EVALUATION OF NINE EGYPTIAN BREAD WHEAT CULTIVARS FOR SALT TOLERANCE AT SEEDLING AND ADULT-PLANT STAGES

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ABSTRACT

The present study was conducted at the Experimental Farm and the Laboratories of Wheat Research Department and Soil Physical and Chemical Research Department of Sakha Agricultural Research Station, Agricultural Research Center, Kafrelsheikh, Egypt, in 2014/2015 season. The objectives of this investigation were to study salinity effect on different nine bread wheat cultivars, to identify salt tolerance in several growth stages, and to identify salt tolerance screening criteria by studying the relationship between wheat yield under salt affected soil and several growth stages characters. Three experiments were conducted in 2014/2015, i.e., seedling test in the lab (open area), adult plant evaluation in pots in open area and field experiment in normal soil and salt affected soil. Salinization in seedling and pots experiments was established using five levels of Mediterranean Sea water to tap water mixtur (0, 26, 29, 31,33and 35% sea water) which established EC 0.48, 13.5, 15.0, 16.0, 17.0 and 18.0 dSm^{-1}, respectively. The nine cultivars Misr 1, Misr 2, Giza 139, Giza 144, Gemmeiza 9, Gemmeiza 3, Hindi 62, Sids1 and Sids 12 were used. Results indicated that increasing salt concentrations caused significant decrease in shoot dry weight, shoot length, root dry weight, root length and emergence index at seedling stage; plant height, biological yield, grain yield, straw yield, number of kernels per spike and kernel weight at adult plant stage; however, shoot root dry weight ratio at seedling stage was increased. The variances due to salt treatments had the major portion of total variance, indicated the large effect of salt stress on growth characters compared to genotypes and genotypes × salt concentration interaction's variances. The treatment 33% sea water mix ($17dSm^{-1}$) seems to be suitable for screening the studied cultivars for salt tolerance. The large variance among the nine cultivars for shoot length, emergence index and shoot-root dry weight ratio under salt stress indicated the importance of these characters in studying the effect of salt stress at seedling stage. Strong and positive correlations were found between biological yield (under salt affected soil) and each of emergence index and shoot length at seedling stage; number of spike per pots, biological and straw yields per pot at adult-plant stage. Based on stress tolerance index, out of the nine studied cultivars, Misr 2 can be classified as salt tolerant cultivar and Gemmeiza 3 and Sids 12 as salt sensitive cultivars.

Kewords: Bread wheat, Salinity stress, seedling and adult-plant salt tolerance.

INTRODUCTION

Wheat is moderately tolerant to salt with threshold without yield loss at 6 dSm^{-1} and with yield 50% loss at 13 dSm^{-1} (Mass and Hoffiman, 1977). Approximately 7% of the world's total land area is affected by salinity (Flowers *et al.*, 1997). The saline area increases by 10% per year all over the world (Ponnamieruma, 1984). Salinity is a major constraint to food production because it limits crop yield and restricts use of land previously uncultivated. In Egypt, 33% of cultivated area suffer severe salinity problems (Ghassemi *et al.*, 1995). The Egyptian Government has spent large sums on reclamation, mainly on drainage projects (more than US$ 30 million annually) to solve salinity problems in irrigated area, but the annual average net income from crops grown with drainage system is more limited than for those grown without drainage system (Amer *et al.*, 1989). Therefore, genetic improvement for salt tolerance particularly in major crops has become an urgent task in dealing with salinity problems in the Egyptian agriculture sector, because this approach is less expensive for poor farmers than others. Regardless of the fact that irrigation waters and agricultural soil solutions are comprised of multiple combinations of cations and anions, the shortcomings of salinity experiments use NaCl as the sole salinizing salt reported by Lazof and Bernstein (1999). So, many researchers used levels of diluted sea water as salinized treatments (Abdelsalam, 2012, Aldesuquy *et al.*, 2012 and Almaghrabi, 2012). Breeding for salt tolerance is a difficult and slow progress due to a combination of many factors: changes in salt tolerance with different growth stages; the large number of physiological parameters that contribute to salt tolerance; lack of effective evaluation methods for salt tolerance among genotypes; low selection efficiency using multiple parameters; the complex interactions of salinity and environment on salt tolerance of plants. Therefore, wheat breeder could use simple, quick and non-destructive screening methods to develop salt tolerant wheat genotypes (El-Hendawy 2004). The objectives of this investigate are to 1) Estimate the salinity effect on nine bread wheat cultivars at several growth stages, 2) Identify salt tolerance cultivars at several growth stages, and 3) Identify salt tolerance screening criteria by studying the relationship among yield of salt affected soil and several growth stages characters.

MATERIALS AND METHODS.

The present study was conducted in the Experimental Farm and the Laboratories of Wheat Research Department and Soil Research Department of Sakha Agricultural Research Station, Agricultural Research Center, Kafrelsheikh, Egypt, in 2014/2015 season. This study includes nine Egyptian bread wheat cultivars (Table 1).

Table 1: Name, pedigree, selection history origin and year of release of the studied Egyptian bread wheat cultivars.

Name	Pedigree	Selection history	Origin	Year of release
HINDI 62	Selected local cultivar.	-	Egypt	1921
GIZA 139	HINDI-90/KENYA-256G.	-	Egypt	1947
GIZA 144	REGENT/2*GIZA-139.	-	Egypt	1958
SIDS 1	HD2172/PAVON"S"//1158.57/MAYA74"S".	SD46-4SD-2SD-1SD-0SD.	Egypt	1996
GEMMEIZA 3	BB/7C*2//Y50/KAL*3//SAKHA-8/4/PRV/WW15/3/BG"S"//ON.	GM4024-1GM-13GM-2GM-0GN.	Egypt	1997
GEMMEIZA 9	ALD"S"/HUAC"S"//CMH74A.630/SX.	GM4583-5GM-1GM-0GM.	Egypt	1999
SIDS 12	BUC//7C/ALD/5/MAYA74/ON//1160-147/3/BB/GLL/4/ CHAT "S" /6/MAYA/VUL//CMH74A.630/4*SX.	SD7096-4SD-1SD-1SD-0SD.	Egypt	2007
MISR 1	OASIS/SKAUZ//4*BCN/3/2*PASTOR.	CMSSOOYO1881T -050M-030Y-030M-030WGY-33M-0Y-0S.	CIMMYT	2011
MISR 2	SKAUZ/BAV92.	CMSS96M03611S-1M-010SY-010M-010SY-8M-0Y-0S.	CIMMYT	2011

Three experiments were established, the first one was established in the laboratory (open area) in order to study the effect of salinity on seedling emergence and seedling characters. In the fourth of March 2014, the seeds of the studied cultivars (12 seeds / cup and 1.5 cm sown depth) were grown in the 6.5 x 13 cm plastic cups, with three drain pores, filled with 600 g of tap water washed sand. Salt stress treatments were induced using diluted sea water. In this respect, six salt concentrations were used (Table 2). The experiment was irrigated every three days with abundant amount of solutions (100 ml per cup) to avoid salt accumulation. The salt stress was applied from the first day of the experiment. All treatments, nine cultivars and six salt concentrations, were arranged in factorial experiment in completely randomized design with three replicates. Seeds were considered emerged when the tip of coleoptile appears on the sand surface. The emerged seedling was counted daily after four days from sowing.

Table 2: Salt treatments, tap and sea water mixture rates, electrical conductivity (EC), anions and cations concentrations.

Salt treatments	Mix rates		Sea water mix percent	EC (dSm^{-1})	Anions (mg/L)				Cation (mg/L)			
	tap water (ml)	sea water (ml)			CO_3^-	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
control	1000	0	0	0.48	-	3.54	0.94	0.32	1.48	1.38	1.72	0.22
1	740	260	26	13.50	-	3.40	131.24	0.82	12.80	38.18	81.41	3.06
2	710	290	29	15.00	-	3.38	146.27	0.87	14.10	42.43	90.61	3.38
3	690	310	31	16.00	-	3.37	156.29	0.91	14.97	45.26	96.74	3.61
4	670	330	33	17.00	-	3.36	166.32	0.94	15.84	48.08	102.87	3.84
5	650	350	35	18.00	-	3.35	176.34	0.99	16.71	50.09	109.00	4.04
Sea water				50.70	-	3.00	502.08	2.22	45.00	142.92	308.23	11.15

Speed of seedling emergence was estimated by the formula described in the Association of Official Seed Analysis (AOSA, 2004) with some modification, Emergence index = [(No of emerged seed / Days of first account) + …+ (No of emerged seed / Days of final account)]. Measurements at the seedling stage were conducted at 21 days after sowing. Ten plants from each cup were harvested and the distance from crown to the highest leaf tip was measured as shoot length. The roots were carefully extracted from the sand by mild washing with tap water. The roots were placed above blotter paper for 10 minutes and the distance from crown to the end of longest root was measured as root length. The samples of shoots and roots were dried at 70 ºC for 48 h to determine the dry weight of shoots and roots and its ratio.

The second experiment (pots) was carried out in order to study the effect of salinity stress on adult plant stage. In the 18^{th} November 2014, the seeds of the studied cultivars (10 seeds / bag and 1.5 cm sown depth) were grown in the 30 x 40 cm black plastic bag, with drain pores, filled with 16 kg of sand washed with tap water. After two weeks (completely germination) only six seedlings were left in each pot. The experiment was irrigated (one litter per pot) twice a week and fertilized until heading date using the NPK, 20:10:20 multinutrient fertilizer (0.5 g / pot / week) added to irrigation solution. Chelating microelements FULV- E contain 5% N, 4% K_2O, 4% Fe, 1.2 % Mn, and 0.6% Zn, 0.2% Cu, 5% Mg, 02% B, 6% citric acid and 8% Fulvic acid (3 cm / L) were sprayed every week. The experiment was protected using the fungicide CABRIO^{TM} TOP 60%WG (1g/ L). Two salt stress treatments (control and 17.0 dSm^{-1}, Table 2) were applied 35 days after sowing until physiological maturity. All treatments, nine cultivars and two salt concentrations, were arranged in factorial experiment conducted in completely randomized design with two replications. The studied characters in the second experiment (pots) were plant height (cm), biological yield (g), grain yield (g), straw yield (g), number of spikes per pot, number of kernels per spike, one hundred kernel weight(g).

The third experiment was conducted in order to study the effect of salinity stress under field condition and to study the relationship among yield under salt affected soil and seedling and adult plant stage characters (normal soil, seedling and pots). This experiment was applied in two environments at the Experimental Farm of Sakha Agricultural Research Station; normal soil at 2ndNattaf farm part 8 and salt affected soil at El-Hamrawy farm part 18 (Table 3).

Table 3: Soil analysis for normal soil (2ndNattaf farm part 8) and salt affected soil (Elhamrawy farm part 18).

Location	Sample depth	Soil structure	EC (dSm^{-1})	Anions (mg/L)				Cations (mg/L)			
				Co_3^{--}	Hco_3^{--}	CL^-	So_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
2ndNattaf farm	0 - 30	clayey	2.02	-	3	8.16	9.12	5.63	3.92	10.48	0.25
part 8	30 - 60	clayey	1.46	-	2.5	4.8	7.18	3.25	2.35	8.57	0.31
Elhamrawy	0 - 30	clayey	8.7	-	4	36.48	47.41	25	17.2	45.22	0.47
farm part 18	30 - 60	clayey	6.49	-	3	28.8	43.17	12.5	10.6	41.52	0.35

The nine cultivars were arranged in a randomize complete block design experiment with three replications. Plot area was $2.7m^2$ (6 rows × 3m long × 0.15m apart). All recommended cultural practices (irrigation, fertilization, weed control, fungicides) were applied at the proper time. The studied characters were plant height (cm), biological yield (kg), grain yield (kg), straw yield (kg), number of spikes per square meter, number of kernels per spike and one thousand kernel weight (g). Salinity tolerance were estimates using the formula described by Fernandez (1992): Stress tolerance index (STI) = [$\frac{(Yp)(Ys)}{\bar{y}(p)^2}$] where: YP Yp is the potential yield of a given genotype in non-stress environment, *Ys* = the potential yield of a given genotype in stress environment and $\bar{Yp}$ = mean yield in non-stress environment. The high STI value, the high stress tolerance genotype. The statistical analysis procedure was according to the regular analysis of variance of completely randomized design (CRD) and complete block design (RCBD). The differences between means were measured using least significant differences (LSD) test at 0.05 probability level. Simple correlation was used to calculate the relationship among yield under salt affected soil and seedling and adult plant stage (normal soil, seedling and pots experiment) characters. In this respect, the statistical computer program Gen-Stat 14th edition was used.

RESULTS AND DISCUSSION

Seedling experiment

The analysis of variance of the studied characters at seedling stage showed highly significant differences among the nine bread wheat studied cultivars, the six salinity concentrations and their interaction for all studied characters (Table 4). The variance due to salinity concentrations had the main portion of the total variance compared with cultivars and cultivars × salinity concentrations interaction variance. These results are in agreement with those obtained by El-Hendawey (2011) and Hussain *et al.*, (2015). Coefficient of variation estimates ranged from 12.3% for shoot- root dry weight ratio to 18.2% for shoot dry weight (Table 4).

Table 4: Mean squares and coefficients of variation (CV %) for the studied characters at seedling stage.

Source of variation	d.f.	Root dry weight		Shoot dry weight		Shoot root dry weight ratio		Root length		Shoot length		Emergence index	
Cultivars	8	0.009	**	0.003	**	10.262	**	22.9	**	11.1	**	19.1	**
Salinity concentrations	5	0.963	**	0.442	**	6.760	**	2474.4	**	164.6	**	777.6	**
Cultivars × Salinity concentrations	40	0.005	**	0.002	**	2.058	**	5.7	**	2.1	**	1.8	**
CV%		17.6		18.2		12.3		15.5		12.5		15.8	

**** Significant at 0.01 level of probability.**

The effect of salinity concentrations on all studied characters at seedling stage are illustrated in Figure 1a and b. Increasing salt concentration led to significant decrease mean values of shoot length, root length, shoot dry weight, root dry weight and emergence index. In contrary, increasing salt concentration led to increase of shoot-root dry weight ratio. This may be due to antagonism between cations, anions of salts and cations, anions of the nutrients i.e., Cl^- and NO_3^-, Na^+ and K^+, in addition to specific effects of some cations like Na^+. Almaghrabi (2012) reported that increasing salt concentration from 0.0 to 8704 ppm caused significant decreases in shoot and root length and increased shoot-root ratio. No significant differences were found between the two salt treatments 26 and 29% for all studied characters and between the two salt treatments 33 and 35% for all studied characters, except shoot length (LSD = 0.351) and emergence index (LSD, 0.545) (Figure 1b). These results showed that the salinity level of the sea water mix percent 33% (17.0 dSm^{-1}) is suitable for screening bread wheat genotypes for salinity at adult plant stage. This may be due to EC above 13 dSm^{-1} affects the tolerant cultivar which helps in for screening wheat genotypes. These results are in agreement with Sharma (2015) who reported that seedling growth response to salinity ranged from stimulation in some cultivars at lower salinity levels (4 to 8 EC) to severe suppression in most cultivars at higher levels (12-16 EC) and the 12 EC considered as critical salt concentration.

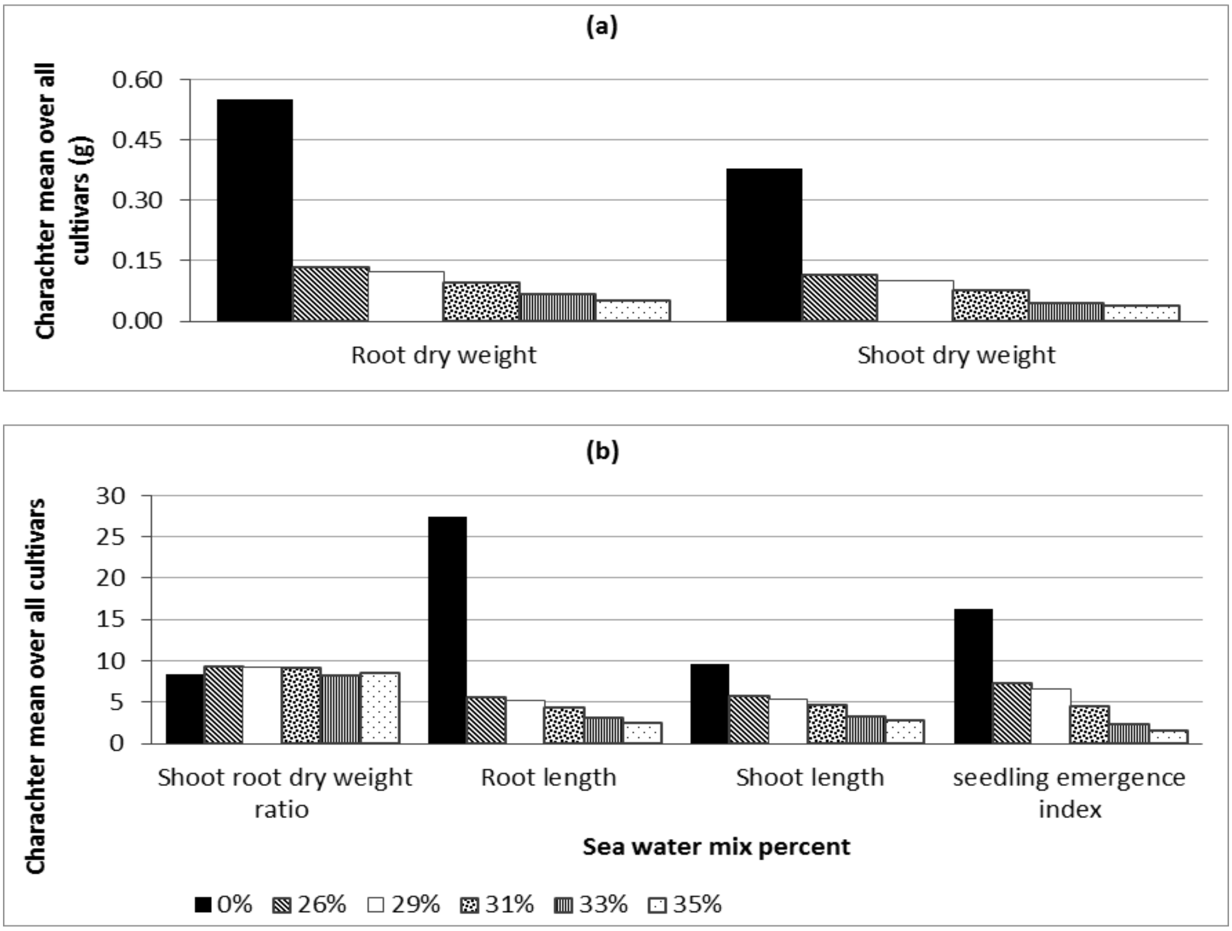

Fig 1a and b: Sea water mix percent effects on root dry weight and shoot dry weight (a) and shoot root dry weight ratio, root length, shoot length and seedling emergence index (b) at seedling stage.

The effect of cultivars on all studied characters at seedling stage are illustrated in Figure 2a and b. The three bread wheat cultivars Sids 12, Gemmeiza 3 and Gemmeiza 9 recorded high root dry weight mean values, while the bread wheat cultivars Sids 1 and Hindi 62 recorded low mean values (LSD, 0.02). The highest shoot dry weight mean values were recorded for Giza 139 and Misr 2, while, the lowest value recorded for the bread wheat cultivars Misr1 (LSD, 0.015). For shoot-root dry weight ratio, the bread wheat cultivars Hindi 62, Misr 2 and Giza 139 had the highest values, but the bread wheat cultivars Sids 12 and Gemmeiza 3 had the lowest values (LSD, 0.709). The bread wheat cultivars Giza 139, Hindi 62, Giza 144 and Misr 2 recorded high mean values for shoot length, while, Misr1 had lowest value (LSD, 0.430). The bread wheat cultivars Misr 2 and Giza 139 had high values of emergence index, while Sids 12 and Gemmeiza 3 had low values (LSD, 0.668).

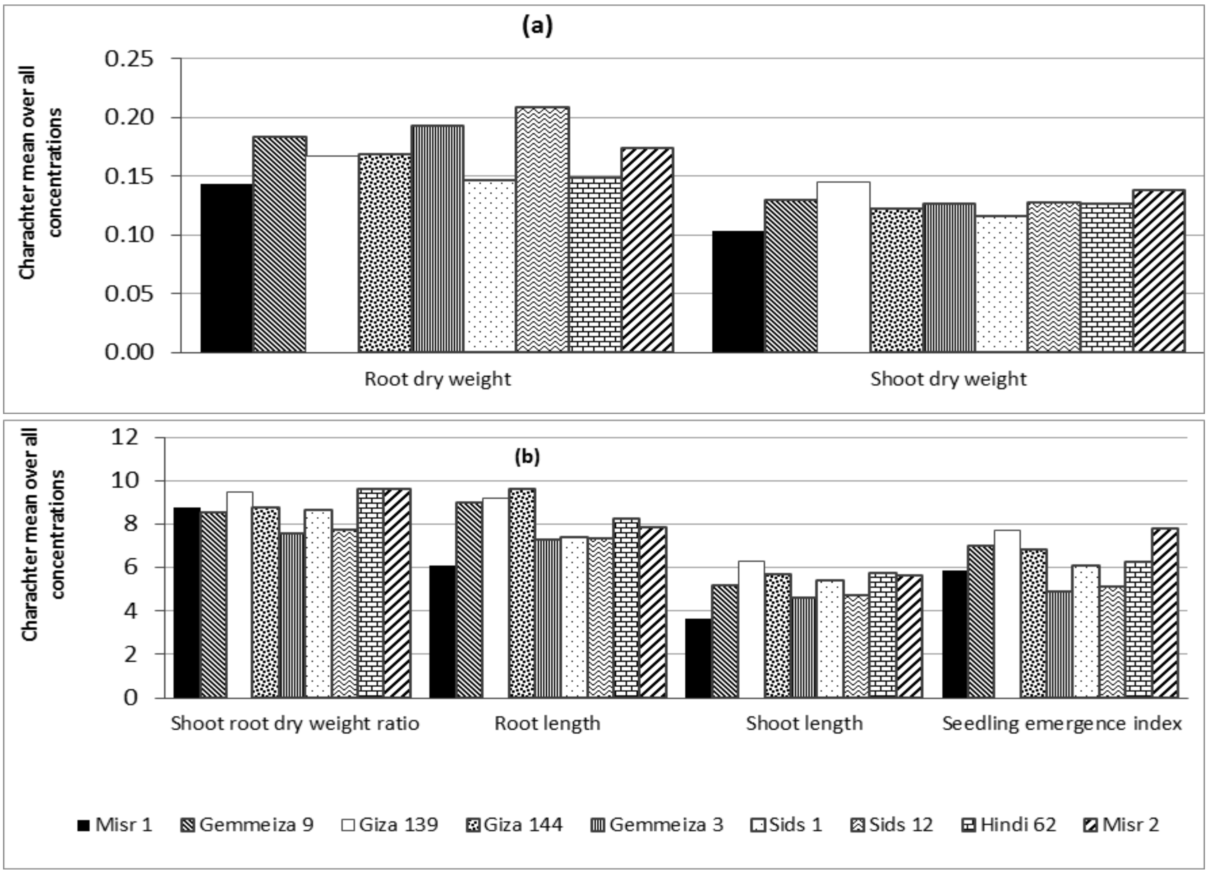

Fig. 2 (a and b): Cultivars effects on root dry weight and shoot dry weight (a) and shoot root dry weight ratio, root length, shoot length and seedling emergence index(b) at seedling stage.

The interaction between salt treatments and cultivars for shoot dry weight, root dry weight and shoot-root dry weight ratio are illustrated in Figure 3.

The nine studied cultivars differed in their response to salinity concentrations. For shoot dry weight, Figure 3 a, high mean values recorded for the bread wheat cultivars Gemmeiza 3 and Sids 12 under control; Giza 139 under 26 and 29% treatments; Misr 2 and Giza 139 under the remain treatments, while constant response (low values) over all salt treatments recorded for the cultivar Misr1 (LSD, 0.048). For root dry weight Figure 3b, high mean values obtained for the cultivar Sids 12 under control; Gemmeiza 9 and Gemmeiza 3 under 26% treatment; Gemmeiza 9, Giza 139, Giza 144 and Gemmeiza 3 under 29% treatment; Gemmeiza 9, Gemmeiza 3, Sids 12 and Misr 2 under 33% treatment; Gemmeiza 3 and Misr 2 under 33% treatment; Misr 1, Gemmeiza 9 and Misr 2 under 35% treatment. Meanwhile, low root dry weight mean values recorded for Misr 1 under control, 26, 29 and 31% treatments; Hindi 62 under 33% treatment; Gemmeiza 3 and Sids 1 under 35% (LSD, 0.037). Regarding shoot-root dry weight ratio, low mean values recorded for the cultivars Gemmeiza 3 under 26, 29, 31 and 33% treatments; Sids1 and Sids 12 under 35% treatment. While Giza 139, Hindi 62 and Misr 2 had high mean values for all salt treatments (LSD, 1.735).

The interaction between salt treatments and cultivars for root length, shoot length and emergence index are illustrated in Figure 4(a, b and c). For root length Figure 4a, the bread wheat cultivar Giza 144 had high mean value under control; Gemmeiza 9 and Giza 139 under 26 and 31% treatment; Gemmeiza 9, Giza 139 and Giza 144 under 29% treatment; Giza 139 under 33% treatment; Gemmeiza 9 under 35% treatment. But low root length mean values recorded for the cultivar Misr 1 under all treatments (LSD, 2.006). Regarding shoot length the bread wheat cultivars Gemmeiza 3, Sids 1, Hindi 62 and Misr 2 recorded high values under control; Giza 139, Sids 1 and Hindi 62 under 26% treatment; Giza 139, Giza 144 and Hindi 62 under 29% treatment; Giza 139 and Giza 144 under 31% treatment; Giza 139 under 33% treatment; Misr 2 under 35% treatment. But low shoot length mean values recorded for the cultivar Misr 1 under all treatments (LSD 1.053). For emergence index, no significant differences were recorded among all studied cultivars under control. High mean values recorded for the cultivars Gemmeiza 9, Giza 139, Hindi 62, and Misr 2 under 26% treatment; Giza 139, Giza 144 and Misr 2 under 29% treatment; Gemmeiza 9, Giza 139, Sids 1 and Misr 2 under 31% treatment; Gemmeiza 9, Giza 139 , Giza 144 and Misr 2 under 33% treatment; Misr2 and Hindi 62 under 35% treatment. While low emergence index mean values recorded for the cultivar Misr 1 under all salt treatments (LSD 1.636). Generally, among the studied characters shoot length, shoot root dry weight ratio and emergence index had wide variability under salt stress and it may be used for detection salt tolerant genotype. Sharma (2015) reported that shoot growth often suppressed more than root growth under 12 dSm^{-1} salt concentration.

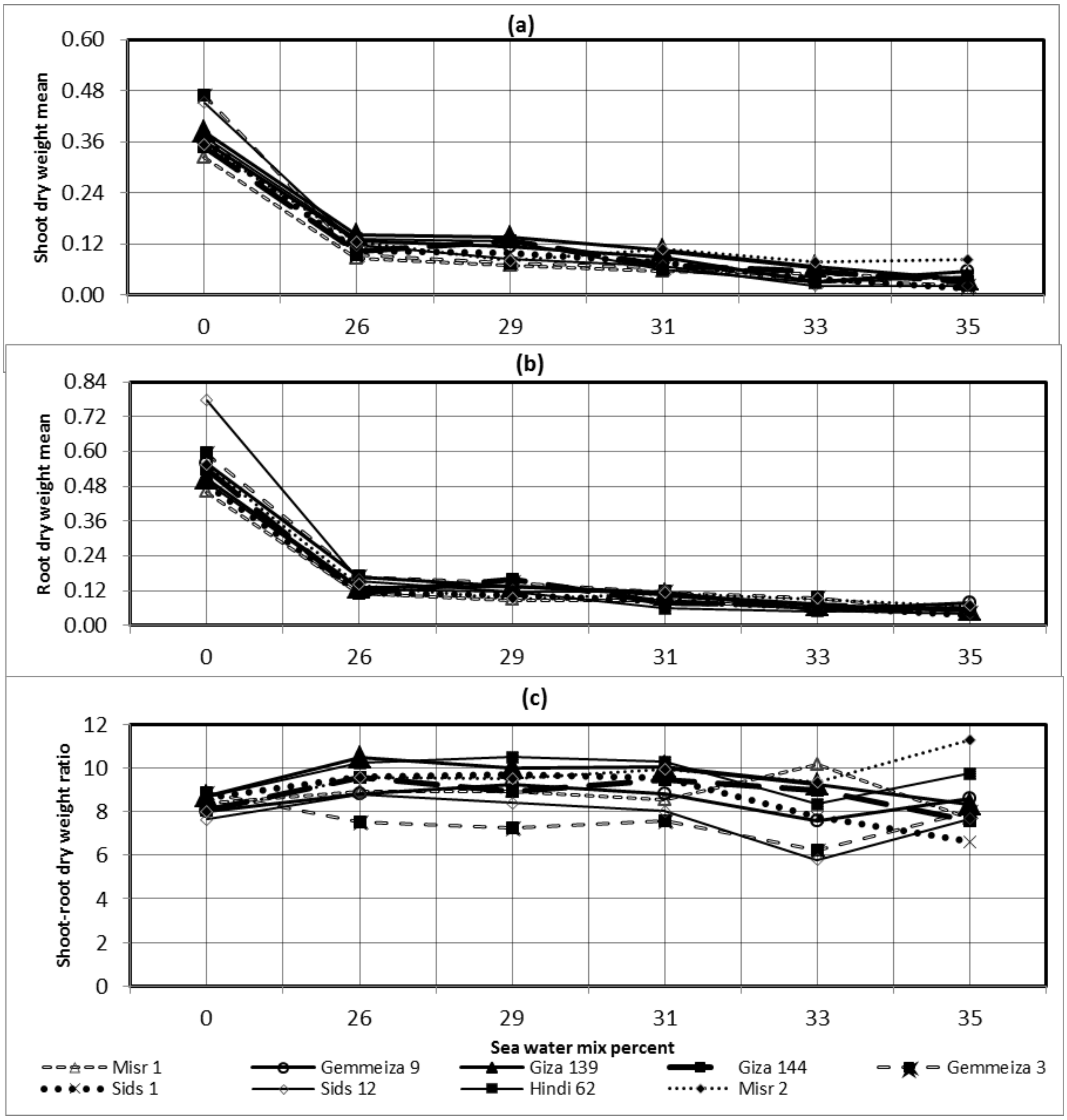

Fig. 3 a, b, and c : Interaction between the studied bread wheat cultivars and sea water mix percent for shoot dry weight (a), root dry weight (b) and shoot root dry weight ratio (c).

Pots experiment

Regarding pots experiment, highly significant differences were found among the nine studied bread wheat cultivars for the studied characters (Table 5).The mean square of salt treatments was highly significant for all studied characters, except number of spikes per pot. While significant and / or highly significant differences were found for cultivars × salt treatments interaction mean square for all studied characters, except grain yield and number of kernels per spike (Table 5). The salt treatments variance had the main portion of the total variance compared with cultivars and cultivars × salt treatments interaction for all studied characters except number of spikes per pot. Coefficients of variation estimates ranged from 4.3% for plant height to 11.0% for number of kernels per spike (Table 5).

The effect of salt treatment on the studied characters of the pot experiments are illustrated in Table 6. Salt treatments led to significant decrease in plant height, grain yield, biological yield, straw yield, number of kernels per spike and one hundred kernels weight. While, number of spikes per pot was not affected by salt treatments. This may be due to salinity effect on the plant by one or more of decreasing water availability, nutrients imbalance and specific ion effect. These results agree with those obtained by Kumar *et al.* (2012) who reported that increasing salinity levels causes significantly decreases in grain yield, biological yield and one thousand kernels weight. Asli and Zanjan (2014) reported insignificant interaction for number of kernels per spike with salinity levels. Nasab *et al.* (2014) found insignificant interaction for number of spikes per square meter, one thousand kernels weight and grain yield with salinity.

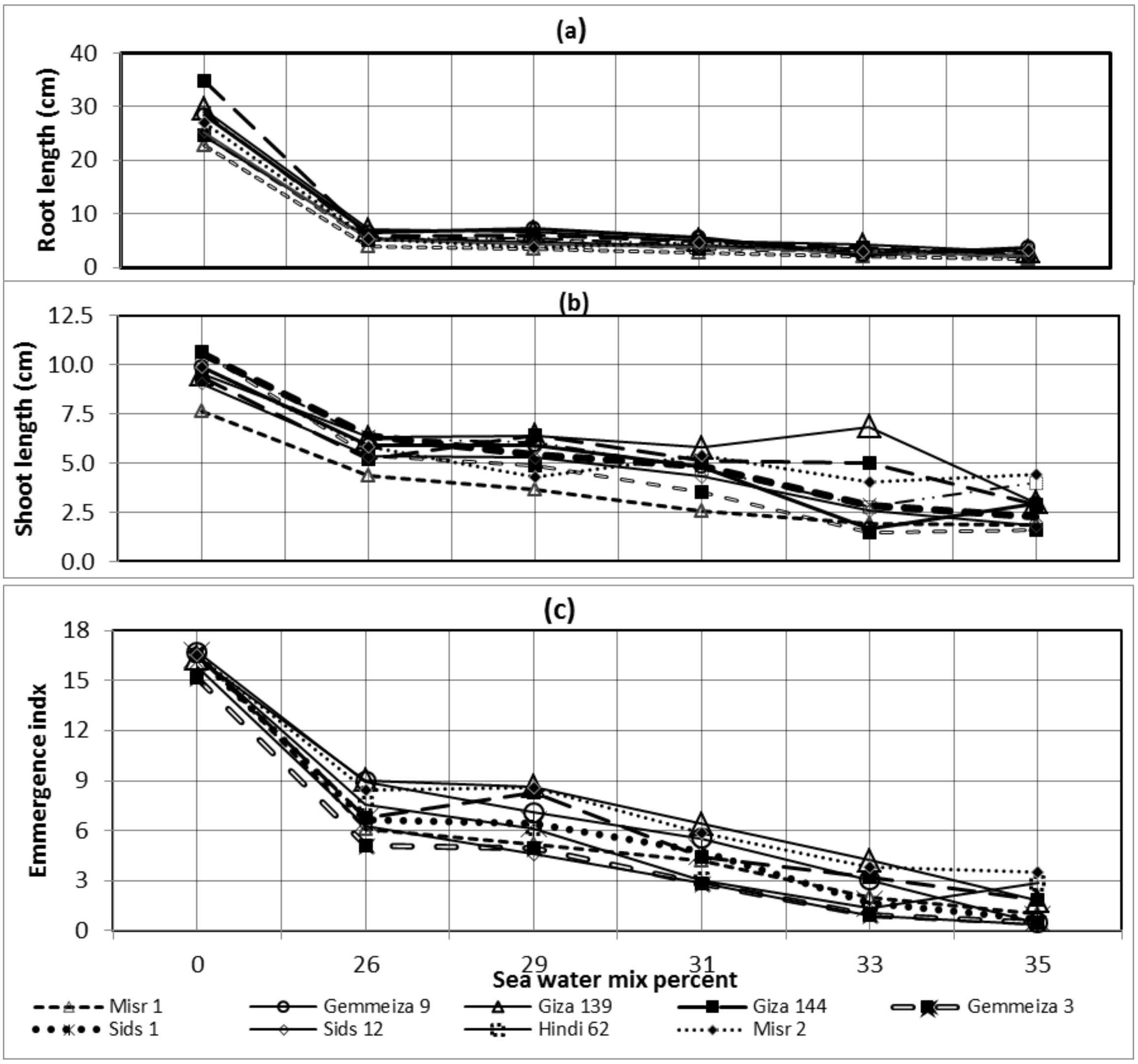

Fig. 4 a, b, and c: Interaction between the studied bread wheat cultivars and sea water mix percent levels for root length (a), shoot length (b) and seedling emergence index(c) at seedling stage.

Table 5: Mean squares and coefficient of variations (CV %) for the studied characters at adult stage in pots experiment.

SOV	df	PH	GY/ pot	BY/ pot	S Y/ pot	S / pot	K / S	100 KW
Cultivars	8	471.4 **	13.5 **	446.0 **	393.5 **	65.0 **	461.0 **	2.3 **
Salt treatments	1	2540.2 **	738.4 **	8332.0 **	4109.7 **	0.16	1182.2 **	9.3 **
Cultivars × Salt treatments	8	86.8 **	13.1	46.4 **	51.0*	9.7 **	14.8	0.45 **
CV%		4.3	10.4	9.3	10.4	8.1	11	10.1

***, ** significant at 0.05 and 0.01 probability respectively. PH= plant height, GY= grain yield, BY= biological yield, SY= straw yield, S= spikes, K W = kernels weight.**

Table 6:Mean of salt treatments for plant height (PH), grain yield (GY), biological yield (BY), straw yield (SY), number of spike per pot (S/pot), number of kernels per spike (K/S) and one hundred kernels weight(100KW) for pots experiment.

Character	PH(cm)		GY(g)		BY(g)		SY(g)		S/pot		K/S		100KW(g)	
Salt	N	S	N	S	N	S	N	S	N	S	N	S	N	S
treatments	86.56	69.89	21.08	12.03	71.44	41.01	50.36	28.99	12.78	12.91	47.33	35.86	3.81	2.79

N =normal. S= salt treatment

The effects of cultivars on the studied characters of the pot experiment are illustrated in Table 7. In this respect, the highest mean values were recorded for the bread wheat cultivars Hindi 62 for plant height; Giza 144 for grain yield and number of spikes per pot; Misr 2 for biological yield and straw yield; Sids 12 for number of kernels per spike; Gemmeiza 3 for one hundred kernels weight. While the lowest mean values were recorded for the bread wheat cultivars Misr 1 for plant height; Giza 139 for grain yield; Sids 12 for biological yield, straw yield and number of spikes per pot; Giza 144 for number of kernels per spike; Misr 2 for one hundred kernels weight. Varying bread wheat genotypes for salinity response was reported by many researchers such as El-Hendawey *et al.* (2011), Hussain *et al.* (2015) and Sharma (2015).

Table 7:Mean of cultivars for plant height(PH), grain yield (GY), biological yield (BY), straw yield (SY), number of spike per pot (S/pot), number of kernels per spike (K/S) and one hundred kernels weight (100KW) for pots experiment.

Cultivar	PH	GY	BY	Straw Y	S/pot	K/S	100KW
Misr 1	65.0	15.39	53.19	37.81	10.25	41.66	3.30
Gemmeiza 9	73.0	15.61	62.99	47.38	12.50	40.55	3.19
Giza 139	76.0	13.95	50.91	36.97	16.70	30.65	2.62
Giza 144	81.0	19.685	62.11	42.42	17.50	28.37	3.83
Gemmeiza 3	74.0	17.83	48.25	30.42	8.75	36.59	5.00
Sids 1	83.5	16.955	62.62	45.66	13.50	44.08	2.87
Sids 12	69.0	14.955	34.40	19.45	6.25	65.52	3.28
Hindi 62	103.0	18.46	63.54	45.07	12.25	46.27	3.26
Misr 2	79.5	16.165	68.06	51.89	17.90	40.69	2.39
$^{\alpha}$ LSD	5.00	2.56	7.76	6.12	1.55	6.77	0.50

$^{\alpha}$LSD, least significant differences at 0.05 level.

The interaction between cultivars and salt treatments for the studied characters are illustrated in Table 8. Under normal condition, high mean values recorded for the bread wheat cultivars Hindi 62 for plant height; Sids 12 for grain yield and number of kernels per spike; Misr 2 for biological yield and straw yield; Gemmeiza 3 for one hundred kernels weight. While the highest mean values under salt treatments recorded for the bread wheat cultivars Hindi 62 for plant height and straw yield; Giza 144 for grain yield; Sids 12 for biological yield and number of kernels per spike; Gemmeiza 3 for one hundred kernels weight. The lowest mean values under normal condition were recorded for the bread wheat cultivars Misr 1 for plant height and grain yield; Sids 12 for biological yield and straw yield; Giza 144 for number of kernels per spike, Misr 2 for 100 kernels weight. The least differences between normal and salt treatment conditions were found in the bread wheat cultivar Sids 1 for plant height; Misr 1 and Giza 144 for grain yield; Hindi 62 for biological yield; Sids 1, Sids 12 and Hindi 62 for straw yield; Gemmeiza 3 for number of kernels per spike; Giza 144 for one hundred kernel weight. In contrast, the largest differences between normal and salt treatment conditions were found in the bread wheat cultivars Giza 139 for plant height, biological yield and straw yield; Sids 12 for grain yield and one hundred kernel weight; Hindi 62 for number of kernels per spike.

Table 8: Means of plant height(PH), grain yield (GY), biological yield (BY), straw yield (SY), number of kernels per spike (K/S) and one hundred kernels weight(100KW) for nine bread wheat cultivars under normal and salt stress conditions, pots experiment.

Cultivar	PH(cm)		GY(g)		BY(g)		SY(g)		K/S		100KW(g)	
	N	S	N	S	N	S	N	S	N	S	N	S
Misr 1	72	58	18.9	11.9	67.1	39.3	48.2	27.4	48.3	35.0	3.6	3.0
Gemmeiza 9	81	65	20.4	10.8	77.4	48.5	57.1	37.7	47.2	33.9	4.0	2.4
Giza 139	95	57	19.3	8.6	73.0	28.8	53.7	20.2	35.2	26.1	3.2	2.0
Giza 144	90	72	22.7	16.7	76.2	48.0	53.5	31.3	31.9	24.8	3.9	3.8
Gemmeiza 3	82	66	24.0	11.7	65.1	31.4	41.2	19.7	39.1	34.1	5.6	4.4
Sids 1	84	83	21.8	12.1	75.9	49.4	54.1	37.3	49.6	38.6	3.3	2.4
Sids 12	76	62	22.9	7.0	48.6	20.3	25.6	13.3	72.9	58.1	4.5	2.1
Hindi 62	112	94	21.4	15.5	73.6	53.5	52.2	38.0	54.8	37.7	3.6	2.9
Misr 2	87	72	18.4	13.9	86.1	50.0	67.7	36.1	46.9	34.5	2.7	2.1
$^{\alpha}$ LSD	7.1		3.6		11		8.7		9.6		0.7	

$^{\alpha}$ LSD, Least significant differences at 0.05 level. N= normal. S=salt treatment

Field experiment

Regarding to field experiment, the analysis of variance of the studied characters are illustrated in Table 9.Significant differences were recorded for all the studied characters among the two environments (normal and salt affected soil), cultivars and their interaction except for number of spikes per square meter and number of kernels per spike for the environments; spikes per square meter for differences among cultivars; number of kernel per spike and one thousand kernels weight for differences due to cultivars × environments interaction (Table 9). The environments variance had the main portion from the total variance for plant height, grain yield, biological yield and straw yield (Table 9).

Table 9:Mean squares and coefficient of variations (CV %) for plant height (PH), grain yield (GY), biological yield (BY), straw yield (SY), number of spike per square meter (S/m^2), number of kernels per spike (K/S) and one thousand kernels weight (1000KW) in the field experiment.

SOV	df	PH	GY	BY	SY	S/m^2	K/S	1000KW
Environments	1	9335.2 **	4.0 **	47.6 **	24.1 **	231	371.3	341.7 **
Cultivars	8	835.9 **	0.8 **	2.6 **	1.2 **	5754	530.7 **	296.3 **
Environments × Cultivars	8	124.8 **	0.4 **	1.1 **	0.2	14332.0 *	49.3	17.5
CV%		3.7	10.5	8	9.6	21	12.9	11.7

***, ** significant at 0.05 and 0.01 probability respectively**

The effect of environments on the studied characters of the field experiments is illustrated in Table 10. Salinity stress caused significantly decrease in plant height, grain yield, biological yield, straw yield and one thousand kernels weight. Meanwhile, number of spike per square meter and number of kernels per spike not affected by salinity stress (Table 10).

Table 10: Means for plant height (PH), grain yield (GY), biological yield (BY), straw yield (SY), number of spike per square meter(S/m^2), number of kernels per spike (K/S) and one thousand kernels weight (1000KW) affected by salt treatment in the field experiment.

Treatment	PH(cm)		GY(kg)		BY(kg)		SY(kg)		S/m^2		K/S		1000KW(g)	
	N	S	N	S	N	S	N	S	N	S	N	S	N	S
Mean	130.7	104.4	2.29	1.75	6.4	4.5	4.1	2.8	349	345	45.9	51.1	46.6	41.6

N= Normal soil. S = Salt affected soil.

The effects of cultivars on the studied characters of the field experiment are illustrated in Table 11. The bread wheat cultivars Hindi 62 and Giza 144 had the highest mean value for plant height; Misr1 and Misr 2 for grain yield; Misr 2 for biological yield; Gemmeiza 9, Giza 144, Sids 1 and Misr 2 for straw yield; Misr 1, Gemmeiza 9, Sids 12 and Misr 2 for number of kernels per spike; Gemmeiza 3 for one thousand kernels weight. On the other hand, the lowest mean values were recorded for the bread wheat cultivar Sids 12 for plant height; Hindi 62 for grain yield; Sids 12, Gemmeiza 3 and Hindi 62 for biological yield; Misr 1, Sids 12 and Gemmeiza 3 for straw yield; Giza 139, Giza 144, Gemmeiza 3 and Hindi 62 for number of kernels per spike; Gemmeiza 9, Sdis 1 and Misr 2 for one thousand kernels weight.

Table 11: Means of cultivar for plant height (PH), grain yield (GY), biological yield (BY), straw yield (SY), number of spike per square meter(S/m^2), number of kernels per spike (K/S) and one thousand kernels weight (1000KW) in the field experiment.

Cultivar	PH (cm)	GY (kg)	BY (kg)	S Y (kg)	S/m^2	K/S	1000KW (g)
Misr 1	106.7	2.50	5.7	3.1	294	56.9	43.4
Gemmeiza 9	110.0	2.01	5.7	3.7	342	55.0	42.4
Giza 139	125.8	1.73	5.3	3.5	328	36.5	43.3
Giza 144	130.0	2.09	6.0	3.9	369	38.2	43.9
Gemmeiza 3	115.8	1.83	4.7	2.9	338	40.5	62.1
Sids 1	115.0	2.13	5.7	3.6	327	51.3	42.2
Sids 12	100.0	1.79	4.5	2.7	358	58.3	37.4
Hindi 62	137.5	1.49	5.0	3.5	363	40.9	40.9
Misr 2	117.5	2.62	6.6	4.0	402	59.3	41.5
LSD	5.1	0.20	0.5	0.4	86	7.4	6.1

LSD, Least significant differences at 0.05 level. N= Normal soil. S = Salt affected soil.

The interaction between cultivars and environments (normal and salt affected soil) and decrease percent for the studied characters are illustrated in Table 12. Under normal condition, the highest mean values were recorded for the bread wheat cultivars Hindi 62 and Giza 144 for plant height; Misr 2 for grain yield; Gemmeiza 9 and Misr 2 for biological yield; Misr 2 and Hindi 62 for number of spikes per square meter. While the highest mean values under salt affected soil recorded for the bread wheat cultivars Hindi 62 and Giza 144 for plant height; Misr 1, Misr 2 and Giza 144 for grain yield; Giza 144, Giza 139, Misr 1, Misr 2 and Sids 1 for biological yield; Giza 144 and Misr 2 for number of spikes per square meter. The lowest mean values under normal condition recorded for the bread wheat cultivar Sids 12 for plant height; Hindi 62 for grain yield; Gemmeiza 3, Sids 12 and Hindi 62 for biological yield; all studied cultivars except Hindi 62 and Misr 2 for number of spikes per square meter; Misr 2 for one thousand kernels weight. While the lowest mean values under salinity affected soil recorded for the bread wheat cultivars Misr 1 Gemmeiza 9, Gemmeiza 3 and Sids 12 for plant height; Sids 12 for grain yield; Gemmeiza 3 and Sids 12 for biological yield; all studied cultivars except Giza 144 for number of spikes per square meter.

Table 12: Means of cultivar environment interaction and decrease percent (%) for plant height (PH), grain yield (GY), biological yield (BY) and number of spike per square meter (S/m^2) for field experiment.

Cultivar	PH (cm)			GY(kg)			BY(kg)			SY(kg)			S/m^2			1000KW			K/S(g)		
	N	S	%	N	S	%	N	S	%	N	S	%	N	S	%	N	S	%	N	S	%
Misr 1	115	98	15	2.8	2.2	21	7	5	26	3.7	2.6	30	327	260	20	45	42	6	51	63	-24
Gemmeiza 9	122	98	19	2.5	1.5	40	7	4	42	4.7	2.7	42	310	373	-20	45	40	10	51	59	-17
Giza 139	143	108	24	1.6	1.9	-17	6	5	9	3.9	3.2	19	372	284	24	46	40	12	36	37	-3
Giza 144	148	112	25	2.1	2.1	3	7	5	21	4.6	3.3	28	308	429	-39	44	44	1	32	44	-37
Gemmeiza 3	133	98	26	2.3	1.4	39	6	3	43	3.7	2.1	44	298	377	-27	63	61	4	41	40	1
Sids 1	125	105	16	2.3	2.0	14	6	5	23	4.2	3	29	308	346	-12	48	36	25	54	49	9
Sids 12	107	93	13	2.4	1.2	51	6	3	45	3.4	2	41	362	354	2	40	35	11	56	61	-9
Hindi 62	155	120	23	1.6	1.4	8	6	4	21	4.1	3	27	460	266	42	45	37	18	37	45	-22
Misr 2	128	107	17	3.1	2.1	31	8	5	33	4.8	3.2	34	392	412	-5	44	39	12	57	62	-10
LSD	6.9			0.3			1			0.6			118			8.2			11		

LSD, Least significant differences at 0.05 level. N= Normal soil. S = Salt affected soil

From the data presented in Table 12, it can be classified the studied cultivars into three groups. The first group was low yield potential (under normal condition) cultivars with low grain yield decrease percent under salt affected soil such as Giza 139, Giza 144 and Hindi 62 (-17, 3 and 8% respectively), it may be due to low effect of salinity stress on number of kernels per spike and one thousand kernels weight and it may be consider as genetic resources for salinity tolerance in breeding program. The second one was high yield potential cultivars with moderate grain yield decrease percent under salt affected soil such as Misr 2, Misr 1 and sids 1 (31, 21 and 14% respectively), these cultivars may be recommended for wheat production under salt affected soil. The third group was high yield potential cultivars with high grain yield decrease percent under salt affected soil such as Gemmeiza 3, Gemmeiza 9 and sids 12 (39, 40 and 51% respectively) it may be consider as salinity sensitive cultivars.

Stress tolerance index (STI)

The stress tolerance index estimates based on shoot dry weight at seedling, biological yield of pots and salt affected soil for the nine studied cultivars are illustrated in Table 13. High estimates of stress tolerance index values based on shoot dry weight (seedling stage) were recorded for the bread wheat cultivars Misr 2, Gemmeiza 9, Hindi 62, and Giza 139, while low estimates for the others. High estimates of stress tolerance index (STI) values based on biological yield (the pot experiment) were recorded for cultivars Misr 2, Gemmeiza 9, Hindi 62, and Giza 144. While high estimates of STI values based on biological yield (the salt affected soil) were recorded for Misr 2, and Giza 144. These result indicated that salinity tolerance depending on the cultivars and growth stage. Based on STI estimates at seedling and adult plant stages, the studied cultivars could be divided to four groups. The first group, cultivar (Misr 2) was salt tolerant at both seedling and adult plant stages. The second group, cultivars (Gemmeiza 3 and Sids 12) were salt sensitive at both seedling and adult plant stages. The third group, cultivars (Misr 1, Sids 1 and Giza 144) were salt sensitive at seedling stage but tolerant at adult plant stage. The forth group, cultivars had varying degrees of tolerance and or sensitivity at seedling and adult plant stages.

Correlation

The correlation among each of biological, grain and straw yields under the salt affected soil condition and the studied characters under the normal soil and at 33% sea water mix treatments (seedling and pot experiments) are illustrated in Table 14. Biological yield of the salt affected soil had significant strong positive relationship with each of seedling emergence index and shoot length (for the seedling experiment); number of spikes per pot, straw yield per pot and biological yield per pot (for the pots experiment) and straw yield (for the normal soil experiment). While, significant weak correlation recorded with number of kernels per spike (for the pot experiment). Regarding to grain yield under the salt affected soil condition, significantly strong positive correlation were found with each of number of spike per pots in pots experiment and biological yield under the normal soil condition, but negative correlation were found for number of kernels per spike for the pot experiment. Straw yield of the salt affected soil had significant strong positive correlation with each of seedling emergence index and shoot length for seedling experiment; number of spikes per pot, straw yield per pot and biological yield per pot for the pot experiment; plant height and straw yield for the normal soils experiment. While, significant negative correlation recorded for number of kernels per spike for the pot experiment. Generally, the bread wheat genotype with the high emergence speed (emergence index) and shoot length at seedling stage and high number of spikes per pot, biological and straw yield per pot at adult stage may be had good performance at the salt affected soil.

El-Hendawy *et al*. (2011) found highly significant correlation between grain yield per plant and shoot parameters (height and dry weight of shoot) at seedling stage. Hussain *et al*. (2015) reported that shoot parameters had comparatively stronger correlations than root parameters.

Table 13: Stress tolerance index (STI) estimates based on shoot dry weight, biological yield per pots and salt affected soil biological yield for the nine studied cultivars.

Cultivar	Shoot dry weight		Biological Yield pots		Salt affected soil biological Yield		Rank sum	Rank mean
	STI	Rank	STI	Rank	STI	Rank		
Misr 1	0.08	5	0.52	6	4.88	4	15	5
Gemmeiza 9	0.14	2	0.74	3	4.73	5	10	3.3
Giza 139	0.10	4	0.41	7	4.3	6	17	5.7
Giza 144	0.07	7	0.72	5	5.55	2	14	4.7
Gemmeiza 3	0.08	6	0.4	8	3.19	8	22	7.3
Sids 1	0.04	9	0.73	4	4.9	3	16	5.3
Sids 12	0.07	8	0.19	9	2.9	9	26	8.7
Hindi 62	0.12	3	0.77	2	3.85	7	12	4
Misr 2	0.21	1	0.84	1	6.54	1	3	1

Table 14: The correlation (r) among biological, grain and straw yield under the saline soil condition and the studied characters of bread wheat cultivars under normal soil and 33% sea water mix treatments (seedling and pots experiments).

Experiment	Character	Field experiment (saline affected soil)					
		Straw yield		Grain yield		Biological yield	
		r	P. value	r	P. value	R	P. value
Field experiment (saline affected soil)	Straw yield	-	-				
	Grain yield	0.66	0.05	-	-		
	Biological yield	0.93	<0.001	0.90	<0.001	-	-
Seedling experiment	Emergence index	0.69	0.04	0.39	0.3	0.61	0.08
	Root Dry weight	0.38	0.31	0.31	0.42	0.38	0.31
	Shoot root ratio	0.32	0.4	0.05	0.89	0.23	0.56
	Root height	0.43	0.25	-0.11	0.78	0.2	0.61
	Shoot dry weight	0.41	0.27	0.26	0.5	0.38	0.31
	Shoot length	0.74	0.02	0.24	0.54	0.56	0.11
Pots experiment	100 kernels weight	-0.25	0.51	-0.06	0.87	-0.19	0.62
	Grain yield	0.57	0.11	0.42	0.26	0.55	0.13
	Plant height	0.35	0.36	-0.09	0.82	0.16	0.68
	Spike /pot	0.93	<0.001	0.62	0.08	0.86	<0.001
	Straw yield	0.64	0.06	0.39	0.3	0.58	0.1
	Kernels / Spike	-0.67	0.05	-0.59	0.1	-0.68	0.04
	Biological yield	0.67	0.05	0.42	0.25	0.61	0.08
Field experiment (Normal soil)	1000 kernels weight	-0.35	0.35	-0.17	0.66	-0.31	0.42
	Biological yield	0.30	0.43	0.49	0.18	0.43	0.25
	Grain yield	-0.20	0.61	0.36	0.35	0.06	0.87
	Plant height	0.62	0.08	0.1	0.81	0.41	0.27
	Spikes per square meter	0.28	0.47	-0.17	0.66	0.09	0.82
	Straw yield	0.70	0.03	0.41	0.28	0.62	0.07
	Kernels / Spike	-0.33	0.38	0.03	0.94	-0.18	0.65

CONCLUSION

Generally, testing the nine bread wheat cultivars at seedling and adult plant stages against salinity stress resulted in significant decreases in most seedling and adult plant characters. Increasing salt concentrations causes significant decrease in shoot dry weight, shoot length, root dry weight, root length and emergence speed (emergence index), plant height, biological yield, grain yield, straw yield, number of kernels per spike and mean kernel weight and increase shoot-root dry weight ratio. The variances due to salt treatments had the major portion of total variance, indicated the large effect of salt stress on growth characters compared with genotype and genotype × salt concentrations interaction variances. The salt concentration 33% sea water mix is not destructive and caused large variation among the studied cultivars so, it can be used for screening wheat cultivars for salt tolerance. The large variance among the nine cultivars for shoot length, emergence index and shoot-root dry weight under salt stress indicated the importance of these characters in studying the effect of salt stress on bread wheat genotypes at seedling stage. Strong and positive correlation were found between biological yield under salt affected soil and emergence index and shoot length at seedling stage; number of spike per pot, biological and straw yield per pot at adult stage. Based on stress tolerance index, of the nine studied cultivars, Misr 2 was salt tolerant while Gemmeiza 3 and Sids 12 were salt sensitive cultivars.

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تقييم تسعة أصناف قمح خبز مصرية لتحمل الملوحة في طور البادرة والنبات البالغ

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أجريت هذه الدراسة في كل من المزرعة البحثية ومعمل القمح ومعمل كيمياء وطبيعة الاراضي بمحطة البحوث الزراعية بسحا كفر الشيخ – مصر في الموسم الزراعي ٢٠١٥/٢٠١٤م, بهدف دراسة تأثير الملوحة على تسعة أصناف قمح خبز مصرية في أطوار النمو المختلفة للنبات و تحديد الأصناف المتحملة للملوحة في أطوار النمو المختلفة و محاولة الوصول الى طريقة فعالة للفرز والانتخاب لتحمل الملوحة وذلك بدراسة الارتباط بين المحصول تحت ظروف الأراضي المتأثرة بالملوحة ومختلف الصفات المدروسة . وقد أجريت ثلاث تجارب في هذه الدراسة (بادرة- أصص - حقلية). وقد تم اجراء معاملات الملوحة في تجربتي البادرة والأصص بخلط ماء البحر وماء الصنبور اشتملت ستة نسب خلط (صفر, ٢٦, ٢٩, ٣١, ٣٣, ٣٥%) والتي أعطت قيم لدرجة التوصيل الكهربي ٠.٤٨, ١٣.٥, ١٥, ١٦, ١٧ , ١٨ملليموز على الترتيب. كما أجريت الدراسة على تسعة أصناف قمح خبز مصرية وهى مصر ١, مصر٢, جيزة ١٣٩, جيزة ١٤٤, سدس ١, سدس ١٢ , جميزة ٣, جميزة ٩, هندي ٦٢. ودرست صفات سرعة الانبثاق وطول الساق وطول الجذر والوزن الجاف للساق والجذر والنسبة بينهما وذلك في تجربة البادرات, كما درست صفات إرتفاع النبات والمحصول البيولوجي ومحصول الحبوب والقش وعدد السنابل في المتر المربع / الإصيص وعدد حبوب السنبلة ومتوسط وزن الحبة وذلك في تجربتي الإصص والحقل. وأظهرت النتائج أن زيادة الملوحة أدت إلى نقص معنوي في سرعة الإنبثاق و الوزن الجاف للساق وطول الساق والوزن الجاف للجذر وطول الجذر وذلك في تجربة البادرات, ونقص معنوي في إرتفاع النبات والمحصول البيولوجي ومحصول الحبوب والقش وعدد حبوب السنبلة ووزن الحبة وذلك في طور النبات البالغ (تجربة الأصص والحقل) , ولكن أدى الى زيادة معنوية في النسبة بين الوزن الجاف للساق والجذر. أظهر تحليل التباين أن التباين الراجع الى الملوحة يمثل القدر الأكبر من التباين الكلي وهذا يعكس التأثير الكبير للملوحة على الصفات المدروسة مقارنة بالتباين الراجع إلى الأصناف والتفاعل بين الأصناف ومعاملات الملوحة. وكانت معاملة الملوحة ٣٣% خلط ماء البحر وماء الصنبور يمكن استخدامها لفرز أصناف القمح لتحمل الملوحة. وكانت الصفات الأكثر تبايناً تحت معاملات الملوحة هي طول الساق و سرعة الإنبات والنسبة بين الوزن الجاف للساق والجذر مما يشير إلى أهمية هذه الصفات في فرز وانتخاب تحمل الملوحة في طور البادرة. كما وجد ارتباط قوي موجب بين المحصول البيولوجي تحت ظروف الأرض المتأثرة بالملوحة وكل من سرعة الانبثاق وطول الساق في طور البادرة, بالاضافة الى عدد السنابل لكل أصيص والمحصول البيولوجي لكل أصيص ومحصول القش لكل إصيص في طور النبات البالغ. وأظهرت نتائج دليل تحمل الملوحة (STI) انه من بين الأصناف المدروسة أعتبر الصنف مصر ٢ متحمل للملوحة والصنفين جميزة ٣ وسدس ١٢ حساسة للملوحة.