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# Characterizing some Egyptian Bread Wheat Cultivars for Salinity Tolerance

**Ragab, Kh. E.[1*] and A. M. S. Kheir[2]**

[1]Wheat Research Department, Field Crops Research Institute, Agriculture Research Centre, Egypt.
[2]Soil, Water and Environment Research Institute, Agriculture Research Centre, Egypt.

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## ABSTRACT

In order to investigate sixteen commercial Egyptian bread wheat cultivars and 2 promising lines for salt tolerance, pot experiment was conducted in cage-house at Wheat Research Department and the Laboratory of Soil Improvement and Conservation Department, Sakha Agricultural Research Station, Kafrelsheikh, Egypt during the two seasons 2015/2016 and 2016/2017. Four salt treatments (0.5, 3.5, 7.0, and 10.5 $dSm^{-1}$) were induced using diluted Mediterranean seawater. Each salt treatment was considered as an independent experiment and combined analysis were done. Stress tolerance index and carve estimation were established to characterize salinity tolerance for the studied genotypes. The results showed that increasing salinity levels causes significant decrease in all studied characteristics. Four Egyptian bread wheat cultivars (Shandweel 1, Gemmiza 10, Sakha 93 and Misr 2) and Line 1 showed desirable values of salinity susceptibility index (SSI< 1) under both 7.0 and 10.5 $dSm^{-1}$. So, it may be considered as salinity tolerance genotypes and can be used as a source of improving salinity tolerance in the wheat breeding program and cultivation under salt affected soils. Line 1 could be evaluated in the national yield trials to be released as a new cultivar for salt affected soil. Sakha 95 and Misr 1 cultivars showed high yield potentiality and desirable values for SSI under 7.0 $dSm^{-1}$, while their SSI values under 10.5 $dSm^{-1}$ were almost 1 and might be recommended also for cultivation under medium salinity soils.

***Keywords:*** Bread wheat, Salinity susceptible index, Carve estimation.

## INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important crop plants worldwide with annual production of about 765 million metric tons (FAO 2019). There is an estimated annual loss of 12 billion US dollars to the world economy due to salinity, and it is still on rise (Lauchli and Luttge, 2004). There are several strategies to increase wheat production in the salt-affected areas such as direct leaching of salts, improving the surface, subsurface and vertical drainage systems of the soil and planting salt tolerant varieties. The salt tolerant wheat cultivars recognized as the most effective way to overcome these limitations. Salinity stress tolerance is a quantitative characteristic and the troubles associated with rising appropriate and replicable testing environments create it complicated to differentiate salt-tolerant lines from sensitive lines. It is recognized 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 was reported by Lazof and Bernstein (1999), whoever many researchers used levels of diluted sea water as salinized treatments (Abdelsalam, 2012 and Ragab and Taha, 2016). In Egypt, almost 35% of the agricultural land suffers from salinity (Kim and Sultan, 2002). The Egyptian government is exerting great efforts to increase agricultural land through establishing national projects to reclaim and cultivate new lands. Salinity of soil and irrigation water is among the biggest challenges facing cultivation in the new lands. Progress in breeding cereal cultivars with salinity tolerance is slow (Volkov and Beilby, 2017). This is often attributed to the genetic and physiological complexities of the salt tolerance trait and lack of a reliable and rapid screening assay (Almeida *et al*., 2017). Therefore, the Egyptian wheat breeders should evaluate and characterize the bread wheat cultivars to salinity tolerance for salt affected and newly reclaimed soils.

The objectives of this investigation are to 1) Estimate salinity effect on yield and some yield attributes of eighteen bread wheat genotypes. 2) Find out salt-tolerant cultivars for cultivation in salt affected soils. 3) Find out a source for improving salinity tolerance in the wheat breeding programs.

## MATERIALS AND METHODS

This investigation was conducted in cage-house (pots experiment) at Wheat Research Department and the Laboratory of Soil Research Department, Sakha Agricultural Research Station, Kafrelsheikh, Agricultural Research Center, Egypt during the two successive wheat seasons, 2015/2016 and 2016/2017. The plant materials were sixteen commercial bread wheat cultivars and two promising lines (Table 1). The experiment was conducted in 30 × 40 cm black plastic bags field with about 17 kg of tap water washed sand. The genotypes were planted on 25[th] November (optimum sowing date) for both growing seasons using 12 uniformed seeds in each pot, about four cm sowing depth. Three salt stress treatments (3.5, 7.0, and 10.5 $dSm^{-1}$) were induced using diluted Mediterranean seawater in addition to the control (tap water, 0.5 $dSm^{-1}$) (Table 2). The eighteen bread wheat genotypes were

**[*] Corresponding author.**
**E-mail address: kragab1972@yahoo.com**
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arranged in randomize complete block design with three replications in each treatment. Each salt treatment was considered as an independent experiment.

The experiment was irrigated every five days with 2 liters $pot^{-1}$ of irrigated solution corresponding each salinity level(enough for irrigation and leaching) to avoid salt accumulation. The salt stress was applied starting from the sowing irrigation. The NPK multi-nutrients fertilizer 20:10:20 was dissolved in irrigation solution as a source of fertilizer by rate of 0.5 g/pot/week. Chelating micro-elements FULV-E (0.6% Zn, 0.2% Cu, 5%Mg, 2%B, 5%N, 4%$K_2O$, 4%Fe, 1.2 Mn, 8% fulvic acid and 6% citric acid) was sprayed every week with the rate of 3 cm $L^{-1}$. The plants were protected against fungi diseases using the fungicide CABRIO$^{TM}$ TOP 60% wg with rate of 1g $L^{-1}$ and against insect damage using the insecticide NASR LATHION/ CHEMINOVA 57% with rat of 5cm $L^{-1}$. After twenty days from sowing, the plants were thinned and only five seedlings carefully left in each pot to grow until maturity.

The studied characteristics were number of spike per pot ($Sp^{-1}$), number of spikelets per spike ($SS^{-1}$), number of kernels per spike ($KS^{-1}$), hundred kernels weight (100KW), biological yield per pot (BY) and grain yield per pot (GY). The collected data were statistically analyzed by "MSTAT-C" statistical package microcomputer program (MSTATC 1990) using one factor model combined over years and salt treatments. The means of genotypes, years, salt treatments and its interactions were obtained and differences were assessed with LSD at 0.05 level of probability. Carve estimation was done to study the relationship between grain yield and salinity level using SPSS 25$^{th}$ statistical computer program. Salinity susceptibility index (SSI) was estimated following the formula described by Fisher and Mourer (1978) as follow: SSI = [1-(Ys/Yp)] / SI where: Yp is the potential yield of a given genotype in non-stress environment; Ys is the yield of a given genotype in a stress environment; SI is the stress intensity and is estimated as, SI = [1-($\overline{YS}$/$\overline{YP}$)] where: $\overline{YS}$ is the mean yields over all genotypes under stress environment, $\overline{YP}$ is the mean yields over all genotypes under non-stress environment.

**Table 1. Name, cross name, selection history and year of release for the bread wheat genotypes and lines under study.**

| Name | Cross name | Selection History | Year of release |
|---|---|---|---|
| GIZA 168 | MRL/BUC // SERI | CM93046-8M-0Y-0M-2Y-0B-0SH | 1999 |
| GIZA 171 | SAKHA 93 / GEMMIZA 9 | S.6-1GZ-4GZ-1GZ-2GZ-0S | 2013 |
| MISR 1 | OASIS / SKAUZ // 4*BCN /3/ 2*PASTOR | CMSS00Y01881T-050M-030Y-030M-030WGY-33M-0Y-0S | 2014 |
| MISR 2 | SKAUZ / BAV92 | CMSS96M03611S-1M-010SY-010M-010SY-8M-0Y-0S | 2014 |
| SAKHA 93 | SAKHA 92 / TR810328 | S.8871-1S-2S-1S-0S | 1999 |
| SAKHA 94 | OPATA / RAYON // KAUZ | CMBW90Y3180-0TOPM-3Y-010M-010M-010Y-10M-015Y-0Y-0AP-0S. | 2004 |
| SAKHA 95 | PASTOR // SITE / MO /3/ CHEN / AEGILOPS SQUARROSA (TAUS) // BCN /4/ WBLL1. | CMA01Y00158S-040POY-040M-030ZTM-040SY-26M-0Y-0SY-0S. | 2019 |
| GEMMIZA 7 | CMH 74A.630 / 5X // SERI 82 /3/ AGENT | GM 4611-2GM-3GM-1GM-0GM. | 2000 |
| GEMMIZA 9 | ALD “S” / HUAC // CMH 74A. 630 / 5X | GM 4583-5GM-1GM-0GM | 2000 |
| GEMMIZA 10 | MAYA 74 "S"/ON//1160-147 /3/ BB / GLL /4 / CHAT"S" /5/ CROW "S" | CGM5820-3GM-1GM-2GM-0GM. | 2004 |
| GEMMIZA 11 | BOW"S"/KVZ"S" // 7C / SER182/3/GIZA168/SAKHA61 | GM7892-2GM-1GM-2GM-1GM-0GM | 2011 |
| GEMMIZA 12 | OTUS /3/ SARA / THB // VEE | CMSS97Y00227S-5Y-010M-010Y-010M-2Y-1M-0Y-0GM | 2013 |
| SIDS 1 | HD 2172 / Pavon “S” // 1158.57 / Maya 74 “S” | S 46-4Sd-2Sd-1Sd-0Sd | 1994 |
| 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 | 2009 |
| SIDS 13 | KAUZ"S" // TSI / SNB"S". | ICW94-0375-4AP-2AP-030AP-0APS-3AP-0APS-050AP-0AP-0SD. | 2010 |
| SHANDWEEL 1 | SITE / MO /4/ NAC / TH.AC // 3*PVN /3/ MIRLO / BUC | CMSS93B00567S-72Y-010M-010Y-010M-3Y-0M-0HTY-0SH | 2011 |
| Line 1 | WHEAR / VIVITSI // WHEAR | CGSS03 B00069T-099Y-099M-099Y-099M-34WGY-0B-0S | - |
| Line 2 | CHEN/AEGILOPS SQUARROSA(TAUS) // BCN /3/ 2* KAUZ /4/ GEN*2 // BUC / FLK /3/ BUCHIN. | S.16280-020S-015S-4S-0S. | - |

**Table 2. Salt treatments and their anions and cations analysis.**

| Salt treatment | Tap water (ml) | Sea water (ml) | Sea water mix (%) | EC ($dSm^{-1}$) | Anions ($mgL^{-1}$) | | | | Cation ($mgL^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $CO^{3-}$ | $HCO^{3-}$ | $CL^{-}$ | $SO4^{-}$ | $Ca^{++}$ | $Mg^{++}$ | $Na^{+}$ | $K^{+}$ |
| 1 (control) | 1000 | 0 | 0.0 | 0.5 | - | 3.54 | 0.94 | 0.32 | 1.48 | 1.38 | 1.72 | 0.22 |
| 2 | 948 | 52 | 5.2 | 3.5 | - | 3.5 | 31.1 | 0.4 | 3.11 | 9.88 | 21.26 | 0.78 |
| 3 | 881 | 119 | 11.9 | 7.0 | - | 3.47 | 65.61 | 0.92 | 6.21 | 19.75 | 42.52 | 1.523 |
| 4 | 823 | 177 | 17.7 | 10.5 | - | 3.42 | 100.6 | 0.98 | 9.32 | 29.63 | 63.77 | 2.28 |
| Sea water | - | - | - | 50.7 | - | 3.00 | 502.1 | 2.22 | 45 | 142.9 | 308.2 | 11.15 |

## RESULTS AND DISCUSSION

The analysis of variance showed highly significant differences due to years, salt concentrations, cultivars and their interactions for all studied characteristics except for years and year × salt concentration in grain yield (Table 3).

The variance due to salt concentrations had the greatest values compared with the other sources of variations revealing that this source conceders as the main portion of total variance. Similar results were recorded by Ragab and Taha (2016) and this was in harmony with those obtained by El- Hendawwey *et al.* (2011), Hussain *et al.* (2015) and Hagras *et al.* (2018). On the other side, Asli and Zanjan (2014) reported insignificant genotypes × salinity interaction for number of kernels per spike. Nasab *et al.* (2014) reported insignificant genotypes × salinity interaction for grain yield. The value of coefficients of variation ranged from 6.3 to 21.4 for number of spikelet per spike and grain yield, respectively (Table 3).

**Table 3. Mean squares of years, bread wheat genotypes, salt concentrations and their interactions for yield and its components during 2015/2016 and 2016/2017 seasons.**

| SOV | df | $SS^{-1}$ | $SP^{-1}$ | $KS^{-1}$ | 100KW | BY | GY |
|---|---|---|---|---|---|---|---|
| Year (Y) | 1 | 0.003** | 160.1** | 9,451.0** | 8.2** | 4,449.3** | 41.7 ns |
| Salt concentration (S) | 3 | 215.1** | 345.8** | 4,135.5** | 13.3** | 45,299.7** | 10,604.1** |
| Y×S | 3 | 21.0** | 171.6** | 440.1** | 10.2** | 746.0** | 188.9 ns |
| R (YS) | 16 | 6.707 | 8.106 | 39.643 | 0.768 | 47.644 | 72.480 |
| Genotype (G) | 17 | 19.5** | 178.9** | 588.8** | 7.7** | 4,647.0** | 788.6** |
| Y×G | 17 | 6.3** | 57.3** | 277.8** | 1.0** | 704.4** | 229.4** |
| S×G | 51 | 3.1** | 23.1** | 245.1** | 0.4** | 759.7** | 104.3** |
| Y×S×G | 51 | 2.5** | 16.9** | 134.9** | 0.4** | 479.9** | 103.2** |
| Error | 272 | 1.309 | 6.871 | 23.929 | 0.251 | 47.048 | 36.174 |
| CV% | - | 6.3 | 16.1 | 8.4 | 12 | 10.3 | 21.4 |

****: significant at 0.01 % probability level, ns: not significant, $SS^{-1}$: number of spikelet per spike, $SP^{-1}$: number of spikes per pot, $KS^{-1}$: number of kernels per spike, 100KW: hundred kernels weight, BY: biological yield per pot, GY: grain yield per pot, CV %: coefficient of variation.**

### Salt concentrations effect

The salt concentrations means for the studied characteristics are illustrated in Table (4). The results showed that increasing salinity levels (from 3.5 to 10.5 $dSm^{-1}$) caused significant decrease in all studied characteristic. While insignificant differences were recorded between means under both 0.5 and 3.5 $dSm^{-1}$ salt concentration treatments for number of spikes per pot and one hundred kernels weight. These results agree with those obtained by Ragab and Taha (2016), Kumar *et al.* (2012) and Genc *et al.* (2019) who reported that increasing salinity levels causes significant decrease in grain yield, biological yield, thousand kernels weight and number of kernels per spike.

**Table 4. Salt concentration effects on yield and its components of the studied bread wheat genotypes.**

| Salt concentration ($dSm^{-1}$) | $SS^{-1}$ | $SP^{-1}$ | $KS^{-1}$ | 100KW (g) | BY (g) | GY (g) |
|---|---|---|---|---|---|---|
| 0.5 | 19.6 | 17.3 | 64.1 | 4.4 | 85.5 | 37.3 |
| 3.5 | 19 | 17.8 | 61.7 | 4.4 | 79.6 | 34 |
| 7 | 18 | 16.3 | 58.7 | 4.2 | 61.9 | 26.3 |
| 10.5 | 16.4 | 13.8 | 49.9 | 3.7 | 39.9 | 15 |
| Average | 18.25 | 16.30 | 58.60 | 4.18 | 66.73 | 28.15 |
| $LSD_{0.05}$ | 0.3 | 0.7 | 1.3 | 0.1 | 1.8 | 1.6 |

**$SS^{-1}$: number of spikelet per spike, $SP^{-1}$: number of spikes per pot, $KS^{-1}$: number of kernels per spike, 100KW: one hundred kernels weight, BY: biological yield per pot, GY: grain yield per pot.**

### Genotype performance

Bread wheat genotype means of the studied characteristics are illustrate in Table (5). The wheat cultivar Sids 1 recorded the highest number of spikes per pot while the lowest values recorded by Sids 12, Gemmiza 11, Giza 171 and Gemmiza 7. Regarding the biological yield, Line 1 had high mean value while Sids 12 had the lowest mean value. For number of kernels per spikes, Sakha 95 and Line 1 recorded high mean values while Sakha 93 recorded the lowest mean value. Respect to the hundred kernels weight, Line 1, Giza 171, Gemmiza 7 and Gemmiza 11 recorded high mean values, while Giza 168 and Sids 13 recorded the lowest mean values. For grain yield per pot, Line 1, Misr 1 recorded high values while Sids 12 and Misr 2 recorded low mean values. Superiority of Line 1and Misr 1 is due to its high values in yield components comparing to Sids 12. The cultivars Gemmiza 9 and Sakha 95 had high number of spikelets per spike but Giza 168, Sids 12, Sakha 93 and Sids 1 had low numbers. These results indicated considerable variation among the studied genotypes under different levels of salinity and confirmed the previous results recorded by Maha *et al.* (2017) and Hagras *et al.* (2018).

**Table 5. Effect of eighteen bread wheat genotypes on yield and its components characteristics.**

| Genotype | $SS^{-1}$ | $SP^{-1}$ | $KS^{-1}$ | 100KW (g) | BY (g) | GY (g) |
|---|---|---|---|---|---|---|
| Giza 168 | 16.7 | 17 | 49.9 | 3.3 | 60.6 | 24.7 |
| Giza 171 | 18.6 | 12.9 | 57.9 | 5.1 | 63.6 | 28.5 |
| Misr 1 | 18.7 | 19.4 | 62.2 | 4.6 | 78.7 | 36.9 |
| Misr2 | 18.9 | 17.7 | 59.3 | 3.6 | 61.6 | 21.4 |
| Sakha 93 | 16.8 | 15.5 | 49 | 3.8 | 53.3 | 23.2 |
| Sakha 94 | 18.4 | 16.2 | 60 | 4 | 70.3 | 28.3 |
| Sakha 95 | 19.3 | 17 | 66.1 | 4.5 | 75.1 | 35.3 |
| Gemmiza 7 | 18.1 | 13.3 | 49.5 | 4.7 | 53.9 | 23.3 |
| Gemmiza 9 | 19.9 | 17.7 | 61.8 | 4.4 | 81.8 | 32.1 |
| Gemmiza 10 | 17.7 | 15 | 57 | 3.7 | 62.3 | 24.9 |
| Gemmiza 11 | 18.6 | 12.5 | 59 | 4.8 | 62.6 | 27.3 |
| Gemmiza 12 | 18.7 | 18.1 | 63.3 | 4.3 | 73.2 | 32 |
| Sids 1 | 17.2 | 22.9 | 58.6 | 4.1 | 84.8 | 29.3 |
| Sids 12 | 16.7 | 11.7 | 62.8 | 3.6 | 42.3 | 19.4 |
| Sids 13 | 18.3 | 17.8 | 59.4 | 3.3 | 55.4 | 23.7 |
| Shandweel 1 | 19 | 15.7 | 58.9 | 4.1 | 66.2 | 27.9 |
| Line 1 | 18.3 | 18.1 | 64.3 | 5.2 | 100.7 | 41.8 |
| Line 2 | 18.4 | 14.9 | 55.6 | 3.9 | 54.9 | 27.1 |
| Average | 18.24 | 16.30 | 58.59 | 4.17 | 66.74 | 28.17 |
| $LSD_{0.}$ | 0.6 | 1.5 | 2.8 | 0.3 | 3.9 | 3.4 |

**$SS^{-1}$: number of spikelets per spike, $SP^{-1}$: number of spikes per pot, $KS^{-1}$: number of kernels per spike, 100KW: hundred kernels weight, BY: biological yield per pot, GY: grain yield per pot.**

**Interaction effects**

The interaction between salt concentrations and genotypes are illustrated in Tables (6 and 7). Significant differences between salt concentration levels and genotypes revealed that, the studied genotypes responded differently to the different salt concentrations, suggesting the importance of genotypes assessment under different condition to identify the best ones for a particular environment.

Regarding 3.5 $dSm^{-1}$ salt concentration, the studied characteristics insignificantly decreased compared with the control treatment (0.5 $dSm^{-1}$) in most studied bread wheat genotypes. Meanwhile, significant or insignificant increase was recorded in some cases lead to conclude that the 3.5 $dSm^{-1}$ salt concentration may cause stimulation in such cases. In this respect, Mass and Hoffiman (1977) reported that wheat is moderately salinity tolerance with threshold without yield loss at 6 $dSm^{-1}$ salinity level.

**Table 6. Effects of the interaction between salt concentrations ($dSm^{-1}$) and the bread wheat genotypes on number of spikelets per spike ($SS^{-1}$), number of spikes per pot ($SP^{-1}$), and number of kernels per spike ($KS^{-1}$).**

| Genotype | $SS^{-1}$ | | | | $SP^{-1}$ | | | | $KS^{-1}$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ×Salt | 0.5 | 3.5 | 7.0 | 10.5 | 0.5 | 3.5 | 7.0 | 10.5 | 0.5 | 3.5 | 7.0 | 10.5 |
| Giza 168 | 18.9 | 17.8 | 16 | 14.3 | 21.3 | 21.3 | 16.5 | 8.7 | 56.3 | 56.3 | 48.9 | 38.2 |
| Giza 171 | 18.8 | 19.0 | 18.0 | 18.5 | 13.3 | 14.5 | 12.3 | 11.3 | 52.1 | 58.6 | 60.2 | 60.4 |
| Misr 1 | 20.3 | 19.5 | 18.8 | 16.4 | 21.0 | 21.0 | 17.8 | 17.7 | 67.9 | 66.0 | 61.4 | 53.3 |
| Misr 2 | 20.3 | 19.7 | 18.7 | 16.7 | 19.5 | 18.0 | 19.3 | 14 | 61.6 | 53.8 | 57.9 | 63.8 |
| Sakha 93 | 17.2 | 16.8 | 16.9 | 16.3 | 13.5 | 18.3 | 15.3 | 14.7 | 44.9 | 50.5 | 54.6 | 46.1 |
| Sakha 94 | 20.2 | 19.7 | 17.8 | 15.8 | 18.2 | 19.2 | 16.2 | 11.3 | 69.4 | 66.4 | 55.7 | 48.5 |
| Sakha 95 | 20.3 | 20.1 | 19.9 | 17.0 | 17.2 | 18.3 | 17.3 | 15.2 | 68.5 | 67.2 | 77.1 | 51.8 |
| Gemmiza 7 | 19.4 | 18.4 | 18.0 | 16.5 | 15.8 | 13.0 | 12.0 | 12.5 | 56.5 | 50.5 | 52.6 | 38.4 |
| Gemmiza 9 | 21.8 | 20.5 | 19.6 | 17.9 | 19.2 | 17.7 | 17.2 | 16.8 | 70.5 | 65.5 | 64.7 | 46.6 |
| Gemmiza 10 | 19.3 | 17.2 | 17.5 | 16.9 | 13.2 | 17.3 | 15.8 | 13.8 | 62.4 | 55.9 | 54.9 | 55.0 |
| Gemmiza 11 | 19.3 | 19.3 | 17.8 | 17.9 | 13.0 | 13.0 | 11.8 | 12.3 | 57.0 | 56.6 | 60.8 | 61.5 |
| Gemmiza 12 | 21.7 | 18.7 | 18.1 | 16.4 | 18.0 | 19.2 | 17.3 | 18.0 | 81.4 | 60.0 | 60.4 | 51.3 |
| Sids 1 | 18.5 | 17.8 | 17.6 | 14.9 | 21.3 | 26.0 | 24.2 | 20.0 | 67.1 | 66.2 | 55.9 | 45.3 |
| Sids 12 | 18.0 | 17.6 | 16.3 | 14.8 | 12.0 | 12.5 | 13.8 | 8.5 | 76.2 | 75.0 | 54.4 | 45.6 |
| Sids 13 | 19.7 | 19.1 | 17.7 | 16.5 | 20.3 | 18.0 | 19.7 | 13.3 | 67.4 | 67.2 | 53.9 | 49.1 |
| Shandweel 1 | 20.2 | 20.2 | 18.6 | 17.0 | 17.3 | 15.7 | 16.3 | 13.5 | 63.6 | 59.3 | 62.6 | 49.9 |
| Line 1 | 19.4 | 19.6 | 18.3 | 15.7 | 18.3 | 18.3 | 18.7 | 17.0 | 66.0 | 73.8 | 62.6 | 54.7 |
| Line 2 | 20.0 | 20.3 | 18.1 | 15.4 | 18.7 | 19.2 | 12.5 | 9.3 | 64.6 | 61.3 | 57.6 | 39.0 |
| Average | 19.6 | 19.0 | 18.0 | 16.4 | 17.3 | 17.8 | 16.3 | 13.8 | 64.1 | 61.7 | 58.7 | 49.9 |
| $LSD_{0.05}$ α | 1.6 | 1.4 | 1.5 | 1.9 | 4.2 | 4.2 | 3.3 | 4.5 | 9.3 | 11.1 | 10.8 | 10.5 |
| $LSD_{0.05}$ § | 1.3 | | | | 3 | | | | 5.5 | | | |

**α : Least significant differences for genotype at the same salt concentration and § : Least significant differences for genotype × salt concentration interaction.**

**Table 7. Effects of the interaction between salt concentrations and bread wheat genotypes on hundred kernels weight (100KW), biological yield per pot (BY) and grain yield per pot (GY).**

| Genotype | 100KW | | | | BY (g) | | | | GY | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| × Salt | 0.5 | 3.5 | 7.0 | 10.5 | 0.5 | 3.5 | 7.0 | 10.5 | 0.5 | 3.5 | 7.0 | 10.5 |
| Giza 168 | 3.3 | 3.7 | 3.8 | 2.6 | 90.4 | 86.7 | 47.5 | 18 | 36.7 | 37.3 | 18.5 | 6.1 |
| Giza 171 | 5.6 | 5.4 | 4.9 | 4.5 | 74.0 | 88.3 | 43.3 | 48.6 | 38.0 | 37.2 | 22.7 | 16 |
| Misr 1 | 4.8 | 4.7 | 4.6 | 4.3 | 97.6 | 93.4 | 80.1 | 43.7 | 48.6 | 43 | 37.4 | 18.4 |
| Misr 2 | 3.9 | 3.5 | 3.7 | 3.2 | 73.0 | 70.9 | 66.7 | 35.7 | 26.9 | 24.1 | 22.3 | 12.4 |
| Sakha 93 | 4.0 | 4.1 | 4.0 | 3.4 | 53.0 | 75.2 | 45.1 | 40.0 | 24.7 | 32.5 | 21.7 | 13.8 |
| Sakha 94 | 4.4 | 4.2 | 3.9 | 3.7 | 93.1 | 89.4 | 56.1 | 42.5 | 39.8 | 34.8 | 22.9 | 15.7 |
| Sakha 95 | 5.0 | 4.9 | 4.5 | 3.7 | 87.5 | 96.2 | 76.7 | 40.0 | 42.0 | 47.2 | 35.2 | 16.8 |
| Gemmiza 7 | 5.4 | 4.9 | 4.8 | 3.8 | 82.6 | 57.6 | 47.8 | 27.5 | 34.3 | 27.6 | 20.7 | 10.7 |
| Gemmiza 9 | 4.5 | 4.6 | 4.6 | 3.8 | 100.1 | 87.7 | 88.9 | 50.4 | 44.7 | 36.8 | 29.3 | 17.5 |
| Gemmiza 10 | 3.7 | 4.2 | 4.1 | 2.9 | 54.4 | 76.0 | 69.2 | 49.6 | 29.2 | 30.1 | 25.8 | 14.6 |
| Gemmiza 11 | 5.2 | 4.8 | 4.7 | 4.7 | 84.5 | 66.9 | 61.6 | 37.6 | 36.6 | 30.7 | 25.7 | 16.5 |
| Gemmiza 12 | 4.5 | 4.5 | 4.3 | 4.1 | 109.6 | 75.7 | 61.6 | 46.1 | 46.4 | 33.1 | 29.1 | 19.4 |
| Sids 1 | 4.1 | 4.5 | 4.1 | 3.5 | 111.5 | 110.5 | 68.5 | 48.6 | 39.1 | 37.1 | 24.2 | 16.8 |
| Sids 12 | 3.9 | 3.7 | 3.6 | 3.2 | 61.6 | 47.0 | 38.3 | 22.3 | 28.5 | 20.6 | 20.1 | 8.5 |
| Sids 13 | 3.5 | 3.5 | 3.6 | 2.9 | 75.7 | 62.0 | 45.6 | 38.4 | 33.9 | 25.7 | 23.7 | 11.5 |
| Shandweel 1 | 4.5 | 3.8 | 4.1 | 3.8 | 78.6 | 62.4 | 74.8 | 48.9 | 30.5 | 33.1 | 27.1 | 20.3 |
| Line 1 | 5.5 | 5.2 | 5.1 | 4.9 | 124.9 | 119.4 | 101.6 | 56.8 | 53.9 | 47.1 | 42.8 | 23.4 |
| Line 2 | 4.2 | 4.5 | 3.9 | 3.0 | 86.5 | 67.8 | 40.8 | 24.4 | 37.7 | 40 | 19.1 | 11.8 |
| Average | 4.4 | 4.4 | 4.2 | 3.7 | 85.5 | 79.6 | 61.9 | 39.9 | 37.3 | 34.3 | 26.0 | 15.0 |
| $LSD_{0.05}$ α | 0.69 | 0.57 | 0.69 | 1.02 | 18.8 | 14.8 | 11.3 | 12.8 | 11.0 | 8.5 | 7.0 | 6.9 |
| $LSD_{0.05}$ § | 0.6 | | | | 7.7 | | | | 6.8 | | | |

**α: Least significant differences for genotype at the same salt concentration and § : Least significant differences for genotype × salt concentration interaction.**

Regarding the other two salt concentrations, 7.0 and 10.5 $dSm^{-1}$, the studied bread wheat genotypes showed different behaviors for the studied characteristics. In this respect, high mean values were recorded under both 7.0 and 10.5 $dSm^{-1}$ salt concentrations in the wheat cultivars Sids 1, Gemmiza 12, Misr1, Gemmiza 9, Sakha 95 and Line 1 for number of spike per pot; Gemmiza 9 for number of spikelets per spike; Line 1and Giza 171 for hundred kernels weight Gemmiza 9 and Line 1 for biological yield per pot; Line 1 and Misr 1for grain yield per pot. On the other hand, low mean values were recorded under both 7 and 10.5 $dSm^{-1}$ salt concentrations in Sids 12 and Line 2 for number of spike per pot; Sids 12 and Giza 168 for number of spikelets per spike; Gemmiza 7 and Giza 168 for number of kernels per spike; Sids 13 and Giza168 for hundred kernels weight; Sids 12 for biological yield per pot; Gemmiza 7, Sids 12, Giza 168 and Line 2 for grain yield per pot (Tables 6 and 7). Meanwhile high mean values were recorded at 7 $dSm^{-1}$ salinity level while low mean values at 10.5 $dSm^{-1}$ salinity levels in Misr 2 and Sids 13 for number of spike per pot; Misr 1 for biological yield per pot; Sakha 95, Gemmiza 9, Shandweel 1 and Line 1 for number of kernels per spike; Gemmiza 7 for one hundred kernels weight; Sakha 95 for grain yield per pot; Sakha 95, Misr 1 and Misr 2 for number of spikelets per spike. Generally, Misr 1 and line 1 had desirable characteristics under both control and salinity levels, so they may be recommended for salt affected soil.

**Salinity susceptibility index**

Salinity susceptibility index (SSI) was used to estimate salinity tolerance for the studied bread wheat genotypes Table (8). The SSI indices were calculated based on grain yield per pot for the two levels of salinity 7.0 and 10.5 $dSm^{-1}$. The low SSI values indicate the high level of salinity tolerance according to Fisher and Mourer (1978). Under this investigation, cultivars that have an SSI < 1 are considered to be salinity tolerant and the cultivars that have SSI > 1 are considered to be salinity susceptible.

**Table 8. Salinity susceptibility index (SSI) values based on grain yield per pot for the eighteen bread wheat genotypes under 7.0 and 10.5 $dSm^{-1}$ salinity levels.**

| Genotype | 7.0 $dSm^{-1}$ | | | | 10.5 $dSm^{-1}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | Reduction % | SSI | Rank | Description€ | Reduction % | SSI | Rank | Description |
| Giza 168 | 49.64 | 1.69 | 18 | S | 83.45 | 1.40 | 18 | S |
| Giza 171 | 40.30 | 1.37 | 15 | S | 58.02 | 0.97 | 9 | T |
| Misr 1 | 23.17 | 0.79 | 7 | T | 62.18 | 1.04 | 13 | S |
| Misr 2 | 17.20 | 0.59 | 5 | T | 54.05 | 0.90 | 4 | T |
| Sakha 93 | 12.20 | 0.42 | 3 | T | 44.32 | 0.74 | 2 | T |
| Sakha 94 | 42.50 | 1.45 | 16 | S | 60.56 | 1.01 | 11 | S |
| Sakha 95 | 16.17 | 0.55 | 4 | T | 59.99 | 1.00 | 10 | S |
| Gemmiza 7 | 39.62 | 1.35 | 14 | S | 68.77 | 1.15 | 15 | S |
| Gemmiza 9 | 34.47 | 1.17 | 11 | S | 60.93 | 1.02 | 12 | S |
| Gemmiza 10 | 11.59 | 0.39 | 2 | T | 49.91 | 0.83 | 3 | T |
| Gemmiza 11 | 29.81 | 1.02 | 9 | S | 54.9 | 0.92 | 5 | T |
| Gemmiza 12 | 37.25 | 1.27 | 12 | S | 58.29 | 0.97 | 8 | T |
| Sids 1 | 38.19 | 1.30 | 13 | S | 57.18 | 0.96 | 7 | T |
| Sids 12 | 29.44 | 1.00 | 8 | S | 70.14 | 1.17 | 17 | S |
| Sids 13 | 30.02 | 1.02 | 10 | S | 66.13 | 1.11 | 14 | S |
| Shandweel 1 | 8.00 | 0.30 | 1 | T | 33.26 | 0.56 | 1 | T |
| Line 1 | 20.51 | 0.70 | 6 | T | 56.67 | 0.95 | 6 | T |
| Line 2 | 49.26 | 1.68 | 17 | S | 68.6 | 1.15 | 16 | S |

**€ s: susceptible, T: Tolerance**

Under 7 $dSm^{-1}$ salinity level, the seven bread wheat genotypes; Shandweel 1, Gemmiza 10, Sakha 93, Sakha 95, Misr 1, Misr 2 and Line 1 recorded SSI values ranged from 0.30 for Shandweel 1 to 0.79 for Misr 1. In addition, the percentage of yield reduction related to control treatment (0.5 $dSm^{-1}$) ranged from 8% for Shandweel 1 to 23.17% for Misr 1. Therefore, these cultivars can be considered as salinity tolerant under 7 $dSm^{-1}$ salinity level (Table 8).

Meanwhile, the remaining genotypes recorded SSI values >1 and yield reduction percent about 50%; these genotypes can be considered as salinity susceptible.

Regarding 10.5 $dSm^{-1}$ salinity level, the five bread wheat genotypes Shandweel 1, Line 1, Gemmeiza 10, Sakha 93 and Misr 2 recorded SSI values < 1 with yield reduction ranged from 33.26% for Shandaweel 1 to 56.67% for Line 1; these genotypes can be considered a salinity tolerant and confirmed the previous results at 7 $dSm^{-1}$ salinity level for these genotypes (Table 8). While, the remaining cultivars recorded SSI > 1 with yield reduction reached to 83.45%; these cultivars can be considered a salinity susceptible cultivars.

Generally, SSI estimates indicate that the five bread wheat genotypes Shandweel 1, Sakha 93, Gemmeiza 10, Misr 2 and Line 1 were salinity tolerance under both 7.0 and 10.5 $dSm^{-1}$ salinity levels, therefore it could be considered as a good source to improve salinity tolerance in the bread wheat breeding program and for cultivation under salt affected soil. However, these genotypes considered as salinity tolerant, Line 1 showed the highest yield potentiality under both stress and non-stress conditions while the other four cultivars showed high yield only under stress condition. In this respect, Fernandez (1992) reported that the SSI fails to distinguish genotypes express uniform superiority in both stress and non-stress environments from genotypes yield relatively higher only in stress environment. Therefore, yield potentiality of the tested genotypes should be considered when selecting based on SSI. Based on these results, Line 1 could be evaluated on the national yield trials to be released as new cultivar for salt affected soil.

The bread wheat cultivars Sakha 95 and Misr 1 had high yield potentiality (35.2 and 37.4, respectively) and desirable values for SSI ( 0.55 and 0.79, respectively) under 7 $dsm^{-1}$ while their SSI values under 10.5 $dSm^{-1}$ were almost one ( Table 7 and 8). Therefore, these cultivars might be recommended also for salt affected soils. These results were close to that reported by Hagras *et al.* (2018) who evaluated some Egyptian bread wheat cultivars under salt affected soils (about 7.0 $dSm^{-1}$) and reported that Misr 1 and Line 1 are salinity tolerant. Maha *et al.* (2017) evaluated some Egyptian bread wheat cultivars under 3 salinity levels of irrigation water using NaCl, tap water (control), 4000ppm (6.25 $dm^{-1}$) and 8000ppm (12.5 $dSm^{-1}$) `and reported that Sakha 93 can be selected to grow under salinity levels of irrigation water and the cultivars Sids 1, Shandweel 1, Misr 2 and Misr 1 are moderate tolerant to salinity stress, while the cultivars Gemmiza 9 and Gemmiza 11 are the most sensitive cultivars.

**Curve estimation**

The curve estimation of grain yield as a dependent variable and salt concentrations as an independent variable for the eighteen bread wheat genotypes are illustrated in Figures (1 and 2).

The liner shape was the fitted relation describing the regression of grain yield per pot on salt concentrations. The $R^2$ values ranged from 0.14 for Shandweel 1 to 0.82 for Gemmiza 7. The *b* value ranged from - 0.70 for Shandweel 1 to -3.34 for Giza 168. The regression formula of the bread wheat cultivars Shandweel 1, Sakha 93, Misr 2 and Gemmiza 10 showed low slop values (*b* = -0.67, -1.34, -1.37 and 1.46, respectively) and low constant values (32.00, 30.39, 28.77 and 32.75, respectively) Figures (1 and 2). These results led to conclude that, these cultivars had good level of salinity tolerance even though the low yield potentiality. Meanwhile, the regression formula of Giza 168 showed the highest slop value (-3.34) and constant value of 42.63. Although the slop of the liner regression of the three genotypes Misr 1, Sakha 95 and line 1 were relatively high, the yield of these genotypes still high under salinity levels compared with other genotypes, revealing that they have good level of salinity tolerance. It is worthily mention that, the results of the curve estimation were in agreement with SSI results Table (8).

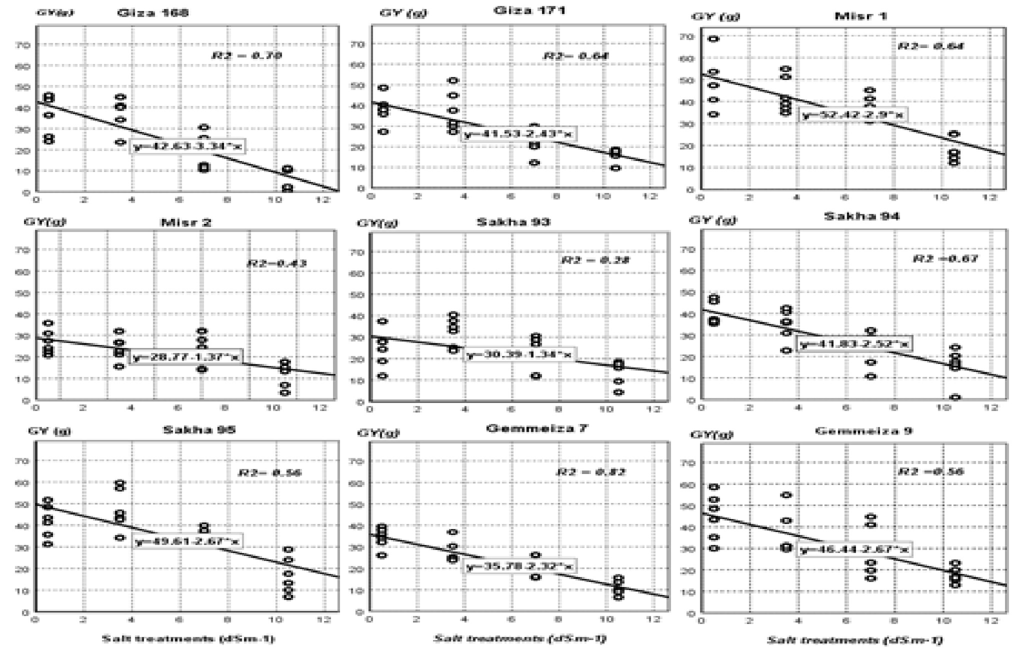


**Fig. 1. Curve estimation of grain yield as a dependent variable and the four studied salt concentrations dSm$^{-1}$ as an independent variable for the wheat cultivars Giza 168, Giza 171, Misr1, Misr 2, Sakha 93, Sakha 94, Sakha 95, Gemmiza 7 and Gemmiza 9.**

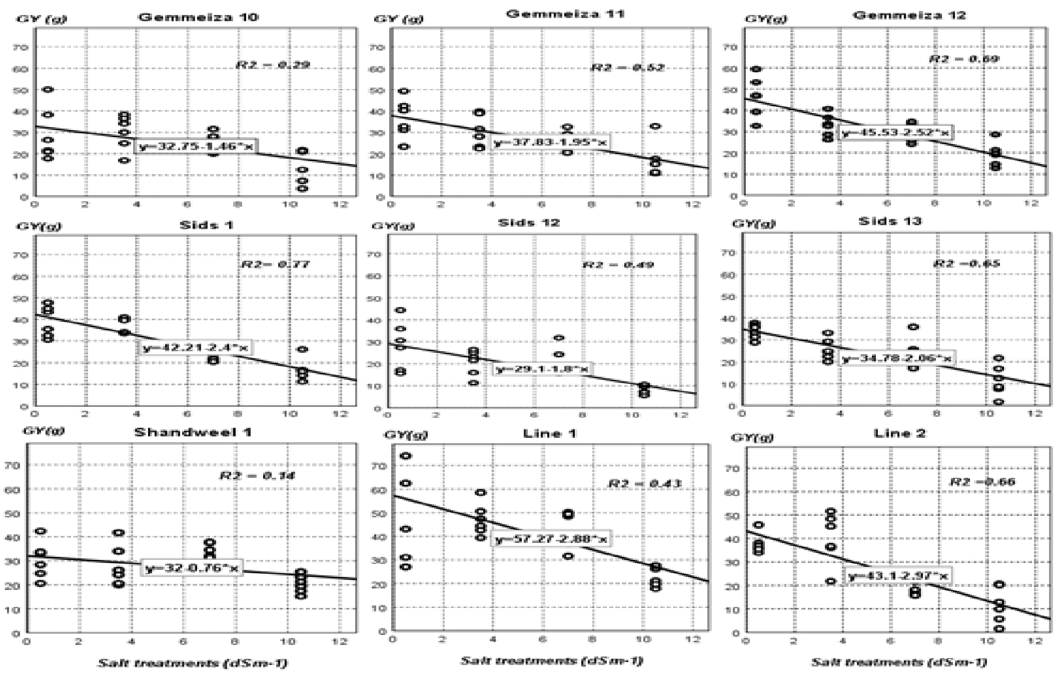


**Fig. 2. Curve estimation of grain yield as a dependent variable and the four studied salt concentrations dSm$^{-1}$ as an independent variable for the wheat cultivars Gemmiza 10, Gemmiza 11, Gemmiza 12, Sids 1, Sids 12, Sids 13 and Shandweeel 1 and Line 1 and Line 2.**

## CONCLUSION

It could be summarized that increasing salinity levels caused significant decrease in grain and biological yield, number of spike per pot, number of kernels per spike, kernel weight and number of spikelet per spike. The five genotypes Shandweel 1, Gemmiza 10, Sakha 93 and Misr 2 and Line 1 are considered as salinity tolerance and could be used as a source for improving salinity tolerance in the wheat breeding programs and for cultivation under salt affected soil. The two cultivars Sakha 95 and Misr 1 had high yield potentiality and desirable values for SSI under 7 $dSm^{-1}$ while their SSI values under 10.5 $dSm^{-1}$ were almost one and might be recommended also for cultivation under moderate salinity level. The bread wheat cultivars Sakha 95 and Misr 1 had high yield potentiality and good level of salinity tolerance under 7 $dSm^{-1}$ and it may be recommended for salt affected soils with moderate salinity levels.

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## تصنيف بعض أصناف قمح الخبز المصري لتحمل الملوحة


**خالد الدمرداش رجب[1] و أحمد محمد سعد خير[2]**

**[1]قسم بحوث القمح –معهد بحوث المحاصيل الحقلية -مركز البحوث الز راعية -مصر**

**[2]معهد بحوث الأراضي والمياه والبيئة -مركز البحوث الز راعية –مصر**



تم إجراء هذا البحث في الصوبة السلكية (تجربة أصص) في قسم بحوث القمح – معهد بحوث المحاصيل الحقلية ومعمل قسم بحوث تحسين وصيانة الأراضي – معهد بحوث الأراضي والمياه والبيئة بمحطة البحوث الزراعية بسخا - كفر الشيخ - مركز البحوث الزراعية – مصر، خلال الموسمين المتعاقبين 2016/2015 و2017/2016. تهدف الدراسة إلى تصنيف تحمل الملوحة في أصناف قمح الخبز المصري تحت ثلاثة مستويات من الملوحة. وكانت المواد النباتية 16 صنف قمح خبز تجارى وسلالتين من السلالات المبشرة وكانت معاملات الملوحة ثلاثة تركيزات وهي 3.5 و7.0 و 10.5 ديسيمنز/ متر وذلك باستخدام مياه البحر المتوسط المخففة بالإضافة إلى معاملة مقارنة (ري بماء الصنبور، 0.5 ديسيمنز/متر). واعتبرت كل معاملة ملوحة تجربة مستقلة. وتم إجراء التحليل التجميعي للأصناف تحت مستويات الملوحة والسنوات. تم تقدير معامل الحساسية للإجهاد وتقدير انحدار المحصول على معاملات الملوحة للتعرف على مدي تحمل الأصناف تحت الدراسة. وكانت الصفات المدروسة هي عدد السنيبلات لكل سنبلة، عدد السنابل لكل اصيص، عدد الحبوب لكل سنبلة، وزن المائة حبة، المحصول البيولوجي لكل اصيص، محصول الحبوب لكل اصيص. أظهرت النتائج أن زيادة مستويات الملوحة تؤدي إلى انخفاض ملحوظ في جميع الصفات المدروسة. سجلت أربعة أصناف قمح خبز مصرية وهى شندويل 1 وجميزة 10 وسخا 93 ومصر2 بالإضافة الى السلالة رقم1 قيم مرغوبة لمعامل الحساسية (اقل من 1) تحت كل من مستويات الملوحة 7.0 و10.5 ديسيمنز/متر مما يدل على تحملها للملوحة ولذلك يمكن استخدامها في برنامج تربية القمح لتحسين صفة تحمل الملوحة وأيضا الزراعة في الأراضي المتأثرة بالأملاح. ويفضل تقييم السلالة رقم 1 وتسجيلها كصنف قمح للزراعة في الأراضي المتأثرة بالأملاح. في حين اظهر الصنفين سخا 95 ومصر1 قدرة محصوليه عالية وقيم مرغوبة لمعامل الحساسية (اقل من 1) تحت مستوى الملوحة 7.0 ديسيمنز/متر وقيم تساوي تقريبا الواحد تحت مستوى الملوحة 10.5 ديسيمنز/متر ولذلك يمكن ان يوصى بزراعتها في الأراضي متوسطة الملوحة.