Salt Tolerance Variability Among 12 Egyptian Wheat Cultivars

El-Haddad, E.H. [1] and M.A. Mostafa[2]

[1]Soil Salinity and Alkalinity Laboratory, Soil, Water, and Environment Res. Institute, A.R.C.

[2] Wheat Research Department, Field Crops Res. Institute, A.R.C.

ABSTRACT

Increased productivity of wheat particularly under saline conditions is a desired goal in irrigated areas in Egypt. Two experiments were conducted to study the salt tolerance variability among 12 Egyptian wheat cultivars at germination and maturity stage. Treatments included five salinity levels (0.5, 4.7, 9.4, 14.0, and 18.8 dS/m) constructed by adding NaCl and $CaCl_2$ salts (2 : 1, molar weight) . At germination, no significant reduction ($p \leq 0.05$) in the final germination percentage and rate of germination (% day^{-1}) with salinity of irrigation water up to 9.4 dS/m. Regardless of salinity, the highest emergence was recorded for Sakha 94 followed by Sakha 93 and Giza 168, whereas it was the lowest for Beni Sweif 3 then Beni Sweif 1. The germination percentage of different cultivars was also variable among different salinities. The cultivars Sakha 94, Sakha 93 and Line3 Nubaria were the most salt tolerance at germination stage, while Beni Sweif 1, Beni Sweif 3, Sohag 2, and Sohag 3 were the most sensitive. At maturity, increasing salinity of irrigation water up to 18.8 dS/m decreased significantly ($p \leq 0.05$) grain yield, number of tillers/pot, number of spikes/pot, number of kernels /spike, 1000-kernels weight, days to heading, days to maturity and plant height. Depending on cultivars means over all salinity treatments Line3 Nubaria and Gemmiza 9 gave the highest grain yield , while Beni Sweif 3, and Sohag 2 illustrated the lowest. Line3 Nubaria produced the greatest number of tillers/pot and number of spikes/pot, while Giza168, Gemmiza 10, and Line3 Nubaria had the highest number of kernels/spike. The maximum 1000-kernel weight was measured for Gemmiza 7, and maximum biological yield was recorded for Gemmiza 9. Days to heading were the highest for Line3 Nubaria and Gemmiza 9 and days to maturity were the highest for Sids 1, Gemmiza 9 and Line3 Nubaria. Finally, Gemmiza 7 and Gemmiza 9 were the tallest cultivar , while Sakha 93 and Beni Sweif 1 were the shortest Giza 168 had the highest relative yield among the other cultivars at salinity level of 18.8 dS/m. followed by Gemmiza 10 and Sakha 93 . Whereas, Beni Sweif 1, Beni Sweif 3, Sohag 2, and Sohag 3 produced the lowest relative yields among the other cultivars and the yield reduction percentage at the highest salinity level were the greatest . On the basis of C_{50} (salinity of saturation extract at which grain yield reduced by 50 %) , the data indicated that Giza 168, Gemmiza 7 and Gemmiza 10 were the most salt tolerance, whereas the cultivars Sohag 2, and Sohag 3 were the most salt sensitive. However, Productivity of wheat under saline conditions requires high yield potential under non-saline conditions and low reduction in yield with increasing salinity.

ADDITIONAL INDEX WORDS: germination percentage, grain yield, salt tolerance, wheat cultivars

INTRODUCTION

Salinity is a wide spread problem in arid and semi-arid regions and seriously affects productivity of cereals in irrigated lands. Increasing food production to meet the needs of the increasing world population on a sustainable basis remains the primary goal of all nations (Kaddah and

Rhodes, 1975). Wheat is one of the important cereal crops for human consumption, especially for the developed countries and much of this wheat grown on soils where salinity already exist or may develop. The inhibitory effect of salinity on plants as a consequence of high salts concentration level has been attributed to water deficit, salt toxicity, or nutritional imbalance (Greenway and Munns, 1980). The plant breeders are attempting to look for seedlings, which are tolerant to salinity. Wheat (*Triticum aestivum* L.) is classified as a moderately salt tolerance crop according to Maas and Hoffman (1977). Improving the salt tolerance of crop requires access to new genetic diversity (either natural or transgenic), and efficient techniques for identifying salt-tolerance. There is probably a wide range of genetic diversity in salinity tolerance in international collections that is undiscovered or under utilization. Screening large numbers of cultivars for salinity tolerance in the field is difficult, due to spatial heterogeneity of soil chemical and physical properties, and to seasonal fluctuations in rainfall. Large numbers of bread and durum wheat cultivars have been screened for salt tolerance (Mass and Hoffman, 1977; Kingsbury and Epstein, 1984; François *et al.*, 1986; Munns and James, 2003). Trails in Egypt for salt tolerance studies on wheat were conducted by many investigators have shown that there were significant variations between cultivars or cultivars under study (Barakat *et al.*, 1970; Omar and Ghowail, 1991; El-Haddad et al, 1993; Shalaby *et al.*, 1993; Hanna et al., 1999; Gawish *et al.*, 1999).

Increasing wheat production in the arid regions may require seeding species which can germinate and persist in saline and rapidly drying seedbeds. Germination in soils is limited by low soil matric and osmotic potentials and possibly toxic concentrations of specific ions. Because germination and seedling salt tolerance may not be correlated for particular plant (Roundy et al., 1983), both germination and seedling studies are necessary in evaluating plant material adaptability to saline lands and saline condition.

This study was initiated to determine the salt tolerance variability among 12 Egyptian wheat cultivars.

MATERIALS AND METHODS

Greenhouse study was conducted at Soil Salinity Laboratory, Alexandria, Egypt to evaluate the relative salt tolerance of 12 wheat cultivars during 2005/2006 growing season (Table 1). Seeds of the wheat cultivars were supplied by Wheat Research Department, Field Crop Res. Institute, Agricultural Research Center. The cultivars were chosen to give a wide range of cultivars that being used by Ministry of Agriculture, Egypt.

Experiment I:

Germination of wheat cultivars was carried out at salinity of 0.5 (control), 4.7, 9.4, 14.0, and 18.8 dS/m .Three replicates of 25 seeds each were planted in earthen pots filled with fine and washed sand. Seed germination counts were made daily over a 21-days period. Measuring germination was continued until no further germination occurred. Average rates of germination were calculated after Maguire (1962) where :

Average germination rate (% day^{-1}) = $\sum_i [g_i - g_{(i-1)} / i]$ in which g is the total germination percentage on an incubation day i minus the total germination percentage on the pervious day $g_{(i-1)}$ divided by the incubation day i. Main effects and interactions of cultivars and salinity of irrigation water were tested for significance.

Experiment II:

A bulk soil samples were collected from Beherah Governorate, air dried and ground to pass 2- mm sieve. The experimental soil was sandy clay loam in texture with 2.0-2.8 % $CaCO_3$; 7.8 – 8.0 pH; and 1.6- 2.8 EC_e (electrical conductivity of the saturated paste extract). The experimental design was a randomized complete block consisting of 5 salinity treatments (0.5 (control), 4.7, 9.4, 14.0, and 18.8 dS/m) and 12 cultivars as presented in Table 1. Each treatment was replicated 5 times.

Seeds of each wheat cultivars was planted till maturity in plastic pots 35 cm in diameter and 30 cm in depth. During the first two weeks, the pots were irrigated with tap water until emergence. Thereafter, the seedlings were thinned to 5 seedlings /pot. Nitrogen fertilizer was applied at the rate of 80 kg N/fed in the form of ammonium sulfate (20.5% N) at three equal doses added at seeding, tillering, and before heading stage. Phosphorus fertilizer was applied in the form of super-phosphate (15.5% P_2O_5) at the rate of 30 kg P_2O_5/fed before planting. Two weeks after planting, saline irrigation waters were prepared by adding NaCl: $CaCl_2$ (1:1 molar weight ratio) and applied in excess amounts to avoid salt accumulation in the pots. All other cultural practices were applied as recommended by the Ministry of Agricultural and Land Reclamation. At harvest time, wheat grain yield, number of tillers/pot, number of spikes /pot, number of kernels/spike, 1000-kernel weight, biological yield, days to heading, days to maturity, and plant height were recorded. The results obtained were statistically analyzed according to SAS (1985). LSD at 0.05 was used to compare the treatments means. Soil samples were taken from each pot during the growth period and after harvesting. The average electrical conductivity of the saturated- soil extracts (EC_e) are give in Table 2.

Table 1. Name and pedigree of the twelve wheat cultivars used in the study during 2005/2006 season.

No.	Name	Pedigree
1	Sakha 93	Sakha 92/TR 810328 S 8871-1S-2S-1S-0S
2	Sakha 94	OPATA/RAYON//KAUZ CMBW 90Y3180-0T0PM-3Y-010M-010M-010Y-10M-015Y-0Y-0AP-0S.
3	Sids 1	HD2172/Pavon"S"//1158.57/maya74"S"Sd46-4Sd-2Sd-1Sd-0Sd
4	Giza 168	MIL/BUC//Seri CM93046-8M-0Y-0M-2Y-0B
5	Gemmiza 7	CMH74 A.630/5X//Seri 82/3/Agent CGM 4611-2GM-3GM-1GM-0GM
6	Gemmiza 9	Ald "S"/Huac"S"//CMH74A.630/5x CGM4583-5GM-1GM-0GM
7	Gemmiza 10	MAYA 74"S"/ON//1160-147/3/BB/GLL/4/ CHAT "S" /5/ CROW"S" CGM 5820- 3GM-1GM-2GM-0GM
8	Beni Sweif 1	Jo"S"/AA//g "S"
9	Beni Sweif 3	Corm "S"/Rufo "S" CD4893-10Y-1M-1Y-0M
10	Sohag 2	Cr "S" /Pellcano//Cr"S"/G"S"
11	Sohag 3	Mexl"S"/Mgh/51792/Durum 6
12	Line3 Nubaria	PFAU/WEAVER CMBW 90M4-30-0Y-29KBY-0KBY-0M-ONUB.

Assessing salt tolerance among cultivars:

A salt-tolerance index has been developed by Van Genuchten (1983) to compare the salt tolerance of various crops. This index has been defined as conductivity of the saturation extract in dS/m associated with 50% reduction in yield using a response function equation as follows:

$$Y_r = Y_m / [1+(C/C_{50})^p]$$

Where: Y_m = yield under non-saline conditions,

C_{50} = salinity in dS/m at which the yield is reduced by 50%, and p = an empirical constant. This model was also applied to determine salinity in dS/m corresponding to 50 % reduction in germination percentage.

Table 2. Average electrical conductivities of soil saturated extract (ECe) under five saline irrigation waters under all studied cultivars.

Cultivar	Salinity of irrigation water (EC_i) – dS/m				
	0.5	4.7	9.4	14.1	18.8
Sakha 93	1.1	4.7	11.2	16.4	20.4
Sakha 94	1.5	4.8	10.6	16.6	21.6
Sids 1	2.2	4.5	11.8	15.5	21.9
Giza 168	1.2	7.6	10.4	15.4	22.1
Gemmiza 7	1.7	5.6	11.2	15.5	22.4
Gemmiza 9	1.6	6.2	12.0	16.3	19.3
Gemmiza 10	1.7	5.0	12.5	15.7	21.7
Beni Sweif 1	1.6	6.6	12.0	15.7	21.9
Beni Sweif 3	1.9	5.2	11.0	17.9	21.6
Sohag 2	1.5	3.4	10.9	15.6	21.5
Sohag 3	1.4	5.8	10.8	15.7	22.0
Line3Nubaria	1.5	4.7	10.0	15.8	19.7
Mean	1.5	5.3	11.2	16.0	21.3

RESULTS AND DISCUSSION

Salinity effects on wheat germination:

Total germination percentage and rate of germination varied statistically among cultivars and among salinity of irrigation waters (Table 3). The results of the total germination percentage showed no significant reduction ($p \leq 0.05$) with salinity of irrigation water up to 9.4 dS/m . Over wheat cultivars, emergence decreased from 98.0 to 30.0 % (almost 70 % reduction) as salinity increased from 0.5 to 18.8 dS/m. To compensate for the failure due to salinity influence on wheat seed germination suitable increment in seeding rate should be determined according to salinity level. Regardless of salinity, the highest emergence was recorded for Sakha 94 followed by Sakha 93 and Giza 168, whereas it was the lowest for Beni Sweif 3 then Beni Sweif 1. The cultivar Sakha 94 followed by Sakha 93 and Line3 Nubaria had the highest germination percentage at the highest salinity level (18.8 dS/m), while Beni Sweif 1, Beni Sweif 3, Sohag 2 and Sohag 3 showed the lowest, where no germination was detected.

On the other hand, germination rate ($\%day^{-1}$) decreased significantly as salinity of irrigation water increased from 0.5 to 18.8 dS/m (almost 80 % reduction). Regardless of salinity, the highest germination rate was recorded for Line3 Nubaria, whereas it was the lowest for Beni Sweif 3 then Beni Sweif 1, Sohag 3, and Sohag 2. At the highest salinity level (18.8 dS/m) Sakha 94 and Line3 Nubaria showed the highest germination rate, whereas, Beni Sweif 1, Beni Sweif 3, Sohag 2, and Sohag 3 had the lowest germination rate..

It is interesting to find that the cultivars Beni Sweif 1, Beni Sweif 3, Sohag 2, and Sohag 3 were either had the lowest germination rate at low and medium saline conditions or not able to germinate at high salinity. Furthermore, Sakha 94 was lower than Sakha 93 or Gemmiza 10 or Line3 Nubaria in germination rate at non-saline conditions and in contrary Sakha 94 was the highest at high salinity.

Values of C_{50} (salinity of irrigation waters at which the germination percentage of wheat cultivars was reduced by 50%) were 20.48, 23.89, 16.69 , 18.45, 18.33, 16.14, 16.39, 12.67, 11.07, 12.58, 12.97, and 21.87 dS/m for Sakha 93, Sakha 94, Sids 1, Giza 168, Gemmiza 7, Gemmiza 9, Gemmiza 10, Beni Sweif 1, Beni Sweif 3, Sohag 2, Sohag 3, and Line3 Nubaria, respectively. Once again, Sakha 94 Sakha 93 and Line3 Nubaria were the most salt tolerance at germination stage, while Beni Sweif 1, Beni Sweif 3, Sohag 2 and Sohag 3 were the most sensitive.

Salinity effects on grain yield, yield components, and growth characters:

As shown in Table 4, the data indicate that raising salinity of irrigation water decreased significantly grain yield by 23.3, 37.8, 49.3, and 57.1 % at 4.7, 9.4, 14.0, and 18.8 dS/m, respectively, as compared with the control treatment. Number of tillers / pot, number of spikes /pot, number of kernels / spike and 1000- kernel weight demonstrated the same trend. Number of tillers/pot was less sensitive to salinity, being reduced by 16.0% at saline water of 18.8 dS/m compared with 26.6% for number of spikes/pot, 20.6% for number of kernels/ spike, and 34.3% for 1000-kernel weight. As a result, the decreased grain yield due to salinity could be attributed to reduction of 1000- kernel weight, spikes number/pot, and number of kernels/ spike rather than reduction of number of tillers/ pot. These results are in consistent with those obtained by earlier investigators (Francois et al., 1986; Francois et al., 1988; Abdul-Halim et al., 1988; El-Haddad et al., 1993). The inhibition effect was also found for biological yield, which showed a reduction of 48.2 % at the highest salinity level (Table 4). Moreover, observations taken at harvest time showed that plants grown at high salinity levels were significantly shorter and matured earlier and reached to heading faster compared with those of the control.

Table 3.Total germination percentage and germination rate (percentage day^{-1}) as affected by salinity (S), wheat cultivars I, and their interactions (S x C).

Cultivar	Salinity of irrigation water (dS/m)					
	0.5	4.7	9.4	14.1	18.8	Mean
	Germination percentage (%)					
Sakha 93	100	100	100	70	60	86
Sakha 94	100	100	100	80	70	90
Sids 1	100	100	100	75	30	81
Giza 168	100	100	100	70	50	84
Gemmiza 7	100	95	95	65	50	81
Gemmiza 9	100	100	100	80	15	79
Gemmiza 10	100	100	100	80	20	80
Beni Sweif 1	85	85	85	35	0	58
Beni Sweif 3	90	90	45	40	0	53
Sohag 2	100	100	75	25	0	60
Sohag 3	100	100	70	35	0	61
Line3Nubaria	100	100	90	65	60	83
Mean	98	98	88	60	30	

$^*LSD_{(0.05)}$ for Salinity (S) = 3.4, cultivars (C) = 5.3 and interaction (G x S) = 11.7

	Average germination rate (% day^{-1})					Mean
Sakha 93	20.0	14.3	14.3	5.4	4.3	11.7
Sakha 94	12.5	14.3	14.3	8.0	5.8	11.0
Sids 1	20.0	14.3	14.3	6.8	4.0	11.9
Giza 168	20.0	14.3	14.3	6.4	4.2	12.5
Gemmiza 7	14.3	7.9	7.9	5.4	4.7	8.1
Gemmiza 9	14.3	14.3	12.5	6.7	2.8	10.1
Gemmiza 10	20.0	20.0	14.3	6.7	3.8	12.8
Beni Sweif 1	8.5	7.1	2.8	1.8	0	4.0
Beni Sweif 3	5.7	6.3	2.3	2.0	0.3	3.3
Sohag 2	14.3	8.3	3.8	1.3	0.8	5.7
Sohag 3	10.0	7.1	3.7	1.8	0	4.5
Line3Nubaria	20.0	20.0	11.3	6.5	5.0	14.3
Mean	15.0	12.4	10.7	4.8	3.0	

$^*LSD_{(0.05)}$ for Salinity (S) = 1.2, Cultivars (C) = 2.0 and interaction (C x S) = 4.2

Table 4 . Salinity level and cultivars effects on grain yield, yield components and growth of 12 wheat cultivars.

	GY	BY	TN	SP	K/SP	1000-KW	DH	DM	PH
		g/pot				g		days	cm
				Salinity level (dS/m)					
0.5	57.36	163.23	29.29	25.65	55.06	46.97	79.42	119.27	81.77
4.7	44.01	116.25	25.73	21.98	53.00	42.88	79.23	112.10	73.67
9.4	35.66	106.77	25.81	19.85	49.85	38.92	79.06	110.81	72.81
14.0	29.08	91.77	25.19	18.50	46.85	33.55	78.79	109.02	69.69
18.8	24.62	83.65	24.56	18.83	43.71	30.88	78.20	108.73	68.85
LSD(0.05)	3.05	6.22	1.49	0.53	3.13	1.35	0.53	1.02	1.66
				Cultivars					
Sakha 93	41.60	106.50	24.15	20.70	49.95	40.64	75.85	111.15	68.35
Sakha 94	41.83	114.00	26.60	21.35	53.35	39.44	79.75	110.25	76.00
Sids 1	41.77	126.75	26.90	21.70	50.90	38.53	79,70	113.45	77.50
Giza 168	40.28	106.75	25.60	20.35	55.40	36.91	74.85	111.10	71.75
Gemmiza 7	38.45	107.00	22.65	17.40	49.85	46.69	77.35	111.15	78.95
Gemmiza 9	46.00	153.50	29.90	21.00	51.45	41.73	81.75	114.35	78.05
Gemmiza 10	35.30	101.50	27.45	19.95	55.30	38.62	79.95	111.95	69.50
Beni Sweif 1	32.87	102.25	25.30	21.00	47.15	38.95	80.05	111.20	69.50
Beni Sweif 3	29.17	85.00	25.70	21.85	43.95	35.80	80.45	110.95	70.25
Sohag 2	28.50	95.25	24.10	20.40	39.70	32.61	77.30	111.10	77.75
Sohag 3	35.51	111.50	25.80	21.15	44.15	36.39	78.50	111.85	72.95
Line3Nubaria	46.50	138.00	32.25	24.70	55.20	37.39	81.80	115.35	69.75
LSD(0.05)	3.81	9.65	2.7	0.82	4.86	2.10	0.83	1.58	2.57

GY= grain yield, BY= biological yield, TN= tillers number/pot, SP= spikes number/pot, KS= kernels number/spike, 1000-KW= 1000- kernels weight, DH= days to heading, DM= days to maturity, PH= plant height. LSD= least significant difference.

Cultivars Effects:

Depending on cultivars means over all salinity treatments (Table 4), Line3 Nubaria and Gemmiza 9 were significantly higher than the other cultivars giving grain yield of 46.50 and 46.0 g/pot, respectively. Whereas, Beni Sweif 3 and Sohag 2 illustrated the lowest grain yield (29.17 and 28.50 g/pot, respectively). Line3 Nubaria produced the greatest number of tillers/pot and number of spikes/pot (32.25 and 24.70, respectively). Giza168, Gemmiza 10, and Line3 Nubaria had the highest number of kernels/spike (55.04, 55.30, and 55.20, respectively), while Sohag 2 had the lowest (39.70). The maximum 1000-kernel weight (46.69 g) was measured for Gemmiza 7 and maximum biological yield (153.50 g/pot) was recorded for Gemmiza 9 (Table 4). Days to heading were the lowest for Giza 168 (74.85 days) and were the highest for Line3 Nubaria and Gemmiza 9 (81.8 and 81.75 days, respectively). Days to maturity were the highest for Sids 1, Gemmiza 9 and Line3 Nubaria (113.45, 114.35, and 115.35 days, respectively). Finally, Gemmiza 7 and Gemmiza 9 were the tallest cultivars (78.95 and 78.05 cm, respectively), at the same time Sakha 93 was the shortest (68.35 cm).

Salinity x Cultivars interactions:

Salinity x cultivars interactions were significant for grain yield, biological yield, number of tillers/pot, number of spikes/pot, number of kernels/spike, 1000-kernels weight , days to heading , and days to maturity (Tables 5 and 6). The data of salinity x cultivars interactions indicate that, for each cultivar under this study increasing salinity of irrigation waters from 0.5 to 18.8 dS/m decreased all characters of wheat cultivars. On the other hand, grain yield of Line3 Nubaria and Gemmiza 9 were the greatest under non-saline conditions giving 75.2 and 67.9 g/pot, respectively. At saline irrigation water of 18.8 dS/m Beni Sweif 1, Beni Sweif 3, Sohag 2, and Sohag 3 provided the lowest grain yield production, although, grain yields of the other cultivars were statistically similar to one another. Moreover, Gemmiza 9 and Line3 Nubaria provided the highest biological yield ($p \leq 0.05$), while Beni Sweif 3 was the lowest in non-saline environment. In addition, Gemmiza 9 gave the highest biological yield at salinity level of (18.8 dS/m), while Beni Sweif 1, Beni Sweif 3, and Sohag 2 produced the lowest among the other cultivars (Table 5). Tillers number was the highest in Line3 Nubaria followed by Gimmiza 10 at the highest salinity level, while Sakha 93 was the lowest. The cultivars Sakha 93, Beni Sweif 3, and Line3 Nubaria offered the highest number of spikes/pot at non-saline conditions, while Line3 Nubaria produced the highest under high saline level (Table 5).

Moreover, Line3 Nubaria, Giza 168, and Gimmiza 10 produced the highest kernels /spike at the highest salinity level, whereas Sakha 93 gave the lowest (Table 6). Similarly, 1000-kernel weight was the lowest for Sids 1, Beni Sweif 3, Sohag 2, and Sohag 3 at the highest salinity levels (18.8 dS/m) , while the differences between the remaining cultivars were not consistent and did not reach the 5% levels of significance. Sakha 93 reached to heading earlier than all other cultivars at the highest salinity level. Sakha 94, Gemmiza 7, and Beni Sweif 3 were matured more rapidly at non- saline condition, in addition there were no significant differences among cultivars at high salinity levels (Table 6).

Salt tolerance among cultivars:

The absolute yield of the wheat crop on saline soils is one of the criteria for appraising salt tolerance. On this basis, Beni Sweif 1, Beni Sweif 3, Sohag 2, and Sohag 3 provided the lowest grain yield at the highest salinity level compared to the other cultivars (Table 5) and there were no significant differences between the remaining cultivars under this study.

Table 5. Means of grain yield, biological yield, tillers number, and spikes number of 12 wheat cultivars under 5 salinity treatments.

Cultivars	Salinity levels (dS/m)					Salinity levels (dS/m)				
	0.5	4.7	9.4	14.0	18.8	0.5	4.7	9.4	14.0	18.8
	Grain yield (g/pot)					Biological yield (g/pot)				
Sakha 93	64.37	45.25	35.25	31.90	31.20	172.50	98.75	83.75	88.75	88.75
Sakha 94	61.75	49.27	42.90	27.57	27.65	166.25	111.25	103.75	97.50	91.25
Sids 1	62.90	49.47	38.65	33.00	24.80	176.25	160.00	117.50	93.75	86.25
Giza 168	51.30	41.00	41.12	34.95	33.02	145.00	111.25	105.00	85.00	87.50
Gemmiza 7	53.37	47.87	35.85	29.85	25.30	150.00	121.25	102.50	83.75	77.50
Gemmiza 9	67.90	53.42	45.17	34.13	29.35	235.00	141.25	157.50	112.50	121.25
Gemmiza 10	48.32	43.82	30.70	28.05	25.60	133.75	108.75	92.50	88.75	83.75
Beni Sweif 1	51.42	36.77	33.65	28.42	14.05	141.25	101.25	115.00	91.25	62.50
Beni Sweif 3	45.32	30.65	29.80	22.05	18.00	120.00	85.00	81.25	75.00	63.75
Sohag 2	50.02	38.60	23.72	15.62	14.50	146.25	111.25	80.00	75.00	63.75
Sohag 3	56.42	45.87	28.17	26.75	20.32	160.00	120.00	101.25	102.50	73.75
Line3Nubaria	75.20	46.00	43.05	36.62	31.60	212.50	131.25	135.00	112.50	98.75
LSD(0.05)			9.43					23.88		
	Tillers number/pot					Spikes number/pot				
Sakha 93	31.25	24.25	20.00	24.00	21.25	30.00	22.50	17.25	17.25	16.50
Sakha 94	29.50	26.50	25.00	27.00	25.00	24.75	21.75	19.50	21.25	19.50
Sids 1	29.25	26.50	26.75	27.25	24.75	26.50	21.75	22.00	19.50	18.75
Giza 168	26.50	23.50	30.75	23.00	24.25	24.25	21.25	20.00	18.00	18.25
Gemmiza 7	25.75	24.25	22.00	19.00	22.25	21.25	20.25	15.50	14.50	15.50
Gemmiza 9	28.50	26.00	29.25	26.25	24.50	25.25	21.75	21.00	19.00	18.00
Gemmiza 10	26.25	27.25	26.50	30.00	27.25	22.75	21.50	18.75	18.25	18.50
Beni Sweif 1	28.25	23.00	26.75	26.00	22.50	25.50	21.50	19.50	19.75	18.75
Beni Sweif 3	32.75	21.75	25.00	24.50	24.50	29.00	19.25	21.75	19.25	20.00
Sohag 2	26.25	26.25	21.00	21.75	25.25	23.00	23.25	18.00	18.25	19.50
Sohag 3	27.00	27.50	25.00	25.75	23.75	26.00	22.75	19.75	17.75	19.50
Line3Nubaria	40.25	32.00	31.75	27.75	29.50	29.50	26.25	25.25	19.25	23.25
LSD(0.05)			5.72					2.02		

When cultivars were compared based on grain yield production under saline conditions as a percent of maximum yield under non-saline control conditions or relative salt tolerance, it was found that Giza 168 had the highest relative yield (64%) among the other cultivars and had the lowest reduction percentage in grain yield (36%) at salinity level of 18.8 dS/m (Figure 1). At the same time, Gemmiza 10 and Sakha 93 were next to Giza 168 in their salt tolerance giving relative yields of 53 and 48 %, respectively, and had reduction percentages of 47 and 52 %, respectively, compared to the control treatment. Whereas, Beni Sweif 1, Sohag 2, and Sohag 3 produced the lowest relative yields among the other cultivars (27, 29, and 36 %, respectively), and the yield reduction percentage at the highest salinity level were the greatest (73, 71, and 64 %, respectively). Means of C_{50} (salinity of saturation extract in dS/m at which the grain yield of wheat cultivars was reduced by 50%) were 16.11, 16.79, 15.83, 28.8, 18.91, 16.01, 20.86, 14.54, 15.68, 10.80, 12.48, and 14.19 dS/m for Sakha 93, Sakha 94, Sids 1, Giza 168, Gemmiza 7, Gemmiza 9, Gemmiza 10, Beni Sweif 1, Beni Sweif 3, Sohag 2, Sohag 3, and Line3 Nubaria, respectively. Once more, the data indicate that Giza 168, Gemmiza 7 and Gemmiza 10 were the most salt tolerance, whereas the cultivars Sohag 2 and Sohag 3 were the most salt sensitive.

Table 6. Means of kernels number/ spike, 1000-kernels weight, days to heading, days to maturity of 12 wheat cultivars under 5 salinity treatments.

Cultivars	Salinity levels (dS/m)					Salinity levels (dS/m)				
	0.5	4.7	9.4	14.0	18.8	0.5	4.7	9.4	14.0	18.8
	Kernels number/spike					1000-kernels weight				
Sakha 93	61.25	53.25	49.75	48.75	36.75	48.87	47.28	36.64	38.46	31.94
Sakha 94	62.25	58.25	50.00	52.75	43.50	46.98	43.53	39.70	33.64	33.33
Sids 1	51.50	53.75	55.25	44.25	49.75	46.02	43.76	38.71	34.47	29.71
Giza 168	62.25	61.25	53.00	50.00	50.50	41.12	39.59	38.66	34.34	30.83
Gemmiza 7	55.50	48.25	51.00	49.50	45.00	53.89	50.31	47.93	45.22	36.10
Gemmiza 9	55.25	54.25	53.75	50.00	44.00	53.79	44.91	42.04	32.85	35.04
Gemmiza 10	60.75	59.25	55.00	49.75	51.75	49.75	44.35	37.40	30.29	31.34
Beni Sweif 1	47.75	52.75	43.00	48.50	43.75	51.76	38.88	38.94	33.75	31.42
Beni Sweif 3	47.25	42.75	46.75	45.25	37.75	43.46	39.00	36.19	30.47	29.88
Sohag 2	44.00	41.75	40.50	37.00	35.25	39.89	37.61	34.00	29.11	22.46
Sohag 3	49.25	51.50	50.50	35.25	34.25	45.32	43.68	38.12	27.41	27.46
Line3Nubaria	63.75	59.00	49.75	51.25	52.25	42.77	41.71	38.78	32.65	31.03
LSD(0.05)			12.02					5.19		
	Days to heading					Days to maturity				
Sakha 93	76.8	75.0	76.0	76.3	75.3	121.0	109.5	107.7	108.7	108.7
Sakha 94	80.5	80.5	80.3	79.3	78.3	116.5	109.5	108.7	108.5	108.0
Sids 1	80.8	80.3	79.8	79.8	78.0	120.7	116.7	111.7	108.5	109.5
Giza 168	74.8	73.5	74.8	75.3	76.0	119.7	109.7	109.5	107.7	107.7
Gemmiza 7	76.8	78.3	78.0	77.5	76.3	116.0	113.0	110.7	107.5	107.5
Gemmiza 9	83.3	82.8	82.5	81.3	79.0	122.5	115.5	112.0	112.0	109.7
Gemmiza 10	81.3	80.3	80.3	80.0	78.0	122.2	111.7	109.0	109.2	107.5
Beni Sweif 1	80.0	80.0	80.0	79.5	79.5	117.0	112.0	109.0	109.5	108.5
Beni Sweif 3	81.5	80.3	80.3	79.3	78.0	115.0	113.5	109.2	108.7	108.2
Sohag 2	78.8	77.5	76.5	76.5	76.0	118.2	110.0	109.7	108.7	108.7
Sohag 3	79.0	78.5	78.5	78.5	77.5	119.7	113.5	109.2	108.5	108.2
Line3Nubaria	84.5	82.5	82.0	80.8	79.5	122.5	114.7	118.7	111.0	109.7
LSD(0.05)			2.06					3.91		

Previous studies have shown that high yielding wheat cultivars are more salt sensitive to stress than cultivars with low yield potential. In this context, Gemmiza 9 and Line3 Nubaria, for instance, produced the highest yield potential on non-saline soil (Table 5), but in the same time were comparatively lower in salt tolerance. On the contrary, Giza 168, Gemmiza 7, and Gemmiza 10 had the highest salt tolerance , indicated by C_{50}, but they produced relatively lower yield potential at non-saline treatments. Moreover, Sohag 1 and Sohag 2 had the lowest yield potential at non-saline conditions and were the most salt sensitive. Thus, it would seem that vigor may be a more important plant characteristic for salt- affected growing regions than salt tolerance (Shannon, 1985). However, the importance of improving both salt tolerance and high yield needs to be recognized in any selection and breeding program. This strategy makes the evaluation and selection become very difficult, and might create a problem in cultivars selection for salt tolerance.

Salt tolerance of the used wheat cultivars also indicates that the cultivars Sohag 2, and Sohag 3 were the most salt sensitive at both germination and maturity stage. This observation was not found for the remaining cultivars. The results are consistent with those found by earlier work initiated in bread wheat (Ashraf and McNeilly,1998; Francois et al.,1986), in durum wheat (Almansouri et al., 2001), and in barley (Norlyn and Epstein, 1982). If one assumes that the soluble salts concentrations of soil solution at field capacity is about twice that of a saturated-soil extract, the equivalent C_{50} for grain yield expressed on the basis of soil water salinity E_{sw} would be twofold of the abovementioned values (U.S. Salinity Laboratory Staff , 1954). On this basis, the results suggest that the wheat cultivars under study were less tolerant to salinity at germination than when salt stress was imposed during seedling stage.

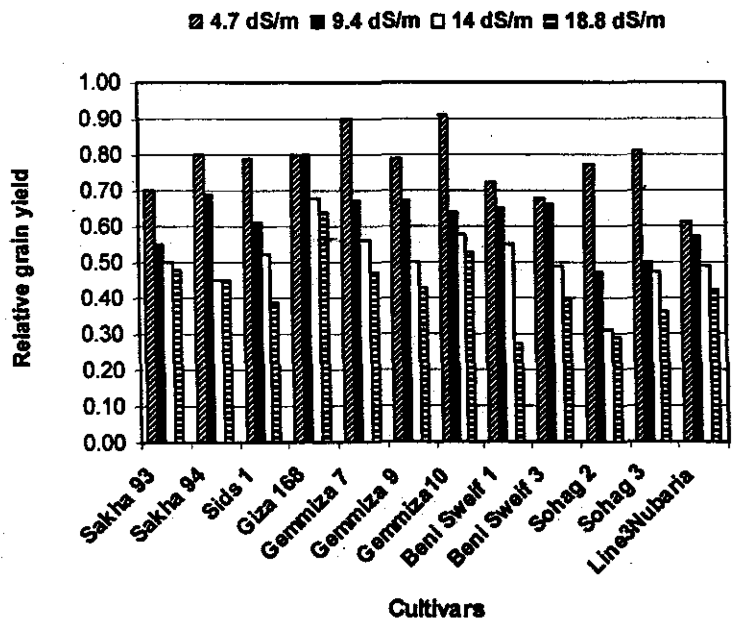

Figure 1. Relative salt tolerance of grain yield of 12 wheat cultivars under different salinity levels.

REFERENCES

Abul-Halim, R. K., H. M. Salih, A. A. Ahmed, and A.M. Abdul-Rahem. 1988. Growth and development of maxipak wheat as affected by soil salinity and moisture levels. Plant and Soil. 112: 255- 259.

Almansouri, M. and J.M. Kinet, S. Lutts .2001. Effect of salt and osmotic stresses on germination in durum wheat (*Triticum durum* Desf.). Plant and soil. 231: 245-256.

Ashraf, M. and T. McNeilly. 1998. Variability in salt tolerance of nine spring wheat cultivars. J. Agron.Crop. Sci. 160: 14-21.

Barakate, M. A., S.I. Fakhry and M. A. Khalil . 1970. Interaction effects of salinity of the soil and nitrogen fertilizer on wheat yield of grain and protein. J. Soil Sci., UAR. Vol. 10: 169-185.

El-Haddad, E. H., M.A. Amer, and M. A. Moustafa.1993. Effect of salinity on growth yield of three cultivars grown in calcareous soil. Menofiya J. Agric. Res. 18(3): 1669-1683.

Francois, L. E., E. V. Mass, Mass, T. J. Donvan, and V. L. Youngs. 1986. Effect of salinity on grain yield and quality, vegetative growth, and germination of semi-dwarf and durum wheat. Agron. J. 78: 1053-1058.

Francois, L. E., T. J. Donvan, E. V. Mass, Mass, and G. L. Rubenthaler. 1988. Effect of salinity on grain yield and quality, vegetative growth, and germination of triticae. Agron. J. 80:642-647.

Gawish, Sh. M., A. F. El-Leboudi, S. M., Abdel- Aziz and M. R. M. Ahmad. 1999. Studies on salt tolerance of certain wheat varieties: I. Evaluation studies for salt tolerance and growth behavior of plants grown under saline conditions. Egypt J. Soil Sci. 39 (4): 437-450.

Greenway, H. and R. Munns (1980). Mechanism of salt tolerance in non-halophytes. Ann. Rev. Plant Physiol.31:149-190.

Hanna, N. S., Sabry, S. R. S., M. M. Khodier and M. Kh. Moshref .1999. Scales for measuring wheat (*triticum Asetivum* L.) salinity tolerance in pot and field Experiments. Annals Agric. Sci., ain Shams Univ., Cairo, 44(22), 573-587.

Kaddah, M. T., and J. D. Rhodes. 1975. Salt and water balance in valley, California. Soil Sci. Soc. Am. J. 40:93-100.

Kingsbury, R. W. and E. Epstein. 1984. Selection for salt resistance spring wheat. Crop Sci. 24, 310-314

Maguire, J.D. 1962. Speed of germination-aid in selection and evaluation for seedling emergence and vigor. Crop Sci. 2: 176-177.

Mass, E.G., and G. J. Hoffman. 1977. Crop salt tolerance. Current assessment. J. irrigation. Drainage. Division. ASCE, 103: 115-134.

Munns, R. and A. James. 2003. Screening methods for salinity tolerance: A case study with tetrapolid wheat. Plant and Soil, 253: 201- 218.

Norlyn, J. D. and E. Epstein. 1982. Barley production: irrigation with sea water on coastal soil. In Biosaline Research: A look to the future. Ed.A. San Pietro,pp525-529. Plenum, New York

Omar, M. S. and S. I. Ghwail .1991. Response of new four Egyptian wheat cultivars (*Triticum aestivum* L.) to irrigation with diluted sea-water. Com. Sci& Dev. Res. 33: 231- 247.

Roundy, B. A., J. A. Young, and R. A. Evans. 1983. Germination of basin wildrye and tall wheatgrass in relation to osmotic and matric potential. Agron. J. 77: 129-135.

SAS Institute Inc.1987. SAS/STAT guide for personal computers. Version 6 ed., Cary, NC

Shalaby, E.E., E. Epstein and C. O. Oulset. 1993. Variation in salt tolerance among some wheat and triticae genotypes. J. Agron. Crop Sci ,171: 298- 308.

Shannon, M. C. 1985. Principles and strategies in breeding plants for higher salt tolerance. Plant & Soli. 89: 227- 241.

U.S. Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils. USDA Handb.60. US Government Printing Office, Washington, DC.

Van Genuchten, M. Th. 1983. Analyzing crop salt tolerance data: Model description and users manual. Res. Report No. 120. U.S. Department of Agric., U. S. Laboratory, Riverside, CA.

الملخص العربى

التغيرات فى التحمل للملوحة بين ١٢ صنف من اصناف القمح المصرى

السيد حسن الحداد [١] ـ مصطفى عزب مصطفى [٢]

١ معمل بحوث الأراضى الملحية والقلوية- معهد بحوث الأراضى والمياة والبيئة

٢ قسم بحوث القمح- معهد بحوث المحاصيل الحقلية- مركز البحوث الزراعية

زيادة انتاجية القمح وخاصة تحت الظروف الملحية يعتبر من الأهداف الهامة المطلوب تحقيقها فى الأراضى المروية فى مصر. اجريت تجربتين لدراسة التغيرات فى التحمل النسبى للملوحة فى مرحلة الأنبات ومرحلة النضج على ١٢ صنف من الأصناف المحلية.وقد اشتملت المعاملات على خمسة تركيزات ملحية (٠,٥، ٤,٧، ٩,٤، ١٤، ١٨,٨ ديسيسمتر/ م) تم تحضيرها باستخدام أملاح ص كل و كاكل٢ بنسبة ٢ : ١ على أساس الوزن. أوضحت الدراسة ان أضافة المعاملات الملحية لم تؤثر معنويا على نسبة الأنبات ومعدل الأنبات (نسبة الأنبات/ يوم) حتى تركيز ٩,٤ ديسيسمتر/ م. وبصرف النظر عن معاملات الملوحة فان أعلى أنبات قد تم تسجيلة للصنف سخا٩٤ يلية سخا٩٣ ثم جيزة١٦٨

بينما كانت أقل ما يكون في أصناف بني سويف٣ وبني سويف ١ . وجد ان نسبة الانبات بين الأصناف كانت تختلف باختلاف تركيز الأملاح المستخدمة في مياة الري، فالأصناف سخا٩٤ وسخا٩٣و نوبارية٣ وجد انهم أعلى الأصناف في التحمل للملوحة في مرحلة الأنبات ، بينما كانت أصناف بنى سويف١ وبنى سويف٣ وسوهاج٢ و سوهاج٣ أقل الأصناف في تحملها للأملاح في مرحلة الأنبات. في مرحلة تمام النضج وجد انة بصفة عامة ان زيادة تركيز الأملاح حتى ١٨,٨ ديسيمتر/ م يؤدى الى نقص معنوى فى محصول الحبوب،عدد الأفرع/ أصيص ،عدد السنابل/ أصيص ، عدد الحبوب/ سنبلة ، وزن ١٠٠٠ حبة ، عدد الأيام حتى تكون السنابل ، عدد الأيام حت النضج ، أطوال النباتات. بغض النظرعن المعاملات الملحية أعطت أصناف نوبارية٣ ، جميزة٩ أعلى محصول للحبوب بينما بنى سويف٣ وسوهاج٢ أعطت أقل الأصناف. وكانت نوبارية٣ الأعلى في عدد الأفرع/ أصيص وعدد السنابل/ أصيص في حين كان أعلى قيمة في وزن ١٠٠٠ حبة في جميزة٧ وأعلى محصول حيوى في جميزة٩ . وأخيرا كان جميزة٧ وجميزة ٩ أطول الأصناف وسخا٩٣ وبنى سويف١ الأقصر. جميز١٦٨ اعطت أعلى محصول حبوب نسبى تحت أعلى مستوى للملوحة (١٨,٨ ديسيمتر/ م) مقارنة بباقى الأصناف تحت الدراسة يليه جميزة١٠ و سخا٩٣ ، بينما أعطت أصناف بنى سويف١ وبنى سويف٣ وسوهاج٢ و سوهاج٣ أقل محصول نسبى وأعلى نسبة نقص في المحصول مع زيادة الملوحة. على أساس C_{50} (ملوحة مستخلص الأرض المشبعة التى عندها يحدث نقص في محصول الحبوب بنسبة ٥٠ %) فان جيزة١٦٨ ، جميزة٧ ، جميزة١٠ أعلى الأصناف في التحمل للملوحة بينما كان سوهاج٢ و سوهاج٣ الأكثر حساسية للملوحة. على اى حال فان انتاجية القمح تحت الظروف الملحية تتطلب ان يكون الصنف ذو انتاجية عالية تحت الظروف الغير ملحية و يعطى أقل نقص في محصول الحبوب مع زيادة الملوحة.