Evaluation of Some Egyptian Bread Wheat (*Triticum aestivum*) Cultivars under Salinity Stress

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ABSTRACT

The aim of this study was to determine salinity stress tolerance of sixteen Egyptian local wheat cultivars, using three salinity levels. These cultivars were grown in pots under greenhouse conditions, and subjected to three salinity levels (tap water or control, 4000 ppm and 8000 ppm). Factorial experiment in CRD design with three replicates was applied. Some agronomical (plant height, number of days to heading, number of spikes/pot, number of grains/spike, thousand grain weight and grain yield) and physiological traits (Na^+, K^+ concentrations and K^+/Na^+ ratio) were determined. The results revealed that there were significant variations with all agronomical and physiological traits, as influenced by salinity levels, cultivars and the interaction between them, except number of grains/spike which was not affected by the interaction. The results also showed that the wheat cultivars responded differently either within the same, or among, the salinity levels for all studied traits except number of grains/spike but in general, all studied agronomical traits were decreased with the increasing of salinity levels. The cultivars Sahel 1 and Sakha 93 recorded the highest value of GY in high salinity level (8000 ppm) (35.20 and 35.06 g/pot, respectively) with the lowest percent of reduction (35.28% and 34.54% respectively). Na^+ concentration increased, while K^+ content decreased with increasing salinity levels. K^+/Na^+ ratio was decreased under highl salinity levels. Sids 1 had the lowest Na^+ raise percent (70.23%) and the highest K^+/Na^+ ratio (0.46) with 8000 ppm, followed by Sakha 93 (90.64 %) and (0.44). Results of SSI revealed that there were variations among the 16 investigated wheat cultivars in their response to salinity stress. Cultivars Sakha 93 and Sahel 1 recorded the lowest value of SSI (0.69 and 0.71 respectively). Correlation between GY and K^+, K^+/Na^+ recorded significantly positive relation (r =0.61 and 0.51 respectively). In contrast correlation between GY and SSI recorded significantly negative relation (r = -0.92). In conclusion, the results of this study suggest that wheat genotypes Sakha 93 and Sahel 1 can be selected to grow under salinity levels of irrigation water. The genotypes Sids 1, Shandweel 1, Misr 2 and Misr 1 were moderate tolerant to salinity stress. in contrast, the cultivars Gemmiza 9 and Gemmiza 11 were the most sensitive cultivars. K^+/Na^+ ratio and SSI are good parameters and they can be used as useful selection criteria for screening the salt tolerance in terms of grain yield among genotypes.

Key words: Wheat, Salinity, Grain yield, K^+/Na^+ ratio, SSI.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important and the most grown cereal crop. It is the staple food of many countries including Egypt. Its importance is derived from many properties and uses of its kernels, which make it a staple food for more than one third of world's population. Moreover, its straw is used as animal feed and also in manufacturing paper (Milad *et al*., 2013). Bread wheat is a major food crop in most of the countries of the world which suffer from saline soils, and therefore increasing salinity tolerance in bread wheat is necessary (Tuna *et al*., 2008).

Wheat is the most important and widely adapted food cereal in Egypt. However, Egypt produces only 40% of its annual domestic demand for wheat (Salam, 2002).Therefore, it is necessary to increase wheat production in Egypt by raising the wheat grain yield.

Salinization is a major problem especially in arid and semiarid areas. Egypt is one of the countries that suffer severe salinity problems (Al-Naggar *et al*., 2015). Expansion of wheat production in Egypt is a necessity to supply the demands of a rapidly growing population and reduce the dependence on importing wheat (Milad *et al*., 2016). Therefore, wheat cultivation was extended to the newly reclaimed lands to increase the production to overcome the gap between consumption and production. But wheat production in the newly reclaimed lands is below average production of Delta and valley because some regions in the newly reclaimed lands are affected by some adverse environmental stresses affecting plant growth and productivity such as limited water supply,

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low soil fertility and soil salinity (Allakhverdiev *et al*., 2000). In bread wheat germplasm, salinity is considered a major factor in limiting plant growth and crop productivity (Rus *et al*., 2000). Chinnusamy *et al*. (2005) reported that soil salinity is an important and major abiotic stress constraint that limits crop productivity and quality. Obviously, the most efficient way to increase wheat yield in Egypt is to improve the salt tolerance of wheat genotypes (Epstein *et al*., 1980; Shannon, 1997 and Pervaiz *et al*., 2002) because this way is much less expensive for poor farmers in developing countries compared with other management practices (e.g. leaching salt from the soil surface etc., (Qureshi and Barrett-Lennard, 1998)). Munns *et al*. (2006) reported that wheat genotypes show large variation for salinity stress tolerance, therefore increasing salt tolerance for wheat genotypes is one of the cheap methods to spread wheat growing in these areas.

The effect of high salinity on plant can be observed at the whole plant level in terms of plant death and /or decreased productivity (Parida *et al*., 2004). Grain yield reducing effect by salinity stress varies from genotype to another. Therefore, grain yield is frequently used in crops such as wheat as the main criteria for salt tolerance (Jafari-Shabestari *et al*., 1995). The physiological traits (Na^+ & K^+: Na^+ ratio) and salinity indices (SSI & STI) were good indices for screening salt tolerant cultivars (Goudarzi and Pakniyat, 2008).

The present investigation was carried out to determine salinity stress tolerance of sixteen Egyptian local wheat cultivars, using three salinity levels.

MATERIALS AND METHODS

The present investigation was conducted in Alkaline and Salinity lab, Soil, Water and Environment Research Institute, Agricultural Research Center, Ministry of Agricultural, Egypt in 2012/2013 season.

Plant material

Sixteen bread wheat cultivars (*Triticum aestivum* L.) were used in this study. These cultivars were obtained from Wheat Research Department, Field Crops Research Institute, Agricultural Research Center, Ministry of Agricultural. Names and pedigree of those cultivars are presented in (Table 1).

Salinity Evaluation

The cultivars were compared at 3 salinity levels of irrigation water using NaCl, tap water (control), 4000 and 8000 ppm. Ten seeds were planted in plastic pots, 35 cm in diameter and 30 cm in depth, filled with sandy soil. The pots were irrigated using tap water until germination (15 days from sowing). After germination five plants were retained in each pot and the pots were subjected to salinity treatments.

Agronomical traits

Six agronomical traits were recorded as an average for each pot. These traits were plant height (PH) in cm, number of days to heading (DH),

Table 1. Names and pedigree of sixteen cultivars of bread wheat used in the study

Cultivars	Pedigree
Sakha 93	Sakha 92/TR 810328 S 8871-1S-2S-1S-0S
Sakha 94	Opata/Rayon//Kauz.
Misr 1	OASIS/SKAUZ//4*BCN/3/2*PASTOR. CMSS00Y01881T -050M-030Y-030M-030WGY-33M-0Y--0EGY
Misr 2	SKAUZ/BAV92. CMSS96M03611S-1M-010SY-010M-010SY-8M-0Y-0EGY
Giza 168	MIL/BUC//Seri CM93046-8M-0Y-0M-2Y-0B
Giza 171	Sakha 93 / Gemmiza 9 S.6-1GZ-4GZ-1GZ-2GZ-0S
Sahel 1	N.S.732/Pim/Vee"S"
Shandweel 1	SITE//MO/4/NAC/TH.AC//3*PVN/3/MIRLO/BUC. CMSS93B00567S-72Y-010M-010Y-010M-0HTY-0SH.
Sids 1	HD2172/Pavon “S”//1158.57/Maya 74”S” Sd46-4Sd-2Sd-1Sd-0Sd
Sids 12	BUC//7C/ALD/5/MAYA74/ON//1160.147/3/BB/GLL/4/CHAT"S"/6/MAYA/VUL//CMH74A.630/4*SXSD70964SD-1SD-1SD-0SD
Sids 13	KAUZ"S"//TSI//TSI/SNB"S"ICW94-0375-4AP-2AP-030AP-0APS-3AP-0APS-050AP-0AP-0SD.
Gemmiza 7	CMH74 A. 630/5x//Seri 82/3/Agent CGM 4611-2GM-3GM-1GM-0GM
Gemmiza 9	Ald”S”/Huac”S”//CMH74A.630/5x CGM4583-5GM-1GM-0GM
Gemmiza10	Maya 74 “S”/On//1160-147/3/Bb/4/Chat”S” /5/ctow.
Gemmiza 11	B0W"S"/KVZ"S"//7C/SERI82/3/GIZA168/SAKHA61.CGM7892-2GM—1GM-2GM-1GM0GM
Gemmiza 12	OTUS/3/SARA/THB//VEE .CCMSS97Y00227S-5Y-010M-010Y-010M-2Y-1M-0Y-0GM

number of spikes/pot (NSP), number of grains/spike (NGS), thousand grain weight (TGW) in g and grain yield (GY) in g/pot.

Physiological traits

At maturity, plant shoot was dried at 70 C^0 for 24h. The dried samples were ground into a fine powder using a mortar and pestle. Samples (1g) were washed by putting them into crucibles and placed in 600 C^0 electric furnace, for 4h, 5mL of 2N HCl were added to cooled ash samples, dissolved in boiling deionized water, filtered and made final volume to 50 mL. K^+ and Na^+ (mg/g) were measured using standard flame photometer procedure (Goudarzi and Pakniyat, 2008). The ratio K^+/Na^+ was calculated.

Stress susceptibility index (SSI) was calculated for the grain yield for each cultivar using the following formula (Fischer and Maurer, 1978):

$$SSI= \frac{1-\left(\frac{GYs}{GYp}\right)}{1-D}$$

Where GYs is the mean of cultivar under stress, Gyp is the mean of cultivar under control and D is the ratio of the overall mean of all cultivars under stress to the overall mean of all cultivars in control.

Statistical analysis

Analysis of variance (ANOVA) was performed for all measured traits (agronomical and physiological traits), according to Gomez and Gomez (1984), in order to test the significance of variance among genotypes, a factorial experiment in CRD design with three replicates was applied. Correlation analysis was done to determine the relation between grain yield and each of physiological traits and salinity index.

Data with numerical characters, were subjected to arcsine transformation prior to statistical analysis. Comparison among means was made via the least significant difference (L.S.D. methed). The data were analyzed using Statistical Analysis System ver 9.13 (2007).

RERSULTS AND DISCUSSION

The analysis of variance, was carried out for all agronomical and physiological traits. Table (2), pointed out that the analysis of variance, expressed a significant variation with all agronomical and physiological traits, as influenced by salinity levels, cultivars and the interaction between them, except number of grains / spike which was not affected by the interaction.

The obtained data and results for each of the nine analyzed traits, could be shown as follows:

I- Agronomical trait:

Data in Table (3) and Fig. (1) revealed that the wheat cultivars responded differently either within the same, or among, the salinity levels for all studied agronomical traits except number of grains / spike but in general, all studied agronomical traits (PH, DH, NSP, NGS, TGW and GY) were decreased with the increasing of salinity levels.

In focus to the grain yield, in general data revealed that the grain yield (GY), of all wheat cultivars was markedly significantly decreased with increasing the salinity levels. It is clear from Table (3) and Fig. (1), that the cultivars Sahel 1 and Sakha 93 recorded the highest value of GY in high salinity level (8000 ppm) (35.20 g/pot and 35.06 g/pot, respectively) with the lowest percent of reduction (35.28% and 34.54% respectively), while cultivar Gemmiza 11 gave the lowest value (17.79 g/pot) with the highest percent of reduction (58.69%), followed by Gemmiza 9 gave (19.66 g/pot) with 58.15% of reduction.

With regard to yield components, traits such as number of spikes per plant (the most important yield component), number of kernels per spike and one thousand kernel weight, all wheat cultivars decreased significantly with increasing salinity levels. For number of days to heading Sakha 93 was early heading under high salinity levels compared to control treatments. Highly significant reductions in grain yield, yield components and different yield parameters were noticed as a result of salinity stress. The cultivars Sakha 93 and Sahel 1 proved to be the tolerant cultivars under salinity condition. These results support the findings of several authors such as El-Emam (2004), Hassan *et al*. (2002), Bhatti *et al*. (2004), Kumar *et al*. (2012), Hamam and Negim (2014) and Ragab and Taha (2016). El-Hendawy *et al*. (2005) and Kandil *et al*. (2013) showed that the cultivar Sakha 93 ranked as one of the most tolerant wheat cultivars to salinity based on various growth parameters. 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). 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). Katerji *et al*. (2006) showed large differences in day number to heading were decreased by increasing salinity levels. Oraby *et al*. (2005) showed that the highest salinity level (200 mM NaCl) caused a significant decrease number of kernels/panicle.

Table 2. Analysis of variance for agronomical and physiological traits as influenced by salinity stress, wheat Cultivars and their interaction

S.O.V.	D.F.	Mean Squares								
		Plant Height (cm)	Number of Days to Heading	Number of Spikes / Plot	Number of Grains / Spike	Thousand Grains Weight (g)	Grain Yield (g)	Na^+ (mg/g)	K^+ (mg/g)	K^+/Na^+ Ratio
Salinity levels(A)	2	805.69**	4.83**	8.63**	7.19**	1175.73**	6955.94**	196.41**	24.41**	27.23**
Cultivars (B)	15	144.90**	0.36**	0.85**	0.91**	173.52**	320.53**	2.36**	1.65**	0.32**
AXB	30	9.07*	0.02**	0.04**	0.08	6.38**	9.36*	1.60**	0.51**	0.29**
Error	96	5.19	0.01	0.02	0.15	2.77	6.21	0.11	0.002	0.03

n.s: denote not Significant.

*,** ; denote Significant at 0.05 and 0.01 level of probability.

Table 3. Means of agronomical traits as influenced by the interaction between a salinity levels and genotypes

Traits	Plant Height (cm)					Number of Days to Heading					Number of Spike/Pot				
Cultivars	control	4000 ppm	R	8000 ppm	R	control	4000 ppm	R	8000 ppm	R	control	4000 ppm	R	8000 ppm	R
1- Sakha 93	72.67	67.67	6.88	63.67	12.38	84.67	81.33	3.94	77.00	9.06	23.00	19.33	15.96	13.00	43.48
2- Sakha 94	76.00	70.33	7.46	62.67	17.54	91.00	85.00	6.59	78.67	13.55	20.00	16.33	18.35	12.00	40.00
3- Misr 1	82.00	76.33	6.91	69.00	15.85	91.33	86.00	5.84	80.67	11.67	20.00	16.67	16.65	15.33	23.35
4- Misr 2	84.33	79.00	5.95	77.67	7.54	91.67	86.00	6.19	81.67	10.91	25.67	19.67	23.37	16.00	37.67
5- Giza 168	83.33	81.33	2.01	74.33	10.45	84.67	77.33	8.67	71.67	15.35	20.67	16.67	19.35	13.00	37.11
6- Giza 171	82.00	73.67	10.16	70.33	14.23	83.67	75.33	9.97	71.00	15.14	17.67	12.67	28.30	9.67	45.27
7- Sahel 1	73.67	71.33	3.18	64	13.13	87.67	83.67	4.56	80.00	8.75	21.33	18.67	12.47	16.67	21.85
8- Shandweel 1	74.67	72.33	3.13	68.33	8.49	86.67	83.00	4.23	79.67	8.08	23.00	18.33	20.30	15.67	31.87
9- Sids 1	82.33	80.00	2.83	77.00	6.47	90.00	86.33	4.08	81.33	9.63	22.00	17.00	22.73	14.67	33.32
10- Sids 12	79.33	76.00	4.20	73.00	7.98	82.67	75.00	9.28	67.67	18.14	19.00	15.33	19.32	13.67	28.05
11- Sids 13	81.67	76.33	6.54	72.33	11.44	88.33	80.67	8.67	73.33	16.98	19.67	14.00	28.83	12.33	37.32
12- Gemmiza 7	81.00	79.00	2.47	75.33	7.00	89.3	80.33	10.04	73.33	17.88	15.00	12.33	17.80	11.67	22.20
13- Gemmiza 9	78.33	75.00	4.25	73.00	6.80	87.67	81.00	7.61	74.67	14.83	20.33	15.00	26.22	14.00	31.14
14- Gemmiza 10	75.33	72.67	3.53	64.67	14.15	85.33	78.00	8.59	72.00	15.62	17.67	14.00	20.77	11.33	35.88
15- Gemmiza 11	80.33	79.33	1.24	77.67	3.31	82.67	76.67	7.26	70.67	14.52	14.67	11.33	22.77	9.33	36.40
16- Gemmiza 12	77.67	73.33	5.59	70.67	9.01	83.67	78.67	5.98	73.33	12.36	17.67	14.00	20.77	10.33	41.54
L.S.D. 0.05 (AxB)			2.60					2.21					1.29		
17- Sakha 93	55.00	51.33	6.67	46.00	16.36	50.33	45.13	10.33	41.77	17.01	53.56	46.69	12.83	35.06	34.54
18- Sakha 94	57.67	53.67	6.94	54.00	6.36	44.27	38.53	12.97	30.87	30.27	44.89	37.14	17.26	21.46	52.19
19- Misr 1	56.33	50.00	11.24	46.00	18.34	52.6	47.63	9.45	43.70	16.92	53.11	47.19	11.15	27.48	48.26
20- Misr 2	60.00	58.33	2.78	52.00	13.33	52.67	46.70	11.33	43.43	17.54	55.44	49.64	10.46	28.79	48.07
21- Giza 168	53.67	50.00	6.84	44.67	16.77	40.50	38.07	6.00	33.50	17.28	45.00	33.02	26.62	21.39	52.47
22- Giza 171	62.33	57.67	7.48	43.67	29.94	50.80	45.40	10.63	41.70	17.91	40.07	30.79	23.16	18.19	54.60
23- Sahel 1	68.00	63.67	6.37	52.33	23.04	50.10	45.30	9.58	43.33	13.51	54.39	47.76	12.19	35.20	35.28
24- Shandweel 1	60.33	58.67	2.75	51.33	14.92	52.50	48.10	8.38	46.27	11.87	51.66	44.73	13.41	27.51	46.75
25- Sids 1	69.00	64.67	6.28	59.00	14.49	55.40	51.10	7.76	45.63	17.64	54.13	47.13	12.93	29.28	45.91
26- Sids 12	59.67	56.00	6.15	50.33	15.65	43.87	39.86	9.14	33.30	24.09	43.48	35.12	19.23	20.23	53.47
27- Sids 13	60.33	58.67	2.75	50.00	17.12	46.00	39.23	14.72	34.17	25.72	41.34	31.55	23.68	18.95	54.16
28- Gemmiza 7	61.33	56.33	8.15	50.00	18.47	49.63	43.33	12.69	40.30	18.80	44.02	32.81	25.47	18.87	57.13
29- Gemmiza 9	50.67	45.00	11.19	39.00	23.03	45.90	40.77	89.61	36.87	19.67	46.98	33.51	28.67	19.66	58.15
30--Gemmiza10	60.00	52.33	12.78	50.33	16.12	47.37	38.53	18.66	34.97	26.18	44.91	33.71	24.94	19.12	57.43
31-Gemmiza11	57.00	51.67	9.35	42.67	25.14	51.53	42.43	17.66	39.90	22.57	43.06	33.74	21.64	17.79	58.69
32-Gemmiza12	62.33	53.00	14.97	43.67	29.94	46.33	36.43	21.37	31.3	32.44	43.04	34.28	20.35	19.24	55.30
L.S.D 0.05 (A×B)			0.44					1.90					2.85		

R: Reduction(%) of control

In addition, Guasmi *et al*. (2007) showed that salinity had significant effect reduced number of kernels per spike. 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. 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). The decrease in grain yield might be caused by the salinity, which induced reduction of photosynthetic capacity leading to less starch synthesis and accumulation in the grain (Turki *et al*., 2012). TKW also decreased in all 10 varieties and accessions regardless of the species. Also the variation in response to salt of the varieties and accessions was closely related to genetic diversity among these species (Turki *et al*., 2012).

II- Physiological traits

Data in Table (4) and Fig. (2) revealed that the wheat cultivars responded differently either within the same, or among, the salinity levels for all studied physiological traits. It is clear that the salinity levels had significant effects on Na^+, K^+ and K^+/Na^+ ratio of the wheat genotypes (Table 4 and Fig. 2). Na^+ concentration increased with increasing salinity levels, while K^+ content decreased with increasing salinity levels. K^+/Na^+ ratio decreased under highly salinity levels. In this study, Sids 1 had the lowest Na^+ raise percent (70.23%) and the highest K^+/Na^+ ratio (0.46) with 8000 ppm, followed by Sakha 93 (90.64 %) and (0.44) while Gemmiza 12 and Gemmiza 10 had the lowest K^+/Na^+ ratio (0.19 and 0.19). Genotypes Misr 1, Misr 2, Sahel 1 and Shandweel 1, 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 other tested genotypes with higher Na^+ content and lower K^+/Na^+ ratio may be considered as non-tolerant cultivars (Table 4). Our results agreed 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 non-tolerant cultivars under saline conditions. The high selectivity of K^+ is an important physiological mechanism of plant survival in saline environments. **(**Flowers and Hajibagheri, 2001). Therefore, using NaCl induced K^+ flux measurements as physiological ' marker' for salt tolerance may benefit wheat-breeding programmers (Tracey *et al*., 2008).

From the present study, it is evident that the cultivars with higher K^+ and lower Na^+ in their tissues produced higher grain yield, also a positive correlation was found between K^+ and growth and a negative relationship between growth and Na^+. These results were also reported by Munns and Rawson (1999), Munns *et al*. (2000), Flowers and Hajibagheri (2001) and Goudarzi and Pakniyat (2008).

Stress susceptibility index (SSI)

Salinity Susceptibility Index (SSI), has been measured according to Fischer and Maurer (1978). This index is an improvement over the simple expression of yield under stress as to a percent of yield under non-stress conditions.

According to that index, cultivars that have an index smaller than one (<1) are considered to be stress tolerant. On the other hand, cultivars that have stress index greater than one (>1) are susceptible.

Results of SSI calculations, shown in Table (5), revealed that there was a variation between the 16 investigated wheat cultivars in their response to salinity stress.

Cultivars Sakha 93 and Sahel 1 recorded the lowest value of SSI (0.69 and 0.71 respectively) so we can conclude that they are the highest salt tolerant genotypes, followed by Sids 1, Shandweel 1, Misr 2 and Misr 1 (ranged from 0.92 to 0.97). In contrast, Gemmiza 11 and Gemmiza 9 had the highest values for SSI (1.17 and 1.16 respectively) therefore, they are the lowest salt tolerant genotypes. The other genotypes recorded SSI ranged from 1.04 to 1.15. Hamam and Negim (2014) reported that, the mean SSI over two years appeared to be a suitable selection index to distinguish resistant genotypes. SSI has been widely used by researchers to identify sensitive and resistant genotypes (Clarke *et al*., 1992).

Table 4. Means of physiological traits as influenced by the interaction between a salinity levels and genotypes

Salinity levels / Cultivars	Na^+ Concentration					K^+ Concentration					K^+/Na^+ Ratio		
	Control	4000 ppm	R^1	8000 ppm	R^1	control	4000 ppm	R	8000 ppm	R	control	4000 ppm	8000 ppm
1- Sakha 93	2.35	3.34	42.13	4.48	90.64	3.81	2.75	27.82	1.98	48.03	1.62	0.82	0.44
2- Sakha 94	1.37	4.62	237.23	5.66	313.14	3.35	2.04	39.10	1.53	54.33	2.45	0.44	0.27
3- Misr 1	2.22	3.49	57.21	4.79	115.77	3.91	2.01	48.72	1.87	52.17	1.76	0.58	0.39
4- Misr 2	1.83	3.17	73.22	4.21	130.05	3.68	2.04	44.57	1.66	54.89	2.01	0.64	0.39
5- Giza 168	1.21	4.83	299.17	6.61	446.28	3.37	1.53	54.60	1.48	56.08	2.79	0.32	0.22
6- Giza 171	2.16	5.06	134.26	6.58	204.63	2.82	2.04	27.66	1.44	48.94	1.31	0.40	0.22
7- Sahel 1	2.50	3.99	59.60	5.24	109.60	3.33	1.95	41.44	1.92	42.34	1.33	0.49	0.37
8- Shandweel 1	1.99	3.70	85.93	5.45	173.87	2.35	2.14	8.94	1.87	20.43	1.18	0.58	0.34
9- Sids 1	2.99	3.39	13.38	5.09	70.23	4.30	2.73	36.51	2.35	45.35	1.44	0.81	0.46
10- Sids 12	1.63	5.87	260.12	6.82	318.40	3.53	1.60	54.67	1.53	56.66	2.17	0.27	0.22
11- Sids 13	1.73	4.56	163.58	6.65	284.39	3.33	1.68	49.55	1.63	51.05	1.92	0.37	0.25
12- Gemmiza 7	1.77	5.22	194.92	6.74	280.79	2.43	2.07	14.81	1.68	30.86	1.37	0.40	0.25
13- Gemmiza 9	1.77	4.64	162.15	6.91	290.40	2.50	1.76	29.60	1.48	40.80	1.41	0.38	0.21
14- Gemmiza 10	1.58	4.92	211.39	6.27	296.84	1.56	1.54	1.28	1.17	25.00	0.99	0.31	0.19
15- Gemmiza 11	1.68	4.90	191.67	5.97	255.36	2.31	1.74	24.68	1.53	33.77	1.38	0.36	0.26
16- Gemmiza 12	1.63	6.23	282.21	6.69	310.43	2.15	1.36	36.74	1.29	40.00	1.32	0.22	0.19
L.S.D 0.05 (A×B)			0.38					0.05				0.198	

R: Reduction (%) of control.
R^1: Raise (%) of control.

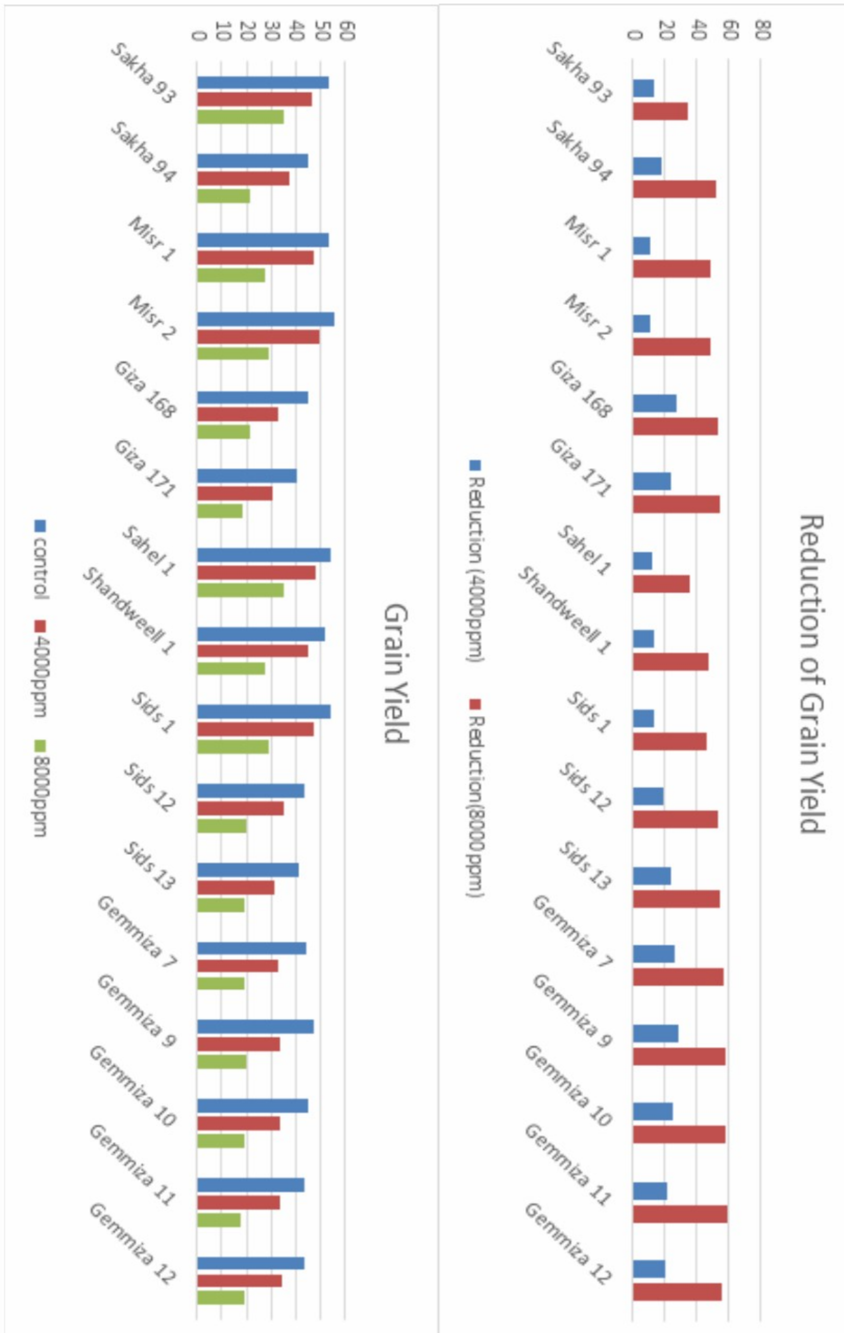

Fig.1. Means for grain yield as affected by the salinity levels and wheat cultivars and its reduction

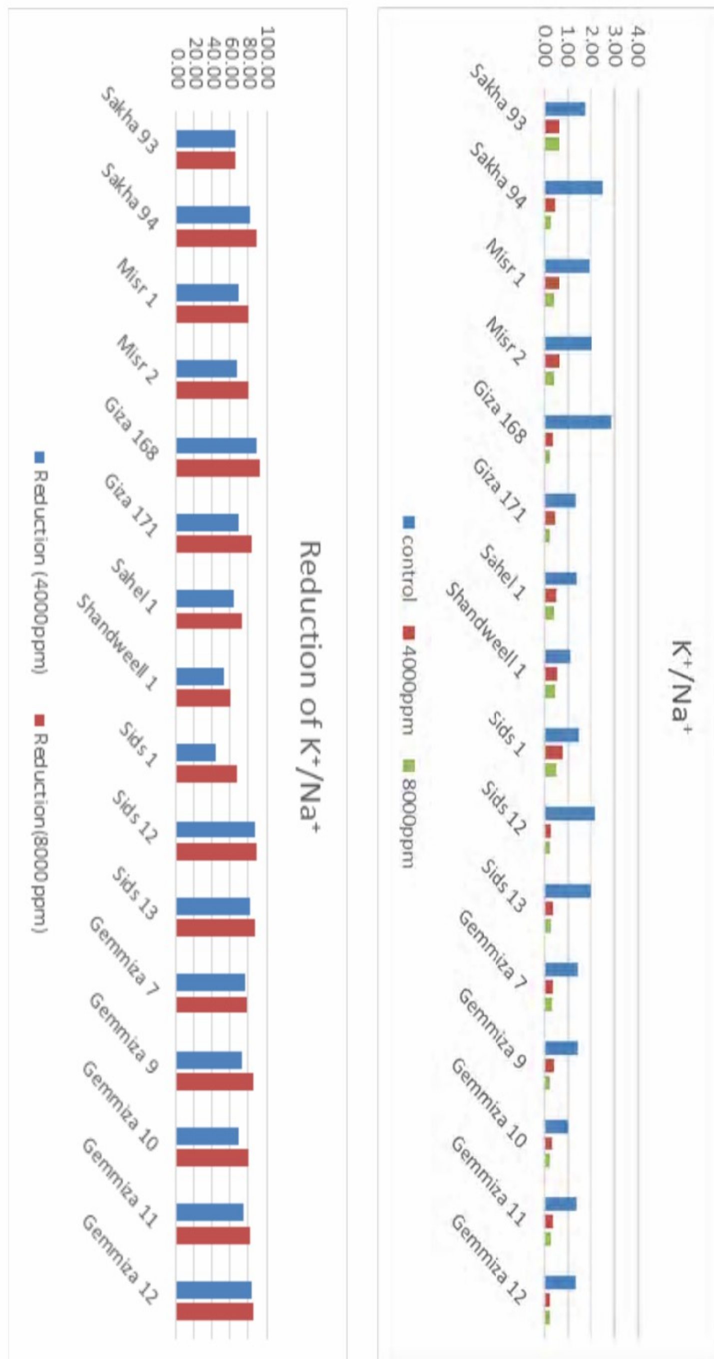

Fig.2. Means for K^+/Na^+ as affected by the salinity levels and wheat cultivars and its reduction

Table 5. SSI based on grain yield for wheat cultivars affected by salinity levels

Salinity levels / Cultivars	SSI
Sakha 93	0.69
Sahel 1	0.71
Sids 1	0.92
Shandweel 1	0.93
Misr 2	0.96
Misr 1	0.97
Sakha 94	1.04
Giza 168	1.05
Sids 12	1.07
Sids 13	1.08
Giza 171	1.09
Gemmiza 12	1.11
Gemmiza 7	1.14
Gemmiza 10	1.15
Gemmiza 9	1.16
Gemmiza 11	1.17

Correlation

Table (6) showed the correlation between GY, physiological traits and salinity index. Correlation between GY and K^+, K^+/Na^+ recorded significantly positive relation (r =0.61 and 0.51 respectively). In contrast correlation between GY and SSI recorded significantly negative relation (r = -0.92), these results revealed that K^+/Na^+ and SSI were good criterion for salinity tolerance in bread wheat.

Table 6. Correlation coefficients between grain yield, Na^+, K^+, K^+/Na^+ and salinity indices

	(1)	(2)	(3)	(4)	(5)
(1) Grain yield	-	-0.29	0.61**	0.51**	-0.92**
(2) Na^+	-	-	-0.61**	-0.84**	0.07
(3) K^+	-	-	-	0.91**	-0.54*
(4) K^+/Na^+	-	-	-	-	-0.35
(5) SSI	-	-	-	-	-

*,** : denote Significant at 0.05 and 0.01 level of probability, respectively.

CONCLUSION

The results of this study suggest that wheat genotypes Sakha 93 and Sahel 1 can be selecteded to grow under salinity levels of irrigation water. The genotypes Sids 1, Shandweel 1, Misr 2 and Misr 1 were moderate tolerant to salinity stress. In contrast, the cultivars Gemmiza 9 and Gemmiza 11 were the most sensitive cultivars. K^+/Na^+ ratio and SSI are good parameters and they can used as useful selection criteria for screening the salt tolerance in terms of grain yield among genotypes.

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الملخص العربي

تقييم بعض أصناف قمح الخبز المصرية (*Triticum aestivum*) تحت إجهاد الملوحة

مها أحمد جاد الله، سناء إبراهيم محمد ميلاد، ياسر محمد مبروك، أميره يوسف أبو يوسف ومحمد عادل جوده

كان هدف هذا البحث تقدير تحمل الإجهاد الملحى لـ ١٦ صنف مصرى محلى من القمح بإستخدام ٣ مستويات ملوحه. ثم تنمية هذه الأصناف فى أصص فى صوبة زجاجية وتمت معاملتها بثلاثة مستويات ملوحة (ماء الصنبور أوالكنترول و٤٠٠٠ و٨٠٠٠ جزء/مليون). تم إستخدام تجربة عاملية فى تصميم عشوائى كامل بإستخدام ثلاث مكررات. تم تقدير بعض الصفات المحصولية (إرتفاع النبات وعدد الأيام لطرد السنابل وعدد السنابل/أصيص وعدد الحبوب/سنبلة و وزن ١٠٠٠ حبه ومحصول الحبوب) والصفات الفسيولوجيه (تركيز الصوديوم Na^+ وتركيز البوتاسيوم K^+ والنسبة بين البوتاسيوم/ الصوديوم K^+/Na^+). أوضحت النتائج أن كل الصفات المحصولية والفسيولوجية قد تأثرت معنوياً بكل من مستويات الملوحة والأصناف والتفاعل بينهما فيما عدا صفة عدد الحبوب/سنبلة لم تتأثر بالتفاعل. أوضحت النتائج أيضاً أن أصناف القمح إختلفت فى درجة إستجابتها داخل المستوى الواحد أو بين المستويات المختلفة من الملوحة ولكن بصفه عامه كل الصفات المحصولية إنخفضت بزيادة مستوى الملوحة. الصنفين ساحل ١ وسخا ٩٣ سجلا أعلى قيمة لمحصول الحبوب مع المستوى العالى من الملوحة (٣٥,٢ و ٣٥,٠٦ جم/أصيص على التوالى) مع أقل نسبة إنخفاض (٣٥,٢٨ % و ٣٤,٥٤ % على التوالى). حدثت زيادة فى تركيز أيون الصوديوم Na^+ وإنخفاض فى تركيز أيون البوتاسيوم K^+ بزيادة الملوحة. نسبة K^+/Na^+ إنخفضت بزيادة مستوى الملوحة. الصنف سدس ١ سجل أقل نسبة زيادة فى تركيز أيون الصوديوم Na^+ (٧٠,٢٣ %) وأعلى نسبة K^+/Na^+ (٠,٤٦) مع مستوى ٨٠٠٠ جزء/ مليون وتبعه فى ذلك صنف سخا ٩٣ (٩٠,٦٤ %) و(٠,٤٤). نتائج SSI أوضحت أن هناك إختلافات بين الاصناف الستة عشر تحت الدراسة فى درجة إستجابتهم لإجهاد الملوحة.الصنفين سخا ٩٣ وساحل ١ سجلا أقل قيمة لـ SSI (٠,٦٩ و٠,٧١ على التوالى). تحليل الارتباط بين محصول الحبوب وتركيز البوتاسيوم K^+ ونسبة K^+/Na^+ سجل علاقة معنوية موجبة (r = ٠,٦١ و ٠,٥١ على التوالى). على العكس فإن العلاقة بين محصول الحبوب و SSI كانت معنوية سالبة (r = − ٠,٩٢). والخلاصة فإن هذه النتائج تفترض أن الصنفين سخا ٩٣ و ساحل ١ يمكن إنتخابهما لزراعتهما تحت المستويات العالية لملوحة مياه الرى. الاصناف سدس ١ و شندويل ١ ومصر ٢ ومصر ١ متوسطى التحمل لإجهاد الملوحه. وعلى العكس فإن الاصناف جميزة ٩ وجميزة ١١ كانا الاعلى فى الحساسية لإجهاد الملوحة. أيضاً يمكن القول بأن النسبة K^+/Na^+ وSSI تعتبر مقاييس جيدة ويمكن إستخدامهما كصفات إنتخابية لتقييم تحمل الملوحة كدلائل لمحصول الحبوب بين الاصناف.