.00	20.00	60.00	55.00	33.80
9	90.00	72.00	76.00	57.00	63.00	71.60	9	17.00	35.00	37.00	23.00	62.00	34.80
10	90.00	81.00	60.00	68.00	67.00	73.20	10	25.00	20.00	27.00	56.00	56.00	36.80
11	88.00	68.00	88.00	67.00	65.00	75.20	11	18.00	25.00	22.00	63.00	57.00	37.00
12	79.00	70.00	69.00	72.00	62.00	70.40	12	18.00	32.00	50.00	55.00	64.00	43.80
13	73.00	74.00	61.00	72.00	60.00	68.00	13	23.00	19.00	43.00	64.00	69.00	43.60
14	70.00	69.00	67.00	75.00	61.00	68.40	14	24.00	26.00	25.00	61.00	64.00	40.00
15	92.00	77.00	90.00	73.00	64.00	79.20	15	10.00	26.00	22.00	49.00	49.00	31.20
16	79.00	75.00	70.00	78.00	74.00	75.20	16	14.00	19.00	36.00	61.00	54.00	36.80
Mean	81.69	74.44	73.13	68.81	62.56	72.13	8.50	19.56	24.19	33.38	57.00	60.56	38.94
		LSD 0.05		LSD 0.01				LSD 0.05		LSD 0.01			
Genotypes (G)			3.03		3.98				3.73		4.91		
Salinity levels (T)			1.69		2.23				2.09		2.74		

G	K^+/Na^+ ratio					Mean	G	K^+/Na^+ ratio					Mean
	T1	T2	T3	T4	T5			T1	T2	T3	T4	T5	
1	3.42	3.14	2.70	1.15	0.98	2.28	9	5.29	2.06	2.05	2.48	1.02	2.58
2	3.09	2.61	1.74	1.23	0.95	1.92	10	3.60	4.05	2.22	1.21	1.20	2.46
3	3.36	3.50	2.70	1.04	0.75	2.27	11	4.89	2.72	4.00	1.06	1.14	2.76
4	4.42	3.04	1.92	0.83	0.83	2.21	12	4.39	2.19	1.38	1.31	0.97	2.05
5	4.24	3.00	0.95	0.99	1.17	2.07	13	3.17	3.89	1.42	1.13	0.87	2.10
6	2.72	2.69	2.21	1.37	1.08	2.01	14	2.92	2.65	2.68	1.23	0.95	2.09
7	7.08	4.89	3.64	1.26	1.13	3.60	15	9.20	2.96	4.09	1.49	1.31	3.81
8	5.93	4.16	4.05	1.22	1.13	3.30	16	5.64	3.95	1.94	1.28	1.37	2.84
							Mean	4.59	3.22	2.48	1.27	1.05	2.52
		LSD 0.05		LSD 0.01									
Genotypes (G)			0.38		0.50								
Salinity levels (T)			0.21		0.28								

T1, T2, T3, T4 and T5 denote; Tap water, 25 mM, 50 mM, 75 mM and 100 mM levels of salinity, respectively.

caused by the displacement of Mn and Zn from soil exchange sites by Na of the saline irrigation water (Ghallab and Usman, 2007).

Genotype groups under salinity stress treatments

The genotypes were divided into four groups based on their yield response to stress conditions according to Fernandez (1992). Data presented in Table 5 over the two seasons (2010/2011 and 2011/2012) wheat genotype Nos. 11, 7 and 15 gave the highest grain yield under both T_1, T_2, T_3, T_4 and T_5 conditions (group A), with an averages (32.65, 28.87 and 28.81) g respectively. On the other hand, under control treatment T_1 (group B) the genotype Nos. 11, 15, 8, 7, 16 and 9 gave the grain yield with an averages 44.16, 40.69, 39.15, 39.15, 38.44 and 38.44 g respectively. The genotype Nos. 11, 7, 15, 16 and 8 gave the highest grain yield under T_2, T_3, T_4 and T_5 (group C) with an averages 29.78, 26.30, 25.84, 25.69 and 25.53 g respectively. While genotype Nos. 6, 13, 12, 2 and 14 gave the lowest grain yield under both T_1, T_2, T_3, T_4 and T_5 conditions with an averages 15.66, 18.89, 21.75, 22.06 and 22.86 g respectively (group D). Thus, indirect selection for a salinity-prone environment based on the results of optimum condition will not be efficient. These results are in agreement with those of Bruckner and Frohberg (1987), Ceccarelli and Grando (1991) and Hamam (2007) they found that landraces of barley and wheat with low yield potential were more productive under stress condition.

Resistance indices of the genotypes

The genotype Nos. 2, 11, 16, 10, 15, 8 and 5 had a high YSI are expected to have high yield under both T_2 and T_1 conditions (Table 8). While under both T_3 and T_1 conditions the genotype Nos. 16, 10, 11 and 8 had a high YSI are expected to have high yield. The results showed genotype Nos. 16, 1, 7, 2, 9 and 11 had a high YSI are expected to have high yield under both T_4 and T_1 conditions. While under both T_5 and T_1 conditions

Table 7 Effect of salinity levels on soil properties after wheat cropping in all soil treatments.

Salinity levels (m M)	pH (1:1susp.)	ECe dS/m	Soluble cations (meq/L)				Soluble (meq/L)		Anions	Mn ppm	Zn ppm	Cu ppm
			Ca	Mg	Na	K	HCO_3	Cl	SO_4			
T1 (Control)	7.95	3.28	20	12	1.8	0.12	1.4	24	6.6	22.2	0.6	0.20
T2 (25 m M)	7.88	5.52	26	18	3.8	0.18	1.6	36	8.4	22.4	0.7	0.22
T3 (50 m M)	7.81	5.58	26	18	6.2	0.22	2.8	42	7.8	23.2	0.8	0.28
T4 (75 m M)	7.80	5.86	28	20	9.5	0.34	4.6	46	8.2	25.6	0.8	0.34
T5 (100 m M)	7.80	6.22	28	20	15.0	0.50	5.2	52	7.2	25.6	0.9	0.36
Mean	7.85	5.29	25.6	17.6	7.26	0.27	3.12	40	7.64	23.80	0.76	0.28

Table 8 Tolerance indices of the sixteen bread wheat genotypes under stress treatment over two years.

G	SSI	MP	TOL	STI	GMP	YSI	YI	SSI	MP	TOL	STI	GMP	YSI	YI
	Salinity stress treatment (T_2)							Salinity stress treatment (T_3)						
1	1.02	33.68	5.42	0.05	33.58	0.85	1.01	1.08	30.57	11.65	0.05	30.01	0.68	0.98
2	0.51	29.14	2.25	0.05	29.11	0.93	0.92	0.96	25.97	8.59	0.04	25.61	0.72	0.86
3	1.01	35.53	5.62	0.06	35.41	0.85	1.07	0.96	32.87	10.94	0.05	32.41	0.71	1.09
4	1.14	30.00	5.42	0.05	29.88	0.83	0.89	0.96	28.06	9.30	0.04	27.67	0.72	0.93
5	0.99	35.37	5.52	0.06	35.26	0.86	1.07	1.07	32.10	12.06	0.05	31.53	0.68	1.04
6	1.08	22.24	3.78	0.03	22.15	0.84	0.67	1.47	18.86	10.53	0.03	18.11	0.56	0.54
7	1.08	36.09	6.13	0.06	35.96	0.84	1.08	0.94	33.68	10.94	0.05	33.24	0.72	1.12
8	0.97	36.39	5.52	0.06	36.29	0.86	1.10	0.92	33.84	10.63	0.05	33.42	0.73	1.13
9	1.20	35.07	6.75	0.05	34.90	0.82	1.04	1.04	32.51	11.86	0.05	31.96	0.69	1.06
10	0.92	34.25	4.91	0.05	34.16	0.87	1.04	0.87	32.00	9.41	0.05	31.65	0.74	1.08
11	0.68	41.97	4.40	0.07	41.91	0.90	1.30	0.89	38.34	11.65	0.06	37.89	0.74	1.29
12	1.40	28.37	6.44	0.04	28.19	0.80	0.82	1.14	26.27	10.63	0.04	25.73	0.66	0.83
13	1.29	24.74	5.11	0.04	24.61	0.81	0.73	1.08	22.95	8.69	0.04	22.54	0.68	0.74
14	1.09	33.33	5.72	0.05	33.20	0.84	1.00	1.13	30.16	12.06	0.05	29.55	0.67	0.96
15	0.95	37.88	5.62	0.06	37.77	0.86	1.15	0.95	34.96	11.45	0.05	34.49	0.72	1.16
16	0.84	36.09	4.70	0.06	36.01	0.88	1.11	0.77	34.04	8.79	0.05	33.76	0.77	1.18
Mean	1.01	33.13	5.21	0.05	33.02	0.85	1.00	1.01	30.45	10.57	0.05	29.97	0.70	1.00
	SSI	MP	TOL	STI	GMP	YSI	YI	SSI	MP	TOL	STI	GMP	YSI	YI
	Salinity stress treatment (T_4)							Salinity stress treatment (T_5)						
1	0.85	29.80	13.19	0.05	29.06	0.64	1.14	0.72	29.14	14.52	0.05	28.22	0.60	1.38
2	0.92	24.28	11.96	0.04	23.53	0.60	0.90	1.08	21.16	18.20	0.03	19.11	0.40	0.76
3	0.97	30.36	15.95	0.05	29.30	0.58	1.10	1.04	27.24	22.18	0.04	24.88	0.42	1.02
4	1.14	24.74	15.95	0.04	23.42	0.51	0.82	1.02	23.41	18.61	0.04	21.48	0.43	0.89
5	1.15	28.78	18.71	0.05	27.22	0.51	0.95	1.03	27.19	21.88	0.04	24.90	0.43	1.03
6	1.19	17.99	12.27	0.03	16.91	0.49	0.58	1.17	16.25	15.74	0.03	14.22	0.35	0.53
7	0.91	31.54	15.23	0.05	30.60	0.61	1.17	0.88	29.60	19.12	0.05	28.01	0.51	1.27
8	1.01	30.67	16.97	0.05	29.47	0.57	1.09	0.98	28.47	21.37	0.04	26.39	0.45	1.13
9	0.93	30.77	15.33	0.05	29.80	0.60	1.13	0.94	28.37	20.14	0.04	26.52	0.48	1.16
10	0.99	28.93	15.54	0.05	27.87	0.58	1.04	0.89	27.60	18.20	0.04	26.06	0.50	1.17
11	0.94	35.27	17.79	0.06	34.13	0.60	1.29	0.96	32.30	23.72	0.05	30.05	0.46	1.29
12	1.07	24.33	14.52	0.04	23.22	0.54	0.84	1.00	22.80	17.58	0.04	21.03	0.44	0.89
13	1.08	21.01	12.57	0.03	20.05	0.54	0.72	1.03	19.47	15.64	0.03	17.84	0.43	0.74
14	1.12	27.55	17.28	0.04	26.16	0.52	0.93	1.17	24.33	23.72	0.04	21.25	0.34	0.79
15	1.04	31.59	18.20	0.05	30.25	0.55	1.10	1.06	28.62	24.13	0.04	25.96	0.41	1.05
16	0.81	31.79	13.29	0.05	31.09	0.65	1.23	1.13	26.32	24.23	0.04	23.37	0.37	0.90
Mean	1.01	28.09	15.30	0.04	27.01	0.57	1.00	1.01	25.77	19.93	0.04	23.71	0.44	1.00

Genotypes = G.
SSI, MP, TOL, STI, MP, YSI, and YI denote; stress susceptibility index, mean productivity, tolerance, stress tolerance index, geometric mean productivity, yield stability index and yield index, respectively.

the genotype Nos. 1, 7, 10, 9 and 11 had a high YSI are expected to have high yield. In the present study, however, genotypes with the highest YSI exhibited the high yield under both T_1, T_2, T_3, T_4 and T_5 conditions (Table 8). YSI, as Bouslama and Schapaugh (1984) reported that evaluate the yield under stress of a genotype relative to its non-stress yield, and should be an indicator of resistant genetic materials. Bansal and Sinha (1991) used this method to assess the stability of wheat accessions over variable environments. Resistance indices were calculated on the – basis of yield of genotypes

Table 9 Percent reduction of study traits under (T2) 25, (T3) 50, (T4) 75 and (T5) 100 mM NaCl treatments as compared with the control treatment over two years.

Traits	T2	T3	T4	T5
Tillers number/plant	20.24	28.43	33.72	40.49
Leaves number/plant	11.80	23.26	32.99	40.87
Leaves number/plant	8.44	18.16	26.49	33.92
Total biomass/one row	16.20	31.92	48.12	66.52
Days to heading	12.25	21.39	29.27	37.78
Number of kernels/spike	10.31	18.42	32.39	45.57
1000-kernel weight (g)	12.68	23.26	34.39	44.64
Grain yield (g)	14.71	30.02	43.12	56.08

over the two years. As shown in Table 8, the results suggested that selection based on TOL will result in reduced yield under T_1 conditions. The greater TOL value were reduction the yield in genotype Nos. 9, 12, 7, 14, 15 and 3 under T_2 condition and the higher sensitivity to salinity. While high yield reduction in genotype Nos. 5, 14, 9, 11 and 1 under T_3. The results showed greater TOL value, reduction the yield in genotype Nos. 5, 15, 11, 14 and 8 under T_4 condition and the higher sensitivity to salinity. While high yield reduction in genotype Nos. 16, 15, 11, 14 and 3 under T_5. Similar results were reported by Sio-Se Mardeh et al. (2006) and Hamam (2007). Rizza et al. (2004) however showed that a selection based on minimum yield decrease under stress with respect to favorable conditions (TOL) failed to identify the best genotypes. Yields under control were more than yields under stress in the present study. Since MP is a mean production under both stress and non-stress conditions (Table 8). For this reason, MP was not able to differentiate genotypes belonging to group (A) genotype Nos. 11, 7 and 15. As described by Hohls (2001) selection for MP should increase yield in both stress and non-stress conditions. Genotype Nos. 11, 7, 15 and 8 under bothT_1, T_2, T_3, T4 and T_5, for example, with relatively low yields under stress conditions, exhibited high MP values. The MP can be related to yield under stress only when stress is not too high stress and the difference between yield under stress and non-stress conditions is not too much. Hossain et al. (1990) used MP as a resistance criterion for wheat genotypes in moderate stress conditions. In this study, some genotypes with a high MP would belong to group A in these situations.

In the present study, the mean SSI over two years appeared to be a suitable selection index to distinguish resistant genotypes The genotype Nos. 2, 11, 16, 10 and 15 were high yield under T_2 produced nearly yield to T_1 conditions and showed the lowest SSI, while high yield under T_3 produced a nearly yield to T_1 conditions and showed the lowest SSI in genotype Nos. 16, 10, 11, 8, 7 and 15. The genotype Nos. 16, 1, 7, 2, 9 and 11 with a lower SSI were identified as resistant genotypes under T_4 produced a nearly yield to T_1 conditions, whereas the genotype Nos. 1, 7, 10, 9, 11 and 8, with the lowest SSI were identified as resistant genotypes under T_5 produced a nearly yield to T_1 conditions (Table 8). Winter et al. (1988) also reported that tall wheat cultivars had a lower SSI. Suggesting that SSI was adversely these traits can contribute to increased yield under stress and reduce stress susceptibility (Fernandez, 1992). SSI has been widely used by researchers to identify sensitive and resistant genotypes (Clarke et al., 1992). In addition, Table 8 showed that STI, GMP and MP were able to identify genotypes producing high yield in both conditions. The MP, GMP, STI and SSI are suggested as useful indicators for wheat breeding. However under less salinity stress condition, we concluded that GMP and STI are able to discriminate group A. YI, proposed by Gavuzzi et al. (1997), this index ranks genotypes only on the basis of their yield under stress (Table 8) and so discriminate genotypes of group B.

Conclusion

The results of this study suggest that wheat genotypes Shakha 93, HAAMA-14 and Shakha 8 can be selected to grow under salinity levels of irrigation water. The genotypes Sides 1, Giza 168, Sahel 1, Shakha 69, line 1009, line 103 and Sides 12 were more moderated to salinity at early growth stages and more tolerant at the later stages, their salt tolerance can be improved by developing strategies for agronomic management according to the different growth stages, indicating that the degree of salt tolerance of wheat genotypes to salinity must be evaluated according to different growth stages and may be useful for further cross breeding programmer. Overall, it can be concluded that substantial variation in salt tolerance among wheat genotypes at the vegetative stage was found in this study. Grain yield related to other parameters confirmed that it is important to use the parameters as useful selection criteria for screening the salt tolerance in terms of grain yield among genotypes at early vegetative growth stage. Most importantly, the parameters can be considered for screening wheat genotypes at different salinity concentrations.

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