Water Salinity Tolerance of Egyptian Barley Cultivars

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ABSTRACT

The present investigation was carried out in a greenhouse at the Agricultural Research Station, Alexandria University in the two successive winter seasons of 2018/2019 and 2019/2020. To study the performance of 15 Egyptian barley cultivars of divergent genetic constitution to saline irrigation water of 0, 6000, and 12000 ppm NaCl. The statistical design was a factorial experiment in a randomized complete block design of four replications in the two seasons. Obtained results indicated that water salinity reduced all physiological, yield, and yield component traits in all cultivars, except days to maturity and grain filing period which were increased by increasing salinity level. Grain yield per pot was reduced by 54.46 % at 6000 ppm by 66.39% at 12000 ppm, as an average of all cultivars. That reduction was a result of the reduction in main yield components such as the number of grains per spike and 100-grain weight. A significant cultivar x salinity level interaction was detected for all studied characters indicating that the genetic constitution of cultivars played an important role in the resilience of cultivars under salinity stress conditions. The yield index, as an indicator of stress tolerance, indicated that cultivars G136, G2000, and G130 were salt tolerant at the highest salinity level and those cultivars have the potential of producing suitable yields in marginal areas characterized by high soil salinity or saline water sources.

Keywords: Barley, water salinity, physiological parameters, yield, yield components.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is an important cereal crop worldwide. It ranked fourth among cereals, following maize, wheat and rice (FAOSTAT, 2022). It is valued for its versatility and wide range of uses. It serves as a key ingredient in brewing of beverages, animal feed and human nutrition. There is an increasing interest in using barley for food given its considerable health benefits and nutritional value such as high fiber content, vitamins, and antioxidants (Izydorczyk, 2002).

As a hardy crop, for its relatively higher tolerance to drought and soil salinity stresses, barley is grown in diverse environments from temperate climates to arid regions such as those prevailing in the north-west coast of Egypt (Hammami *et al*., 2016 and Moustafa *et al*., 2021). Moreover, barley would be an ideal winter crop for growing in soils of the new extension projects implemented by the Egyptian government in marginal and desert areas, characterized by high soil and/ or underground water salinity levels (ElBeih, 2021).

The salinity of soil is a worldwide abiotic stress that affects the growth and productivity of field crops. In Egypt, 35 % of cultivated lands are affected by different levels of salinity due to a combination of several factors such as low precipitation, poor drainage, high evaporation, excess use of mineral fertilizers, and irrigation using low-quality water (Kotb *et al*., 2000). Climate change in arid regions, including Egypt, will be accompanied by a rise in temperature and a severe reduction in rainfall which has the potential to elevate salinity problems further (Attia *et al*., 2021). The salinity of irrigation water imposes several problems to crop plants such as water stress due to physiological drought, ion toxicity due to excessive salt uptake, in addition to reduction in nutrients uptake and translocation to different plant parts. These disorders have disruptive effects on physiological processes such as photosynthesis and respiration (Mansour *et al*., 2020 and Desoky *et al*., 2021), which eventually lead to a reduction in plant growth and productivity. Several researchers reported that increase of water salinity levels decreased barley plants' vegetative traits such as plant height, leaf area, and spike length per plant (Tadayon & Emam, 2007; Abd El-Maaboud, 2016 and Sorkhi, 2020). Hammami *et al.* (2020) reported that biomass and grain yield were decreased by 40 % and 27 % by increasing water salinity from 5 to 15 %. Similarly, Abdelrady *et al.* (2024) found that plant growth of four barley cultivars decreased significantly with irrigation water salinity levels of 12 and 16 dSm^{-1}. Moreover, grain yield and yield components, i.e. number of tillers per plant, number of grains per spike and 1000-grain weight, were significantly reduced with increasing water salinity level (Kumar *et al.*, 2014; Mathinya *et al*., 2021; Mansour *et al.*, 2021 and Ghonaim *et al*., 2023).

The Egyptian collection of barley cultivars includes genotypes of different types, i.e. six-rowed (hulled and hulless) and two-rowed. Considerable variability in response to water salinity level was reported by several researchers (Abd El-Wahed *et al.*, 2015; Ali *et al.*, 2017; Mansour *et al*., 2021; Ghonaim *et al*., 2023 and Abdelrady *et al*., 2024) indicating the presence of genotype * salinity interaction. Mansour *et al*. (2021) found that Giza 126 and Giza 136 were the most

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tolerant cultivars for irrigation with saline water at concentrations ranging from 5.25 to 11.12 dSm^{-1}. Ghassab (2019) reported that both six-rowed and two-rowed barley genotypes were similar in their tolerance to saline water at the vegetative stage, but the six-rowed showed better tolerance for salinity in biological yield. The present investigation was carried out to evaluate the performance of 15 Egyptian barley cultivars to water salinity levels of 6000 and 12000 ppm NaCl compared to the control.

MATERIAL AND METHODS

Two glasshouse experiments were carried out in the winter successive seasons of 2018/2019 and 2019/2020 at the Agricultural Research Station, Alexandria University, to investigate the effect of water salinity levels (0, 6000, and 12000 ppm) on 15 barley cultivars (Table 1) with regard to their growth and productivity performances. Salinity was applied as NaCl salt. The experimental design was a randomized complete block with four replications in the two seasons.

Ten seeds from each cultivar were planted in plastic pots (25 cm in a diameter and 30 cm in depth) filled with sandy clay loam soil (Table 2). Sowing date was December 1st in both seasons. The pots were irrigated with tap water up to 21 days after sowing then the salinity treatments were applied. Irrigation water was applied every seven days at the rate of 1 L/ pot (according to field capacity). An additional 25 % was added with irrigation with saline solutions to supply leaching fraction requirements. Supply of macronutrients was added, for each pot, as recommended for barley at the rate of 48 kg P_2O_5/ ha and 144 kg N/ ha (split in three doses of 48 kg N/ ha at sowing, 21 days and 42 days after sowing).

Table 1. Type and Pedigree of Egyptian barley cultivars used in the study

Cultivars	Type and Pedigree
	6-rowed, hulled
Giza 123	Giza 117/FAO86
Giza 124	Giza 117//Bahteem52//Giza118/FAO86
Giza 125	Giza 117//Bahteem52//Giza118/FAO86 (sister line to G.124)
Giza 126	Baladi Bahteem/ S D729-Por12762-BC
Giza 132	Rihane-05//AS 46/Aths*2Athe/ Lignee 686
Giza 133	ICB91-0343-0AP-0AP-0AP-281AP-0AP
Giza 134	ICB91-0343-0AP-0AP-0AP-289AP-0AP
Giza 2000	Giza117/Bahteem52// Giza118/ FAO86 / 3/Baladi16/ Gem
	6-rowed, hulless
Giza 129	Deir Alla 106/Cel//As46/Aths*2”
Giza 130	Comp.cross”229//Bco.Mr./DZ02391/3/Deir Alla 106
Giza 131	CM67B/CENTENO//CAMB/3/ROW906.73/4/GLORIABAR/COME-B/5/FALCON BAR/6/LINO
Giza 135	ZARZA/BERMEJO/4/DS4931//GLORIABAR/COPAL/3/SEN/5/ AYAROS
Giza 136	PLAISANT/7/CLN-B/LIGEE640/3/S.P-B//GLORIAAR/ COME B/5/ FALCONBAR/6/LINOCLN-B/A/S.P-/LIGNEE640/3/S.P-B// GLORIA- BAR/COME B/5/FALCONBAR/6/LINO
	2-rowed
Giza 127	W12291/B0gs/Hamal-02
Giza 128	W12291/4/11012-2170-22425/3/’’Apam’’/’’B65”//”A16”

Provided by barley Research Department, Field Crops Research Institute, Agriculture Research Centre, Giza, Egypt.

Table 2. Some physical and chemical properties of the experimental soil

Soil properties	Values
Physical properties	
Sand	61.59
Silt	11.82
Clay	26.59
Soil texture	Sandy
pH (1:2.5), (Soil: Water)	Clay Loam
EC dSm^{-1}(1:1), (Soil:	8.29
Water)	2.49
Soluble cations ($Cmol.Kg^{-1}$)	
Ca^{2+}	161.2
Mg^{2+}	68.84
Na^{+}	197.42
K^{+}	38.44
Soluble anions ($Cmol.Kg^{-1}$)	
HCO_3^-	403.52
Cl^-	174.27
SO_4^{--}	340.06
Total N (%)	0.08
Available Phosphorus ($mg.Kg^{-1}$)	4.81
Available potassium ($mg.Kg^{-1}$)	303.22
Total carbonate,%	63.12
Organic matter %	0.96
CEC ($Cmol.Kg^{-1}$)	3.56

The following characters were measured (or calculated) for each experimental unit:

1- Leaf area index (LAI): calculated as the sum of leaf area of plants divided by area of pot.

2- Number of fertile spikes per pot (NFS).

3- Maturity date (MD, days): number of days from sowing to physiological maturity.

4- Grain filling rate (GFR, g/ day): was calculated using the following formula:

GFR = DW2 – DW1 / t

Where: DW2= grains dry weight (in g) at harvest,

DW1= grains dry weight (in g) at 7 days after heading (DAH), and t= time (in days).

5- Grain filling period (GFP): number of days from 7 DAH to harvest.

6- Number of grains/ spike (NGS).

7- 100-grain weight (HGW): weight in grams as an average of two 100-grain samples taken from each pot.

8- Grain yield/ pot (GY/ pot, g).

9- Yield Index (YI): was calculated according to Gavuzzi et al. (1997) using the following formula: YI = Ys/ $\bar{Y}$s, **where:**

Ys: grain yield of each cultivar at each salinity level

$\bar{Y}$s = average grain yield of all genotypes at each salinity level.

Data were statistically analyzed according to Gomez and Gomez (1984) using SAS (Statistical Analyses System) ver. 9.4, 2020. Test of homogeneity of error (Hartley, 1950) indicated that the error was statistically homogeneous for the two seasons, hence data were combined over the two seasons. Means of factor levels and interaction were compared using the Least Significant Difference (LSD) at 5 % level of probability.

Appropriate transformation of data for numbers and percentages were performed using square root and angular transformation respectively. The analysis of variance revealed that the season component and its first and second-order interactions were insignificant for all studied characters; therefore, the data for these components were not presented.

RESULTS AND DISCUSSION

Salinity levels, cultivars, and their interaction all contributed significantly to the variance for all studied barley traits (Table 3). Since the experiments were carried out under controlled conditions in a greenhouse in the two seasons, the year component and its interaction with salinity level and cultivars were insignificant and enabled the performance of combined analysis of variance over seasons.

1- Effect of water salinity levels:

Increasing salinity levels to 6000 and 12000 ppm NaCl affected the studied traits of barley cultivars in various magnitudes (Table 4). Salinity level of 6000ppm significantly reduced leaf area index (18.38%), number of fertile tillers per plant (10.02%), grain filling rate (50.72%), number of grains per spike (27.36%), 100-grain weight (35.47%) and grain yield per pot (54.62%), while it increased days to maturity (4.25%) and grain filling period (13.96%) compared to the control. The effect of increasing salinity level to 12000 ppm was more pronounced, compared to the control, and reached 29.4, 21.18, 59.81, 36.86, 49.71, 66.39, 10.32 and 23.69%for the above mentioned traits, respectively. These results were in accordance with those reported by several researchers in barley including Tadayon & Emam (2007); Ghassab (2019); Sorkhi (2020); Mathinya et al. (2021); Hussain et al. (2022) and Abdelrady et al. (2024). Hammami et al. (2020)

reported that biomass and grain yield of barley genotypes were decreased by Ho and 27%, respectively, with increasing water salinity level from 5 to 15 dsm-1. Ghonaim et al. (2023) found that increasing water salinity level up to 8000 ppm decreased plant height, spike length, number of grains per spike and grain yield per plant.

Irrigation with saline water results in the deprivation of plants from water due to the higher osmotic pressure in the root zone, in addition to the toxic effect due to ion imbalance that alters the K+/ Na+ rate and increases the concentration of Na+ and Cl-. That may lead to disruption of cellular functions such as photosynthesis (Ghassab, 2019).

The response of studied traits was found to be quadratic (Figs 1-8) which indicated that the change in traits response (decrease or increase) from 6000 to 12000 ppm was of lower magnitude than the change from control to 6000 ppm except for days to maturity and grain filing period .The changes in studied traits from 6000to 12000 ppm were 13.60, 12.41, 5.82, 18.45, 8.54, 13.08, 22.07 and 25.66% for leaf area index, number of fertile rate, grain filling period, number of grain per spike, 100-grain weight and grain yield per pot, respectively. Similar findings were reported by Tadayon and Emam (2007) for leaf area, Mansour et al. (2021) for grain yield and Hussain et al. (2022) for grain yield and its components.

2-Performance of barley cultivars:

Barley cultivars varied significantly in their performance, as an average over the three water salinity levels for all studied traits (Table 5). Giza 125 had the highest number of fertile tillers per plant, and relatively high number of grains per spike which resulted in its significantly highest grain yield per pot (63.59g) compared to other cultivars. On the other hand, Giza 129 had low number of fertile tillers per plant, relatively low number of grains per spike, a short grain filing period and lowest grain filing rate which led to the significantly lowest 100-grain weight and the significantly lowest grain yield per pot (41.04g). Giza 136 had the highest grain filing rate and shortest grain filing period resulting in high 100-grain weight which compensated for its relatively low number of grains per spike and produced on intermediate grain yield per pot (59.27g).

Table 3. Mean squares for combined analysis of variance for studied characters as affected by salinity levels, barley cultivars and their interaction

S.O.V.	d.f.	Leaf area index	Fertile tillers/ plant	Maturity date	Grain filing rate	Grain filling period	No. of grains/ spike	100 grain weight	Grain yield
Rep	3	0.008	1.31	27.46	0.0006	36.92	53.02	0.273	0.910
Season	1	0.101	1.11	0.011	0.00003	0.011	3.67	0.044	3.96
Rep*season	3	0.016	1.33	0.011	0.00005	0.011	4.35	0.034	0.44
Salinity	2	6.05**	1.87**	2686.30**	0.547**	3311.34**	4265.00**	358.62**	463.19**
season*salinity	2	0.005	0.131	0.011	0.00001	0.011	3.41	0.007	5.73
Cultivars	14	0.028**	0.615**	61.40**	0.006**	48.39**	13.49**	4.78**	26.84**
season * cultivars	14	0.015	0.042	0.011	0.00002	0.011	2.11	0.022	2.18
Salinity * cultivars	28	0.023**	2.27**	47.12**	0.005**	48.48**	41.00**	5.98**	27.32**
season*salinity* cultivars	28	0.014	0.011	0.011	0.00003	0.011	3.34	0.045	2.12
Error	264	0.012	0.248	7.48	0.0001	8.21	6.21	0.174	10.51

Table 4. Means for the effect of salinity levels on studied barley traits

Levels (ppm)	Leaf area index	Fertile tillers/ plant	Maturity date (days)	Grain filling rate (g/day)	Grain filling period (days)	No. of grains/ spike	100 grain weight (g)	Grain yield (g/ pot)
Control	1.53 a	4.39 a	126.23 c	0.209 a	34.95 c	32.31 a	6.88 a	86.28 a
6000	1.25 b	3.95 b	131.59 b	0.103 b	39.83 b	23.47 b	4.44 b	39.15 b
12000	1.08 c	3.46 c	139.26 a	0.084 c	43.23 a	20.40 c	3.46 c	29.00 c
L.S.D.	0.03	0.11	0.87	0.003	1.07	0.93	0.14	3.27

Table 5. Means of barley cultivars for all studied traits averaged over salinity levels

Varieties	Leaf area index	Fertile tillers/ plant	Maturity date (days)	Grain filling rate (g/day)	Grain filling period (days)	No. of grains/ spike	100 grain weight (g)	Grain yield (g/ pot)
Giza 123	1.30 a	4.08 ab	127.58 c	0.152 b	34.91 c	25.77 ab	5.04 cd	59.71 b
Giza 124	1.33 a	3.83 b	130.00 bc	0.152 b	38.16 b	26.01 ab	5.58 a	60.56 b
Giza 125	1.32 a	4.33 a	130.66 bc	0.145 bc	38.25 b	24.86 ab	5.06 cd	63.59 a
Giza 126	1.29 a	4.00 b	131.25 b	0.139 c	39.41 ab	25.62 ab	5.23 bc	59.14 b
Giza 127	1.30 a	4.00 b	131.25 b	0.122 e	40.33 a	18.72 cd	4.60 f	53.64 d
Giza 128	1.28 ab	3.83 b	129.33 c	0.120 ef	37.66 b	17.08 d	4.33 g	44.06 f
Giza 129	1.28 ab	3.91 b	129.16 c	0.104 g	38.58 b	25.53 ab	4.01 h	41.04 g
Giza 130	1.32 a	3.91 b	131.33 b	0.131 d	39.16 ab	26.65 a	4.92 d	52.76 d
Giza 131	1.33 a	4.00 b	132.25 ab	0.118 ef	40.16 a	19.49 c	4.50 fg	50.24 e
Giza 132	1.32 a	3.91 b	133.00 a	0.113 f	39.50 ab	25.73 ab	4.27 g	46.06 f
Giza 133	1.26 b	3.91 b	129.33 c	0.126 de	37.83 b	25.97 ab	4.63 ef	49.55 e
Giza 134	1.22 c	4.16 ab	131.41 b	0.125 de	40.16 a	24.29 b	4.87 de	52.79 d
Giza 135	1.27 ab	4.25 ab	132.25 ab	0.137 cd	39.33 ab	23.93 b	5.20 bc	56.95 c
Giza 136	1.28 ab	4.16 ab	130.58 bc	0.161 a	37.16 b	24.45 b	5.40 ab	59.27 b
Giza 2000	1.22 c	4.25 ab	133.58 a	0.137 cd	39.41 ab	25.22 ab	5.10 cd	52.78 d
L.S.D.	0.07	0.30	1.52	0.008	1.58	2.01	0.25	2.59

Within the two rowed barley groups Giza 127 was more productivity than Giza 128 (53.64 and 44.06g/ pot, respectively) due to its higher number of fertile tillers per plant, higher grain filing rate and longer grain filing period, and significantly higher 100- grain weight.

Variation in cultivar performance in studied traits may be attributed to differences in genetic makeup and type of the cultivars (Table1). Several researches reported considerable genotype variability in six rowed barley Abdel-Wahed *et al.* (2015); Mansour *et al.* (2021); Hussain *et al*. (2022) and Abdelrady *et al.* (2024). Similarly, variation within two-rowed barley genotypes were reported by Ajeetpratap (2011); Bensemane *et al.* (2011); Bratković *et al.* (2018) and Ghassab (2019).

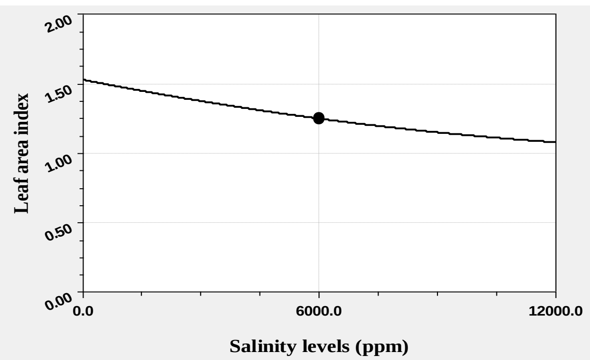

Fig.1. Effect of salinity levels on leaf area index

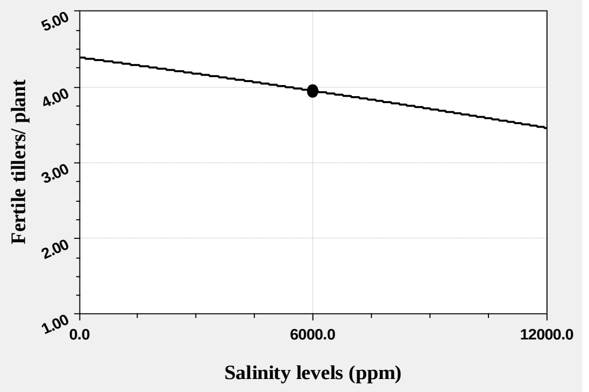

Fig. 2. Effect of salinity levels on Fertile tillers/ plant

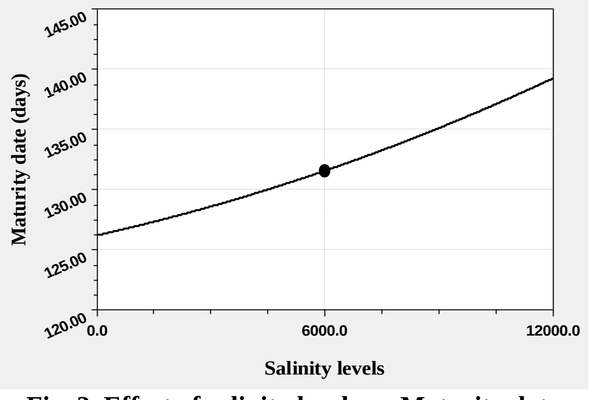

Fig. 3. Effect of salinity levels on Maturity date

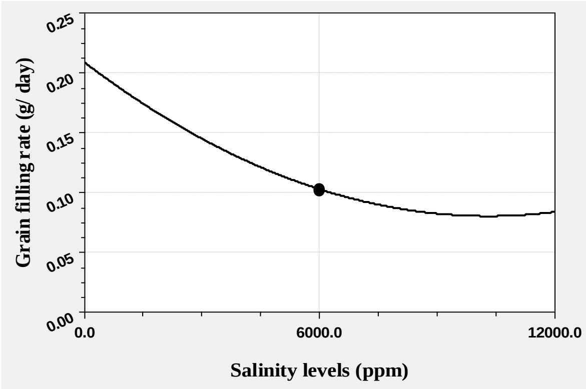

Fig.4. Effect of salinity levels on Grain filling rate

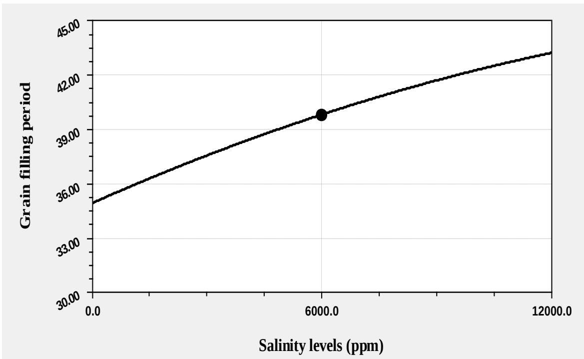

Fig. 5. Effect of salinity levels on Grain filling period

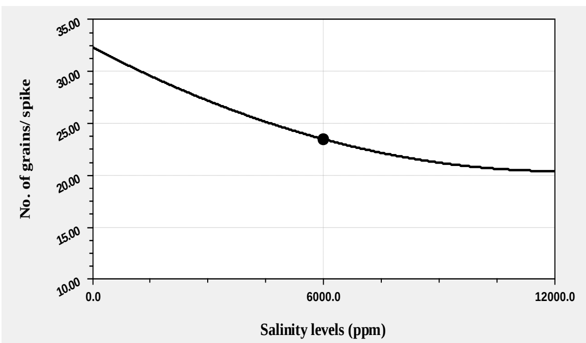

Fig. 6. Effect of salinity levels on no. of grains/ spike

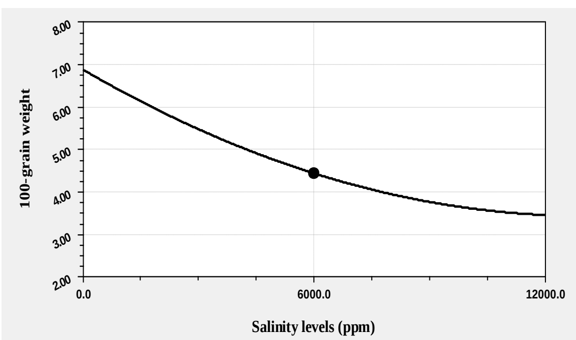

Fig. 7. Effect of salinity levels on 100-grain weight

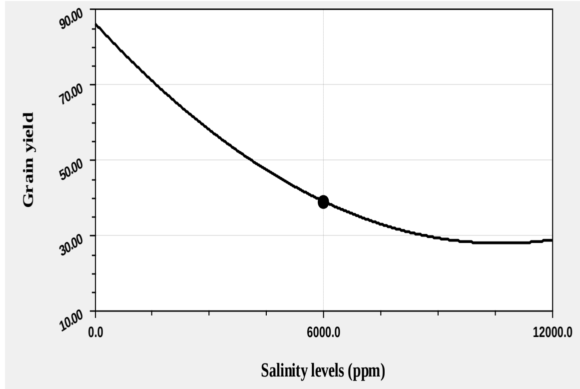

Fig. 8. Effect of salinity levels on grain yield

3-Barley cultivar x Salinity level interaction:

Significant variation in barley cultivars response to increasing water salinity levels were observed in all studied traits (Tables 6 & 7). As mentioned previously, increasing salinity level reduced leaf area index, number of fertile tillers per plant, grain filing rate, number of spikes per plant, 100 grain weight and grain yield per pot, while it increased days to maturity and grain filing period in all barley cultivars. However, cultivars varied in the intensity of decrease\increase in those traits. For example, Giza136 had the highest increase in grain filing period at 12000 ppm compared to the control (19.5 days), while Giza 136 was relatively not affected by salinity levels in that trait. With regard to 100- grain weight, Giza 136 suffered the least reduction (40.1%), while Giza 124 recorded the highest reduction in 100-grain weight (60.70%). These variations between cultivars in physiological and yield components traits were reflected in variation in grain yield reduction percentages (Table 8) at the two saline water levels. At 6000 ppm, Giza 129 and Giza 2000 showed relatively low reduction percentage (29.59 and 21.75% respectively) compared to other varieties, while Giza 125 suffered the highest reduction percentage (77.38%). At 12000 ppm, Giza 128, Giza 129 and Giza 2000 reduction percentage in grain yield per pot were relatively lower than all other cultivars (55.68, 49.65 and 55.01%), respectively, followed by a group of cultivars with reduction percentage of 60 to 70 % (Giza 130, 131, 132, 133 and 136). The remaining cultivars suffered reduction in grain yield per pot than 70%. These variations in cultivars response to saline water levels are a combination of changes in physiological and agronomical traits as influenced by the genetical constitution of the cultivar. These findings were in accordance with those reported by several researchers who recorded significant genotype x salinity level interaction (Abd El-Wahed *et al.*, 2015; Mansour *et al.*, 2021; Hussain *et al.*, 2022; Ghonaim *et al.*, 2023 and Abdelrady *et al.*, 2024).

Table 6. Means of barley cultivars * salinity levels interaction for leaf area index, fertile tillers per plant, grain filling rate and maturity date

Barley Cultivars	Salinity (ppm)											
	Leaf area index			Fertile tillers/ plant			Maturity date (days)			Grain filling rate (g/ day)		
	Control	6000	12000	Control	6000	12000	Control	6000	12000	Control	6000	12000
Giza 123	1.50	1.35	1.06	5.00	4.00	3.25	124.75	134.00	143.00	0.265	0.101	0.092
Giza 124	1.55	1.33	1.12	4.00	4.00	3.50	127.00	138.50	144.50	0.263	0.090	0.105
Giza 125	1.61	1.26	1.08	5.00	4.25	3.75	125.25	131.50	135.25	0.267	0.077	0.090
Giza 126	1.55	1.23	1.09	4.75	4.12	3.75	126.75	131.50	135.50	0.238	0.085	0.095
Giza 127	1.55	1.27	1.10	4.75	3.95	3.00	127.00	130.25	136.50	0.200	0.085	0.082
Giza 128	1.46	1.21	1.18	4.00	3.75	3.18	125.50	131.00	139.50	0.176	0.095	0.090
Giza 129	1.60	1.18	1.07	3.75	3.25	2.95	127.00	130.25	138.25	0.128	0.100	0.085
Giza 130	1.58	1.26	1.12	3.90	3.50	3.25	127.00	130.00	137.00	0.200	0.107	0.087
Giza 131	1.55	1.31	1.13	4.75	4.25	4.00	127.00	129.50	140.25	0.187	0.092	0.075
Giza 132	1.51	1.35	1.10	4.00	3.50	3.25	127.00	131.50	144.50	0.190	0.077	0.072
Giza 133	1.57	1.20	1.01	4.00	3.75	3.00	128.00	139.50	140.50	0.175	0.115	0.090
Giza 134	1.42	1.25	0.99	4.25	4.00	3.75	127.00	132.00	139.25	0.193	0.102	0.081
Giza 135	1.50	1.18	1.13	4.75	4.55	4.00	127.00	132.00	137.75	0.201	0.135	0.077
Giza 136	1.53	1.25	1.06	4.00	3.95	3.25	123.00	130.00	138.75	0.262	0.132	0.090
Giza 2000	1.51	1.11	1.06	5.00	4.50	4.02	125.00	127.25	138.50	0.203	0.130	0.080
L.S.D.$_{0.05}$		0.15			0.69			3.81			0.010	

Table 7. Means of barley cultivars * salinity levels interaction for grain filling period, no. of grains/ spike, 100-grain weight and grain yield

Barley Cultivars	Salinity (ppm)											
	Grain filling period (days)			No. of grains/ spike			100 grain weight (g)			Grain yield (g/ pot)		
	Control	6000	12000	Control	6000	12000	Control	6000	12000	Control	6000	12000
Giza 123	30.25	35.50	39.00	29.60	26.45	21.25	7.98	3.57	2.34	118.10	30.69	30.35
Giza 124	34.00	39.50	41.00	32.12	24.55	21.37	8.92	4.32	3.51	114.60	36.93	30.16
Giza 125	31.25	40.00	43.50	31.80	23.07	19.72	8.32	4.30	3.57	132.29	29.92	28.55
Giza 126	33.75	40.00	43.50	29.20	26.17	21.50	8.11	4.34	3.97	112.49	34.14	30.79
Giza 127	34.00	40.50	46.50	22.99	19.85	15.15	6.86	4.42	3.52	103.95	30.74	26.24
Giza 128	31.00	40.00	42.00	21.00	17.25	13.65	5.40	4.05	3.55	65.02	38.35	28.82
Giza 129	34.00	40.25	41.50	33.57	22.00	21.02	5.43	4.20	3.40	55.77	39.27	28.08
Giza 130	34.00	40.00	43.50	36.47	23.37	20.10	6.76	4.32	3.70	86.29	40.38	31.61
Giza 131	34.00	39.50	47.00	35.77	22.82	21.25	6.42	4.55	3.55	86.12	34.43	30.18
Giza 132	34.00	41.50	43.00	31.87	23.15	22.17	6.47	4.12	3.23	82.48	29.53	26.17
Giza 133	36.00	38.50	40.00	31.75	25.65	20.50	6.32	4.40	3.18	80.26	42.32	26.08
Giza 134	34.00	42.00	44.50	31.77	22.25	18.87	6.61	4.50	3.52	89.25	42.55	26.57
Giza 135	34.00	40.00	44.00	28.80	24.00	19.00	6.82	5.45	3.32	93.30	52.32	25.23
Giza 136	26.00	40.00	45.50	34.25	21.07	18.03	6.81	5.30	4.08	93.30	50.25	34.27
Giza 2000	30.00	40.25	44.00	35.72	21.45	18.50	6.11	5.75	3.45	70.93	55.50	31.91
L.S.D.$_{0.05}$		3.98			3.48			3.47			3.26	

Table 8. Reduction percentage and yield Index in grain yield per pot for barley cultivars as affected by salinity levels

Barley cultivars	Reduction %		Yield index(*)		
	6000(1) ppm	Total(2) ppm	Control	6000 ppm	12000 ppm
Giza 123	74.01	74.30	1.28	0.78	1.05
Giza 124	67.77	73.68	1.24	0.94	1.04
Giza 125	77.38	78.42	1.43	0.76	0.98
Giza 126	69.65	72.63	1.22	0.87	1.06
Giza 127	70.43	74.76	1.13	0.79	0.90
Giza 128	41.02	55.68	0.70	0.98	0.99
Giza 129	29.59	49.65	0.60	1.00	0.97
Giza 130	53.20	63.37	0.94	1.03	1.09
Giza 131	60.02	64.96	0.93	0.88	1.04
Giza 132	64.20	68.27	0.89	0.75	0.90
Giza 133	47.27	67.51	0.87	1.08	0.90
Giza 134	52.32	70.23	0.97	1.09	0.92
Giza 135	43.92	72.96	1.01	1.34	0.87
Giza 136	46.14	63.27	1.01	1.28	1.18
Giza 2000	21.75	55.01	0.77	1.42	1.10

(*) Yield Index = Mean of cultivar / Total mean at each salinity levels.
(1) reduction at 6000 ppm compared to the control
(2) total reduction at 12000 ppm compared to the control

4-Tolerance of barley cultivars to water salinity:

Tolerance of cultivars was tested using yield index (Gavuzzi *et al.,* 1997) and data are presented in (Table 8). Cultivars with value more than unity (1.0) are considered tolerant science they yielded more than the average yield of all cultivars, while those with an index below unity are considered sensitive to water salinity. The data revealed that Giza 135, Giza 136 and Giza 2000 were highly tolerant at 6000 ppm, while Giza 129,130,133,134 were tolerant. On the other hand, Giza 124 and Giza 128 moderately sensitive, while the remaining cultivars were sensitive to 6000 ppm water salinity level. At the 12000 ppm level, Giza 136 and Giza 2000 maintained their tolerance level. In addition to Giza 123,124,126,130 and Giza 131. The data also revealed that not all cultivars that enjoyed high yield at control maintained their superiority at the 6000 and 12000 ppm salinity levels (Giza 125 and Giza 127) and that was in accordance with the findings of Barakat *et al.* (2014). These results confirm those reported Mansour *et al.* (2021) who found that Giza 136 was highly tolerant to water salinity levels up to 11.12 dS/m while Giza 123 was of high and stable tolerance and Giza 127,129,134 were moderately sensitive.

In conclusion, the present investigation revealed a wide variability in Egyptian barley cultivars tolerance to water salinity level (12000 ppm) indicating their potentiality to give acceptable grain yield under such high stress levels. Moreover, the study revealed that cultivars with high yield at optimal conditions may not be suitable for high salinity level condition.

CONCLUSION

Water salinity reduced physiological yield and yield components in all cultivars, while days to maturity and grain filing period increased with salinity. Significant genotype-by-salinity interaction was also found, implying that genotypic responses shift across salinity levels. Genotypes G136, G2000, and G130 demonstrated high and stable salt tolerance and are recommended for commercial cultivation in saline areas.

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الملخص العربي

تحمل أصناف الشعير المصرية لملوحة مياه الري

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أجريت تجربة في الصوبة الزراعية بمحطة البحوث الزراعية بجامعة الإسكندرية، محافظة الإسكندرية، مصر خلال موسمي 2019\2018 و 2020\2019 وذلك بهدف دراسة سلوك خمسة عشر صنفاً من أصناف الشعير المصرية المختلفة وراثياً تحت تأثير مستويات مختلفة من الملوحة (٠ و٦٠٠٠ و١٢٠٠٠) جزء في المليون من كلوريد الصوديوم. وقد نفذت التجربة بتصميم القطاعات الكاملة العشوائية بأربع مكررات في الموسمين. وقد أوضحت النتائج أن ملوحة مياه الري أدت إلى انخفاض قيم الصفات الفسيولوجية والمحصولية ومكونات المحصول في جميع الأصناف عدا عدد أيام النضج وفترة امتلاء الحبوب التي زادت بزيادة مستوى الملوحة. وقد بلغ متوسط انخفاض محصول الأصيص بنسبة ٥٤,٤٦ % عند مستوى ملوحة ٦٠٠٠ جزء في المليون وبنسبة ٦٦,٣٩% عند ١٢٠٠٠ جزء في المليون وذلك كمتوسط لجميع الأصناف. وكان هذا الانخفاض راجعاً إلى انخفاض قيم المحصول الرئيسية مثل عدد الحبوب لكل سنبلة ووزن ال١٠٠ حبة. كما أظهرت النتائج وجود تفاعل معنوي بين الصنف ومستوى الملوحة لجميع الصفات تحت الدراسة مما يشير إلى أن التركيب الجيني للأصناف لعب دوراً هاماً في مرونة الصنف تحت ظروف الاجهاد الملحي. هذا وقد بينت الدراسة انه يمكن استخدام دليل المحصول كمؤشر لتحمل الاجهاد. أظهرت الأصناف G136 و G2000 وG130 تحمل للملوحة عند أعلي مستوي من تركيزات الملوحة (١٢٠٠٠ جزء\ المليون) تحت الدراسة وأن الأصناف لديها القدرة علي إنتاج محصول حبوب في المناطق الهامشية والتي تتميز بمصادر مياه ري وتربة ملحية أو كلاهما.

الكلمات المفتاحية: الشعير، ملوحة المياه، الصفات الفسيولوجية، المحصول، مكونات المحصول.