Physiological characterization of Egyptian salt tolerant rice varieties under different salinity levels

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Abstract: Salinity is one of the main constrains of agriculture production in Egypt; particularly rice production. Addressing physiology of rice salt tolerance might be beneficial for good rice salinity program breeding in Egypt. For this approach, three different rice varieties; Giza178rice salt tolerant variety and Giza 177 rice salt sensitive and Sakha 104 as moderately salt tolerant variety were tested under three salinity level; 2.0.4.5and 8.5 dSm^{-1} under greenhouses of RRTC, Sakha, Kafr El-Shekh, Egypt in 2012 and 2013 seasons. Tryptophan, proline amino acids, plant pigment (chlorophyll,aand b (Chla and Chlb), Total chlorophyll (Tchl), some elements, Na^{+1}, K^{+1}, Ca^{+}2, Mg^{+2} and P as well as Na^{+1}/K^{+1} and Na^{+1}/Ca^{+2} ration, photosynthesis rate, stomata conductivity, proline were measured at mid of booting stage. Dry mater hill-1, flag leaf area and, leaf area index (LAI), yield attributes, grain yield hill^{-1}, biological yield hill^{-1}and harvest index were estimated. The all above-mentioned traits markedly differed among the tested three rice varieties.Giza178 significantly had higher amino acids, leaf pigments, elemental contents; Na^{+1}, K^{+1}, Ca^{+2}, Mg^{+2} and P, photosynthesis(PN), stomatal conductance, growth traits, yield attributes, biological yield, grain yield hill^{-1} and lower Na^{+}/K^{+} and Na^{+1}/Ca^{+2} ration and lower sterility comparing to other varieties. Giza177 recorded the lower means of abovementioned traits and Sakha 104 was in the second order after Giza 178 but it gave heaviest 1000 grain weight. Leaf pigments, K^{+1}, Mg^{+2} and P ions, photosynthesis, stomatal conductance growth and yield and yield components were significantly declined by increasing salinity levels up to higher salinity level of 8.5 dsm^{-1}.On the other hand, Amino acids, Na^{+1}, Ca^{+2}, Na^{+}/K^{+} and Na^{+1}/Ca^{+2} and unfilled grain in the terms of sterility were significantly increased with increasing salinity level since, they reached their maximum mean at higher salinity level of 8.5dSm^{-1}. The interaction between rice varieties and salinity levels exhibited significant effect of all measured traits except stomatal conductivity and biological yield and harvest index in both seasons. The interaction effect supported that Giza 178 was less affected by increasing salinity levels giving higher growth, yield attributes and yield that mainly attributed to its ability to accumulate more amino acids as osomo-protectants, high ion selectivity, leaf pigments maintenance under salt stress and keeping high photosynthesis rate and high qualification stomatal conductivity arrangement under higher salinity level. The opposite was holding true with Giza 177. Sakha 104 showed moderate salt tolerant case.

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1-Introduction

Salt stress became the most serious environment stress in Egypt with noticeable climate change effect and water shortage, which can be considered as the most widespread soil problem that rice production is universally facing at present (Hong *et al*., 2007). Salinity is one of the most serious abiotic stresses that hinder agriculture production in irrigated land in Egypt. Rice is the main crop cultivated in the salt affected soils in Egypt, which affected his yield (Zayed *et al.,* 2013). It has been stated that plantscultivated in saline soil had higher contents of ions and low relative humidity, which affects the equilibrium necessary for normal metabolic reactions Atak(2012). The solute accumulation especially sugars and amino acids have been reported as common observation associated with salt stress (**Ahmed and Sharma, 2010,** Ashraf ***et al.*,2012).** It has been reported that salt stress inhibits the activities of cell wall enzymes (cytoplasmic enzymes) of both halophytes and glycophytes plants(Thiyagarajah *et al.*, 1996). The inhibition of CO_2 assimilation caused by salinity leads to decrease in CO_2 reduction which in turn decreases photosynthesis (Sudhakar *et al.*, 2002). **Jamile** *et al.***(2012) and Abdulaziz** *et al.*(2014) found that tryptophan and proline showed an significant increase against salt stress. In rice, Zayed *et al.*(2004) revealed that proline concentration was increase with salinity level increasing and the rice varieties varied significantly in the concentration of proline under various salinity level. Cha-um *et al.*(2007), Jamil *et al.*(2012) and Farshid and Rad(2012) found that increasing salinity level in rice significantly reduced Chl-a and Chl-b, total chlorophyll, potassium and calcium contents while, increased sodium content and rice varieties significantly varied in this issue. The salt stress had marked inhabitation in photosynthesis of rice (Zayed *et al.*, 2005).

Mirza *et al.*(2009), Rad *et al.*(2012) and Zayed *et al.* (2012) showed that increase in salinity levels of irrigation water or soil significantly decreased length of panicle, number of filled grains per panicle, number of panicle numbers, grain yield, biological yield and harvest index, but increased sterility percentage. Furthermore, Mirza *et al.*(2009) Rad *et al.*(2012) and Zayed *et al.*(2012) observed variation in rice growth, physiology, yield and yield component of rice varieties under different salinity levels.The aim of the current study was to find out the physiological mechanism of salt tolerance in Egyptian rice varieties.

2. Material and methods

The study aimed to characterize the physiological performance of some rice varieties, Giza177, Giza178and Sakha104 under varying salinity levels. The experiment was conducted at Green house of RRTC, Sakah, Kafr Elsheikh under controlled system to avoid any other effect except, salt stress. The experiments were carried out during 2012 and 2013 seasons. The experiment was conducted in cement sinks with area of 7.5 m^{2} (2.0x3.75x0.5m). The studied salinity levels were 2.0, 4.5 and 8.5 dsm^{-1}. A strip plot design was used with three replications in current experiment. The vertical plots were devoted to the tested three rice varieties. The horizontal plots were allocated to the three salinity levels. The sinks were filled with soil brought from original area suffering from salts associated to the studied salinity levels that is to simulate the original problem in Egypt. The chemical analysis of original soils matching studied salinity levels used in this experiment was presented in Table1.

Table1. The chemical analysis of original soils used in the experiment.

Soil	EC_e(dS.m^{-1})	pH		Cation and anion meq L^{-1} (soil paste)						Available ppm		
			Na^{+1}	Ca^{+2}	Mg^{+2}	K^{+1}	HCo^{-}	Cl	SO_4^{+2}	N	P	K
Normal (S1)	2.0	8.20	13.10	4	3	1.40	6	11	3.0	34	18	487
Salinity level2(S2)	4.5	8.1	25	13	7	0.36	7	20	18	31	14	311
Salinity level3(S3)	8.5	8.0	49.0	21	15	0.31	8	41	36	30	11	300

Salinity levels of soils in sinks were weekly measured and readjusted by adding the solution of sodium chloride and calcium chloride to keep the tested levels at the ration of 2:1, besometer were installed in each sinks and Ec and pH were monitored and based on their levels, the concentration of solution from (NaCl and $CaCl_2$)) were prepared then added to soil.

Rice seedlings were transplanted at the age of 25 days in spaces of 20 X 20 apart. Each studied variety was represented in six rows. Three replications in the terms of each two rows matching one replicate. One row was left as a border in each side on cement sink. The phosphorus and potassium fertilizers in the form of calcium super phosphate and potassium sulphate in the rate of 37 kg P_2O_5 and 50 kg K_2O ha^{-1} were applied according to the recommendation of saline soil. Nitrogen fertilizer was applied in the form of urea (46%) at the rate of 165 kg N ha^{-1}. the rest culture practices and management of rice were applied according to recommendation package of saline affected soil.

At the mid of booting stage of each variety, three plants were harvested. After measuring the dry matter accumulation, the dried plants at 65°C to a constant dry weight and the dry biomass was ground for use in determining tryptophan, proline accumulation, Na^{+},Ca^{+2} Mg^{+2}, K^{+} and P leaf content as well as the Na^{+}/K^{+} and Na^{+}/Ca^{+2}ratio, which were estimated. Photosynthesis leaf pigments; Chlorophyll-a (Chla), Chlorophyll-b(Chlb) and total chlorophyll (Tchll) contents were also determined at the same stage.

Flag leaf weight, flag leaf area and leaf area index were determined at heading according to Yoshida *et al.,*(1976).

Plant height and number of panicles $hill^{-1}$ as well as panicle length were recorded at harvest. Five panicles were taken from each plot to determine the main yield components. Panicles were first air-dried at room temperature for 24 h before yield components were recorded. The grains were separated from panicles to determine the number of grains and grain weight (filled and unfilled grain) $panicle^{-1}$ as well as 1000-grain weight. The plants from five central hills were harvested and air-dried to determine the rice grain and biological yield at 14% moisture content then, the yields were converted to g $hill^{-1}$.

Extraction and estimation of amino acids:

Free amino acids were extracted from oven dry plant shoot using ethyl alcohol (80%, v/v). The qualitative and quantitative determination of amino acids was carried out using LKB 415 alpha plus amino acid analyzer according to Christias *et al.*(1975).

Photosynthetic pigment concentrations:

Dried samples of leaves were analyzed for photosynthetic pigmentcontents. These pigments were extracted with 96 percentmethanol as described by Lichtentaler & Wellburn (1985). The supernatant was separated and the absorbance were read on UV-visible spectrophotometer. The absorbance spectra of Chl a, and Chl b of the extracts were measured at 666and 653. Total amount of pigments was determined with equations recommended by Lichtentaler&Wellburn (1985).

Estimation of ion accumulation:

A known weights of oven dry leaf samples were digested and Na^+, K^+, Mg^{2+} and $Ca^{2+}$and P wereestimated according to the method of Wolf (1982) using a flame-photometer Jenway Flame Photometer, Bibby Scientific Ltd-Stone- Staffs-St15 0SA–UK.

Photosynthesis rate and stomata conductance measurements

Portable photosynthesis system (ADC 2250 Gas Analyzer ADC, England) was used for measurement of photosynthetic rate (PN), and stomatal conductance (*g*s). All the measurements were recorded under ambient air composition (350 µmol mol-1 CO_2 and 210 mmol mol-1CO_2).

Statistical analysis

The collected data were analyzed for analysis of variances according to Gomes and Gomes (1984). Multiple mean comparison analysis for treatment combinations of variety and stress treatment was performed by using least significant different at α = 0.05 level when F-test was significant.

3. Results and discussion

Amino acids

The data of amino acid in Table2, the data showed that the tested varieties significantly varied in amino acids accumulation. Giza 178 significant accumulated more than other two varieties followed by Sakha 104 and then Giza 177. The result confirmed that Giza 178might have ability to accumulate such kind of amino acids as a mechanism of osomo-protectants for salt.

The analysis revealed the presence of two free amino acids in proline and tryptophan significant increase was observed as salinity levels were increased (Table 2).The maximum amine acids were obtained under high salinity level that hold true with the two amino acids, while minimum values of the them were recorded when rice plant grown under normal conditions. The interaction between rice varieties an d salinity levels recorded significant effect in both seasons for the two amino acids (Table3). The interaction showed the capability Giza 178 to accumulate more tryptophan and proline under high salinity level compared to other two varieties.The current results are in accordance with Goudarzi and Pakniyat (2009) who also observed low salt concentration decreases FAA and high concentrations increases FAA in wheat. Zayed *et al.*, 2004 also reported the increase in proline under salt stress in in rice cultivars with different degree based on their tolerance. The increment of free amino acids due to salinity is correlated with protease activity, which increased during salt stressplaying a role in resistance mechanism under salt stress (Hameed *et al.*, 2008). Rao *et al.* (2012) has also reported that tryptophan plays an important role in alleviation of salinity stress in maize. Proline is the key osmolyte, which helps plants to maintain cell turgor and helps to avoid salinity (Farkhondeh *et al.*, 2012). Zayed *et al.*(2004) found similar results in the terms of proline accumulation in rice varieties growing under different salinity levels.

Plant pigments:

Data of plant pigments in Table 2 showed that the three tested rice varieties significantly had various content of pigment in both seasons Sakha 104 had higher pigment followed by Giza 178 In chl a and Chlb. Giza 177 gave the lowest values of Chla&b. This variation in chlorophyll pigments might be due its genetic background and their ability in salt withstanding.

Chl a, Chl b and total chlorophyll content in salt stressed plants were significantly decreased depending on salinity levels When plant grown without salt stress, the significantly showed higher concentrations of major pigments as compared to plants under salt stress. Meanwhile, the lower pigments were recorded in higher salinity level of $8.5 dSm^{-1}$ (Table 2). After salt stress, the pigment concentrations of the rice plants were several folds lower than plants grown without salt-stress (Table2). A marked decline in chlorophyll pigments concentration in salinized plants could be attributed to increased activity of the chlorophyll-degrading enzyme chlorophyllase (Reddy &Vora, 1986). Sodium accumulation in leaves also adversely affected chlorophyll concentration by affecting cytoplasm in structure (Dubey, 1997). Data in Table 3 indicated that the chlorophyll pigments (Chla,b and total chlorophyll) significantly responded to the interaction between rice varieties and salinity levels in both seasons. The findings of the interaction in Table3 showed that Giza 178's pigments did not affected by increasing salinity levels since it increased by increasing salinity level against others (Zayed *et al.*, 2004., Cha-um *et al.*(2007), Farshid and Rad(2012), Jamil *et al.*(2012) and Zayed *et al.*, 2012).

Table 2: Some amino µg/gdry weight acids and pigments leaf content ppm of rice affected by rice varieties and salinity levels in 2012 and 2013 seasons

Variety	Tryptophan		proline		Chla		Chlb		Total chll	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Giza 177	1.21	1.21	6.66	6.08	15.09	14.32	4.20	3.97	34.55	36.22
Giza 178	1.34	1.36	9.54	9.57	16.31	16.40	3.70	3.74	31.96	34.51
Sakha 104	1.17	1.19	6.90	6.91	18.00	17.15	5.30	5.24	43.06	41.25
LSD0.05	0.068	0.022	0.40	0.39	0.81	0.811	0.12	0.23	2.45	0.612
Salinity level										
2.0dSm^{-1}	1.20	1.24	4.75	4.75	16.90	16.42	4.93	4.82	37.92	39.30
4.5dSm^{-1}	1.25	1.27	7.46	7.46	17.00	16.55	4.56	4.28	36.64	37.08
8.5dSm	1.26	1.25	10.35	10.35	15.50	14.90	3.75	3.85	35.02	35.60
LSD0.05	0.044	0.013	0.34	0.35	0.75	0.61	0.35	0.30	1.51	0.945
Interaction	**	**	**	**	**	**	**	**	**	**

Table3: average of some amino acids µg/g dry weight and plant pigment ppm of leaf content as affected by the interaction between rice varieties and salinity levels in 2012 and 2013 seasons.

Variety	S. level	Tryptophan		proline		Chla		Chlb		Total chl	
		2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Giza177	2.0dSm^{-1}	0.11	1.20	4.96	4.36	15.84	15.36	4.76	4.53	37.80	34.00
	4.5dSm^{-1}	1.22	1.23	6.63	6.33	15.60	14.76	4.36	4.1c	34.06	34.23
	8.5dSm^{-}	1.28	1.30	8.4d	7.56	13.83	12.83	3.46	3.30	31.80	35.30
Giza178	2.0dSm^{-1}	1.28	1.28	5.46	5.03	15.30	15.80	3.56	3.40	31.80	34.00
	4.5dSm^{-1}	1.29	1.33	10.62	10.3	16.63	16.40	3.47	3.60	31.56	34.23
	8.5dSm^{-}	1.17	1.19	12.53	13.4	17.00	17.00	4.07	4.20	32.53	35.30
Sakha 104	2.0dSm^{-1}	1.23	1.14	4.90	4.86	19.56	18.10	6.46	6.53	44.16	43.23
	4.5dSm^{-1}	1.51	1.53	6.16	5.76	18.76	18.50	5.86	5.16	44.30	41.36
	8.5dSm^{-1}	1.06	1.09	9.63	10.10	15.66	14.86	3.73	4.03	40.73	39.16
LSD 0.05	-	0.077	0.024	0.58	0.26	1.30	1.06	0.604	0.523	2.62	1.636

Elemental content:

Data of elemental contents of leaf in Tables 4 and 6 indicated that the three rice varieties had significant differences in the contents of measured elemental in both seasons. Higher sodium (Na) ion accumulation and Na/k ratio as well as Na+/Ca^{+2} were observed in Giza177 while it exerted lower K^{+}, Ca^{+2} and Mg^{+2}. Giza 178 exhibited the higher K^{+}, Ca^{+2} and Mg^{+2} and lower Na/K^{+}Na^{+}/Ca^{+2} was more pronounced in Giza 177. Sakha came in the middle order between Giza 177 and Giza 178 regarding the lower or higher the pattern of elemental accumulation.

Salinity levels exhibited significant effects on ion concentrations of rice plants, Sodium (Na^{+}) and Calcium (Ca^{+2}) ions accumulation in rice plants was directly enhanced relating to salinity level since the soil salinization was adjusted by the solution of NaCl+ CaCl. In Table, 1 it was observed that Ca^{+2} was increased in soils represented different salinity levels That might be attributed to increasing Ca^{+2}with increasing salinity levels. In contrast, potassium (K^{+}) ion and Magnesium (Mg^{+2}) and phosphorous (P) ions in salt-stressed plants were significantly reduced as salinity level increased. This implied a competition between Na^{+} and K^{+} absorption in rice plants under stress, resulting in a Na^{+}/ K^{+} antagonism. Furthermore, increasing salinity level significantly increased Na$^{+/}$Ca^{+2} ratio in both seasons (Tables4&6) in spite of salinity levels increased Ca^{+2} accumulation. The reduction in K^{+} uptake caused by Na^{+} is likely to be the result of the competitive intracellular influx of ions The all measured elemental significantly responded to the interaction between rice varieties and salinity levels (Tables 5&7). The data of interaction confirmed the ability of Giza 178 to keep lower Na^{+}/ K^{+} and Na$^{+/}$Ca^{+2} ration indicating its high ion selectivity under all salinity levels. Giza 177 was the worst in the terms of ion selectivity according the findings of interaction (Tables 5&7) The present finding are in agreement with those reported by Cha-um *et al.* (2007), Farshid and Rad(2012) and Jamil *et al.* (2012), except in Ca^{+2}

Photosynthesis rate and stomatal conductivity

The results related to the variation in photosynthesis rate and stomata conductivity of studied varieties are in Table6. The photosynthesis rate and stomata conductivity of studied varieties significantly varied among the three varieties in both seasons. The Giza178 rice continues to fix its superiority which gave maximum photosynthesis and stomatal conductivity. On contrary, Giza 177 had lower photosynthesis and stomatal conductivity in both seasons (Table6). As for salinity level effect, it was observed that increasing salinity level up to 8.5

dSm^{-1}greatly sabotaged the photosynthesis rate and reduced the affinity of stressed planted to maintain its stomata conductivity at optimum case. Higher salinity level inhibited lower photosynthesis and stomata conductivity in both seasons. On the other hand non stressed plants had higher photosynthesis and large open of stomata. The current results are in line with Zayed *et al.*(2005). The reduction in photosynthesis might be mainly attributed to low area of photosynthesis, low photosynthesis pigments, low CO_2 intercultural concentration and affecting PS11 as well low water content, nutrient content and low stomata conductivity (Sudhakar*etal.*, 2002).The interaction between rice varieties and salinity levels had significant effect in the terms of photosynthesis. The results of interaction indicated that Giza 178 was the best under higher salinity level while Giza 177 was the worst (Table7). Similar data have reported by Zayed *et al.*(2005).

Table 4: Average of elemental contents of leaf of some rice varieties as affected by and salinity levels in2012 and 2013 seasons

Variety	Na^+		K^+		Ca^{+2}		Mg^{+2}		Na /ca	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Giza177	308.0	311.9	948.2	956.4	86.0	86.3	117.8	119.1	3.08	3.24
Giza 178	276.8	273.4	1024.6	1038.5	100.4	104.3	112.7	114.1	2.16	2.06
Sakha 104	315.2	327.5	981.2	967.0	88.4	88.6	112.0	112.4	2.83	2.87
LSD0.05	2.804	6.11	5.44	6.136	1.98	0.96	1.45	0.74	0.06	0.05
Salinity level										
2.0dSm^{-1}	31.44	35.16	948.2	956.4	59.8	62.1	133.7	139.6	0.53	0.57
4.5dSm^{-1}	191.71	197.1	1024.6	1038.5	73.2	75.1	107.9	108.3	2.72	2.73
8.5dSm	676.8	680.6	981.2	967.0	141.8	141.9	97.6	97.8	4.82	4.88
LSD0.05	2.209	3.02	7.38	8.065	1.34	1.38	2.07	0.97	0.06	0.049
Interaction	**	**	**	**	**	**	**	**	**	**

Table 5 Average of elemental contents of leaf of rice as affected by the interaction between rice varieties and salinity levels in 2012 and 2013 seasons.

Variety	S. level	Na^+		K^+		Ca^{+2}		Mg^{+2}		Na^+/Ca^{+2}	
		2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Giza177	2.0dSm^{-1}	34.0	33.5	1245	1243	62.7	65.9	144.3	144.7	0.45	0.57
	4.5dSm^{-1}	194	199.0	974.6	991.3	60.3	64.0	110.8	113.0	3.61	3.62
	8.5dSm^{-}	696	703.3	625.0	635.0	135	129	110.8	99.8	5.18	5.53
Giza178	2.0dSm^{-1}	32.0	34.6	1188.3	1194	57.3	57.3	127.7	132.7	0.56	0.58
	4.5dSm^{-1}	163.3	160.6	1069.0	1081.6	86.5	86.5	112.0	109.0	1.89	1.79
	8.5dSm^{-}	635.3	625.0	816.7	840.0	157	157	101.0	100.5	4.04	3.82
Sakha 104	2.0dSm^{-1}	28.3	37.3	1225.0	1213.3	59.5	59.5	129	141	0.57	0.55
	4.5dSm^{-1}	218.0	231.6	1003.0	1005.0	72.7	72.7	101	103	2.67	2.78
	8.5dSm^{-1}	699.3	713.0	715.0	685.0	133	133	96	93.0	5.23	5.29
LSD 0.05		3.827	5.24	12.78	13.97	2.32	2.4	3.59	3.69	0.11	0.09

Table 6: Na^+/K^+,P mmol/g dry weight, photosynthesis µmol Co2 m^{-2} s^{-1}, Stomata conductivity mol m^{-2} s^{-1},dry matter hill-^{1} and flag leaf area cm^2 of some rice varieties as affected by salinity levels in 2012 and 2013 seasons.

Variety	Na^+/K^+		P		photosynthesis		Stomata conductivity		Dry matter hill^{-1}		Flag leaf area	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Giza177	0.447	0.445	149.3	142.6	13.70	12.62	0.327	0.331	213	20.2	17.44	17.53
Giza 178	0.319	0.307	158.5	161.7	15.52	14.36	0.438	0.496	33.8	31.2	22.97	24.77
Sakha 104	0.406	0.434	158.7	154.7	12.40	14.92	0.389	0.379	23.3	22.4	20.84	21.22
LSD0.05	0.004	0.009	2.75	0.68	0.589	0.215	0.039	0.019	1.90	0.84	0.95	0.98
S. level												
2.0dSm^{-1}	0.026	0.029	166.8	166.0	16.30	16.80	0.495	0.525	40.8	39.9	27.64	29.23
4.5dSm^{-1}	0.190	0.193	157.8	155.7	14.51	14.38	0.391	0.411	22.5	20.2	20.72	21.00
8.5dSm	0.957	0.965	141.9	137.2	10.82	10.72	0.227	0.270	15.1	13.8	12.90	13.30
LSD0.05	0.004	0.007	3.25	1.76	0.797	0.55	0.048	0.021	1.41	0.71	0.77	0.84
Interaction	**	**	**	**	**	**	NS	NS	**	**	**	**

Table 7: Na^{+}/K^{+},P mmol/g dry weight, photosynthesis (µmol Co2 m-2 s-), Stomata conductivity, Dry matter hill-1 and flag leaf area of some rice varieties affected by the interaction between rice varieties and salinity levels in 2012 and 2013 seasons.

Variety	S. level	Na^{+}/ K^{+}		P mmol/g dry weight		Photosynthesis µmol Co2 m-2 s-		Dry hill-1 g		Flag leaf area	
		2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Giza177	2.0dSm^{-1}	0.027	0.027	166.3	154.6	17.33	16.1	36.7	35.7	25.1	26.7
	4.5dSm^{-1}	0.199	0.201	148.33	141.3	15.06	12.5	18.5	16.3	18.5	17.3
	8.5dSm^{-}	1.114	1.108	133.3	132.0	8.72	9.26	8.6	8.6	8.7	8.5
Giza178	2.0dSm^{-1}	0.027	0.029	163.3	169.3	15.86	15.7	47.7	47.5	29.3	31.7
	4.5dSm^{-1}	0.153	0.149	159.6	165.0	15.86	15.6	30.3	26.3	23.3	24.7
	8.5dSm^{-}	0.778	0.744	152.6	150.0	14.86	11.8	23.3	20.0	16.8	18.
Sakha 104	2.0dSm^{-1}	0.023	0.031	170.8	174.0	15.73	18.6	38.0	36.6	28.5	29.3
	4.5dSm^{-1}	0.217	0.231	165.6	161.0	12.6	15.1	18.7	18.1	20.3	21.1
	8.5dSm^{-1}	0.978	1.042	139.6	129.0	8.87	11.1	13.3	12.7	13.7	13.3
LSD 0.05		0.012	0.011	5.638	3.05	1.380	0.960	2.44	1.24	1.34	1.46

Growth characteristics

Data analysis variance of growth characteristics referred that the three rice varieties inhabited marked variation in their growth under various salinity levels. Giza 178 keeps higher dry matter/hill, LAI and flag leaf area (Tables6 & 8). On the other hand, Giza 177 inhibited lower dry matter/hill, leaf area index and flag leaf area. The data of Giza 178 in growth traits showed its ability to maintain its metabolism enzyme, biochemical content and photosynthesis events at health level resulted in reasonable growth Sakha 104, salinity levels significantly restricted rice growth in both season (Tables 6&8). The growth characteristics were significantly declined as salinity levels were increased. Salinity affect nutrient uptake, increased free radicals, affected cell growth and structure, metabolism processes, photosynthesis operation resulted poor growth characteristics. The interaction between rice variety and salinity had significant effect on all measured growth. According to the interaction effect finding Giza 178 was the best variety and Giza 177 was the worst one. Moreover, Giza 178 had less reduction in measured growth traits as salinity increased and the opposite was correct with Giza 177**(**Tables 7&9**).**

Table8: Average of LAI, plant height cm, panicle weight g panicle numbers hill^{-1}of some rice varieties as affected by salinity levels in 2012 and 2013 seasons.

Variety	LAI		Plant height		Panicle length		Panicle weight		Panicle number	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Giza77	3.66	3.74	79.6	79.2	16.7	16.6	1.80	1.87	10.5	11.2
Giza 178	3.94	5.18	85.7	84.7	18.8	18.6	2.16	2.24	17.0	16.5
Sakha 104	5.30	4.31	90.9	88.4	17.9	17.8	2.23	2.25	11.9	12.2
LSD0.05	0.27	0.11	0.84	0.77	0.93	0.87	0.12	0.06	0.53	0.34
Salinity level										
2.0dSm^{-1}	5.84	6.08	98.7	97.5	21.7	21.9	2.97	2.99	18.8	18.7
4.5dSm^{-1}	3.98	4.03	84.1	82.7	17.3	16.9	2.05	2.07	12.4	12.6
8.5dSm	3.08	3.11	73.7	71.9	14.5	14.1	1.17	1.30	8.2	8.6
LSD0.05	0.23	0.13	0.71	1.03	0.64	0.69	0.05	0.18	0.83	0.76
Interaction	**	**	**	**	**	**	**	**	**	**

Table 9: Average of LAI, plant height cm, panicle weight g and panicle numbers hill^{-1} as affected bythe interaction between rice varieties and salinity levels in 2012 and 2013 seasons.

Variety	S. level	Leaf area index		Plant height		Panicle NO		Panicle length		Panicle weight	
		2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Giza177	2.0dSm^{-1}	5.63	5.88	90.3	91.3	16.8	17.0	21.4	21.6	2.88	2.93
	4.5dSm^{-1}	3.10	3.30	80.3	78.8	10.0	11.0	15.3	15.3	1.72	1.72
	8.5dSm^{-}	2.20	2.03	68.	67.4	48.0	5.6	13.3	12.77	0.8	0.95
Giza178	2.0dSm^{-1}	6.33	6.18	96.7	94.8	21.8	20.7	21.7	21.97	2.63	2.71
	4.5dSm^{-1}	5.37	5.06	82.3	82.0	16.0	16.1	19.0	18.5	2.34	2.37
	8.5dSm^{-}	4.20	4.31	78.0	77.3	13.3	12.7	15.8	15.33	1.52	1.65
Sakha 104	2.0dSm^{-1}	5.56	6.20	109.0	106.3	17.7	18.4	22.1	22.17	3.4	3.33
	4.5dSm^{-1}	3.46	3.75	89.7	87.8	11.3	10.7	17.4	17.0	2.08	2.13
	8.5dSm^{-1}	2.80	2.98	74.0	71.0	6.7	7.6	14.3	14.1	1.2	1.3
LSD 0.05		0.40	0.22	1.24	1.78	1.44	1.32	1.11	1.19	0.25	0.32

Yield attributes and grain yield

Data pertaining to yield attributes in Tables 8 & 10 show that all yield attributes distinctly differed among tested varieties in both season. Giza 178 gave the higher Data presented in Tables 8and 10 indicate that the three tested rice varieties markedly varied in their yield attributing characteristics in both seasons. Giza177 gave the lower shortest plants and, panicle numbers hill^{-1} on average, panicle length, panicle weight, No. of filled grains panicle^{-1} and 1000-grain weight, while it gave the highest values of unfilled grains panicle^{-1} in both seasons of study. Sakha104 had heaviest 1000 grain weight, panicle and tallest plants in both seasons (Table 10). Giza 178 gave the maximum panicles number and longest panicles, higher filled grains panicle^{-1} and lower unfilled grains panicle^{-1} in both seasons. Giza178 continued to confirm its superiority over the salt sensitive rice varieties by giving the greatest values for number of filled grains panicle^{-1}, low sterility and higher panicle number in both seasons. However, Giza 177 also returned the highest unfilled grains panicle-^{1}in both seasons (Table 10). Giza 178 produced significantly the lowest unfilled grain panicle^{-1} in the terms of sterility in both seasons.

Salinity levels stresses significantly exhibited apparent reduction in all yield attributing characteristics (Tables8and 10). Salinity stress dramatically reduced plant height, panicle length and number of panicles plant^{-1} in both seasons (Tables 8 & 10), with an average reduction through higher salinity level of around 56.4and 54.0% of the panicle number obtained by the control (normal) treatment in the two seasons, respectively, confirming that stressfulness of salinity is more on panicle. The poor plant stand resulting from two salinity level stresses caused a marked reduction in panicle number plant^{-1}. It is worthy of mention that panicle length contributed to the same pattern of plant height under various stresses**.**

Salinity levels stress severely affected panicle weight, number of filled grains panicle^{-1} and 1000-grain weight with companied high sterility as salinity levels increased in both seasons (Table 10). For example, the reduction in panicle weight associated with high salinity of 8.5 dS/m reached 60.6and 56.5% of weights under normal conditions. Stress conditions significantly magnified sterility %by sharp reduction in filled grains comparing g to the control treatment. The unfilled grains panicle^{-1} in the terms of the sterility% raised around 234.6% and 260%over the control because of high salinity level, and about 93.4& 100% under medium salinity level in the first and second seasons, respectively. At the same time,, the reduction in filled grains panicle associated with high salinity of 8.5 dS/m reached 51 and 50 % of filled grains of normal conditions. Thereby reducing the sterility in grains happened under saline stress is an option to increase yield of rice under such conduction Similar results were reported by Farooq *et al.* (2008) and Zayed *et al.*(2012).

The interaction between rice varieties and stress treatments significantly affected panicle numbers plant^{-1}, panicle length and weight, number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1} and 1000-grain weight for all varieties in both seasons (Tables 9 and 11). Salinity stress sharply decreased panicle number and panicle weight of Giza 177. Giza 178 continued to perform best under both salinity levels and produced the best results out of three tested varieties, which exhibited the highest values of abovementioned traits under both stresses of salinity levels comparing other two varieties under similar salinity levels in both seasons. It was found that stress maximized the number of unfilled grains of panicle for all varieties, particularly Giza 177 grown under high salinity stress, which induced greater sterility than that obtained by other two varieties (Table11). Giza 178 was less affected by salinity levels in the terms of unfilled grains panicle^{-1}. The interaction effects related to unfilled grains panicle^{-1} in the terms of sterility confirmed the superiority of the Giza 178 varieties under both salinity levels comparing to control treatment. However, Giza 177 is not recommended under such conditions (Table11). Sakha104 is valid under medium salinity level but Giza 178 is relevant for all salinity level upt0 8.5 dSm^{-1} Similar data has been reported by Farooq *et al.,* (2008) and Zayed *et al.*(2012).

Yields

Data listed in Table 10 indicate that both grain and biological yields as well as harvest index varied significantly among the three tested rice varieties in both seasons. The data confirmed the superiority of Giza 178 against the two other tested varieties Sakha 104 and Giza 177 in the two seasons, respectively. Sakha104 intermediated the salt sensitive variety Giza177 and salt-tolerant Giza178 considering yields. On the same time, Sakha 104 gave the highest values of harvest index indicating its moderately tolerant for salt and its ability to produce more grain against straw under salt stress.

Table 10 refers the data for stress effects on yields, providing that salinity levels significantly inhibited grain and biomass yields as well as harvest index of rice in both seasons. Yield reduction in medium and high salinity levels was amounted to be 38,7 & 60.99. and 39.2 & 66.0 out of the standard regime soil, in the first and second seasons, respectively. The same pattern was recorded with biological yield in both seasons. Increasing salinity levels significantly and gradually declined the harvest index in both seasons(Table10). Lower harvest index was produced by higher salinity level of 8.5dS/while, the higher harvest index was recorded with unstressed plants. The interaction effect was significant in the terms of grain yield g plant^{-1} in both seasons. The data of interaction between rice varieties and salinity level referred the superiority of Giza 178 in higher salinity level (Table11).

Salinity stresses significantly inhibited growth, yield and yield attributed of rice in both seasons, with salinity having the greater impact through several pathways such as high osmotic pressure, ion imbalance and ion toxicity. Salinity affected cell elongation, cell membrane stability, cell division and cell enlargement as well as cell turgor. Salinity stress also induced its harmful effects on rice plants by high osmotic.

High salinity environment surrounding the roots can restricted ions uptake as seen in phosphorus causing loss of the normal physiological functions of the roots and destruction of the root cell structure (Li *et al.*, 2009). Salinity stress can also inhibit absorption of inorganic anions such as Cl–, NO3 – and H_2PO_4 –, greatly affect the selective absorption of K^+-Na^+, and break the ionic balance (Yang *et al.*, 2008, 2009). Generally, stresses of salinity might be affected tiller formation, panicle formation, photosynthesis rate, metabolic and assimilates processes, nutrient uptake, nutrient transportation between plant organs, and transformation of assimilates and solutes. These stresses might also have affected plant phenology and grain filling processes, resulting overall in poor plant populations, poor growth, poor yield attributes, high sterility and low filled grains panicle^{-1} leading finally to low grain yield. The current finding are in the line with Mirza *et al.*(2009), Rad *et al.*(2012 and Zayed *et al.*(2012**).**

Table10: Average of number of filled grains panicle^{-1}, of number of unfilled grains panicle^{-1}, 1000-grain weight g, grain yield g plant^{-1} Biological yield g plant^{-1} and harvest index of some rice varieties as affected by salinity levels in 2012 and 2013 seasons.

Variety	N. filled grain		Unfilled grain		1000-grain wt.		Grain yield g plant^{-1}		Biological yield g plant^{-1}		Harvest index	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Giza 177	81.6	83.3	26.9	27.8	24.09	24.37	27.21	25.33	72.54	72.13	0.366	0.338
Giza 178	102.3	104.2	17.6	17.8	21.42	21.10	34.94	32.49	85.03	83.82	0.413	0.389
Sakha 104	83.9	83.9	22.7	25.6	25.23	25.36	27.78	25.82	76.52	75.14	0.355	0.338
LSD0.05	1.78	1.09	2.66	0.73	0.44	0.66	0.76	1.39	2.27	0.47	0.015	0.034
Salinity level												
2.0dSm^{-1}	122.1	122.9	10.7	10.8	25.23	25.79	44.89	42.14	109.1	108.1	0.411	0.390
4.5dSm^{-1}	85.9	87.0	20.7	21.6	23.30	23.18	27.53	25.58	78.97	78.24	0.374	0.325
8.5dSm	59.8	61.6	35.8	38.9	22.21	21.86	17.51	15.92	46.02	44.80	0.348	0.350
LSD0.05	2.56	0.91	2.98	0.89	0.46	0.27	1.01	1.41	1.73	1.03	0.019	0.023
Interaction	**	**	**	**	**	**	**	**	NS	NS	NS	NS

Table 11: Average of number of filled grains panicle^{-1}, of number of unfilled grains panicle^{-1}, 1000-grain weight g and Grain yield g plant rice as affected by the interaction between rice varieties and salinity levels in 2012 and 2013 seasons.

Variety	Salinity levels	Filled grains		Unfilled grains no		1000 grain weight		Grain yield g plant	
		2012	2013	2012	2013	2012	2013	2012	2013
Giza177	2.0dSm^{-1}	119.7	120.0	10.7	8.7	25.6	26.6	43.3	41.0
	4.5dSm^{-1}	78.3	80.3	20.3	21.7	24.1	23.8	25.4	23.7
	8.5dSm^{-}	46.7	49.7	49.7	53.0	22.6	22.8	12.9	11.3
Giza178	2.0dSm^{-1}	130.7	132	12.0	11.3	22.2	22.1	48.7	44.8
	4.5dSm^{-1}	98.7	100.3	17.3	17.7	21.7	21.5	31.8	31.3
	8.5dSm^{-}	77.7	80.3	23.3	24.3	20.4	19.7	24.3	21.4
Sakha 104	2.0dSm^{-1}	116.0	116.7	9.3	12.3	27.9	28.8	42.7	40.7
	4.5dSm^{-1}	80.7	80.3	24.3	25.6	24.2	24.2	25.3	21.7
	8.5dSm^{-1}	55.0	54.7	34.3	39.3	23.6	23.1	15.3	15.1
LSD 0.05		4.44	5.34	5.15	5.25	0.8	0.64	1.75	2.44

It could be concluded that Egyptian salt tolerant variety Giza 178 was found to be effective under higher salinity level that attributed to high ion selectivity, high affinity of osomo-protectants accumulation such as tryptophan an proline, keeping high photosynthesis and leaf pigments and so on.

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