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Effect of Saline Irrigation Water on Grain Yield and Quality of Some Rice Varieties and Lines

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TWO LYSIMETER experiments were carried out in the Rice Research and Training Center (RRTC), Sakha, Kafrelsheikh, Egypt. during 2004 and 2005 seasons under controlled conditions to determine the effect of irrigation with different levels of saline water on yield and grain quality of some local and introduced rice varieties and lines (four varieties and seven lines). The salinity levels were adjusted to 2000 ppm, 4000 ppm and 6000 ppm. In addition, the control was kept to be irrigated by tap water. The water was artificially salinized by applying sodium chloride (NaCl) and calcium chloride ($CaCl_2$) at the ratio of 2: 1, respectively. A split plot design with three replications was used in conjunction with salinity levels on the main plots and varieties and lines in sub plots.

The obtained results could be summarized as follows:

*The highest mean value of yield and its components were produced at tap water treatment (control) whereas the lowest one of them were produced by 6000 ppm salinity level.

*The results also showd that Giza 178, Sakha 104, line AC-YT-2003-10 and line AC-AT-2003-33 had the highest values of grain yield and yield components.

*Increasing salinity level up to 6000 ppm markedly increased gelatinization temperature, while the highest values of hulling and milling percentage were produced at tap water treatment.

*Giza 177, line AC-YT-2003-41, line GZ1368-5-5-4 and line AC-YT-2003-6, gave the highest values of grain quality.

*The varieties and lines GZ1368-S-5-4, Giza 178, Sakha 104, AC-YT-23003-41 and AC-YT-2003-15 had the highest salinity index values for grain yield under 2000, 4000 and 6000 ppm salinity levels. These varieties and lines which had the highest value of salinity index had low reduction % for grain yield in both seasons.

Kaywords: Rice (*Oryza sativa* L.), Varieties, Salinity, Yield, Quality.

Rice (*Oryza sativa*) is one of the world's most important cereal crops, providing staple food for nearly one half of the world population. In many developing countries, rice is the main source of food security and is intimately associated with local life styles and culture. Rice crop plays a significant role in Egypt's strategy for sustaining the food self-sufficiency and for increasing the export. The average of rice production is 6 million metric tons of rough rice annually (national average of about 9.9 ton/ha). Farther increase in rice production through increased yield per unit area is needed. This can be achieved through varietal improvement, optimizing cultural practices as well as controlling weeds, diseases, insects and improving productivity of saline area (RRTC, 2004).

Soil salinity is one of the most serious constrains to rice production in millions of hectares in tropical and subtropical regions. This problem extends also to arid and semiarid zones. The Northern Nile Delta in Egypt is an example of an area with extensive salt affected soils in which the exchangeable sodium percentage (ESP) may reach 70% of the cation exchangeable capacity (CEC) and electrical conductivities of more than 8 dS/m in saturated paste soils. The average of rice production in the salt affected area in Egypt is much lower than the average yield in normal soils and negatively affects the national average of rice production per unit area (EL-Mowafy, 1994).

Most of commonly cultivated rice cultivars, young seedlings and reproductive growth stages are particularly sensitivity to root-one salinity (IRRI, 1996). More importantly though, the yield components related to final grain yield are also severely affected by salinity. For example, panicle length, spikelets per panicle and grain yield are significantly reduced by salt treatments (Khatun*et al.*, 1995).

One possible solution to this problem is the introduction of improved salt tolerant varieties, or hybridization between these varieties and our local high yielding potential varieties and good grain quality.

Genetic information about the type and the magnitude of the genetic variances should be studied, to develop and sustain high yielding rice varieties with salinity tolerance.

The main objectives of the present investigation are to:

1. Evaluate the performance of different rice genotypes under saline conditions.
2. Identify the most desirable genotypes as donors in future breeding programs through identifying selective characters.

Materials and Methods

This investigation was carried out in the lysimeter of the Rice Research and Training Centre (RRTC), Sakha, Kafrelsheikh, Egypt, during 2004 and 2005 seasons under controlled conditions to determine the effect of irrigation with different levels of salinity on yield and grain quality of some local and introduced rice varieties and lines (four varieties and seven lines) of different genotype groups .The origin and main characteristics of entries are shown in Table 1. A split plot design with three replications was used in conjunction with salinity levels on the main plot and varieties and lines in sub-plot.

TABLE 1. Origin and main characters of the entries.

No. of varieties and lines	Entries	Origin	Reaction to salinity	Type
Var. 1	Giza 177	Egypt (Giza 177/Yomj/ piNo.4)	Sensitive	Japonica
Var. 2	Giza 178	Egypt (Giza 175 x Milyang 49)	Tolerant	Indica
Var. 3	Sakha 104	Egypt (GZ4096-8-1162 4109)	Tolerant	Japonica
Var. 4	Gaori	Korea (GZ5591-1-1-1-1/Taikeeng 7)	Tolerant	Japonica
L_1	GZ1368-S-5-4	Egypt (IR1615-31/ BG 94-2)	Tolerant	Indica
L_2	Giza 178/IR65829-2B-2R-4-P	Egypt (AC-YT-2003-6)	Tolerant	Japonica
L_3	GZ 5385-1-1/Gaori/GZ 5721-19-1	Egypt (AC-YT-2003-41)	Tolerant	Japonica
L_4	GZ5310-20-3-3/Hexi 24//GZ5721-19-1-1)	Egypt (AC-YT-2003-36)	Tolerant	Japonica
L_5	GZ5310-20-3-3/Norin22//Gaori	Egypt (AC-YT-2003-33)	Tolerant	Japonica
L_6	GZ5385-29-3-2//Gaori	Egypt (AC-YT-2003-15)	Tolerant	Japonica
L_7	Sakha 101/IR65829-2B-95-P	Egypt (AC-YT-2003-10)	Tolerant	Japonica

Salinity, irrigation and drainage cycle were accurately controlled. The salinity levels were adjusted to 2000 ppm, 4000 ppm and 6000 ppm The water was artificially salinized by applying sodium chloride (NaCl) and calcium chloride ($CaCl_2$) at the ratio of 2: 1, respectively (El-Mowafy, 1994; Hassan, 2003 and Soltan, 2006). The mean values of electrical conductivity (EC) of the irrigation water were 0.77 mmhos/cm for tap water 3.98, 7.9 and 10.6 mmhos/cm at 25°C for the three salinity levels, respectively in both seasons. In addition, the control was irrigated with tap water.

Sowing date were 21 and 18 May in the two seasons, respectively. After thirty days from sowing, seedlings of each cultivar and line were transplanted in one row, 1 m length for each variety, in three replications, with a spacing of 15 x 15 cm between rows. The plots were salinized 15 days after transplanting and salinization was fixed till harvest. Plants were irrigated every day by auto pumping the salt solution from salt solution tanks.

Studied characters

Grain yield and its components:

1.Panicle length (cm).
2.Panicle weight (g).
3.Spikelet fertility percentage (%): Which was calculated as follows:

$$\text{Fertility } (\%) = \frac{\text{No. of fertile spikelets per paicle}}{\text{No. of spikelets per panicle}}$$

4. Number of grains per panicle.
5. Number of effective tillers.
6. 1000-grain weight (g).
7. Grain yield per plant (gm).
8. Harvest index (%): Which was calculated using the following formula as reported by IRRI (1996) as follows:

$$\text{Harvest index } (\text{HI}\%) = \frac{\text{Grain yield (economic yield)}}{\text{Biomass biological yield}} \times 100$$

Some grain quality characters

1. Hulling percentage:

$$\text{Hulling } \% = \frac{\text{Brown rice weight (g)}}{\text{Total rough rice weight (g)}} \times 100$$

2. Milling percentage:

$$\text{Milling } \% = \frac{\text{Total mild rice weight (g)}}{\text{Total rough rice weight (g)}}$$

3. Grain shape: Length/width ratio was determined by using the standard evaluation system for rice (IRRI, 1996).

4. Gelatinization temperature (G.T): The GT which was visually rated on a 7-point numerical scale adopted by Little *et al.* (1958).

Salt tolerance characters

1. Salinity index (SI): The salinity index (SI) for each character was calculated by the formula of Dwivedi *et al.* (1991) and El-Mowafy (1994).

$$\text{SI} = \frac{\text{Value of each character under saline situation}}{\text{Value of each character under normal situation}} \times 100$$

2. Reduction percentage: Value of each character under normal condition - value of each character under saline conditions divided by the value under normal condition x 100.

$$R = \frac{N - S}{N} \times 100$$

Statistical analysis

The analysis of variance was carried out according to Gomez & Gomez (1984). Treatment means were compared by Duncan's multiple range test (Duncan, 1955). All statistical analysis was performed using analysis of variance technique by means of "MSTAT" computer software package.

Results and Discussion

Yield and yield component

Panicle length (cm)

Panicle length (cm) which is one of the determinates of grain yield was highly significantly affected by the salinity levels in both seasons (Table 2).

Comparing the different treatments of salinity levels, it was observed that the mean tallest panicle (17.18 and 21.79 cm) was obtained under tap water in 2004 and 2005 seasons, respectively. While, the mean shortest panicle value was recorded under salinity level 6000 ppm in both seasons. The results indicate that increasing salinity level from 2000 ppm to 6000 ppm caused significant reduction in panicle length. This might be due to the unfavorable effect of salinity on plant elongation, *i.e.* cell elongation. This finding is in close agreement with those reported by El-Mowafy (2004), Hasssan (2003) and Soltan (2006).

Highly significant varietal differences were noticed in panicle length (cm) during 2004 and 2005 seasons. Giza 178 (var. 2) had the tallest panicle in both seasons, while AC-YT-2003-41 (L_3) gave the shortest panicle length in both seasons, that might be due to genetic make up.

There was no significant interaction between salinity levels and cultivars in both seasons.

Panicle weight (g)

Panicle weight (gm) was significantly affected by the salinity levels in both seasons (Table 2).

It was observed that the heaviest panicle weight was obtained by tap water, while 6000 ppm of salinity level gave the lowest one in both seasons. The results indicated that panicle weight (g) was decreased by increasing salinity level, the effect was much sharper at 4000 ppm and 6000 ppm of salinity levels. The reduction of panicle weight due to increasing salinization stress may be attributed to adverse effects of salinization stress on the number of filled grains per panicle and 1000-grain weight. These results are in agreement with those reported by Zayed (2002), Zeng *et al.* (2003) and Khan *et al.* (2003).

The data in Table 2 showed that panicle weight (g) significantly differed among varieties and lines in both seasons. In 2004 season the heaviest panicle weight was produced by Giza 178 (var. 2) and AC-YT-2003-10 (L_7) and the lightest panicle was produced by AC-YT-2003-41 (L_3). While in 2005 season the heaviest panicle weight was produced by Sakha 104 (var. 3) and AC-YT-2003-10 (L_7). Likewise, the lightest panicle was produced by GZ 1368-S-5-4 (L_1). Such differences might be due to genetic effects, the varieties that had the lightest panicle weigh in both seasons sensitive to salinity during the reproductive stage. On the other hand, the varieties and lines which had the heaviest panicle weight, may reflect the high ability of these genotypes to tolerat salinity. These results are in agreement with those reported by El-Mowafy (1994), Zayed (2002) and Soltan (2006).

TABLE 2. Effect of saline irrigation water at different levels on grain yield and its components of some rice varieties and lines in 2004 and 2005 seasons.

Variables \ Factors	Season	Salinity levels (A)				Cultivars and lines (B)											Interaction
		Control tap water	2000 ppm	4000 ppm	6000 ppm	Var. 1	Var. 2	Var. 3	Var. 4	L_1	L_2	L_3	L_4	L_5	L_6	L_7	A x B
Panicle length (cm)	2004	17.18 a	16.15 b	14.76 c	13.64 d	15.3 bcd	17.50 a	15.33 bcd	14.33 c	15.92 bc	16.08 b	13.00 f	14.83 de	15.17 cd	16.17 b	16.08 b	NS
	2005	21.79 a	16.69 b	18.27 c	16.64 d	17.99 cd	21.87 a	18.41 cd	18.79 c	19.07 c	20.30 b	17.32 d	18.12 cd	19.08 c	18.13 cd	20.98 ab	NS
Panicle weight (gm)	2004	1.90 a	1.46 b	1.27 c	1.02 d	0.99 de	1.79 a	1.17 d	1.13 d	1.65 abc	1.63 abc	0.85 e	1.44 c	1.45 bc	1.71 ab	1.73 a	NS
	2005	1.51 a	1.22 b	1.03 c	0.87 d	1.13 a-d	1.18 a-d	1.30 a	1.15 a-d	0.92 e	1.10 bcd	1.03 de	1.28 ab	1.24 abc	1.09 cd	1.31 a	NS
Spikelet fertility percentage	2004	90.12 a	81.75 b	74.54 c	64.76 d	58.78 e	85.72 a	81.19 b	79.63 bc	88.38 a	79.83 bc	76.08 cd	75.19 cd	79.61 bc	71.81 d	79.41 bc	*
	2005	88.81 a	83.47 b	72.67 c	51.38 d	74.77 ab	74.63 ab	80.45 a	80.30 a	70.11 bc	67.53 c	68.86 bc	80.53 a	80.14 a	68.15 bc	69.49 bc	**
Number of grains/panicle	2004	95.58 a	72.49 b	61.97 c	50.42 d	53.70 c	80.17 a	73.50 a	64.50 b	80.00 a	74.33 a	65.50 b	65.67 b	65.00 b	75.83 a	73.00 a	**
	2005	83.82 a	67.09 b	58.91 c	51.91 c	53.25 e	79.75 a	68.83 bc	64.33 cd	62.08 d	71.42 b	62.08 d	61.08 d	60.75 d	69.92 bc	66.25 cd	**
Number of effective tillers	2004	6.94 a	5.97 b	5.00 c	3.97 d	6.00 bc	7.58 a	5.42 bcd	4.92 d	6.25 b	5.50 bcd	2.92 e	5.00 d	5.83 bcd	5.25 cd	5.00 d	NS
	2005	10.44 a	7.89 b	6.84 c	5.37 c	8.27 b	9.86 a	8.76 ab	6.53 c	9.17 ab	6.17 c	6.38 c	8.73 ab	8.11 b	5.88 c	6.14 c	NS
1000-grain weight (gm)	2004	26.97 a	23.78 b	22.40 bc	19.78 c	23.77abc	17.89 e	25.72 a	23.56abc	20.78 d	22.92 bc	22.64 cd	25.78 a	24.06abc	23.57abc	24.91 ab	**
	2005	26.52 a	22.89 b	21.46 c	19.71 d	24.10 ab	18.91 e	23.51 b	23.47 b	20:03 de	21.08 cd	22 62 bc	25.73 a	23.00 bc	22.87 bc	23.87 ab	*
Grain yield/plant (gm)	2004	10.22 a	7.96 b	6.43 c	5.62 d	5.63 f	8.68 bc	9.54 a	8.43 c	8.23 c	5.65 f	6.60 de	6.78 d	9.38 ab	5.95 ef	8.25 c	**
	2005	10.25 a	8.20 b	7.10 c	5.77 d	6.33 f	8.72 c	9.58 b	6.95 de	8.83 c	6.48 f	7.25 d	6.90 e	9.98 a	6 52 f	8.58 c	**
Harvest index (%)	2004	33.45 a	28.18 b	24.14 c	21.79 d	21.57 f	30.02 b	31.77 a	29.10 bc	29.04 bc	21.94 ef	24.34 d	24.92 d	31.40 a	22.80 e	28.91 c	**
	2005	33.70 a	28.84 b	25.97 c	22.30 d	23.39 g	29.98 c	32.15 b	25.36 e	30.37 c	24.41 f	26.30 d	25.44 e	32.99 a	24.55 f	29.77 c	**

*, ** and NS indicate $P < 0.05$, $P < 0.01$ and not significant, respectively.

Means within the same column of each factor designated by the same letter are not significantly different at the 5% level, according to Duncan's Multiple Range Test (1955).

The interaction between salinity levels and cultivars was not significant.

Spikelet fertility percentage (%)

Salinity levels had obviously highly significant effect on spikelet fertility percentage. It was observed that the highest value was obtained by tap water, while 6000 ppm treatment gave the lowest one in both seasons. The results indicate that spikelet fertility percentage was decreased by increasing salinity level and the effect was much sharper at 4000 ppm and 6000 ppm salinity levels. The reduction of spikelet fertility percentage due to increasing salinization stress may be due to sensitivity of this stage to salinity stress. Similar relationship of decreasing the fertility with increasing salinity concentration, were reported by Khan *et al.* (2003) and Aisha *et al.* (2005).

Highly significant varietal differences were noticed in spikelet fertility percentage during 2004 and 2005 seasons. In 2004 season the highest value was produced by Giza 178 (var. 2) and GZ1368-S-5-4 (L_1) and the lowest value were obtained by Giza 177 (var. 1). In 2005 seasons the highest value was recorded by Sakha 104 (var. 3), Gaori (var. 4), AC-YT-203-33 (L_5) and AC-YT-2003-36 (L_4). While, the lowest value was obtained by AC-YT-2003-6 (L_2) (Table 2). Such difference might be due to genetic make up. Several investigations claimed varietal differences in spikelet fertility such as Zayed (2002), Hassan (2003) and Soltan (2006).

The spikelet fertility percentage was highly significantly affected by the interaction between salinity levels and varieties. The highest spikelet fertility percentage (94.87%) were obtained by GZ1368-S-5-4 (L_1) with tap water treatment in 2004 seasons, while the lowest spikelet fertility percentage (46.15%) were obtained by 6000 ppm with Giza 177 (var. 1) and (32.04%) with AC-YT-2003-6 (L_2) in both seasons respectively.

Number of grains/panicle

The data in Table 2 indicate that highly significant differences existed among the salinity levels on number of grains per panicle, the highest value was obtained with tap water treatment (control) in both seasons while the lowest one was obtained at 6000 ppm treatment in 2004 season and 4000 ppm and 6000 ppm in 2005 season. The results indicated that increasing salinity level from 2000 ppm to 6000 ppm caused significant reduction in number of grains per panicle. These results are in accordance with those obtained by Asch & Wopereis (2001) and Khan *et al.* (2003). They reported that the number of grains per panicle was markedly reduced by high salinity level.

Significant varietal differences were noticed in number of grains per panicle during 2004 and 2005 seasons. In 2004 season the highest value was given by Giza 178 (var. 2), Sakha 104 (var. 3), AC-YT-2003-6, (L_2) and AC-YT-20063-10 (L_7), while the lowest value were obtained by Giza 177 (var. 1). In 2005 season the highest value was given by Giza 178 (var. 2) and the lowest value was obtained by Giza 177 (var. 1) (Table 2). These results are in harmony with those reported by Asch & Woperies (2001).

The interaction (A x B) was highly significant in both seasons. The highest number of grains per panicle (133.00) were obtained by GZ1368-S-5-4 (L_1) with tap water treatment and the lowest value (37.33) was obtained by Giza 177 (var. 1) with 6000 ppm (var. 4) in 2004 season. In 2005 season the highest value (98.00) was given by Gaori (var. 4) with tap water treatment and the lowest one (45.33) was obtained by Giza 177 (var. 1) with 6000 ppm salinity level.

Number of effective tillers

The data in Table 2 indicate that highly significant differences existed among the salinity levels on number of effective tillers per plant. The highest value was obtained with tap water treatment in both seasons, while the lowest value was obtained at 6000 ppm in 2004 season and 4000 ppm and 6000 ppm in 2005 season. The results also indicate that increasing salinity level from 2000 ppm to 6000 ppm caused significant reduction in number of effective tillers per plant. The adverse effect of different degree of salinization on number of effective tillers per plant may be attributed to the increase in Na uptake, Na/K ratio, Cl^- uptake and decrease in K^+ uptake by plants at panicle initiation stage, which was adversely reflected in the number of developed panicles per plant. Similar results were obtained by El-Mowafy (1994) and Zeng *et al.* (2003).

The data in Table 2 showed a highly significant difference among cultivars and lines in number of effective tiller per plant in both seasons. Giza 178 (var. 2) was superiority in mean value of number of effective tiller per plant in both seasons, while the lowest were obtained by AC-YT-2003-41 (L_2) in 2004 season and AC-YT-2003-15 (L_6) in 2005 season.

There was no significant difference interaction between salinity levels and cultivars in both seasons.

1000-grain weight (g)

Comparing the different treatments of salinity, it was observed that the highest weight of 1000 grain was obtained by tap water, while 6000 ppm treatment gave the lowest one in both seasons (Table 2). The results indicate that 1000-grain weight (gm) was decreased by increasing salinity level and the effect was much sharper at 6000 ppm salinity level. The reduction of panicle weight was due to increasing stress on the number of filled grains per panicle and the 1000-grain weight. This finding is in agreement with that reported by Asch & Woperis (2001) and Khan *et al.* (2003).

The difference among cultivars and lines in 1000-grain weight was highly significant in both seasons (Table 3) which gave the highest mean value in 2004 season and AC-YT-2003-36 (L_4) in 2005 season, while the lowest weight were obtained by Giza 178 (var. 2) in both seasons (Table 2). The varietal differences in 1000-grain weight was mainly due to genetic make up. Varietal differences in 1000-grain weight has been shown by Zayed (2002), Hassan (2003) and Soltan (2006).

The interaction between salinity levels and rice cultivars and lines were highly significant in both seasons. Highest weight of 1000-grain (36.07 gm) was obtained by AC-YT-2003-36 (L_4) with tap water treatment and the lowest value (16.43 gm) was obtained by Giza 178 (var. 2) with 6000 ppm salinity level in both seasons.

TABLE 3. Mean values of hulling and milling percentage, grain shape and gelatinization temperature (GT) of some rice cultivars and lines as affected by different salinity levels during 2004 and 2005 seasons.

Variables	Salinity levels (A)				Cultivars and lines (B)											Interaction
	Control tap water	2000 ppm	4000 ppm	6000 ppm	Var. 1	Var. 2	Var. 3	Var. 4	L_1	L_2	L_3	L_4	L_5	L_6	L_7	A x B
	2004 season															
Hulling %	79.38 b	80.90 a	79.79 b	79.53 b	80.68 ab	80.29 ab	79.69 b	79.73 ab	79.85 ab	81.05 a	79.35 bc	80.05 ab	80.07 ab	78.23 c	79.93 ab	**
Milling %	69.59 a	71.18 a	71.50 a	68.90 b	71.52 a	69.50 cd	68.85 d	69.50 cd	71.14 ab	70.80 ab	69.05 d	71.48 a	71.05 ab	70.22 bc	70.33 bc	**
Grain shape	2.44	2.38	2.36	2.41	2.20 d	2.53 abc	2.60 ab	2.29 cd	2.37 bcd	2.73 a	2.29 cd	2.28 cd	2.20 d	2.43 bcd	2.44 bcd	*
GT	5.46 b	4.85 c	5.61 ab	5.79 a	5.83 a	5.25 cd	5.00 d	5.00 d	5.50 bc	5.75 ab	5.75 ab	5.33 c	5.67 ab	5.33 c	5.25 cd	**
	2005 season															
Hulling %	80.24 a	79.90 ab	78.89 b	77.63 c	80.28 a	79.80 ab	80.07 ab	78.51 c	79.82 ab	79.63 abc	78.87 bc	79.14 abc	79.35 abc	76.10 d	79.25 abc	**
Milling %	72.11 a	69.60 b	72.00 a	70.76 ab	72.89 a	70.07 bc	68.55 c	72.75 a	70.40 abc	71.75 ab	71.00abc	71.57 ab	70.25 abc	71.67 ab	71.39 ab	**
Grain shape	2.39	2.35	2.38	2.49	2.36 bc	2.59 ab	2.44 bc	2.34 bc	2.78 a	2.28 c	2.35 bc	2.44 bc	2.27 c	2.22 c	2.38 bc	**
GT	5.72 ab	5.67 b	5.79 ab	5.85 a	5.25 c	5.75 ab	5.83 ab	5.75 ab	6.00 a	5.92 a	6.00 a	5.75 ab	5.75 ab	5.50 bc	5.82 ab	**

Grain yield per plant (gm)

The data in Table 2 indicate that highly significant differences existed among the salinity levels on grain yield/plant. The highest value of grain yield/plant was obtained with tap water treatment (control) while. the lowest one was obtained at 6000 ppm in both seasons. The results indicate that increasing salinity level from 2000 ppm to 6000 ppm caused significant reduction in grain yield/plant. This finding could be attributed to the adversely effect of NaCl and $CaCl_2$ on most studied yield components such as number of effective tillers, panicle weight, panicle length and 1000-grain weight which reflected the earlier reduced of dry matter accumulation during the vegetative stage which on the other hand, negatively affected the rice yield outturn. Many investigators came to similar results such as Zayed (2002), Hassan (2003), Zeng *et al.* (2003), Khan *et al.* (2003), Aisha *et al.* (2005) and Soltan (2006).

The data in Table 2 indicate a highly significant difference among cultivars and lines in grain yield/plant in both seasons. Sakha 104 (var. 3) and AC-YT-2003-15 (L_6) gave the highest mean value of grain yield in 2004 season, while AC-YT-2003-15 (L_6) gave the highest mean value of grain yield in 2005 season. Giza 178 (var. 2). AC-YT-2003-10 (L_7) and GZ 1368-S-5-4 (L_1) were ranked second in both seasons. The lowest value of grain yield were obtained by Giza 177 (var. 1) in both seasons. The variation in grain yield among the different genotypes could be attributed to the variation in their genetic construction. The varietal differences were reviewed by Cheong *et al.* (1996) and Zayed (2002).

The interaction between salinity levels and varieties was highly significant in both seasons.

The highest grain yields (12.9, 12.9 and 13.0 gm) were obtained by Sakha 104 (var. 3), Gaori (var. 4) and AC-YT-2003-33 (L_5) with tap water treatment and the lowest grain yield (3.9 gm) were obtained by Giza 177 (var. 1) with 6000 ppm in 2004 season. In the 2005 season the highest grain yields (12.3 gm) were obtained by AC-YT-2003-33 (L_5) with tap water and the lowest grain yield (3.9, 5.0 and 4.9 gm) were exerted by Giza 177 (var. 1), AC-YT-2003-36 (L_4), Gaori (var. 4) in the 6000 ppm treatment. These results were in conformity with those reported by El-Mowafy (1994), Hassan (2003) and Soltan (2006).

In general, we can conclude that the variety Sakha 104 (var. 3) and line AC-YT-2003-33 (L_5), may represent the best variety and line having more ability to tolerate salinity than the others.

Harvest index (%)

Comparing different treatments of salinity, it was observed that the highest value of harvest index was obtained with tap water treatment in both seasons while, the lowest one was obtained at 6000 ppm in both seasons. The results indicate that increasing salinity level from 2000 ppm to 6000 ppm caused significant reduction in harvest index. This finding could be attributed to the adverse effect of NaCl and $CaCl_2$ on grain yield and straw weight of plant and these could reduce the harvest index in both seasons by increasing salinity levels. These results are in agreement with what obtained by Zayed (2002), Hassan (2003) and Soltan (2006).

The data in Table 3 indicate also clearly a highly significant difference among cultivars and lines on harvest index in both seasons. Sakha 104 (var. 3) and AC-YT-2003-33 (L_5) gave the highest mean values of harvest index in 2004 season. Also, AC-YT-2003-33 (L_5) gave the highest mean value of harvest index in 2005 season. GZ1368-S-5-4 (L_1) and AC-YT-2003-10 (L_7) were ranked secondly in both seasons. The lowest value of harvest index were obtained by Giza 177 (var. 1) in both seasons. The varietal differences in harvest index were reported by Rana (1986) and Zayed (2002).

Interaction between salinity levels and rice cultivars and lines were highly significant in both seasons. The highest harvest index value (39.26, 39.20 and 39.37%) were obtained by Sakha 104 (var. 3), Gaori (var. 4) and AC-YT-2003-33 (L_5) with tap water treatment and the lowest one (16.30%) were obtained by Giza 177 (var. 1) with 6000 ppm treatment in 2004 season.

In 2005 season the highest harvest index (38.07%) were obtained by AC-YT-2003-33 (L_5) and the lowest one (16.33, 20.00 and 19.70%) were exerted by Giza 177 (var. 1), AC-YT-2003-36 (L_4) and Gaori (var. 4) with 6000 ppm salinity level.

Some grain quality characters

Hulling percentage (%)

The data in Table 3 indicate that highly significant differences existed among the salinity levels on hulling percentage (%). The highest value of hulling percentage was obtained with tap water treatment (control), while the lowest one was obtained at 6000 ppm in both seasons (Table 3). The results indicate that increasing salinity level from tap water to 6000 ppm caused significant reduction in hulling percentage. Similar results were obtained by Hassan (2003).

The data in Table 3 showed that there were highly significant differences among cultivars and lines in hulling percentage in both seasons. AC-UYT-2003-6 (L_2) and Giza 177 (var. 1) gave the highest values of hulling %, while AC-YT-2003-15 (L_6) obtained the lowest in both seasons, respectively. The observed varietal differences might be due to genetic make up. Similar results were obtained by Zayed (2002) and Hassan (2003).

The interaction between salinity levels and varieties had significant effect on hulling % in both seasons. The highest hulling percentage (81.60 and 82.43%) were obtained by AC-YT-3003-6 (L_2) and Sakha 104 (var. 3) with tap water treatment and the lowest one (72.67 and 71.77%) were recorded for AC-YT-2003-15 (L_6) with 4000 and 6000 ppm salinity levels in both seasons, respectively.

Milling percentage (%)

The data in Table 3 indicate that highly significant differences existed among the salinity levels on milling percentage in both seasons. The highest value of milling percentage was obtained with tap water treatment (control) while, the lowest one was obtained at 6000 ppm in both season. The results indicate that increasing salinity levels from tape water to 6000 ppm caused significant reduction in milling percentage. Similar results were obtained by Cheong *et al.* (1995) and Hassan (2003).

Highly significant varietal differences were detected among the studied lines and cultivars in milling percentage in both seasons (Table 3). The highest mean value of milling percentage was produced by AC-YT-2003-36 (L_4) and Giza 177 (var. 1) in 2004 season, while in 2005 season Gaori (var. 4) and Giza 177 (var. 1) gave the highest mean value in milling percentage. Sakha 104 (var. 3) gave the lowest one in both seasons. The varietal differences in milling percentage were reviewed by Zayed (2002) and Hassan (2003).

The highest milling percentage (75%) were obtained by GZ1368-S-5-4 (L_1) with 2000 ppm treatment and the lowest one (62%) were obtained by AC-YT-2003-41 (L_3) with 6000 ppm in 2004 season. while in 2005 season, the highest milling percentage (77%) were obtained by AC-YT-2003-36 (L_4) with 4000 ppm treatment and the lowest one (67.3%) were produced by (L_4) x 6000 ppm salinity level.

Grain shape

The data in Table 3 indicate that the salinity levels had insignificant effect on grain shape in both seasons.

The data in Table 4 showed that there were highly significant differences among cultivars and lines in grain shape. The highest value of grain shape were recorded by AC-YT-2003-6 (L_2) and GZ1368-s-5-4 (L_1) while, the lowest one were obtained by Giza 177 (var. 1) in both seasons, respectively (Table 3). The observed varietal differences might be due to genetic make up. The varietal differences were reviewed by Lee *et al.* (1990), El-Mowafy (1994), Hassan (2003) and Soltan (2006).

For interaction the highest grain shape (3.00) were obtained by Sakha 104 (var. 3) with 2000 ppm treatment and the lowest one (2.00) were obtained by Giza 178 (var. 2) with 2000 ppm in 2004 season, while in 2005 season the highest value (3.32) were obtained by Giza 178 (var. 2) with 6000 ppm and the lowest one (1.76) were exert by AC-YT-2003-15 (L_6) with 4000 ppm treatment.

Gelatinization temperature (G.T)

The data in Table 3 indicate that highly significant differences existed among the salinity levels on gelatinization temperature (G.T). The highest value of gelatinization temperature was obtained with 6000 ppm while, the lowest one was obtained at tap water (control) in both season. The results indicate that increasing salinity level from tap water to 6000 ppm caused significant increase in gelatinization temperature.

TABLE 4. Salinity index and reduction for grain yield in 2004 and 2005 seasons.

Entries	Season 2004			Seasons 2005			Season 2004			Seasons 2005		
	Salinity index %						Reduction %					
	2000 ppm	4000 ppm	6000 ppm	2000 ppm	4000 ppm	6000 ppm	2000 ppm	4000 ppm	6000 ppm	2000 ppm	4000 ppm	6000 ppm
Giza 177 (var. 1)	71.06	48.24	45.76	56.10	47.81	37.14	28.94	51.76	54.24	43.90	52.19	62.86
Giza 178 (var. 2)	86.33	72.48	60.00	81.44	61.36	52.88	13.67	27.52	40.00	18.56	38.54	47.12
Sakha 104 (var. 3)	86.62	58.08	50.50	90.35	85.96	59.91	13.38	41.92	49.50	9.65	14.04	40.09
Gaori (var. 4)	58.91	52.71	51.47	65.38	54.81	47.12	41.09	47.29	48.53	34.62	45.19	52.88
GZ1368-S-5-4 (L_1)	85.57	82.47	71.44	82.06	71.47	58.15	14.43	17.53	28.56	17.94	28.53	41.85
AC-YT-2003-6 (L_2)	84.92	83.26	72.40	9.45	76.92	70.62	15.08	16.74	27.60	20.55	23.08	29.38
AC-YT-2003-41 (L_3)	64.26	50.74	49.56	74.85	62.87	51.90	35.74	49.26	50.4	25.15	37.13	48.10
AC-YT-2003-36 (L_4)	72.80	53.07	51.12	90.70	72.09	58.14	27.20	46.93	48.88	9.30	27.91	41.86
AC-YT-2003-33 (L_5)	79.75	58.66	50.04	89.51	78.86	56.34	20.25	41.34	49.96	10.49	21.14	43.66
AC-YT-2003-15 (L_6)	95.73	79.66	63.02	90.67	80.00	77.33	4.27	20.34	36.98	9.33	20.00	22.67
AC-YT-2003-10 (L_7)	78.97	68.87	55.19	80.84	71.66	59.04	21.03	31.13	44.81	19.16	28.34	40.96

The date in Table 3 showed that there were highly significant differences among cultivars and lines in gelatinization temperature (G.T).

Giza 177 (var. 1), GZ 1368-S-5-4 (L_1), AC-YT-2003-6 (L_2) and AC-YT-2003-41 (L_3) produced the highest values of (G.T), while Sakha 104 (var. 3), Gaori (var. 4) and AC-YT-2003-15 (L_6) gave the lowest one in both seasons (Table 3).

Data reported that highly significant interaction was observed among factors tested in this trait in both seasons.

Salt tolerance characters

The salinity index (SI) values for grain yield and reduction grain yield % are presented in Table 4.

The data indicate that grain yield reduced under saline condition, given low SI. The varieties and lines GZ1368-S-5-4 (L_1), Giza 178 (var. 2), Sakha 104 (var. 3), AC-YT-2003-6 (L_2) and AC-YT-2003-15 (L_6) had the highest salinity index (SI) values for grain yield under 2000 ppm, 4000 ppm and 6000 ppm in 2004 season, while in 2005 season the highest salinity index (SI) values were obtained by Sakha 104 (var. 3), AC-YT-2003-36 (L_4) and AC-YT-2003-15 (L_6) under 2000, 4000 and 6000 ppm (Table 4). These varieties which had the highest value of salinity index (SI), had low reduction % value in both seasons. This indicated that low reduction correlated with high salinity index for grain yield. These varieties reflected good salt tolerance potential, so, it could be used as a donor in a breeding program. Similar results was also obtained by Lee *et al.* (1990), El-Mowafy (1994) and Soltan (2006).

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تأثير الرى بالماء المالح على محصول وجودة الحبوب لبعض أصناف وسلالات الأرز

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أجريت تجربتان فى الليزوميتر بمركز البحوث والتدريب فى الأرز بكفرالشيخ خلال موسمى الزراعة ٢٠٠٤ ، ٢٠٠٥ تحت ظروف محكمة ، وذلك لتقييم تأثير الرى بالماء المالح بتركيزات مختلفة من الملوحة على محصول وجودة الحبوب لبعض أصناف وسلالات الأرز (اربعة أصناف وسبع سلالات).

وقد استخدم لهذه الدراسة ثلاثة مستويات مختلفة من التمليح وهى ٢٠٠٠ ، ٤٠٠٠ ، ٦٠٠٠ جزء فى المليون بالإضافة إلى المعاملة الكنترول (ماء الصنبور) وقد تم التمليح الصناعى باستخدام ملح كلوريد الصوديوم وكلوريد الكالسيوم بنسبة ٢ : ١.

وكان التصميم الاحصائى المستخدم هو قطاعات منشقة مرة واحدة ذو ثلاثة مكررات اشتملت القطع الرئيسية على مستويات التمليح ووزعت الأصناف والسلالات فى القطع المنشقة.

ويمكن تلخيص أهم النتائج المتحصل عليها كما يلى:

- تم الحصول على أعلى القيم للمحصول ومكوناته باستخدام ماء الصنبور فى الرى (المعاملة الكنترول). فى حين أدى زيادة ملوحة ماء الرى إلى ٦٠٠٠ جزء فى المليون إلى خفض المحصول ومكوناته.
- أظهرت النتائج أن الأصناف جيزه ١٧٨ وسخا ١٠٤ وكذلك السلالات AC-YT-2003-10 ، AC-YT-2003-33 كانت متفوقة فى المحصول ومكوناته بالمقارنة بالأصناف والسلالات الأخرى.
- زيادة التمليح إلى ٦٠٠٠ جزء فى المليون أعطى أعلى قيمة لصفة درجة الجلتنة (GT) فى حين أدى استخدام الماء العذب فى الرى إلى زيادة نسبة التقشير والتبييض.
- الصنف جيزه ١٧٧ والسلالات AC-YT-2003-41 ، AC-YT-2003-6 ، GZ1368-5-5-4 كان لهم تأثير معنوى وإيجابى على صفات جودة الحبوب.
- الأصناف جيزه ١٧٨ ، سخا ١٧٧ ، والسلالات GZ1368-s-5-4 ، AC-YT-2003-41 ، AC-YT-2003-15 أعطت أعلى القيم لصفة دليل الملوحة تحت تركيز ٢٠٠٠ ، ٤٠٠٠ ، ٦٠٠٠ جزء فى المليون.

وقد وجد أن الأصناف والسلالات التى اعطت أعلى قيمة لدليل الملوحة هى التى أعطت قيمة أقل لمعدل النقص فى المحصول فى كلا الموسمين.