# Response of Some Egyptian Wheat (*Triticum aestivum L.)* Genotypes to Salinity Stress

**M. G. Attia and A. A. M. El-Araby**
Soil Salinity & Alkalinity Research Department- Soils, Water & Environment Research Institute- Agricultural Research Center (ARC), Alexandria, Egypt.

**ABSTRACT:** A pot experiment was carried out under greenhouse conditions to test the reaction of different wheat genotypes to salt stress. The seeds of 15 wheat genotypes were grown in pots containing sandy loam soil and later on the seedlings were subjected to 3 levels of saline irrigation water after 2 weeks of seed germination. The selected wheat cultivars included Shakha 93, Sakha 94, Misr1, Sids1, Sids12, Sids13, Giza168, Giza171, Sahel 1, Shandawil 1, Gemmiza 7, Gemmiza 9, Gemmiza 10, Gemmiza 11 and Gemmiza 12. The salinity of irrigation water was prepared by dissolving an appropriate amount of NaCl in tap water and adjusted to give 4500 and 8500 mg/l, beside the control treatment of tap water (500 mg/l). After 5 months of saline water application, the plants were harvested, whereas plant growth indices, grain and straw yields, as well as the harvest index were recorded. The results have shown that plant growth characteristics and yield potentials were significantly suppressed with increasing the salinity stress levels, but the rate of decline varied considerably among all trails. The more serious effect of the salinity exposure was manifested on grain yield, being 39.8 and 54.5% at 4500 and 8500 mg/l, respectively. Wheat genotypes, namely Gemmiza 7, Gemmiza 9 and Sids 1 were more superior in grain yield performance, even at the highest concentration level of irrigation water. Unlike, Gemmiza 11, 12; Misr 1, Sakha 94, Giza 168, 171, Shandweel 1 and Sids 12, 13 were reacted as the more salt-sensitive cultivars. The remaining genotypes were intermediate in reaction. On the evaluation and screening wheat cultivars to salt stress, the simple regression equation of the type y=a + b $\sqrt{X}$ was considered to give a better expression for the quantitative assessment. According to our calculations, genotypes, i.e. Gemmiza 7, Gemmiza 9 and Sids1 were classified as salt tolerant cultivars and Sakha93, Sahel 1 & Gemmiza 10 as moderately salt tolerant and the remaining cultivars showed higher sensitivity to salt tolerance. It could be concluded that the more salt tolerant varieties could be used as a valuable cultivars in breeding programs under salt-stressed condition.

**Keywords:** wheat genotypes – salinity stress – screening –salt tolerant

## INTRODUCTION

Soil salinity is one of the major abiotic stresses affecting agricultural production in semi-arid regions and has negative impacts on plant growth and global crop productivity (Dehdari *et al*., 2005; Munns *et al*., 2006 and Huang *et al*., 2008).The salinity problems in these areas may be a result of limited water availability, unsuitable irrigation practices, improper drainage, and high evaporation (Abd Alrahman *et al.,* 2005). In order to sustain food crop production in such regions, it is necessary to introduce cultivars with enhanced salinity tolerance (Munns *et al*., 2006; Abu Hasan *et al*., 2015).

Wheat, as the most important crop for human consumption in the world, is frequently grown in regions with saline and alkaline soils. Therefore, breeding for realizing salt tolerance would be an effective mean for improving yield and yield stability under such conditions (Genc *et al*., 2007). Many investigators have reported marked retardation in the germination and plant growth of seedlings of several field crops at the higher salinity levels (Bernstein, 1961). However plant species differ in their sensitivity or tolerance to salts (Torech and Thompson, 1993).

Screening large numbers of genotypes to salt stress in the field is difficult, due to spatial heterogeneity of soil chemical and physical properties and to the seasonal fluctuations in rainfall (Munns and James, 2003). Screening techniques that can be carried out under controlled environments have therefore often been used as measurements of growth (root elongation, leaf elongation, biomass or yield), measurements of injury (Leakage from leaf discs, chlorophyll content or chlorophyll fluorescence) and specific ion accumulation, including $Na^+$ and/or $Cl^-$ exclusion and $K^+/Na^+$ ratio (Munns and James, 2003). Large numbers of bread and durum wheat genotypes have been screened for the relative salt tolerance in glasshouses, using the criteria of biomass production at high salinity up to 250 mM NaCl (Kingsbury and Epstein, 1984; Martin *et al.*, 1994).

The effects of salt stress on wheat plant growth and development have been attributed to the retardation of seed germination and seedling growth performances (Almansouri *et al.*, 2001), reduced grain yields (Maas and Poss, 1989) via accelerating apex development (Grieve *et al.*, 1992; Katerji *et al.*, 2005), shortening the spiklelet development, reducing number of spikelets per spike (Frank *et al.*, 1987), kernels per spike, and the number of spike tillers (Maas and Grieve,1990; Katerji *et al.*, 2005) due to the disruption of water uptake and nutritional supply in rooting zone.

The main goal of the present study is being proposed to evaluate the salt tolerance, growth and yield performance of some different wheat genotypes to salt stress in Egypt.

## MATERIALS AND METHODS

This investigation was performed to test the reaction of 15 different wheat genotypes to salt stress. The plant materials were provided from the Crop Research Institute, Agricultural Research Center (ARC) in Giza, Egypt. The selection was, however, considered to cover the crop adaptation to all environmental conditions prevailing in Egypt. Based on this concept, 15 wheat cultivars, namely, Sakha 93, Sakha 94, Misr 1, Sids 1, Sids 12, Sids 13, Giza 168, Giza 171, Sahel 1, Shandawil 1, Gemmiza 7, Gemmiza 9, Gemmiza 10, Gemmiza 11 and Gemmiza 12 were selected to test their salt tolerance under greenhouse conditions at the Soil Salinity Department, ARC- Alexandria. The seeds were planted in pots (30cm in diameter and 30cm in height) containing sandy loam soil (15 kg), during the growing season 2013/2014. The initial chemical and physical properties of the used soil and the tap water characteristics are given in Table 1.

A factorial trait, comprising of 15 wheat genotypes and 3 saline irrigation water levels, i.e., 500, 4500 and 8500 mg/l NaCl, were replicated 3 times in a complete randomized block design. After seed germination (8 December 2013), the seedlings were thinned, keeping the stand at 5 plants /pot. The growing plants were subjected to salt stress after 3 weeks up to the harvest time. Nitrogen and potassium were applied as ammonium nitrate and potassium sulfate fertilizers, at rates of 100 kg N/fed and 48kg $K_2O$/fed, respectively, partitioned in 3 equal doses for N ( at planting, 3 weeks after the planting date and before tillering stage). While phosphorus fertilizer rate 15.5 kg $P_2O_2$/fed was initially incorporated to the soil before cultivation. K was applied, in a single dose, after 6 weeks of planting date.

At maturity (May 2014), the plants were harvested and agronomic data including plant height, grain yield (GY), straw yield (SY), number of tillers and number of spikes for the different wheat cultivars were recorded.

The term "harvest index, HI %" is being introduced to relate the GY to total plant biomass. Accordingly, HI was calculated using the following relation:

$$HI (\%) = \{GY/ (GY+SY)\} X 100$$

The obtained data were subjected to the analysis of variance (ANOVA) using CoSTAT Program described by Co Hort (1986). The significant differences among treatment means were evaluated on the basis of the calculated values of LSD (Duncan, 1965). Besides, regression/correlation analyses were carried out to give a quantitative expression on the reaction of the involved wheat genotypes to salt tolerance.

**Table (1). Soil and tap water characteristics**

| Characteristics | Soil | Tap water |
|---|---|---|
| Soil pH (1:2 soil-water) | 7.73 | 7.50 |
| Soil EC (1:2 soil-water) ($dSm^{-1}$) | 1.70 | 0.78 |
| **Soluble cations (meq/L)** | | |
| Calcium ($Ca^{++}$) | 7.00 | 3.20 |
| Magnesium ($Mg^{++}$) | 4.00 | 1.75 |
| Sodium ($Na^{+}$) | 5.60 | 2.50 |
| Potassium ($K^{+}$) | 0.59 | 0.35 |
| **Soluble anions (meq/L)** | | |
| Bicarbonate ($HCO_3^{-}$) | 4.64 | 1.60 |
| Chloride ($Cl^{-}$) | 9.00 | 3.85 |
| Sulphate ($SO_4^{--}$) | 3.55 | 2.3 |
| Total $CaCO_3$ (%) | 15.5 | - |
| Total nitrogen (%) | 0.02 | - |
| Total phosphorus (%) | 0.15 | - |
| Total potassium (%) | 3.56 | - |
| Organic matter (%) | 0.16 | - |
| **Mechanical analysis (%)** | | |
| Clay | 2.8 | - |
| Silt | 77.8 | - |
| Sand | Sandy loam | - |
| Soil texture | | - |

## RESULTS AND DISCUSSION

The analysis of variance (ANOVA) presented in Table (2) revealed that the main effects, including wheat genotypes and the salt stress exposure as well as their interaction imposed significant trend on the all selected traits at P≤ 0.05. To eliminate the diversion effects of the single and combined treatments on GY and SY performances, the term "harvest index percentage; HI %" and relative grain yield are being introduced to relate the GY to total plant biomass and GY at $S_0$ treatment, respectively.

**Table (2). Analysis of variance (ANOVA) for plant growth indices , grain and straw yield records**

| SOV | df | Significant level | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Plant growth indices | | | Grain & Straw yield records | | | |
| | | Plant height(cm) | Spikes No /pot | Tilleres No /pot | Straw yield g/pot | Grain yield g/pot | Harvest Index % (HI) | Relative yield % |
| Blocks | 2 | ns | ns | ns | ns | ns | ns | ns |
| Main Effects | | | | | | | | |
| varieties | 14 | ** | ** | ** | ** | ** | ** | ** |
| salinity | 2 | ** | ** | ** | ** | ** | ** | ** |
| Interaction | | | | | | | | |
| varietiesXsalinity | 28 | * | ** | ** | ** | ** | ** | ** |
| **MS Error** | | 8.09 | 1.96 | 23.22 | 15.02 | 8.92 | 13.45 | 20.69 |

ns = No significant difference ** = Significant at 1 % level * = Significant at 5 % levels

### 1. Main treatment effects

#### 1.1. Effect of saline irrigation water

Regardless to the main effects of wheat genotypes, the plant growth indices, including plant height, spikes and tillers numbers per pot, yield components (straw, grain yields and harvest index) and relative grain yield (RGY) were significantly decreased with increasing salinity levels from $S_o$ to $S_2$ (Table 3a and Figure1). Relative to the control treatment, increasing the salinity level to 8500 mg/l decreased the plant height and the number of spikes by 13.9 and 29.5%, respectively, accompanied by extensive drop in the number of tillers (44.8%). The calculated inhibiting effects on yield components at the highest salt stress exposure accounted for marked significant decrements, defined by 39.8 and 54.5% for straw and grain yields, respectively. Similar trend was recorded on HI % and RGY, but the depressive effect varied considerably between the respective traits from 6.6 to 46.1%, respectively. The correlation analysis between the agronomic data (Table 3b) revealed that there are highly positive correlation between the all possible combination of the studied traits under salt stress conditions, whereas the r values ranged between 0.92 and 0.99 (below the diagonal line). However, the corresponding coefficient of determination was, subsequently, 85-98%.

Growth and yield reduction could explained to a number of reasons, basically to the inhibitory effect of the osmotic effects of salt in the soil solutions, that causes acting to induce the acceleration senescence due to leaf water deficit or hormonal disruption from rooting system (Dura *et al.*, 2011). Under such conditions, it seems possibly that nutrients uptake and its translocation to the aerial plant parts are being disturbed, due to the excessive $Na^+$ accumulation. This holds true, because the highest concentrations of irrigation water may induce toxic effects on leaves as result of excessive salt accumulation in cytoplasm or cell wall (Sairam and Tyagi, 2004). These results are in agreement with the data reported by Chartzoulakis and Klapaki (2000) indicating that salinity affected plant growth processes; in terms of plant height, fresh and dry weights of roots, stem and leaves expression grain yield potentials and deterioration of the product quality.

**Table (3a). Main effect of salinity and wheat cultivars treatments on grain yield and the attendent tillering**

| Treatments | | Plant growth indices | | | Yield components | | | |
|---|---|---|---|---|---|---|---|---|
| | | plant Height(cm) | No. of spikes/pot | Tilleres No /pot | Straw yield g/pot | Grain yield g/pot | Harvest Index % | Relative Yield % |
| Salinity | $S_0$ | 78.49 | 17.63 | 27.56 | 51.70 | 44.02 | 47.09 | 100.00 |
| | $S_1$ | 72.42 | 14.76 | 16.78 | 39.72 | 30.42 | 43.76 | 70.03 |
| | $S_2$ | 67.82 | 12.43 | 15.22 | 31.09 | 19.96 | 40.48 | 46.13 |
| | **L.S.D.** | 1.19 | 0.59 | 2.02 | 1.62 | 1.25 | 1.54 | 1.91 |
| Wheat cultivars | Sakha 93 | 62.78 | 12.88 | 18.33 | 35.81 | 26.89 | 42.68 | 75.47 |
| | Sakha 94 | 69.78 | 15.83 | 23.89 | 40.34 | 33.56 | 43.71 | 69.43 |
| | Misr 1 | 73.00 | 16.83 | 27.78 | 43.20 | 34.72 | 44.88 | 68.61 |
| | Sids 1 | 79.11 | 18.67 | 26.11 | 64.93 | 32.96 | 33.80 | 81.94 |
| | Sids 12 | 72.56 | 8.11 | 11.67 | 29.40 | 27.52 | 48.41 | 64.54 |
| | Sids 13 | 60.78 | 18.44 | 26.11 | 29.64 | 32.59 | 52.19 | 65.68 |
| | Giza 168 | 69.11 | 15.33 | 23.89 | 37.60 | 31.72 | 46.01 | 67.80 |
| | Giza 171 | 79.00 | 11.44 | 17.78 | 25.31 | 33.44 | 55.09 | 67.11 |
| | Sahel 1 | 76.44 | 15.67 | 21.67 | 46.84 | 35.48 | 42.48 | 73.78 |
| | Shandweel 1 | 75.39 | 15.67 | 21.11 | 49.42 | 30.60 | 37.21 | 68.18 |
| | Gemmiza 7 | 78.11 | 11.05 | 13.89 | 40.90 | 30.13 | 42.34 | 85.10 |
| | Gemmiza 9 | 75.00 | 19.44 | 20.56 | 52.48 | 31.44 | 37.98 | 86.13 |
| | Gemmiza 10 | 70.11 | 16.56 | 16.67 | 36.32 | 32.57 | 46.97 | 71.20 |
| | Gemmiza 11 | 80.17 | 12.44 | 13.33 | 43.13 | 30.03 | 40.92 | 69.21 |
| | Gemmiza 12 | 72.33 | 15.72 | 15.00 | 37.21 | 28.31 | 41.96 | 66.62 |
| | **L.S.D.** | 2.66 | 1.31 | 4.51 | 3.63 | 2.80 | 3.44 | 4.26 |

**Table (3b). Correlation analysis between grain yield and some agronomic data**

| | | Varieties | | | |
|---|---|---|---|---|---|
| | | Grain yield | Straw yield | Spikes No | Tilleres No |
| **Salinity** | Grain yield | | ns | ns | ns |
| | Straw yield | 0.99** | | 0.55 * | ns |
| | Spikes No | 0.99** | 0.98** | | 0.74** |
| | Tilleres No | 0.92** | 0.92** | 0.90** | |

* ,** = significant at 5% and 1 % levels, respectively - ns= nonsignificant

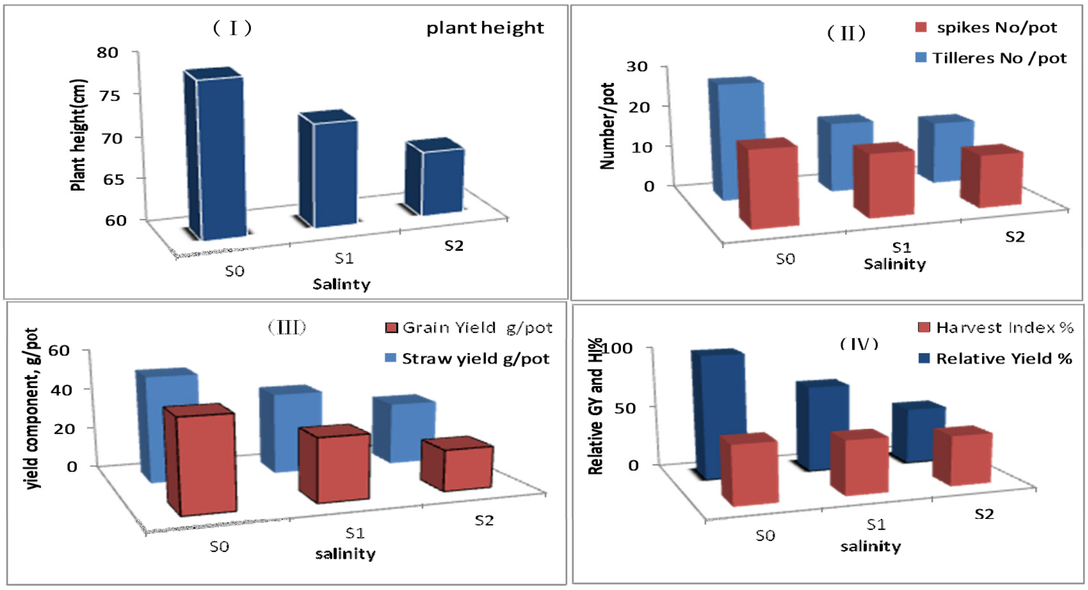


**Fig.(1). Main effect of salinity on plant height (I), growth index term (II), yield component (Ⅲ) and relative yield (Ⅳ) of wheat plant.**

### 1.2. Varietal effect of wheat genotypes:

Irrespective to the salinity treatment, the results given in Table 3a indicated that there are wide variations in all traits among wheat genotypes. Despite of the insignificant trend existed between sids1 and Gemmiza 9, particularly, in the number of spikes, GY and RGY data, as revealed from LSD comparisons, opposite significant trend were detected on plant height, number of tillers and HI (Table 3a). The present data demonstrated that the number of spikes, GY and RGY for sids1 were 18.67, 32.19 g/pot and 81.94%, respectively. The respective records for Gemmiza 9 were, subsequently, 19.44, 31.44 g/pot and 86.13%. The reaction of the remaining wheat cultivars with respect to their performance on plant growth indices and yield components as well as RGY is not clearly defined. Except the detected positive correlations existed between SY and the number of spikes and/or spikes and tillers numbers (above the diagonal line), weak correlation were appeared between the remaining traits (Table 3b). Such variations would suggest that there are several interacting factors have been taken place within the plant under salt-stressed conditions affecting the pathway of metabolic processes including marked differentiation on the mode of plant growth and yield components (Sharma, 2013).

It seems possibly that such variation could be also inferred the inherent capacity and the presence of marked genes that control the plant capability to salt stress (Naz *et al*., 2015). In this regard, Naz *et al.* (2015) stated that the salt tolerance within plant species and/or cultivars could be ascribed to the dominant genes (Krishania *et al*., 2015).

The superior plant growth of the more salt tolerant cultivars (Sids1 & Gemmiza 9) than sensitive ones (Sids 12 & Sids 13) could be due to the reduction in Na+ accumulation and mobilization of the defense mechanisms including antioxidative enzymes which might have suppressed the $Na^+$ transport to further tissues (Gupta and Huang, 2014).The reduction in fresh and dry biomass with increasing salinity can be attributed to reduced photosynthesis rate and other physiological functions. These results are in agreement with Khan *et al.*(2004); *Kanwal et al.* (2011); Rao *et al.* (2013) and El-Haddad and Mostafa (2007).

**2. The 2-way interaction:**

The interaction study of the two involved treatments indicated that the differences in plant growth, in terms of plant height, between the coupled cultivars, e.g., Sahel 1, Schandweel 1 and Gemmiza 7 at any given salinity were not significant at P≤0.05 (Table 4a and Fig.2). The results also showed that although the variations in plant height criteria between $S_0$ and $S_2$ for Sakha 93, Giza 168 and Gemmiza 12 cultivars were significant, the reaction of respective cultivars did not exhibit any significant trend between $S_0$ and $S_1$ (Table 4a & Fig.2). In contrast, the differences in plant height between the all comparisons at any given salinity level of the remaining wheat cultivars imposed marked significant variations at P≤ 0.05.

Except the reaction of Misr 1, Sids 1, Sahel 1, Shandweel 1 and Gemmiza 12, the results detected on the number of spikes per pot demonstrated that the variations in this criteria between $S_1$ and $S_2$ for all cultivars were significant at P≤ 0.05 (Table 4a and Fig.2). Based on the LSD comparisons, the insignificant trend was also recorded on the variation of spikes numbers between $S_0$ and $S_1$ for cultivars Sakha 93, Sids 12, Giza 171, Gemmiza11 and 12.

**Table (4a). The interaction effect of salinity and wheat varieties treatments on plant growth indices**

| wheat varieties | Plant Growth Indices | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Plant height (cm) | | | Spikes No /pot | | | Tillers No/pot | | |
| | $S_0$ | $S_1$ | $S_2$ | $S_0$ | $S_1$ | $S_2$ | $S_0$ | $S_1$ | $S_2$ |
| Sakha 93 | 65.7 | 62.7 | 60.0 | 15.7 | 13.7 | 9.3 | 26.7 | 18.3 | 10.0 |
| Sakha 94 | 76.3 | 70.3 | 62.7 | 19.5 | 15.5 | 12.5 | 33.3 | 23.3 | 15.0 |
| Misr 1 | 81.7 | 71.0 | 66.3 | 19.2 | 16.0 | 15.3 | 43.3 | 20.0 | 20.0 |
| Sids 1 | 84.0 | 81.3 | 72.0 | 23.0 | 16.7 | 16.3 | 43.3 | 16.7 | 18.3 |
| Sids 12 | 80.7 | 71.0 | 66.0 | 10.0 | 8.0 | 6.3 | 13.3 | 8.3 | 13.3 |
| Sids 13 | 66.3 | 61.3 | 54.7 | 20.7 | 18.7 | 16.0 | 40.0 | 20.0 | 18.3 |
| Giza 168 | 71.7 | 69.0 | 66.7 | 17.7 | 15.3 | 13.0 | 35.0 | 18.3 | 18.3 |
| Giza 171 | 82.7 | 80.0 | 74.3 | 13.0 | 12.0 | 9.3 | 21.7 | 16.7 | 15.0 |
| Sahel 1 | 81.3 | 75.0 | 73.0 | 18.0 | 15.0 | 14.0 | 28.3 | 18.3 | 18.3 |
| Shandweel 1 | 81.5 | 75.0 | 69.7 | 19.0 | 15.0 | 13.0 | 30.0 | 16.7 | 16.7 |
| Gemmiza 7 | 81.3 | 78.0 | 75.0 | 12.5 | 11.7 | 9.0 | 16.7 | 13.3 | 11.7 |
| Gemmiza 9 | 83.0 | 73.0 | 69.0 | 24.0 | 18.7 | 15.7 | 23.3 | 18.3 | 20.0 |
| Gemmiza 10 | 77.7 | 68.0 | 64.7 | 20.0 | 16.7 | 13.0 | 18.3 | 15.0 | 16.7 |
| Gemmiza 11 | 88.2 | 78.3 | 74.0 | 14.7 | 13.0 | 9.7 | 18.3 | 11.7 | 10.0 |
| Gemmiza 12 | 75.3 | 72.3 | 69.3 | 17.7 | 15.5 | 14.0 | 21.7 | 16.7 | 6.7 |
| Mean | 78.5 | 72.4 | 67.8 | 17.6 | 14.8 | 12.4 | 27.5 | 16.8 | 15.2 |
| L.S.D at 5% | | 4.6 | | | 2.3 | | | 6.8 | |

**Table (4b). The interaction effect of salinity and wheat varities treatments on straw and grain yield records**

| wheat varieties | Grain and straw yield records | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Straw weight, g/pot | | | Grain yield, g/pot | | | Relative Grain yield % | | | Harvest Index % | | |
| | $S_0$ | $S_1$ | $S_2$ | $S_0$ | $S_1$ | $S_2$ | $S_0$ | $S_1$ | $S_2$ | $S_0$ | $S_1$ | $S_2$ |
| Sakha 93 | 49.5 | 36.2 | 21.8 | 35.6 | 29.6 | 15.4 | 100.0 | 83.1 | 43.3 | 41.8 | 45.0 | 41.2 |
| Sakha 94 | 48.1 | 41.2 | 31.7 | 48.3 | 35.1 | 17.2 | 100.0 | 72.6 | 35.6 | 50.1 | 46.0 | 35.1 |
| Misr 1 | 63.0 | 43.0 | 23.6 | 50.6 | 33.2 | 20.4 | 100.0 | 65.5 | 40.3 | 44.5 | 43.6 | 46.5 |
| Sids 1 | 84.8 | 55.5 | 54.5 | 40.2 | 32.9 | 25.8 | 100.0 | 81.7 | 64.1 | 32.2 | 37.2 | 32.0 |
| Sids 12 | 39.4 | 33.2 | 15.7 | 42.6 | 22.5 | 17.4 | 100.0 | 52.9 | 40.8 | 52.0 | 40.6 | 52.6 |
| Sids 13 | 24.9 | 34.1 | 29.9 | 49.6 | 30.5 | 17.6 | 100.0 | 61.6 | 35.4 | 66.4 | 47.3 | 42.8 |
| Giza 168 | 57.3 | 32.8 | 22.8 | 46.8 | 28.4 | 20.0 | 100.0 | 60.7 | 42.7 | 45.1 | 46.5 | 46.4 |
| Giza 171 | 28.0 | 26.1 | 21.9 | 49.8 | 31.3 | 19.1 | 100.0 | 62.9 | 38.4 | 64.0 | 54.6 | 46.7 |
| Sahel 1 | 57.7 | 38.4 | 44.5 | 48.1 | 35.1 | 23.3 | 100.0 | 73.0 | 48.4 | 45.5 | 47.6 | 34.3 |
| Shandweel 1 | 58.6 | 55.7 | 34.0 | 44.9 | 29.9 | 17.0 | 100.0 | 66.6 | 37.9 | 43.4 | 34.9 | 33.4 |
| Gemmiza 7 | 47.5 | 40.5 | 34.7 | 35.4 | 31.9 | 23.1 | 100.0 | 90.1 | 65.2 | 42.9 | 44.2 | 40.0 |
| Gemmiza 9 | 72.2 | 45.1 | 40.1 | 36.5 | 34.3 | 23.5 | 100.0 | 94.0 | 64.4 | 33.6 | 43.4 | 37.0 |
| Gemmiza 10 | 46.7 | 35.1 | 27.2 | 45.7 | 28.6 | 23.3 | 100.0 | 62.6 | 51.0 | 49.5 | 45.0 | 46.4 |
| Gemmiza 11 | 61.8 | 39.4 | 28.1 | 43.4 | 28.9 | 17.8 | 100.0 | 66.7 | 41.0 | 41.2 | 42.7 | 38.9 |
| Gemmiza 12 | 36.1 | 39.5 | 36.0 | 42.5 | 23.9 | 18.5 | 100.0 | 56.3 | 43.5 | 54.2 | 37.8 | 33.9 |
| Mean | 51.7 | 39.7 | 31.1 | 44.0 | 30.4 | 20.0 | 100.0 | 70.0 | 46.1 | 47.1 | 43.8 | 40.5 |
| L.S.D at 5% | | 6.3 | | | 4.86 | | | 7.39 | | | 5.97 | |

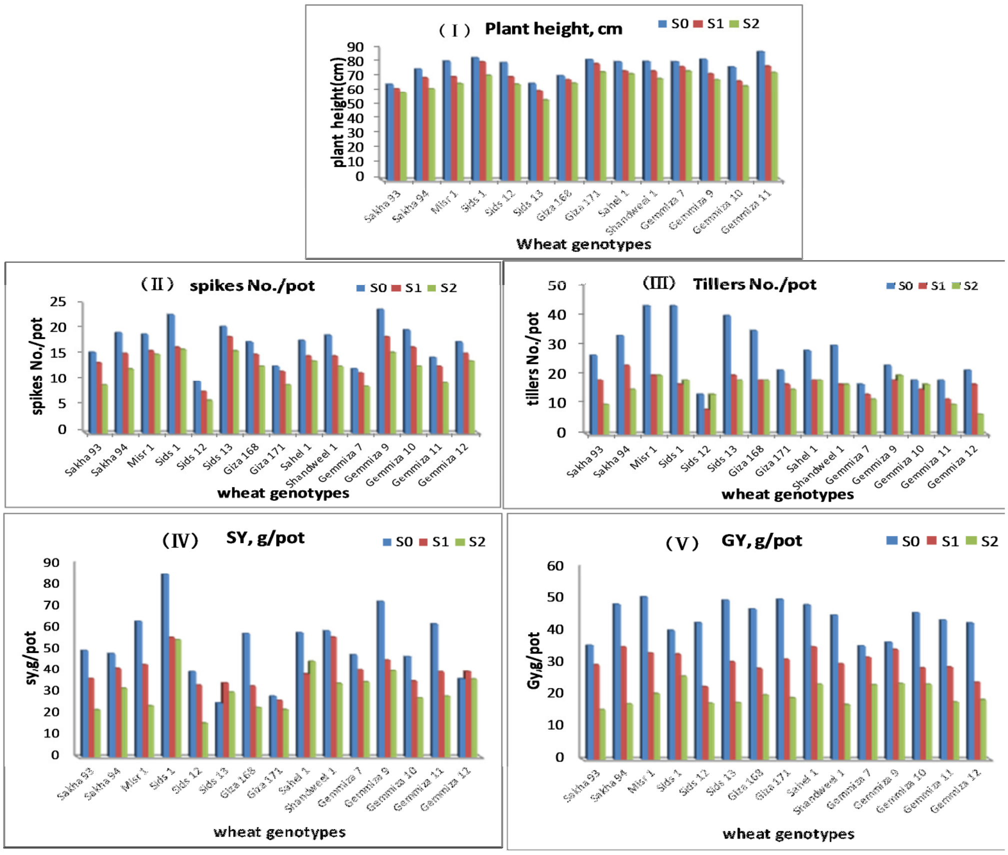


**Fig. (2). Effect of saline irrigation water on growth indices (Ⅰ, Ⅱ, Ⅲ) and yield records (Ⅳ & Ⅴ) of wheat genotypes**

The performance of remaining wheat cultivars imposed remarkable significant trend on the variations of this trait between all the comparisons at each salinity level.

The results outlined on the number of tillers per pot showed that the variations in these criteria between $S_1$, $S_2$ for all cultivars except the reaction of Sakha 93, 94 and Gemmiza 12 were not significant (Table 4a and Fig.2). Based on the LSD comparisons, the insignificant trend was also registered on the variation of tillers numbers between $S_0$ and $S_1$ for Sids 12, Gemmiza 7, 9, 10, 11 and 12 cultivars. The performance of the remaining wheat cultivars exerted remarkable significant trend on the variations of this trait between the all comparisons of salt treatments.

Moreover, the interaction study of the two implicated salinity treatments indicated that the differences in straw yield between the coupled salinity levels, e.g., $S_1$ and $S_2$ were not significant at $P \leq 0.05$ for sids 1, sids 13, giza 171, sahel 1, gemmiza 7, 9 and 12 cultivars (Table 4a, Fig. 2). The results also revealed that the variations in straw yield criteria between $S_0$ and $S_1$ for Sids 12, Giza 171 and Gemmiza 12 cultivars were also limited with no significant trend (Table 4b and Fig.2). The performance of the other wheat cultivars showed significant trend on the variations of this criteria between all the comparisons of salt treatments.

In accordance to the LSD comparison, only, the variations in grain yield data between $S_0$ and $S_1$ for Gemmiza 7 and 9 cultivars were insignificant at $P \leq 0.05$ (Table 4b and Fig.2). The differences in this criteria between all the comparisons at any given salinity level for the remaining wheat cultivars showed marked significant trend at $P \leq 0.05$.

On the other hand, when the grain yield of salt- treated cultivars were compared as a percent of maximum yield (relative grain yield, RGY), the differences in this criteria for all the comparisons between the salinity treatment for any given wheat cultivars imposed significant variations (Table 4b). The results documented in Table 4b proved that wheat cultivars ,namely , Sakha 93, Misr 1, Sids 1, Giza 168, Gemmiza 7 and 11 behaved similarly with respect to the attendant variations in harvest index (HI), unlike the reaction of the remaining wheat cultivars exerted remarkable and significant variations in (HI) across the salt exposure treatments.

**3. Salt tolerance assessment of wheat genotypes**

The results given in Table (5) showed that wheat cultivars exhibited differential response in grain yield potentials across the all levels of salinity exposure. Such differences are being expected, due to the genotypic variability of the respective plant materials (Naz *et al.*, 2015). Quantitative screening to salt tolerance, under such condition, is apparently difficult. To meet the objectives, all the actual records of grain yield data were expressed in terms of relative values (Table 3a). Accordingly, a quantitative rating system of the respective wheat cultivars on the basis of a fixed scale was, however, realized to evaluate the performance of salt tolerance concept. In this regard, different types of regression equations were preliminary tested to select the best expression that describes the reaction of wheat cultivars. This concept has been previously proposed by Soliman *et al.* (1978) and is being applicable, taking into account the highest correlation coefficient (r) and/or $R^2$, together with the lowest standard error of the calculated regression coefficient (b). Our trails proved that the simple regression equation, namely, $y=a + b\sqrt{X}$ gave the best fitting for grain yield data and more impressive if it is compared with the other tested equations.

Since the regression coefficient value (b) give an accurate indication for the rate grain yield depression across the salinity level, the calculated values (Table 5) showed that Gemmiza 7, Gemmiza 9 and Sids 1 cultivars behaved similarly and were relatively the highest in salt tolerance and the least in salt injury providing minimum b values( -0.466, -0.475 and -0.502, respectively). These results are being confirmed by comparing the bs' values, whereas the ratio accounted for 1.0, 1.02 and 1.08 for the respective cultivars. In this respect, the predicted salt concentration of the irrigation water, associated with 50% of the relative grain reduction, as defined by (Richards, 1954), accounted for 18475, 17984 and 15401 mg/l, respectively. On the contrary, Gemmiza 11, Misr 1, Sakha 94, Giza 168, Shandweel 1, Gemmiza 12, Giza 171, Sids 13 and Sids 12 cultivars were relatively more salt sensitive. The corresponding salt concentration of irrigation water incorporated for the 50% reduction in relative grain yield were subsequently, 6982, 6817, 6811, 6725, 6626, 6489, 6407, 6029 and 5974 mg/l. The attendant ratio of bs' values were relating the highest, being 1.79, 1.81, 1.90, 1.78, 1.87, 1.82, 1.88, 1.97 and 1.87, respectively, and consequently these cultivars were rated as the more sensitive cultivars (Tables 4a and 4b). The remaining cultivars namely, Sakha 93, Sahel 1 and Gemmiza 10 imposed intermediate salt reaction, where the bs' values ranged between 1.54 and 1.64. The corresponding salinity levels inducing 50% reduction in relative grain yield accounting for 8822, 8715 and 8120 mg/l, respectively.

Many reports from the literature cited on the salt tolerance of wheat (Meiri and Shalhevest, 1973) revealed that when the salt concentrations in the soil reached 10-14 dS/m, yields were reduced from 25-50%. They added that further increase in salt stress from 14-16 dS/m, the yield potentials were severely dropped by 50% or more. The unequal trend between the critical salinity levels, associated with 50% reduction in grain yield, in our experimental data and the predicted values defined by Meiri and Shalhevest (1973) is being directed to their assessment of ECs' values in the soil extract, which is quite different from our calculations, that takes into account the ECs' values of irrigation water. Besides, the genotypic variations of plant materials (Sharma, 2015) and the changes in climatically and environmental conditions (Xu, 2016) are among of the important factors that contribute well for such deviations.

**Table (5). Quatitive evalution of the relative grain yield and salt tolerance index of wheat varities under salt stress condition using the linear regression (y = a +b √x ) ***

| Varieties | a | b | bs' ratio | r | $R^2$ | Calculated Salt Conc. for 50 % of RGY (mg/l) |
|---|---|---|---|---|---|---|
| gemmiza7 | 113.34 | -0.466 | 1 | 0.907 | 0.823 | 18475 |
| gemmiza9 | 113.7 | -0.475 | 1.02 | 0.999 | 0.808 | 17984 |
| sids1 | 112.3 | -0.502 | 1.08 | 0.966 | 0.934 | 15401 |
| Sakha93 | 121.57 | -0.762 | 1.64 | 0.914 | 0.836 | 8822 |
| sahel1 | 117.59 | -0.724 | 1.55 | 0.962 | 0.925 | 8715 |
| gemmiza10 | 114.61 | -0.717 | 1.54 | 0.978 | 0.956 | 8120 |
| gemmiza11 | 113.69 | -0.834 | 1.79 | 0.991 | 0.982 | 6982 |
| misr1 | 119.77 | -0.845 | 1.81 | 0.989 | 0.978 | 6817 |
| sakha94 | 123.04 | -0.885 | 1.90 | 0.952 | 0.906 | 6811 |
| giza168 | 117.9 | -0.828 | 1.78 | 0.981 | 0.962 | 6725 |
| shandweel1 | 120.98 | -0.872 | 1.87 | 0.978 | 0.956 | 6626 |
| gemmiza12 | 116.78 | -0.85 | 1.82 | 0.984 | 0.969 | 6489 |
| giza171 | 120.12 | -0.876 | 1.88 | 0.998 | 0.996 | 6407 |
| sids13 | 121.2 | -0.917 | 1.97 | 0.99 | 0.98 | 6029 |
| sids12 | 117.4 | -0.872 | 1.87 | 0.978 | 0.956 | 5974 |

bs' ratio was calcaulated with respect to lowst b value ( -0.466)

* y = relative grain yield % a = intercept (relative grain yield at S0)

b = regression coefficient x = salt concentration of irrigation water , mg/l

## REFERENCES


**Abed Alrahman, N.M., R.A. Shibli, K.I. Ereifej and M.Y.Hindiyeh ( 2005).** Influence of salinity on growth and physiology of in vitro grown cucumber (*Cucumis sativus L.*). Jordan J. Agric. Sci., 1: 93–106.

**Abu Hasan, H., R. Hafiz, N. Siddiqui, R. Islam and A. Ai Mamun (2015).** Evaluation of wheat genotypes for salt tolerance based on some physiological traits. J. Crop Sci. Biotech., 18 (5) : 333 – 340

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

**Bernstein, L. (1961).** Osmotic adjustment of plants to saline media. I. Steady state. Am. J. Bot., 48: 909-918.

**Chartzoulakis, K. and G. Klapaki (2000).** Response of two greenhouse pepper hybrids to NaCl salinity during different growth stages. Scientia Horticulturae, 86: 247-260.

**CoHort software (1986).** CoSTAT user manual version 3.03. Berkeley, CA, USA.

**Dehdari, A., A. Rezai and S. A. M. Maibody (2005).** Salt tolerance of seedling and adult bread wheat plants based on ion contents and agronomic traits. Communications in Soil Sci. Plant Anal, 36: 2239-2253.

**Duncan, D.B.(1965).** A Bayesian approach to multiple comparisons. Technometrics, 7:171-222.

**Dura, S.A.M., M.A. Duwayriand and M.M. Nachit (2011).** Effects of Different Salinity Levels on Growth, Yield and Physiology on Durum Wheat (*Triticum turgidum* var. durum). Jordan J. Agric. Sci., 7(3) : 518-527

**El-Haddad, E.H. and M.A. Mostafa (2007).** Salt tolerance variability among 12 Egyptian wheat cultivars. J. Adv. Agric. Res., 12 (1):35-49.

**Frank, A.B., A. Bauer and A.L. Black (1987).** Effects of air temperature and water stress on apex development in spring wheat. Crop Sci., 27: 113-116.

**Genc, Y., GK Mcdonald and M Tester** (**2007).** Reassessment of tissue Na+ concentration as a criterion for salinity tolerance in bread wheat. Plant, Cell Environ., 30: 1486-1498.

**Grieve, C.M., S.M. Lesch, L.E. Francois and E.V. Maas (1992).** Analysis of main-spike yield components in salt stressed wheat. Crop Sci., 32:697-703.

**Gupta, B. and B. Huang (2014).** Mechanism of salinity tolerance in plants: Physiological, biochemical and molecular characterization. International Journal of Genomics. Volume 2014, dx.doi.org/10.1155/701596: 1-18 (cited by Naz *et al.*, 2015)

**Huang, S., W. Spielmeyer, E. S. Lagudah and R. Munns (2008).** Comparative mapping of HKT genes in wheat, barley, and rice, key determinants of transport and salt tolerance. J. Exp. Bot., 59: 927-937.

**Kanwal, H., M. Ashraf and M. Shahbaz (2011).** Assessment of salt tolerance of some newly developed and candidate wheat (*Triticum aestivum* L.) cultivars using gas exchange and chlorophyll fluorescence attributes. Pak. J. Bot., 43: 2693-2699.

**Katerji, N., J.W. van Hoorn, A. Hamdy, M. Mastrorilli, M.M.Nachit and T. Oweis (2005).** Salt tolerance analysis of chickpea, faba bean and durum wheat varieties: II. Durum wheat. Agricultural Water Management, 72:195-207.

**Khan, M.A., N. Hussain, M. Abid and T. Imran ( 2004).** Screening of wheat *(Triticum aestivum* L.) cultivars for saline conditions under irrigated arid environment. J. Res. Sci., 15: 471-477.

**Kingsbury, R. W. and E. Epstein (1984).** Selection for salt-resistant spring wheat. Crop Sci., 24, 310–14.

**Krishania, S., S. Mittal and O.P. Khedar (2015).** Improving salinity tolerance in crops: a biotechnological view. Suresh Gyan Vihar University. International Journal of Environment, Science and Technology, 1(1): 66-69

**Maas, E.V., and C.M. Grieve (1990).** Spike and leaf development in salt stressed wheat. Crop Sci., 30:1309-1313.

**Maas, E.V., and J.A. Poss (1989).** Salt sensitive of cowpea at various growth stages. Irrig. Sci., 10: 313-320.

**Martin, P. K., M. J. Ambrose and R. M. D. Koebner (1994).** A wheat germplasm survey uncovers salt tolerance in genotypes not exposed to salt stress in the course of their selection. Aspects Appl. Biol., 39: 215–222

**Meiri, A. and J. Shalhevest (1973).** Crop growth under saline conditions. In: Yaron, B., Danfors, E. and Vadia, Y. (eds.). Arid Zone Irrigation. Springers, Berlin, Heidelberg, New York, pp. 277-290.

**Munns, R. and R. A. James (2003).** Screening methods for salinity tolerance: a case study with tetraploid wheat. Plant and Soil, 253: 201–218

**Munns, R., R. A. James and A. Lauchli (2006).** Approaches to increasing the salt tolerance of wheat and other cereals. J. Experi. Bot., 57: 1025-1043.

**Naz, T., J. Akhtar, M. A. ul-Haq and M. Shahid (2015).** Genetic variability in wheat genotypes for salt tolerance, growth and physiological responses. Soil Environ., 34(2): 187-199.

**Rao, A., S.D. Ahmad, S.M. Sabir, S.I. Awan, A.H. Shah, S.R. Abbas, S. Shafique, F. Khan and Chaudhary (2013).** Potential antioxidant activities improve salt tolerance in ten varieties of wheat (*Triticum aestivum* L.). Amer.J.Plant Sci, 4:69-76.

**Richards, L.A. (1954).** United Salinity Laboratory staff, Diagnosis and Improvement of Saline and Alkali Soils. Agricultural Handbook No. 60. pp. 65-67.

**Sairam, R.K., and A. Tyagi (2004).** Physiology and molecular biology of salinity stress tolerance in plants. Curr. Sci., 86: 407-421.

**Sharma, R. (2013).** Screening for salt tolerance – Selection of salt tolerant and salt sensitive wheat cultivars; Third National Conference on Innovations in Indian Science, Engineering and Technology (Bilingual Hindi & English) Organized by Swedish Science Movement of India, Delhi at CSIR National Physical Laboratory and IARI, New Delhi, Feb. 25 – 27.

**Sharma, R. (2015).** Genotypic response to salt stress: I – Relative tolerance of certain wheat cultivars to salinity. Adv. Crop Sci. Tech., 3(4): 1-7

**Soliman, M.F., I.M. Anter, N.F. Soliman and M.A.Hendi (1978).** Evaluation of high salty waters for irrigation as tested by wheat and barley plants. Agric. Res. Rev., 56:21-29

**Torech, F.R. and L.M. Thompson (1993).** Soils and Soil Fertility. Oxford University Press, New York.

**Xu, Y. (2016).** Envirotyping for deciphering environmental impacts on crop plants. Theor. Appl. Gen., 129:653–673

## الملخص العربي

# أستجابة بعض اصناف القمح المصرية للاجهاد الملحي

**منى جميل عطية – اميرة احمد محمد العربي**

معمل بحوث الاراضي الملحية والقلوية – معهد بحوث الاراضي والمياه والبيئة

من الاهداف الهامة التي تسعى اليها مصر في الوقت الحالي هي زيادة انتاجية القمح تحت ظروف الري بالمياه المالحة في ظل نقص الموارد المائية العذبة. في اطار تحقيق هذا الهدف اجريت تجربة اصص تحت ظروف الصوبة الزراعية لدراسة تأثير الري بالمياه الملحية على التحمل النسبي للملوحة لـ ١٥ صنف من اصناف القمح المصرية . وشملت اصناف القمح المختارة سخا ٩٣، سخا ٩٤ ، مصر ١، سدس ١، سدس ١٢، سدس ١٣، جيزة ١٦٨، جيزة ١٧١، سهل ١، شندويل ١، جميزة ٧، جميزة ٩، جميزة ١٠ ، جميزة ١١، جميزة ١٢ . وقد تم تجهيزمياه الرى بدرجات ملوحة مختلفة عن طريق إذابة كمية مناسبة من كلوريد الصوديوم فى ماء الصنبور لنحضيرمياه رى بثلاث مستويات من الملوحة (٥٠٠ ، ٤٥٠٠ ، ٨٥٠٠ ميليجرام/لتر ). اوضحت الدراسة انه عند تمام النضج وجد ان زيادة تركيز الاملاح حتى ٨٥٠٠ ميليجرام/لتر يؤدي لنقص معنوي في اطوال النباتات وعدد السنابل والخلفات لكل اصيص ومحصولي القش والحبوب. وبغض النظر عن المعاملات الملحية ، اعطت اصناف

سدس ١ ، جميزة ٩ اعلى محصول للحبوب (٣٢.٦، ٣١.٤ جم/اصيص على التوالي) بينما الاصناف سخا ٩٣ ، جميزة ١٢ اقل الاصناف (٢٦.٩ ، ٢٨.٣ جم/ اصيص على التوالي). واخيرا اعطت اصناف سدس ١ ، جميزة ٧ ، جميزة ٩ اعلى محصول حبوب نسبي ( ٦٤.١، ٦٥.٢، ٦٤.٤ % على التوالي) عند اعلى مستوى للملوحة (٨٥٠٠ ملليجرام/ لتر) مقارنة بباقي الاصناف موضع الدراسة بينما اعطت الاصناف سدس ١٣، سخا ٩٤ ،شندويل ١ ، جيزة ١٧١ اقل محصول نسبي عند نفس المستوى من الملوحة (٣٥.٤ ، ٣٥.٦، ٣٧.٩ ، ٣٨.٤ % على التوالي).

ومن خلال التحليل الكمي لبيانات محصول الحبوب النسبي للاصناف موضع الدراسة تم تقسيم الاصناف الى اصناف عالية التحمل للملوحة (سدس ١ ، جميزة ٧ ، ٩) واصناف متوسطة التحمل (سخا ٩٣ ، سهل ١ ، جميزة ١٠) وصنفت باقي الاصناف كاصناف حساسة للاجهاد الملحي.

وبناء على ذلك فأن الأصناف التى أظهرت أكثر تحملا للملوحة يمكن استخدامها فى برامج التربية لأستنباط أصناف جديدة يمكن زراعتها تحت ظروف الأراضى الملحية.