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COMPARATIVE STUDY ON HYBRID AND INBRED RICE UNDER DROUGHT AND SALINE STRESSES

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ABSTRACT

The high heterosis displayed by hybrid rice might be exploitable for the enhancement of rice productivity in the presence of economically-important stresses such as drought and salinity.

The current study aimed to find out the possibility of exploring hybrid rice under drought and salinity stresses. Rice varieties, Giza 177 and Giza 178 (inbred rice varieties) and SK2034H (the first hybrid rice released in Egypt) were tested under normal, saline and drought conditions using a split plot design with four replications. The investigation conducted under a controlled system in the greenhouse and field(Farm) of Rice Research and Training Center, Sakha, Kafr EL-Sheikh as well as at El-Sirw Agriculture Research Station i.e. saline soils, Egypt during two growing seasons of 2010 and 2011 in greenhouse and in 2011 under field conditions.

The three rice varieties varied significantly in all estimated parameters and in their stress tolerance. The hybrid variety SK2034H was more tolerant to salinity and drought than Giza 178, the most tolerant Egyptian inbred rice varieties. This high capability of the Egyptian-developed hybrid might be mainly attributed to its greater root vigor, leaf area, flag leaf area, chlorophyll content, dry matter production, filled grains number, panicle number and weight; and lower sterility percent (sterility%). Furthermore, SK2034H had higher Na^+ and K^+ content than Giza 178, leading to a resulting in improved tolerance to stress. On the other hand, Giza 177 was more stress sensitive, possibly due to weakness of root system, poor growth, chlorophyll degradation, high Na/K ratio, and high sterility both stresses. The result obtained from saline soil and drought tested under field conditions came to confirm the obtained one under green house. Interestingly, both SK2034H and Giza 178 were at the same level for salinity tolerance, while SK2034H was more drought tolerant than Giza 178. stress. From the aforementioned results, SK2034H could be used on large scale especially under salt affected areas and in the end tail of irrigation canal.

Keywords: hybrid rice, drought, salinity, stress.

INTRODUCTION

Drought and highly saline soil are among the most serious challenges to crop production in the world nowadays. This is particularly true in developing countries, where these abiotic stresses limit growth and productivity. Understanding plant responses to abiotic stresses at the physiological and morphological levels provides an essential foundation for future breeding.

Rice is considered the primary staple food for more than two billion people worldwide, and is the largest consumer of water of all the major cereals. Therefore, breeders, physiologists and geneticists are paying more attention to breeding rice varieties with tolerance to both water deficit and salt affected soils. Development of rice hybrids with high yield potential under drought conditions and in high saline soils would be an exciting research route to overcoming the crisis created by these major stresses.

Rice hybrids have a mean yield advantage of 10–15% over inbred varieties (Li, 1981 and Yang and Sun, 1988). Growth and development processes associated with higher yields of rice hybrids include a more vigorous and extensive root system (Yang and Sun, 1988) that increases growth rate during vegetative growth, more efficient sink formation, greater sink size, greater carbohydrate translocation from vegetative parts to the spikelets, and a larger leaf area index during the grain filling period (Peng *et al.*, 1998).

Rice hybrids develop an extensive root system which is essential for efficient N absorption from the soil under field conditions, and hybrids have greater root fresh and dry weights, along with greater root volume and root length density than inbred varieties (Yang and Sun, 1992). Zayed *et al.* (2005, 2006 and 2007) and Babu *et al.* (2007) found that hybrid rice showed a higher degree of salt tolerance than inbred rice, and also demonstrated higher root growth, seedling vigor, nutrient uptake vegetative growth, yield attributing characteristics, yields and harvest index.

Yang *et al.* (2002) and Tao *et al.* (2006) indicated that translocation and allocation for carbohydrate from sheath to grains, as well as rice grain filling and zeatin content in the roots and shoots of hybrid rice, were severely affected by drought. Amudha and Thiyagarajan (2008) and Malarvizhi *et al.* (2009) stated that some hybrid rice varieties showed superiority for cell integrity, drought-affected root length, root dry weight, harvest index, root-shoot ratio, number of productive tillers, panicle length, number of filled grains, spikelet fertility, total dry matter production, grain yield and harvest index under drought and normal conditions as compared to inbred rice varieties. The present study aimed to compare the behavior (high heterosis) of hybrid rice and inbred rice under both salinity and drought stresses.

MATERIALS AND METHODS

Plant materials and rice culture

This study was conducted in the greenhouse of the Rice Research and Training Center (RRTC), Sakha, Kafr el Sheikh, Egypt in the 2010 and 2011 seasons. Three cultivated rice varieties (the salt-sensitive inbred variety Giza 177, the salt-tolerant inbred variety Giza 178 and the new rice hybrid variety SK2034H) were used in this study. In both seasons, seeds of these varieties were sown on April 20 in an enclosed greenhouse plot containing soil obtained from a rice-growing area at the seedling stage. Twelve kilograms of air-dried and ground normal soil (EC =1.5 dsm^{-1}, pH=7.9 loamy clay soil) were then placed in perforated plastic polybags of 40 cm x 40 cm size. Eight seedlings from 20-day-old hills were transplanted per pot so that each pot contained two hills of 20 cm x 20 cm; one hill being nominated to growth parameters and the other used for assessing yield and yield components. Thinning was carried out one week after transplanting to leave five seedlings per pot.

Standard cultivation procedures for rice growing in saline conditions, normal conditions and drought conditions were followed throughout the studies. Seedling growth and development were monitored daily.

Saline and water stress treatments

At seven days after transplanting those pots nominated to be under saline stress were irrigated with water containing a salt mixture of CaCl-$NaCl_2$ in a 1:2 ratio and the salinity level adjusted to 8.50 dS m^{-1}. The pots were irrigated every two days up to 3 cm depth. Water samples were collected from the root zone in each saline pot immediately before irrigation through bizometer allocated in the middle of the plot and a conductivity meter used in adjusting EC and pH values in each pot.

At the same time, the pots allocated for water stress were subjected to drought treatment for five days, followed by a restricted watering regime designed to keep plants stressed up to the end of season.

The control plants were left submerged in fresh water in their pots throughout the study. Basal applications of phosphorous, potassium and zinc were made for each pot and precisely mixed with the soil. Recommended nitrogen was applied as three equal doses after transplanting.

Experimental fields.

Two field experiments were conducted during 2011 season at El Sirw Agricultural Research Station Farm (as saline soil), Dammietta and Sakha Agriculture Research Station Farm, Sakha, Kafr El sheikh (Normal soil and water stress). The same three varieties had been tested under previous conditions for comparing the results obtained under greenhouse and open field. The design of tested experiments was randomized complete block with four replications. The recommended package of each condition was followed. The data were collected at heading stage (for growth and chemical analysis determination) and at harvest stage for yield and yield components.

The root characteristics were determined at maximum tillering stage. The salinity level at El-Sirw Station was also selected to be 8.5 dS/m as that is in under control system.

Determination of root characteristics and Na/K ratio.

At 30 days after transplanting, three plants were harvested. Plants were uprooted carefully and washed with distilled water. After measuring the shoot dry weight and shoot length, plants were oven-dried at 65°C to constant dry weight and the dry biomass ground for use in determining Na^+ and potassium plant content as well as the Na^+/K^+ ratio, which was estimated according to Yoshida *et al.* (1976). Plant leaf area, flag leaf area and chlorophyll content, as well as flag leaf dry weight, were determined at heading.

Also, Plant height, number of tillers and number of panicles/pot were calculated at harvest. Five panicles were taken from each pot 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 grains weight (filled and unfilled spikelets) per panicle as well as 1000-grain weights. The plants from each pot were harvested and air-dried to determine the rice grain yield and straw yield per pot at 14% moisture content.

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 treatments was performed by using least significant different at α = 0.05 level when F-test was significant.

RESULTS

Root length and dry weight

The analysis variance of data revealed that the three rice varieties tested varied significantly in their root parameters, i.e. root dry weight and root length (Table 1). SK2034H hybrid rice variety, having the longest and heaviest roots, significantly surpassed the other rice varieties in both seasons. Giza 178 inbred rice variety ranked the second, with the other inbred rice variety, Giza 177 which placed last for root weight and root length. High heterosis of hybrid rice might have contributed to the high values for root length and dry weight conferring superiority over inbred rice. Similar results were obtained by Amudha and Thiyagarajan (2008) and Malarvizhi *et al.* (2009)

Table 1: Effect of abiotic stress on root growth during 2010 and 2011 seasons

Trait	Root dry weight (g)		Root length (cm)	
	2010	2011	2010	2011
Variety				
Giza 177	141.78	148.33	18.86	18.33
Giza 178	158.67	160.67	19.76	18.61
SK2034H	234.67	247.78	31.54	29.96
F test	**	**	**	**
LSD at 0.05	8.77	3.37	1.93	1.03
Stresses				
Salinity	106.11	109.33	18.74	17.25
Drought	167.33	169.56	25.07	24.24
Control	261.67	277.89	26.32	25.41
F test	**	**	**	**
LSD at 0.05	6.231	5.06	1.71	0.86

It was also found that the various stress treatments significantly restricted root growth in the form of root length and root weight. Salinity stress had more significant impact on root growth than did drought stress. As a result, the reduction in both root length and dry weight under saline conditions was greater than under drought, because salinity causes high osmotic pressure, ion imbalance and ion toxicity, while drought releases high osmotic pressure around the root growth zone. The unfavorable impact of salinity is stronger than for drought. Generally, rice growth is accomplished through cell elongation and cell division, which might have been restricted by the two stresses studied, resulting in less root growth. A further possible stress scenario for the reduced root growth is that nutrients and agonic solutes transmission from shoot to root were blocked. Yang *et al.* (2002) and Tao *et al.* (2006) reported similar findings.

As for the interaction effect, the interaction between rice varieties and the various tested stresses was significant for root length and root dry weight (Table 2). Giza 177 was the most affected one under both drought and salinity stresses in both seasons. The heaviest dry weight was obtained by SK2034H under normal conditions, while the lightest result was recorded for Giza 177 in saline conditions. The combination of Giza 177 and salinity stress produced the shortest root (Table 2). From data related to root characteristics, it seems that the hybrid rice variety SK2034H was more able to withstand salinity and drought stresses than the tolerant inbred variety Giza 178. A similar conclusion was obtained by Amudha and Thiyagarajan (2008).

Table 2: Root characters as affected by the interaction between rice varieties and different stresses during 2010 and 2011 seasons

Variety		2010			2011		
		Stress treatments					
		Salinity	Drought	Control	Salinity	Drought	Control
Root dry weight	Giza 177	48.00	135.33	242.00	47.66	139.0	258.33
	Giza 178	81.33	151.66	243.00	87.33	139.66	255.0
	SK2034H	189.00	215.00	300.00	193.00	230.00	320.33
	LSD at 0.05	10.794			8.772		
Root length (cm)	Giza 177	11.56	19.33	25.66	11.57	19.41	24.0
	Giza 178	16.66	23.33	19.23	15.16	21.2	19.46
	SK2034H	28.0	32.55	34.06	25.0	32.1	32.76
	LSD at 0.05	2.97			1.49		

Na^+,K^+ content and Na^+/K^+ ratio in plant tissue

Data Table 3 showed that the three tested rice varieties had significant variation for Na^+ and K^+ content in plant tissues in both seasons. Giza 177 had the significantly highest Na^+ content and the lowest K^+ content, keeping a high Na^+/K^+ ratio and greater salt sensitivity. The SK2034H hybrid ranked second to Giza 177 for Na^+ content, but on the other hand had higher K^+ content. Giza 178 produced the lowest value for Na^+ content and an intermediate value for K+ content, producing the lowest Na^+/K^+ ratio in plant tissue, followed in this respect by SK2034H (Table 3). Ion selectivity of Giza 177 is minor, whereas it has a greater uptake of Na^+ than K^+ to provide its salt sensitivity. Giza 178 showed contrary trends, while SK2034H showed a low Na^+/K^+ ratio thanks to a significantly higher K^+ content outweighing a slightly high Na^+ content. As a result, SK2034H had a strong ability to take up high K because of its high heterosis of element uptake reducing its Na^+/K^+ ratio. These findings are in accordance with those ratified by Babu *et al.* (2007).

With respect to stress effects, Na^+ and K^+ as well as Na^+/K^+ ratio in plant tissue were significantly affected by various stresses compared with normal conditions (Table 3). Both salinity and drought stress significantly reduced K^+ uptake and increased both the Na^+ uptake and the Na^+/K^+ ratio as compared to the control treatment. The highest values of Na^+ content and Na^+/K^+ ratio were obtained from rice plants under salinity stress, ahead of the results under drought stress. As shown in Table 3 drought stress reduced

K^+ uptake and resulted in high Na+ uptake, while the control rice plants in a standard practice regime adsorbed the highest values of K+ and gave the lowest values for Na^+ and Na^+/K^+ ratio. Similar results were indicated by Babu *et al.* (2007).

Table 3: contents of Na^+ ppm, K^{+1} ppm and Na^+/K^+ ratio of the three rice varieties as affected by various stresses during 2010 and 2011 seasons

Trait	Na^+		K^+		Na^+/K^+	
	2010	2011	2010	2011	2010	2011
Variety						
Giza 177	294.11	306.44	947.22	912.22	0.411	0.412
Giza 178	241.22	254.22	1108.33	1099.33	0.234	0.247
SK2034H	292.11	310.78	1198.33	1253.44	0.255	0.256
F test	*	*	**	**	**	**
LSD at 0.05	35.05	30.190	54.37	41.03	0.044	0.032
Stresses						
Salinity	456.67	480.56	893.33	935.00	0.568	0.565
Drought	275.44	295.00	1046.66	1047.67	0.261	0.278
Control	95.33	95.89	1313.89	1282.33	0.071	0.072
F test	**	**	**	**	**	**
LSD at 0.05	19.09	13.71	34.08	20.97	0.026	0.0199

Interestingly, the interaction effect of stress and variety had significant impact on Na^+, K^+ contents and Na^+/K^+ ratio in plant tissue over the two years of results (Table 4). The salt sensitive variety Giza 177 allied to salinity stress produced the highest values of Na^+ content and Na^+/K^+ ratio in both seasons, significantly higher for Na^+ content in plant tissue than the combination of hybrid rice variety SK2034H with salinity stress. The highest value for Na^+ content accompanied by the highest value of Na^+/K^+ ratio under control conditions was produced by SK2034H.

Table 4: contents Na^{+1} ppm, K^+ ppm and Na^+/K^+ ratio of rice as affected by the interaction between rice varieties and different stresses during 2010 and 2011 seasons

Variety		2010			2011		
		Stress treatments					
		Salinity	Drought	Control	Salinity	Drought	Control
Na^{+1}	Giza 177	610.00	216.33	56.0	655.0	212.66	51.66
	Giza 178	375.33	283.33	65.0	380.0	313.66	69.00
	SK2034H	384.66	326.66	165.0	406.66	358.66	167.0
	LSD at 0.05	33.056			23.745		
K^{+1}	Giza 177	635.40	948.8	1272.7	690.0	870.0	1176.6
	Giza 178	990.32	1041.7	1300.0	978.3	1043.0	1276.6
	SK2034H	1056.75	1150.2	1398.3	1136.6	1230.0	1393.6
	LSD at 0.05	59.03			36.31		
Na^+/K^+	Giza 177	0.96	0.228	0.044	0.949	0.244	0.043
	Giza 178	0.379	0.272	0.050	0.388	0.300	0.054
	SK2034H	0.364	0.284	0.118	0.357	0.291	0.119
	LSD at 0.05	0.046			0.034		

Furthermore, SK2034H under normal conditions gave the highest values of K^+ content, even under drought and salinity stresses when compared to other inbred varieties, i.e. Giza 177 salt-sensitive variety and /or Giza 178 salt-tolerant variety. Generally, salt-sensitive Giza 177 gave a higher Na^+/K^+ ratio under both salinity and drought stresses as compared to the salt-tolerant variety demonstrating its sensitivity to both drought and salinity stresses. SK2034H showed high nutrient uptake heterosis resulting in high potassium content for dealing with salinity and drought stresses. On the other hand, Giza 178 had high affinity for ion selectivity, resulting in reduced sodium uptake and a boost for potassium uptake leading to a low Na^+/K^+ ratio. In effect, both Giza 178 and SK2034H could be considered salt-tolerant varieties (Khan and Abdullah, 2003 and Zayed *et al.*, 2007).

Table 5 : Root dry weight, root length, and Na^+ ppm leaf content of some rice varieties as affected by a biotic stress in field conditions during 2011 season.

Variety	Root dry weight (g/hill)			Root length (cm)			Na^+ (ppm)		
	Saline soil	Drought stress	Normal soil	Saline soil	Drought stress	Normal soil	Saline soil	Drought stress	Normal soil
Giza 177	103.42	140.66	280.43	20	29	35	761	280	68
Giza 178	156.93	198.53	296.79	30	40	44	567	310	79
EHRI	187.73	228.22	353.27	35	45	47	630	360	150
LSDat0.05	7.01	8.3	12.3	3.57	2.34	1.83	26	16.1	20

Table 6 : Content of K^+ ppm, Na^+/K^+ ratioand flag leaf area cm^2 of some rice varieties as affected by abiotic stress in field conditions during 2011 season.

Variety	K^+ ppm			Na^+/K^+			Flag leaf area cm^2		
	Saline soil	Drought stress	Normal soil	Saline soil	Drought stress	Normal soil	Saline soil	Drought stress	Normal soil
Giza 177	510	750	1250	1.570	0.373	0.05	15.31	19.5	27.2
Giza 178	720	1057	1300	0.788	0.293	0.06	33.2	35.5	42.2
EHRI	830	1163	1396	0.759	0.309	0.107	36.2	37.8	44.4
LSDat0.05	14	26	35	0.34	0.03	NS	2.55	1.23	1.46

Growth parameters at heading stage

Data documented in Tables 7 and 9 show that the three tested rice varieties exhibited significant variation in their performance with regard to growth traits at the heading stage, i.e. dry matter, dry weight of flag leaf, flag leaf area, leaf area plant^{-1} and chlorophyll content under green house . It was detected that the SK2034H hybrid rice variety significantly surpassed the other two inbred rice varieties for all these growth traits. However, Giza 177 was ranked the last in this study with regards to the performance of the growth parameters. Giza 178 was rated second after SK2034H, which gave significant highest values for dry matter plant^{-1}, dry weight of flag leaf, flag leaf area plant^{-1}, leaf area plant^{-1} and chlorophyll content in both seasons under green house.

Table 7: Effect of abiotic stresses on growth characters of some rice varieties during 2010 and 2011 seasons

Trait	Plant height		Leaf area/plant		Flag leaf area	
	2010	2011	2010	2011	2010	2011
Variety						
Giza 177	79.79	79.86	105.79	106.67	19.59	19.41
Giza 178	81.27	83.58	130.53	130.27	24.59	25.19
SK2034H	87.93	88.48	182.69	184.89	34.65	35.52
F test	**	**	**	**	**	**
LSD at 0.05	1.74	1.89	5.39	2.78	1.43	0.63
Stresses						
Salinity	75.43	75.66	90.94	95.33	19.51	20.27
Drought	82.48	83.26	139.98	137.49	24.54	24.72
Control	91.09	93.00	188.09	189.00	34.79	35.14
F test	**	**	**	**	**	**
LSD at 0.05	2.63	1.46	4.77	2.51	1.11	0.64

Table 8: Growth characters as affected by the interaction between rice varieties and different stresses during 2010 and 2011 seasons

	Variety	2010			2011		
		Stress treatments					
		Salinity	Drought	Control	Salinity	Drought	Control
Plant height	Giza 177	71.43	78.33	89.6	71.4	78.33	89.83
	Giza 178	76.37	81.11	86.33	77.43	82.13	91.60
	SK2034H	78.46	88.00	97.33	78.13	89.30	98.00
	LSD at 0.05	4.56			2.53		
Leaf area/plant	Giza 177	68.72	104.76	143.86	71.0	102.0	147.0
	Giza 178	98.46	115.13	178.0	99.66	115.8	175.33
	SK2034H	105.63	200.03	242.0	115.33	194.66	244.66
	LSD at 0.05	8.27			4.34		
Flag leaf area	Giza 177	9.98	18.9	29.9	9.24	18.6	30.4
	Giza 178	19.24	21.33	33.2	20.76	21.28	33.53
	SK2034H	29.30	33.40	41.26	30.80	34.26	41.50
	LSD at 0.05	1.92			1.11		

Table 9: Effect of abiotic stresses on physiological traits during 2010 and 2011seasons

Trait	Chlorophyll content		Dry matter at heading		Flag leaf dry matter	
	2010	2011	2010	2011	2010	2011
Variety						
Giza 177	33.81	33.03	24.67	25.08	0.440	0.456
Giza 178	37.30	37.51	30.96	30.78	0.676	0.680
SK2034H	40.53	41.19	41.43	41.56	0.796	0.794
F test	**	**	**	**	**	**
LSD at 0.05	1.12	1.85	1.92	0.87	0.026	0.013
Stresses						
Salinity	34.74	34.71	25.58	25.47	0.481	0.493
Drought	36.99	36.40	29.18	29.28	0.617	0.620
Control	39.91	40.62	42.30	42.67	0.814	0.817
F test	**	**	**	**	**	**
LSD at0.05	1.33	1.14	0.84	0.98	0.027	0.020

Table 10: Physiological characters as affected by the interaction between rice varieties and different stresses during 2010 and 2011 seasons

Variety		2010			2011		
		Stress treatments					
		Salinity	Drought	Control	Salinity	Drought	Control
Chlorophyll content	Giza 177	28.93	33.93	38.56	28.3	30.96	39.83
	Giza 178	36.23	36.66	39.0	36.5	37.0	39.03
	SK2034H	39.06	40.36	42.16	39.33	41.23	43.0
	LSD at 0.05	2.29			1.98		
Dry matter at heading	Giza 177	15.86	22.53	35.60	15.3	23.03	35.9
	Giza 178	26.20	27.55	39.13	25.43	27.96	38.93
	SK2034H	34.66	37.45	52.16	34.66	36.83	53.16
	LSD at 0.05	1.46			1.69		
Flag leaf dry matter	Giza 177	0.263	0.410	0.646	0.270	0.436	0.663
	Giza 178	0.533	0.666	0.830	0.556	0.653	0.83
	SK2034H	0.640	0.776	0.966	0.653	0.770	0.96
	LSD at 0.05	0.047			0.047		

The data listed in Tables 11 and 12 related to the result of experiments conducted under filed conditions showed the same trend regarding the above-mentioned traits. Therefore, the superiority of Egyptian hybrid one and Giza 178 had been confirmed by the result obtained under field conditions. On the other hand, the lowest values for the above-mentioned growth parameters were recorded by Giza 177 in both green house and field conditions.. Several authors, such as Peng *et al.* (1998), Zayed *et al.* (2007) and Malarvizhi *et al.* (2009), have reported variation between hybrid rice and inbred rice regarding growth performance under normal and saline soils.

Table 11: LAI, Flag leaf dry weight and Chlorophyll content SPAD value of some rice varieties as affected by abiotic stress in field conditions during 2011season.

Variety	LAI			Flag leaf dry weight g			Chlorophyll content		
	Saline soil	Drought stress	Normal soil	Saline soil	Drought stress	Normal soil	Saline soil	Drought stress	Normal soil
Giza 177	2.73	2.68	5.32	0.110	0.112	0.206	33.1	34.0	44.0
Giza 178	4.81	4.90	5.85	0.142	0.135	0.221	37.9	36.0	40.2
EHRI	5.32	5.52	6.52	0.164	0.160	0.258	38.7	37.0	42.0
LSDat0.05	0.23	0.24	0.43	0.021	0.009	0.019	1.20	1.65	1.22

Table 12: Dry matter at heading (g) m^2, plant height cm and number of panicles $hill^{-1}$ cm of some rice varieties as affected by abiotic stress in field conditions during 2011 season.

Variety	Dry matter at heading			Plant height			No. of panicles $plant^{-1}$		
	Saline soil	Drought stress	Normal soil	Saline soil	Drought stress	Normal soil	Saline soil	Drought stress	Normal soil
Giza 177	515.9	519.24	1068	80.5	81	102	10.3	11	19
Giza 178	805.4	799.03	1200	84.7	88	101	13.9	18	23
EHRI	848.9	919.71	1560	90.0	92	102	16.4	20	27
LSDat 0.05	20.0	19.67	35	3.6	6.01	NS	1.37	3.73	2.64

Generally speaking, the two tested stresses of salinity and drought significantly inhibited dry matter plant^{-1},dry weight of flag leaf, flag leaf area, leaf area plant^{-1} and chlorophyll content in both study years (Tables 7,9,11 and 12) under both green house and field conditions.. As seen previously, salinity stress had greater impact than drought stress on measured growth parameters. Salinity stress produced the minimum values for dry matter plant^{-1}, dry weight of flag leaf, flag leaf area, leaf area plant^{-1} and chlorophyll content in both seasons. Meanwhile, the control treatment gave the maximum values for such traits. Stresses such as salinity and drought might have affected growth by suppressing cell enlargement and cell division, by reducing cell turgor, photosynthesis rate, metabolic and assimilate processes, pigment formation, and water and nutrients uptake as well as the transportation of organic solutes from one organ to another in the rice plants. Many scientists, including Sultana *et al.* (1999) and Yang *et al.* (2002) have obtained similar results.

The interaction between rice varieties and the applied stress significantly affected dry matter plant^{-1}, dry weight of flag leaf, flag leaf area, leaf area plant^{-1}, and chlorophyll content in both 2010 and 2011 seasons (Tables 8 and 10). The relevant data on growth and the performance of growth parameters confirmed that salinity stress was more harmful than drought stress. Giza 177 was most sensitive to both salinity and drought stresses. Giza 178 and SK2034H were more tolerant of both studied stresses, although SK2034H proved more tolerant for both salinity and drought stress than Giza 178. High growth heterosis of SK2034H hybrid rice, starting from root growth characteristics up to chlorophyll content, was found to be effective in enabling its healthy growth under such circumstances. The possibility of using high heterosis of hybrid rice under diverse conditions was supported by the current results. The lowest values for the above-mentioned traits were produced by the combination of Giza 177 and salinity treatment. Meanwhile, the combination of SK2034H and the control treatment gave the maximum values of growth parameters. Under stressful conditions of salinity and drought, SK2034H also gave the highest values of growth parameters compared to Giza 178 and Giza 177 under the same conditions. Chlorophyll content of Giza 178 and SK2034H was comparable under both drought and salinity stress both seasons. These findings are in agreement with those reported by Mushtaq and Zaibunnisa (2003), Wanichananan *et al.* (2003) and Farooq *et al.* (2008).

Yield attributing characteristics

Data documented in Tables 13 and 15 indicate that the three tested rice varieties greatly differed in their yield attributing characteristics in both seasons under green house. Also data in Tables 12,19 and 20 revealed that the salinity and drought stresses induced under field conditions significantly retracted the yield attributing characteristic. Giza 177 gave the shortest plants and least panicles number hill^{-1} on average, while Giza 178 had the longest plants and gave the highest values for panicle numbers in both seasons (Table 13).

Table 13: Number of panicles plant^{-1}, no. of filled grains and sterility% of three rice varieties as affected by various stresses during 2010 and 2011 seasons

Trait	No. of panicles plant^{-1}		No. of filled grains		Sterility%	
	2010	2011	2010	2011	2010	2011
Variety						
Giza 177	10.80	10.26	74.19	79.20	17.63	20.33
Giza 178	14.67	14.76	105.10	105.70	13.87	13.83
SK2034H	19.96	19.49	115.80	119.20	22.27	21.22
F test	**	**	**	**	**	**
LSD at0.05	1.02	1.07	3.06	3.16	1.39	0.99
Stresses						
Salinity	11.71	11.53	82.19	84.40	22.57	24.33
Drought	14.06	13.19	104.00	95.31	19.14	19.42
Control	19.66	19.78	119.44	124.40	12.07	11.63
F test	**	**	**	**	**	**
LSD at0.05	1.27	0.72	3.68	3.30	1.44	1.17

Table14: Yield components (panicles number, number of filled grains/panicle and sterility % of rice as affected by the interaction between rice varieties and abiotic stresses during 2009 and 2010 seasons

Variety		2010			2011		
		Stress treatments					
		Salinity	Drought	Control	Salinity	Drought	Control
Panicles number	Giza 177	6.30	9.33	16.76	5.76	8.33	16.66
	Giza 178	12.66	12.33	19.00	12.53	12.23	19.50
	SK2034H	16.00	20.50	23.20	16.00	19.0	23.16
	LSD at 0.05	2.20			1.25		
Filled grains	Giza 177	53.64	65.40	103.50	56.40	65.70	115.50
	Giza 178	9149	103.20	120.60	91.80	103.23	122.09
	SK2034H	101.39	114.89	131.10	105.03	117.00	135.59
	LSD at 0.05	6.40			3.59		
Sterility %	Giza 177	24.9	19.0	9.0	31.66	22.33	7.0
	Giza 178	18.6	14.0	9.0	17.33	14.16	10.0
	SK2034H	24.2	24.42	18.2	24.0	21.76	17.0

Table 15: 1000-grain weight, panicle length and panicle weight of three rice varieties as affected by various stresses during 2010 and 2011seasons

Trait	1000-grain weight (g)		Panicle length (cm)		Panicle weight (g)	
	2010	2011	2010	2011	2010	2011
Variety						
Giza 177	24.41	24.53	17.84	17.71	1.69	1.77
Giza 178	18.96	18.86	18.99	19.48	2.19	2.17
SK2034H	22.30	22.49	21.52	21.31	2.89	2.88
F test	**	**	*	*	**	**
LSD at0.05	0.77	0.42	1.65	0.91	0.16	0.16
Stresses						
Salinity	19.91	20.01	16.88	17.00	1.68	1.77
Drought	21.60	21.7	19.43	19.19	2.11	2.12
Control	24.00	24.10	22.04	22.31	2.97	2.92
F test	**	**	**	**	**	**
LSDat 0.05	0.43	0.31	0.72	0.67	0.12	0.06

SK2034H gave the longest panicles and Giza 177 had the shortest panicles. SK2034H continued to confirm its superiority over the inbred rice varieties by giving the greatest values for number of filled grains panicle^{-1} in both seasons. However, SK2034H also returned the highest percentages for sterility while, Giza 178 produced significantly lower sterility% in both seasons.

Salinity and drought stress significantly inhibited all yield attributing characteristics (Table 13 and 15). Salinity stress dramatically reduced plant height and number of panicles plant^{-1} in both seasons (Table 13), with an average reduction through salinity of around 40% of the panicles number obtained by the control (normal) treatment. Meanwhile, the reduction in panicles number caused by drought was found to be around 28% of that obtained under the control treatment, confirming that salinity stress is more harmful to panicles number than drought. The poor plant stand resulting from either stress caused the marked reduction in panicles number plant^{-1}. It is worthy of mention that panicle length contributed to the same pattern of plant height under various stresses.

Salinity stress severely impacted panicle weight, number of filled grains panicle^{-1} and 1000-grain weight in both seasons (Tables 13 and 15). For example, the reduction in panicle weight associated with salinity stress reached 41–43% of weights under normal conditions but reduction by drought stress was found to be 27–29% under the same conditions. Stress conditions significantly magnified sterility% comparing to the control treatment. Salinity stress induced more sterility than resulted from drought stress. Interestingly, the data related to the yield attributing characteristics gathered under field condition came to confirm the results obtained under green house(Tables 12, 19 and 20).. The sterility% increased around two-fold over the control because of salinity, and about one-and–a-half-fold under drought. Similar results were reported by Mushtaq and Zaibunnisa (2003), Wanichananan (2003) and Farooq *et al.* (2008).

With respect to interaction effects, the interaction between rice varieties and stress treatments significantly affected panicles number plant^{-1}, panicle weight, number of filled grains panicle^{-1}, sterility% and 1000-grain weight for all varieties in both seasons (Tables 14 and 16). Salinity stress sharply decreased panicles number and panicle weight of Giza 177 by up to 60% of the results from the control treatment. SK2034H continued to perform best under both stress conditions and produced the best results of the three tested varieties under control conditions.

It was found that stress maximized sterility% of all varieties, particularly Giza 177 grown under salinity stress, which induced greater sterility than did drought stress. Sterility of hybrid rice under both salinity and drought conditions was at a par in both seasons (Table 14). Giza 178 was less affected by salinity and drought with regard to sterility%. The interaction effects related to sterility% confirmed the superiority of the SK2034H and Giza 178 varieties under both drought and salinity stress. However, Giza 177 is not recommended under such conditions. Similar data has been reported by Mushtaq and Zaibunnisa (2003), Wanichananan (2003) and Farooq *et al.* (2008).

Table 16: 1000-grain weight, panicle length and panicle weight of rice as affected by the interaction between rice varieties and different stresses during 2010 and 2011 seasons

Variety		2010			2011		
		Stress treatments					
		Salinity	Drought	Control	Salinity	Drought	Control
1000-grain weight (g)	Giza 177	21.7	24.66	26.86	21.63	24.96	27.0
	Giza 178	17.53	17.76	21.56	17.43	17.53	21.6
	SK2034H	20.5	22.83	23.56	20.96	22.8	23.7
	LSD at 0.05	0.75			0.54		
Panicle length (cm)	Giza 177	14.63	17.96	20.93	15.0	16.9	21.23
	Giza 178	16.33	19.0	21.63	16.66	19.56	22.2
	SK2034H	19.66	21.33	23.56	19.33	21.1	23.5
	LSD at 0.05	1.25			1.16		
Panicle weight (cm)	Giza 177	1.03	1.65	2.40	1.23	1.61	2.45
	Giza 178	1.65	2.14	2.76	1.67	2.17	2.66
	SK2034H	2.36	2.53	3.76	2.40	2.57	3.65
	LSD at 0.05	0.20			0.10		

Yields

Data listed in Table 17 and 20 indicate that both grain and straw yields varied significantly among the three tested rice varieties in both seasons under green house and field, respectively. The data confirmed the superiority of SK2034H over the best inbred rice variety (Giza 178) by 28–30% and by 52–53% over Giza 177 that was fact under green house and open field.

Table 17: Grain yield and straw yield of three rice varieties as affected by various stresses during 2010 and 2011 seasons

Trait	Grain yield		Straw yield	
	2010	2011	2010	2011
Variety				
Giza 177	15.505	16.21	26.781	28.688
Giza 178	24.335	24.275	31.692	31.688
SK2034H	33.244	34.888	40.157	40.588
F test	**	**	**	**
LSD at 0.05	1.3639	1.732	1.512	1.866
Stresses				
Salinity	16.62	17.707	24.691	25.00
Drought	19.328	19.444	27.025	27.10
Control	37.136	38.222	46.914	48.866
F test	**	**	**	**
LSD at 0.05	1.085	1.415	1.2357	1.329

The interaction between rice variety and stress significantly affected both grain and straw yields in both seasons under green house (Table 18). It was detected that salinity sharply decreased rice grain yields in the 2010 and 2011 seasons by 77.8% and 78.6%, respectively, for Giza 177, by 48.6% and 42.2% for Giza 178, and by 45% and 42.1% for SK2034H. Moreover, drought stress decreased rice grain yield by 68.6% (2010) and 70.9% (2011) for Giza 177, and 45.2% and 42.2% respectively for Giza 178, and 35.2% and 35.1% for SK2034H hybrid rice. It could be concluded that both Giza 178 and

SK2034H rice varieties had considerable affinity for withstanding salinity stress to similar levels under the experimental salinity level. However, SK2034H is more drought tolerant than Giza 178, which could be regarded as a second option as a drought tolerant variety. SK2034H gave the best root growth, physiological growth, vegetative growth and higher heterosis of yield attributing characteristics as well as higher heterosis of K uptake that might be contributory to higher heterosis of yield. Similar findings have been reported by Wanichananan (2003), Zayed *et al.* (2007) and Farooq *et al.* (2008)

Table 18: Grain yield and straw yield of rice as affected by the interaction between rice varieties and different stresses during 2010 and 2011 seasons

Variety		2010			2011		
		Stress treatments					
		Salinity	Drought	Control	Salinity	Drought	Control
Grain yield (g hill^{-1})	Giza177	6.76	9.20	30.55	6.86	9.43	32.33
	Giza178	18.23	19.35	35.42	19.06	18.43	35.33
	SK2034H	24.86	29.43	45.43	27.2	30.46	47.0
	LSD at 0.05	1.88			2.45		
Straw yield (g hill^{-1})	Giza177	15.23	18.11	47.0	16.23	17.93	51.90
	Giza178	24.43	27.83	42.41	25.7	27.2	42.16
	SK2034H	33.40	35.73	51.33	33.06	36.16	52.53
	LSD at 0.05	2.14			2.30		

Table 19: Panicle length, Number of filled grains panicle^{-1}and sterility % of some rice varieties as affected by abiotic stresses in field conditions during 2011 season.

Variety	Panicle length (cm)			No. of filled grains			Sterility%		
	Saline soil	Drought stress	Normal soil	Saline soil	Drought stress	Normal soil	Saline soil	Drought stress	Normal soil
Giza 177	16.76	15	21.5	80.0	101.0	122	35	30	7
Giza 178	18.91	20	23.1	128.0	125.0	140	15	12	5
EHRI	20.10	22	24.4	138.0	135.0	156	23	25	10
LSDat0.05	1.30	2.33	2.40	5.23	7.3	6.3	3	4	3.58

Table 20: Panicle weight (g), 1000 grain weight (g) and yield t ha^{-1} of some rice varieties as affected by abiotic stress in field conditions during 2011 season.

Variety	Panicle weight (g)			1000-grain weight (g)			Grain yield		
	Saline soil	Drought stress	Normal soil	Saline soil	Drought stress	Normal soil	Saline soil	Drought stress	Normal soil
Giza 177	2.11	1.9	3.6	23.6	24	28.0	4.56	5.0	9.90
Giza 178	2.72	2.8	3.1	19.51	19	21.0	7.42	7.2	10.90
EHRI	3.13	3.5	4.0	20.4	21	23.0	7.93	7.67	11.80
LSD at0.05	0.43	0.32	0.41	0.62	0.74	0.56	0.40	0.65	0.72

DISCUSSION

As a result, the reduction in both root length and dry weight under saline conditions was greater than under drought, because salinity causes high osmotic pressure, ion imbalance and ion toxicity, while drought releases high osmotic pressure around the root growth zone. The unfavorable impact of salinity is stronger than for drought. Generally, rice growth is accomplished through cell elongation and cell division, which might have been restricted by the two stresses studied, resulting in less root growth. A further possible stress scenario for the reduced root growth is that nutrients and agonic solutes transmission from shoot to root were blocked. Yang *et al.* (2002) and Tao *et al.* (2006) reported similar findings.

Na^+, K^+ content and Na^+/K^+ ratio in plant tissue

Generally, salt-sensitive Giza 177 gave a higher Na^+/K^+ ratio under both salinity and drought stresses as compared to the salt-tolerant variety demonstrating its sensitivity to both drought and salinity stresses. Aforementioned result related to the sensitivity of Giza 177 allied to salt and drought is mainly due to its poor ion selectivity which enforced it to uptake more Na against K. High Na^+/K^+ ratio for Giza 177 indicated it sensitivity for both drought and salinity stress. On contrary, it seem that Giza 178 might be had high ability for ion selectivity resulted in low Na^+/K^+ ratio in the terms of low Na uptake with high K uptake. SK2034H showed high nutrient uptake heterosis resulting in high potassium content for dealing with salinity and drought stress. In effect, both Giza 178 and SK2034H could be considered salt-tolerant varieties (Muhammed and Neue, 1987, Qader 1998 and Zayed *et al.*, 2007).

Growth parameters at heading stage

Salinity stress produced the minimum values for dry matter plant^{-1}, dry weight of flag leaf, flag leaf area, leaf area plant^{-1} and chlorophyll content in both seasons. Meanwhile, the control treatment gave the maximum values for such traits. Stresses such as salinity and drought might have affected growth by suppressing cell enlargement and cell division, by reducing cell turgor, photosynthesis rate, metabolic and assimilate processes, pigment formation, and water and nutrients uptake as well as the transportation of organic solutes from one organ to another in the rice plants. Many scientists, including Sultana *et al.* (1999) and Yang *et al.* (2002) have obtained similar results.

Yield attributing characteristics

As previously mentioned, stress restricts rice growth during the early growth stages and poor vegetative growth might have resulted in fewer assimilates, lower carbohydrate formation, dry matter production and poor population leading to poor yield attributes. A second possibility is that the stresses might block stored assimilates to grains resulting in poorly-filled grains panicle^{-1} and high sterility% by releasing more ABA. Yet another possibility is stress-induced interference with photosynthesis resulting in poor grain filling and subsequent high sterility, light panicles and poorly-filled grains panicle^{-1} because of shorter active grain filling periods. Similar results were reported by Mushtaq and Zaibunnisa (2003), Wanichananan (2003) and Farooq *et al.* (2008).

Yields

It could be concluded that both Giza 178 and SK2034H rice varieties had considerable affinity for withstanding salinity stress to similar levels under the experimental salinity level. However, SK2034H is more drought tolerant than Giza 178, which could be regarded as a second option as a drought tolerant variety. SK2034H gave the best root growth, physiological growth, vegetative growth and higher heterosis of yield attributing characteristics as well as higher heterosis of K uptake that might be contributory to higher heterosis of yield. Table 13 discloses the data for stress effects on yields, confirming that drought and salinity stresses significantly inhibited grain and straw yields 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. Drought stress induced its harmful effects on rice plants by high osmotic pressure that might also affect cell growth but to a lesser degree than was caused by salinity. Generally, stresses of salinity and drought 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 phonology 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.Similar findings have been reported by Wanichananan (2003) , Zayed *et al.* (2007)and Farooq *et al.* (2008).

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دراسة مقارنه على الأرز الهجين المربى داخليا تحت ظروف الملوحة والجفاف

بسيونى عبدالرازق زايد ، رأفت عبداللطيف النمكى ، ياسر زيـــن العابـــدين الرفـــاعى و صابر السيد محمد صديق
مركز البحوث والتدريب في الأرز ، معهد المحاصيل الحقلية ، مركز البحوث الزراعية .

قوة الهجين المميزة للأرز الهجين يمكن استغلالها في زيادة إنتاجيه الأرز تحت ظروف الاجهـــادات البيئية مثل الملوحة والجفاف .

أجريت هذه الدراسة في الصوبة الزجاجية و الحقل بمركز البحوث والتدريب في الأرز بخسا وكذلك بمحطة بحوث السرو الزراعية بدمياط تحت ظروف الأرض الملحية خلال موسمي ٢٠١٠و ٢٠١١ للصوب و ٢٠١١ للحقل بالمحطتين لدراسة القدرة الانتاجيه لكل من الأرز الهجين و بعض اصـــناف الارز المربـــاه داخليا خاصه لمحصول الحبوب تحت ظروف الملوحه والجفاف . اختبرت أصناف جيزة ١٧٧، جيزة ١٧٨ (أصناف مرباه داخليا) و هجين مصرى ١ تحت ظروف الملوحه والجفاف باســتخدام تــصميم القطاعـــات المنشقه مرة واحده .وقد اوضحت النتائج:

اختلفت الثلاث اصناف معنويا فى كل الصفات المدروسة وكذلك فى تحملها للاجهـــادات البيئيـــة ، حيث اظهر صنف الارز الهجين مصرى ١ قدرة على التحمل اكثر لكل مـــن الملوحــــه والجفـــاف مقارنـــه بالصنف جيزة ١٧٨ (أكثر الاصناف المصريه المرباه داخليا تحملا لهذه الاجهادات البيئيه).

ولقد اوضحت النتائج ان القدره العاليه للتحمل الارز الهجين ربما ترجع الى تفوقه واحتوائه علـــى نظام جذرى قوى ، مساحه الورقه ، مساحه ورقه العلم ، محتوى الكلورفيل ، انتاج المـــاده الجافـــه ، عـــدد الحبوب الممتلئه ، عدد السنابل ، وزن السنبله و النسبه المئوية المنخفضه لعقم السنيبلات ، عـــلاوة علـــى ان صنف الارز الهجين مصرى ١ لديه محتوى عالى من كلا من الصوديوم والبوتاسيوم مقارنه بالصنف جيـــزة ١٧٨ وهذا يؤدى الى زياده فى قدرته فى تحمل الاجهادات البيئيه .

على الجانب الاخر لقد اظهر الصنف جيزة ١٧٧ حساسيه للتحمل لهذه الاجهـــادات البيئيـــه وذلـــك يرجع الى ضعف عام فى نظام المجموع الجذرى ، النمو ، انخفاض الكلورفيـــل ، ونـــسبه الـــصوديوم / البوتاسيوم العاليه ، وزياده النسبه المئويه للعقم تحت هذه الظروف من الاجهادات البيئيه .

مما يجدر ذكره ان نتائج الحقل كانت مؤكدة لما تم الحصول علية في الصوبة.

عموما فان كل من صنفى الارز الهجين مصرى ١ وجيزة ١٧٨ أظهرا نفس القدر من التحمل للملوحه بينما أظهر الصنف الهجين مصرى ١ قدره اعلى فى تحمل الجفاف مقارنه بالصنف جيزة ١٧٨ .

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