J.Agric.Chem.and Biotechn., Mansoura Univ.Vol. 9 (1): 37- 42, 2018

Combining Ability Analysis in Hybrid Rice Under Normal and Saline Soil Conditions

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ABSTRACT

The present investigation was conducted to study the combining ability through L x T design of experiment hybrids for agronomic and yield and its component traits under normal and saline soil conditions. Six CMS lines were crossed with seven restorer lines to produce 42 hybrids where they along with their parental lines were evaluated. The analysis of variance for combining ability revealed highly significant differences among CMS and restorer lines for all agronomic and yield and its studied characters except for grain yield (ton/fed) under both normal and saline soil conditions. Among the CMS lines; Pusa 6A and IR69625A while among the restorers, PR3 and Giza 178R are proved to be good combiners for the majority of the characters including yield, by exhibiting values for high GCA effects. Out of 42 hybrid rice combinations, the top five hybrids based on SCA effects for grain yield characters under saline soil conditions are IR68902A/Giza 182R, IR70368A/Giza 178R, IR69625A/PR2, Pusa 3A/GZ6296R and IR58025A/PR2.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the major staple food crops for Egyptians and also a cash crop when exported. Since 1986 much more work have been directed to improve the productivity of this crop to keep up with Egypt's rapid increasing population. The national yield average had exceeded 9.57 ton/ha. In the year of 2011 (RRTC, 2012).

Rice (*Oryza sativa* L.) crop is more relevant and common crop cultivated under area affected by salt stress in Egypt. Grain yield of rice under target area is still low as compared to normal soil or national average. Furthermore, people living in such area suffer from severe poverty. Thereby, increasing grain yield of rice in these areas is badly needed for food security and poverty alleviation (El-Mowafi, 1994 and Zayed *et al*., 2015).

Demand of rice is expected to grow faster than production in most countries so much that by the year 2025, 800 million ton of it will be needed annually (Anonymous, 1994). Population increase will be more in developing countries. Combining ability analysis is a powerful tool to discriminate good as well as poor combinors and selecting out appropriate parental material and best hybrid combinations (Patil and Mehta, 2014).

The present investigation was therefore, under taken with an objective to estimate the general and specific combining ability of the CMS and restorer lines and their hybrids under normal and saline conditions using L x T analysis.

MATERIALS AND METHODS

The experimental material for the present investigation consisted of 13 parents (six CMS lines and seven males) as shown in Table 1 and their 42 hybrid rice combinations. The hybridization programme was carried out using six CMS lines and seven restorers adopting isolation plots during summer 2011 at Sakha Station Farm. Thus seeds of 42 hybrids were obtained. Complete sets of 55 entries comparing of 42 F_1s, six females, seven males were evaluated during summer 2012 at two locations viz Sakha under normal soil condition and El-Sirw under saline soil condition (Table 2). The trials were conducted in Randomized Complete Blocks Design (RCBD), with three replicates. Recommended agronomical practices under normal and saline soil conditions were followed while raising the rice crop. Data were recorded on the ten randomly selected plants from each location in each replication for days to heading (day), plant height (cm), tillers plant^{-1}, spikelets panicle^{-1}, panicle length (cm), panicles plant^{-1}, filled grains panicle^{-1}, spikelets fertility %, 1000-grains, weight (g), and grain yield (ton/fed.), combining ability analysis was calculated following the method suggested by Kempthorne (1957). Combining ability was determined for selecting superior parents with good general combining ability (GCA) and hybrids with superior specific combining ability (SCA) effects. Means were used for analysis of variance for line x tester analysis including parents.

Table 1. Cytoplasmic male sterile and restorer lines used of the experiment.

Genotype	Cytoplasmic source	Origin
CMS lines (female):		
1.Pusa 3A	WA (Wild abortive)	India-Egypt
2.Pusa 6A	WA	India-Egypt
3.IR58025A	WA	IRRI
4.IR69625A	WA	IRRI
5.IR70368A	WA	IRRI
6.IR68902A	WA	IRRI
Restorer/tester lines		
1.PR1	New restorer line developed by Egyptian HRB program	Egypt
2.PR2	New restorer line developed by Egyptian HRB program	Egypt
3.PR3	New restorer line developed by Egyptian HRB program	Egypt
4.Giza 178R	Restorer and tolerant to salinity	Egypt
5.Giza 182	Restorer of Indica type	Egypt
6.GZ5121R	Restorer and tolerant to salinity	Egypt
7.GZ6296R	Restorer of Indica/Japonica	Egypt

Table 2. Some chemical characteristics of the experimental farm soil at Sakha and El-Sirw in summer season of 2012.

Characteristics	Normal soil (Sakha) 0-30 cm	Saline soil (El-Sirw) 0-30 cm
Electrical conductivity (dS/m)*	1.5	7.5-10.3
pH (1:2.5)	7.8	7.8-7.9
TDS mg/litre (ppm)	915	4697-6919
Soluble cations (mg/litre)**		
Ca^{++}	2.61	9.1-13.9
Mg^{++}	2.98	13.2-16.9
Na^{+}	8.9	50.7-76.4
K^{+}	0.06	0.76-1.53
Soluble anions (mg/litre)**		
CO_3^{--}	0.30	0.10-0.14
HCO_3^{-}	2.73	4.10-6.10
Cl^{-}	9.80	55.0-80.5
SO_4^{--}	0.30	20.5
Texture grade	Clay	Clay

*** Measure of soil saturation.**
**** Measure of soil water extract 1:5.**

RESULTS AND DISCUSSION

Analysis of variance and combining ability:

The analysis of variance (Tables 3 and 4) revealed highly significant differences among the 55 genotypes 42 hybrid rice combinations, six CMS lines and seven testers or restorer lines which tested for all agronomic characters and yield and its components under both normal and saline conditions. The parental lines and the hybrid rice combinations showed highly significant differences for all studied characters under both normal and saline conditions. Parents *vs* crosses mean square indicated that average heterosis was significant in all crosses under both normal and saline conditions for all agronomic and yield studied characters under investigation.

Table 3. Mean square for the analysis of variance of combining ability for agronomic characters under normal and saline conditions.

S.O.V.	df	Days to heading (day)		Plant height (cm)		Tillers $plant^{-1}$		Spikelets $panicle^{-1}$		Panicle length (cm)	
		N	S	N	S	N	S	N	S	N	S
Reps	2	0.345^{NS}	1.479**	1.042^{NS}	5.752*	0.581^{NS}	2.776**	16.113^{NS}	7.874^{NS}	0.033^{NS}	0.061^{NS}
Genotypes	54	46.803**	49.840**	136.45**	188.67**	24.298**	21.26**	3341.788**	2196.855**	10.023**	17.933**
Parents	12	61.590**	104.05**	321.308**	188.66**	29.274**	24.04**	2390.536**	1842.300**	12.477**	16.816**
Hybrids	41	38.855**	34.78**	85.168**	186.06**	15.694**	16.49**	2200.984**	1380.899**	6.035**	10.376**
P. vs. H	1	195.245**	16.77**	21.016**	296.35**	317.330**	183.39**	61529.79**	39905.713**	143.811**	341.182**
Lines	5	66.705**	35.91**	62.851**	20.85**	49.629**	57.23**	6049.66**	5448.078**	8.755**	21.129**
Restorer (tester)	6	168.601**	166.05**	478.053**	1186.77**	31.035**	37.85**	7228.07**	3540.369**	29.131**	44.559**
L x T	30	8.264**	8.34**	10.310**	13.450**	6.970**	5.42**	554.121**	271.142**	0.963^{NS}	1.747^{NS}
Error	108	0.722	0.63	1.524	1.887	0.535	0.54	22.001	8.583	0.084	1.98
C.V		0.84	0.77	1.17	1.43	3.25	3.93	2.20	1.63	1.08	1.91

***, ** significant at 0.05 and 0.01 levels of probability and NS not significant**
N = Normal S = Saline soil

Table 4. Mean square for the analysis of variance of combining ability for yield and yield component characters under normal and saline conditions.

S.O.V.	d.f	Panicles $plant^{-1}$		Filled grains $panicles^{-1}$		Spikelets fertility %		1000-grain weight (g)		Grain yield (ton/fed)	
		N	S	N	S	N	S	N	S	N	S
Reps	2	0.650^{NS}	0.84^{NS}	14.558^{NS}	6.109^{NS}	0.898^{NS}	2.102^{NS}	0.119^{NS}	0.045^{NS}	0.004^{NS}	0.000^{NS}
Genotypes	54	24.387**	18.545**	2542.865**	1530.998**	27.472**	44.283**	8.286**	12.892**	1.662**	0.456**
Parents	12	27.676**	22.89**	1957.253**	1362.035**	45.160**	77.647**	21.061**	27.949**	0.672**	0.549**
Hybrids	41	15.851**	14.34**	1517.632**	931.013**	22.812**	34.235**	4.405**	7.036**	0.306^{NS}	0.165**
P. vs. H	1	334.909**	138.71**	51604.745**	28157.909**	6.252**	55.895**	14.137**	72.304**	69.127**	11.268**
Lines	5	54.246**	34.16**	2920.148**	3077.348**	81.838**	100.599**	23.282**	37.393**	1.157**	0.669**
Restorer (tester)	6	28.008**	47.61**	5866.518**	3072.218**	45.824**	107.003**	8.103**	10.527**	0.539**	0.406**
L x T	30	7.021**	4.39^{NS}	414.102**	145.049**	8.372**	8.620**	0.519^{NS}	1.278^{NS}	1.118**	0.033**
Error	108	0.560	0.63	12.485	6.920	0.976	1.040	0.077	0.138	0.006	0.006
C.V%		3.49	4.91	1.84	1.88	1.10	1.13	1.04	1.57	1.48	2.76

***, ** significant at 0.05 and 0.01 levels of probability and NS not significant**
N = Normal S = Saline soil

The analysis of variance for combining ability given in Tables 3 and 4 revealed highly significant differences among the CMS and tester lines for (GCA) for all agronomic and yield and its components under both normal and saline soil conditions. Highly significant mean squares of lines x testers (SCA) for all characters except panicle length indicated that they interacted and produced markedly different combining ability effects, and this might be due to the wide genetic diversity of CMS lines and testers (restorer lines). The estimate of variance due to GCA was higher than that due to SCA for all agronomic and yield studied characters under both normal and saline conditions suggesting greater importance of additive variance which is in agreement with the results of El-Mowafi (1994), and Soltan (2007) under both normal and saline condition, El-Mowafi *et al*. (2005); Abd El-hadi and El-Mowafi (2005); Alam *et al*. (2007); El-Diasty *et al*. (2008); Nassar (2013) and El-Mowafi (2015) under normal conditions.

GCA effects:

Significant differences of GCA effects were observed among the CMS lines for studied character (Tables 5 and 6). The CMS lines Pusa 6A was the best combiner for days to heading, plant height, spikelets panicle^{-1}, filled grains panicle^{-1}, and grain yield (t/fed.). IR69625A was the best combiner for days to heading, tillers plant^{-1}, panicles plant^{-1}, spikelets fertility%, 1000-grain weight and grain yield (ton/fed.); IR58025A was the best combiner for plant height and panicles plant^{-1}. Pusa 3A was best combiner for panicles plant^{-1} and good combiners for spikelets panicle^{-1} and filled grains panicle^{-1}. IR70368A was the best combiner for tillers plant^{-1}, panicle length, panicles plant^{-1}, spikelet fertility % and 1000-grain weight under both normal and saline soil conditions which is in agreement with the results of Tiwari *et al*. (2011); Podmavathi *et al*. (2012) and Veeresha *et al*. (2015).

Table 5. Estimation of GCA effects of female (CMS) lines for agronomic characters under normal and saline soil conditions.

CMS (Female lines)	Days to heading (day)		Plant height (cm)		Tillers plant^{-1}		Spikelets panicle^{-1}		Panicle length (cm)	
	N	S	N	S	N	S	N	S	N	S
1 Pusa 3A	1.476**	-0.103^{NS}	-0.206^{NS}	0.659*	-2.46**	-2.769**	16.286**	14.919**	-0.688**	-0.663**
2 Pusa 6A	-3.095**	-1.769**	-1.492**	-0.865**	-0.068^{NS}	0.321**	23.162**	21.138**	-0.654**	0.418**
3 IR58025 A	-0.238^{NS}	0.611**	-1.7789**	-1.246**	-0.739**	-0.850**	1.709^{NS}	5.757**	0.532**	-1.106**
4 IR69625 A	-0.762**	-1.103**	2.937**	0.183^{NS}	1.551**	1.745**	-20.28**	-13.576**	-0.365**	0.961**
5 IR70368 A	1.476**	0.468*	0.889**	1.468^{NS}	1.669**	1.441**	-12.248**	-11.709**	0.391**	1.242**
6 IR68902 A	1.143**	1.897**	-0.349^{NS}	-0.198^{NS}	0.051^{NS}	0.112^{NS}	-8.629	-16.529**	0.784**	-0.853**
L.S.D. 0.05	0.375	0.351	0.544	0.606	0.323	0.325	2.069	1.292	0.008	0.194
L.S.D. 0.01	0.501	0.469	0.727	0.811	0.432	0.435	2.769	1.728	0.011	0.258

***, ** significant at 0.05 and 0.01 levels of probability and NS not significant**
N = Normal S = Saline soil

Table 6. Estimation of GCA effects for female lines (CMS) lines for yield and yield component characters under normal and saline soils.

CMS (Female lines)	Panicles plant^{-1}		Filled grains panicles^{-1}		Spikelets fertility %		1000-grain weight (g)		Grain yield (ton/fed)	
	N	S	N	S	N	S	N	S	N	S
1 Pusa 3A	-2.589**	-2.179**	7.114**	14.037**	-3.266**	1.062**	-0.150*	-1.563**	-0.394**	-0.244**
2 Pusa 6A	-0.056^{NS}	0.273^{NS}	19.252**	14.199**	-0.728**	-1.000**	0.379**	-0.472**	0.154**	0.115**
3 IR58025 A	-0.652**	-0.560**	0.371^{NS}	-0.572^{NS}	-0.537*	-2.629**	-0.765**	-0.459**	0.028^{NS}	0.046**
4 IR69625 A	1.663**	1.306**	-13.15**	-6.844**	2.358**	2.062**	0.827**	1.708**	0.239**	0.238**
5 IR70368 A	1.734**	1.135**	-8.863**	-4.489**	0.887**	2.548**	1.280**	1.576**	0.125**	0.012^{NS}
6 IR68902 A	-0.099^{NS}	0.025^{NS}	-4.715**	-16.331**	1.287**	-2.043**	-1.571**	-0.789**	-0.152**	-0.167**
L.S.D. 0.05	0.330	0351	1.558	1.160	0.436	0.449	0.122	0.164	0.034	0.034
L.S.D. 0.01	0.442	0.469	2.085	1.552	0.584	0.603	0.165	0.219	0.045	0.045

***, ** significant at 0.05 and 0.01 levels of probability and NS not significant**
N = Normal S = Saline soil

Among the testers or restorer lines (Tables 7 and 8), PR1 was good combiner for spikelets panicle^{-1}, panicle length, and filled grains panicle^{-1}; PR2 was good combiner for spikelets panicle^{-1}, panicle length and filled grains panicle^{-1}. However, PR3 was the best combiner for spikelets panicle^{-1}, panicle length, filled grains panicle^{-1}, spikelets fertility, 1000-grain weight and grain yield (ton/fed.). Giza 178R was the best restorer for tillers plant^{-1}, panicles plant^{-1}, spikelets fertility, grain yield (ton/fed) under both normal and saline soil conditions and filled grains panicle^{-1} under saline soil conditions. GZ5121R was good combiner for tillers plant^{-1}, panicles plant^{-1}, spikelets fertility % under both normal and saline soil conditions and good combiner for grain yield under saline conditions. GZ6296R was the best combiner for days to heading and plant height under both normal and saline soil conditions and good combiner for grain yield under saline soil condition which is in agreement with the results of Mishra *et al*. (1990); El-Mowafi, (1994); El-Mowafi and Abou Shousha (2003); Soltan (2007) and Hasan *et al*. (2013).

Table 7. Estimation of GCA effects of male parents (restorer) or tester line for agronomic characters under normal and saline soil conditions.

Male lines (Tester)	Days to heading (day)		Plant height (cm)		Tillers plant^{-1}		Spikelets panicle^{-1}		Panicle length (cm)	
	N	S	N	S	N	S	N	S	N	S
1 PR1	0.048^{NS}	1.579**	5.754**	4.786**	-1.382**	-0.879**	19.656**	12.133**	1.113**	1.201**
2 PR2	-0.230^{NS}	0.191^{NS}	5.643**	6.564**	-1.510**	-1.507**	10.656**	5.578**	1.021**	1.589**
3 PR3	0.325^{NS}	-0.087^{NS}	3.310**	8.064**	-0.704**	-0.352*	23.0112**	13.967**	1.776**	1.889**
4 Giza 178	1.881**	1.357**	0.198^{NS}	2.286**	1.596**	2.048**	-3.488**	7.150**	-1.244**	-0.099^{NS}
5 Giza 182	-0.564**	-0.365^{NS}	-3.302**	-6.659**	-0.348*	-1.185**	-17.399**	-21.844**	-0.729**	-1.799**
6 GZ5121R	4.325**	3.524**	-4.191**	-0.391^{NS}	0.829**	1.959**	-32.610**	-16.683**	-1.369**	-1.705**
7 GZ6296R	-5.786**	-6.198**	-7.413**	-14.659**	1.518**	-0.085^{NS}	0.1341^{NS}	-0.300^{NS}	-0.567**	-1.077**
L.S.D. 0.05	0.405	0.379	0.588	0.654	0.348	0.351	2.234	1.396	0.137	0.209
L.S.D. 0.01	0.542	0.507	0.587	0.876	0.466	0.469	3.305	1.868	0.182	0.279

***, ** significant at 0.05 and 0.01 levels of probability and NS not significant**
N = Normal S = Saline soil

Table 8. Estimation of GCA effects of male parents (restorer) or tester lines for yield and yield component characters under normal and saline soils.

Male lines (Tester)	Panicles/plant		Filled grains panicles^{-1}		Spikelets fertility %		1000-grain weight (g)		Grain yield (ton/fed)	
	N	S	N	S	N	S	N	S	N	S
1 PR1	-1.183**	-0.828**	17.160**	8.746**	-0.233^{NS}	-0.346^{NS}	0.288**	0.465**	-0.001^{NS}	-0.046*
2 PR2	-1.494**	-1.256**	9.849**	3.909**	0.0341^{NS}	-0.129^{NS}	0.194**	-0.054^{NS}	0.069**	-0.106**
3 PR3	-0.750**	0.122^{NS}	22.571**	12.729**	0.779**	0.954**	0.908**	1.125**	0.221**	0.072**
4 Giza 178	1.656**	2.156**	0.877^{NS}	8.756**	1.768**	1.637**	-1.186**	-0.428**	0.146**	0.129**
5 Giza 182	-0.344*	-1.678**	-16.45**	-25.149**	-0.277^{NS}	-4.674**	-0.094^{NS}	-1.345**	-0.297**	-0.274**
6 GZ5121R	0.917**	2.328**	-27.123**	-7.713**	1.118**	3.126**	-0.465**	0.076^{NS}	-0.129**	0.125**
7 GZ6296R	1.200**	-0.844**	-6.879**	-1.278*	-3.188**	-0.568*	0.353**	0.162^{NS}	-0.008^{NS}	0.099**
L.S.D. 0.05	0.356	0.379	1.683	1.253	0.471	0.486	0.132	0.177	0.037	0.037
L.S.D. 0.01	0.477	0.507	2.252	1.676	0.639	0.649	0.177	0.237	0.049	0.049

***, ** significant at 0.05 and 0.01 levels of probability and NS not significant**
N = Normal S = Saline soil

Specific combining ability (SCA) effects:

Estimates of SCA effects for the 42 hybrid rice combinations for ten agronomic and yield and its components under both normal and saline soil conditions are shown in Tables 9 and 10.

The data of the SCA given in Tables 9 and 10 revealed that it would be useful in the hybrid rice program to develop good combinations in rice hybrids for days to heading, eight different rice hybrids should negatively under both normal and saline soil conditions. The hybrids Pusa 3A/GZ62696R; Pusa 6A/PR1 and IR58025A/PR3 were best hybrid rice combinations for earliness under both normal and saline soil conditions. In case of plant height, significant negative SCA effects was recorded for nine and seven hybrid rice combinations under both normal and saline soil conditions, respectively.

Table 9. Estimates of SCA effects for hybrid rice combinations of agronomic characters under both normal and saline conditions

Hybrid combinations	Days to heading (days)		Plant height (cm)		Tillers plant^{-1}		Spikelets panicle^{-1}		Panicle length (cm)	
	N	S	N	S	N	S	N	S	N	S
1 Pusa 3A x PR1	-0.476^{NS}	0.325^{NS}	-2.183**	-0.548^{NS}	1.425**	1.641**	-0.219^{NS}	-4.652**	-0.117^{NS}	0.6183**
2 x PR2	-0.865^{NS}	-0.283^{NS}	-0.071^{NS}	-1.659*	2.852**	0.769^{NS}	-5.780*	-5.230**	-0.354*	0.729**
3 x PR3	1.246*	0.992*	-0.405^{NS}	-2.159**	0.747^{NS}	0.980*	10.564**	1.881^{NS}	-0.147^{NS}	0.229^{NS}
4 x Giza 178	0.357^{NS}	0.881^{NS}	2.373**	1.952*	-2.139**	-2.020**	1.464^{NS}	-0.436^{NS}	0.239^{NS}	-0.482^{NS}
5 x Giza 182	1.802**	0.603^{NS}	2.206**	3.230**	-0.709^{NS}	-0.953*	-4.291^{NS}	10.725**	0.358*	0.185^{NS}
6 x GZ5121R	0.246^{NS}	1.714**	-0.571^{NS}	-1.048^{NS}	-1.753**	-0.864*	-1.380^{NS}	2.031^{NS}	0.364*	-0.909**
7 x GZ6296R	-2.310**	-4.230**	-1.349^{NS}	0.230^{NS}	-0.442^{NS}	0.447^{NS}	-0.358^{NS}	-4.319*	-0.338*	-0.371^{NS}
8 Pusa 6A x PR1	-2.905**	-1.675**	-0.897^{NS}	-4.357**	1.496**	1.484**	-0.295^{NS}	-0.905^{NS}	0.058^{NS}	0.537*
9 x PR2	-1.627**	1.048*	-1.786*	0.865^{NS}	-1.543**	-0.52^{NS}	-1.056^{NS}	2.351^{NS}	0.106^{NS}	0.348^{NS}
10 x PR3	-1.183*	1.992**	0.214^{NS}	1.365^{NS}	-0.882^{NS}	-0.843^{NS}	-0.612^{NS}	4.629**	-0.263^{NS}	0.415^{NS}
11 x Giza 178	1.262*	-0.786^{NS}	0.658^{NS}	1.476^{NS}	0.518^{NS}	1.256**	23.421**	8.712**	0.147^{NS}	0.237^{NS}
12 x Giza 182	-0.960^{NS}	-1.730**	2.492**	0.421^{NS}	0.463^{NS}	-0.210^{NS}	36.499**	23.573**	0.590**	0.171^{NS}
13 x GZ5121R	2.817**	0.714^{NS}	-1.286^{NS}	-1.190^{NS}	-0.115^{NS}	-1.255**	-33.489**	-19.188**	-0.204^{NS}	-1.090**
14 x GZ6296R	2.595**	0.437^{NS}	0.603^{NS}	1.421^{NS}	0.063^{NS}	0.089^{NS}	-24.467**	-19.171**	0.336*	-0.618*
15 IR58025A x PR1	1.238*	3.944**	0.722^{NS}	1.357^{NS}	-0.866^{NS}	-0.578^{NS}	1.324^{NS}	-1.524^{NS}	0.516**	0.161^{NS}
16 x PR2	-0.484^{NS}	0.333^{NS}	-1.66*	-0.421^{NS}	-1.371**	0.317^{NS}	-5.437^{NS}	-6.535**	0.608**	0.339^{NS}
17 x PR3	-2.039**	-1.056*	0.500^{NS}	1.079^{NS}	-1.077*	-0.872*	5.474*	0.676^{NS}	-0.458**	0.206^{NS}
18 x Giza 178	1.738**	0.167^{NS}	0.944^{NS}	-0.810^{NS}	0.623^{NS}	-1.006*	-6.959*	-4.107*	-0.148^{NS}	-0.339^{NS}
19 x Giza 182	0.183^{NS}	-2.111**	0.111^{NS}	-1.198^{NS}	0.001^{NS}	-0.606^{NS}	-9.115**	1.121^{NS}	-1.862**	0.294^{NS}
20 x GZ5121R	-0.706^{NS}	-2.00**	-1.667*	0.190^{NS}	2.023**	2.650**	0.829^{NS}	4.226*	0.001^{NS}	-0.500^{NS}
21 x GZ6296R	0.071^{NS}	0.722^{NS}	-0.444^{NS}	-0.198^{NS}	0.667^{NS}	0.094^{NS}	13.885**	6.143**	1.342**	-0.161^{NS}
22 IR69625A x PR1	-0.571^{NS}	-1.341**	2.008**	3.928**	-0.423^{NS}	-1.306**	-0.419^{NS}	1.943^{NS}	-0.057^{NS}	-0.161^{NS}
23 x PR2	-0.294^{NS}	-1.952**	0.786^{NS}	1.151^{NS}	1.605**	0.045^{NS}	5.553*	-0.202^{NS}	0.716**	-0.739**
24 x PR3	-0.183^{NS}	-0.675^{NS}	-1.214^{NS}	0.317^{NS}	1.933**	0.965*	-8.136**	-4.424*	0.196^{NS}	-0.894**
25 x Giza 178	-1.071^{NS}	-0.119^{NS}	-1.769*	0.095^{NS}	-0.867*	0.933*	-0.669^{NS}	-0.274^{NS}	0.136^{NS}	0.561*
26 x Giza 182	0.706^{NS}	0.937*	1.730*	-2.627**	-0.723^{NS}	0.599^{NS}	-8.758**	-12.113**	0.492**	0.361^{NS}
27 x GZ5121R	-0.183^{NS}	0.048^{NS}	0.952^{NS}	-0.238^{NS}	-0.001^{NS}	-0.279^{NS}	12.953**	2.393^{NS}	-0.239^{NS}	-0.239^{NS}
28 x GZ6296R	1.595**	3.103**	-2.492**	-2.627**	-1.523**	-0.867*	-0.525^{NS}	12.676**	0.189^{NS}	1.633*
29 IR70368A x PR1	0.524^{NS}	-0.579^{NS}	-1.278^{NS}	-1.024^{NS}	0.458^{NS}	1.232**	-2.9857^{NS}	2.976^{NS}	-0.277^{NS}	0.439^{NS}
30 x PR2	1.135*	0.476^{NS}	0.833^{NS}	-0.468^{NS}	0.186^{NS}	0.759^{NS}	-6.3468*	0.232^{NS}	-0.095^{NS}	-0.853**
31 x PR3	1.246*	-0.913^{NS}	0.167^{NS}	-0.635^{NS}	1.380**	1.204**	-3.3357^{NS}	-4.624**	0.426*	-1.142**
32 x Giza 178	0.024^{NS}	-0.357^{NS}	-1.722*	-1.190^{NS}	0.580^{NS}	-0.796^{NS}	-6.5357*	0.159^{NS}	0.009^{NS}	-0.509^{NS}
33 x Giza 182	-0.532^{NS}	1.698**	-3.889**	-2.913**	-0.542^{NS}	-0.363^{NS}	-8.6246**	-11.079**	0.365*	0.347^{NS}
34 x GZ5121R	-0.421^{NS}	-0.190^{NS}	2.667**	3.143**	-1.287**	-1.240**	21.3865**	1.193^{NS}	-0.095^{NS}	-0.486^{NS}
35 x GZ6296R	-1.976**	-0.135^{NS}	3.222**	3.087**	-0.775^{NS}	-0.796^{NS}	6.4421*	11.143**	-0.331^{NS}	1.686**
36 IR68902A x PR1	2.190**	-0.675^{NS}	1.627**	0.643^{NS}	-2.089**	-2.473**	2.5952^{NS}	2.162^{NS}	-0.123^{NS}	0.954**
37 x PR2	2.135**	0.381^{NS}	0.405^{NS}	0.532^{NS}	-1.729**	-1.279**	13.0675**	9.384**	0.455**	0.245^{NS}
38 x PR3	0.913^{NS}	-0.341^{NS}	0.738^{NS}	0.032^{NS}	-2.101**	-1.434**	-3.9548^{NS}	1.862^{NS}	0.347*	0.619*
39 x Giza 178	-2.310**	0.214^{NS}	-0.484^{NS}	-1.524^{NS}	1.266**	1.633**	-10.7214**	-4.055*	0.383*	-0.125^{NS}
40 x Giza 182	1.198**	0.603^{NS}	-2.651**	3.087**	1.510**	1.533**	-5.7103*	-12.227**	0.056^{NS}	0.075^{NS}
41 x GZ5121R	-1.754**	-0.286^{NS}	-0.095^{NS}	-0.857^{NS}	1.133*	0.988*	-0.2992^{NS}	9.345**	0.175^{NS}	-0.819**
42 x GZ6296R	0.024^{NS}	0.103^{NS}	0.460^{NS}	-1.913*	2.010**	1.033*	5.0230^{NS}	-6.471**	-0.527**	0.247^{NS}
LSD 0.05	0.991	0.928	1.440	1.603	0.853	0.859	5.473	3.418	0.335	0.514
LSD 0.01	1.327	1.241	1.927	2.145	1.142	1.150	7.323	4.572	0.445	0.684

***, ** significant at 0.05 and 0.01 levels of probability and NS not significant**
N = Normal S = Saline soil

Table 10. Estimates of SCA effects for hybrid rice combinations of yield and yield components characters under both normal and saline conditions

	Hybrid combinations	Panicles/plant		Filled grains/panicles		Spikelets fertility %		1000-grain weight (g)		Grain yield (ton/fed)	
		N	S	N	S	N	S	N	S	N	S
1	Pusa 3A x PR1	1.412**	1.218*	-1.308^{NS}	-4.148**	-0.2008^{NS}	-0.206^{NS}	-0.294^{NS}	0.008^{NS}	0.047^{NS}	0.055^{NS}
2	x PR2	2.889**	0.713^{NS}	-4.3302*	-3.524*	0.4659^{NS}	0.277^{NS}	-0.000^{NS}	0.003^{NS}	0.204**	-0.098^{NS}
3	x PR3	0.379^{NS}	-0.198^{NS}	7.5809**	7.429**	-0.412^{NS}	2.594**	-0.337*	-0.029^{NS}	0.375**	-0.052^{NS}
4	x Giza 178	-2.560**	-1.565**	-3.7913^{NS}	0.619^{NS}	-2.267**	0.377^{NS}	-0.247^{NS}	-0.529*	-0.150**	-0.083^{NS}
5	x Giza 182	-0.594^{NS}	-0.032^{NS}	0.6421^{NS}	3.061^{NS}	1.677**	-2.145**	-0.622**	-0.136^{NS}	0.159**	0.066^{NS}
6	x GZ5121R	-1.521**	-1.071*	-3.0246^{NS}	-2.618^{NS}	-1.417*	-2.345**	0.525**	-0.217^{NS}	-0.574**	-0.016^{NS}
7	x GZ6296R	-0.005^{NS}	0.935*	4.2310*	-0.819^{NS}	2.155**	1.449*	0.974**	0.900**	-0.062^{NS}	0.126**
8	Pusa 6A x PR1	1.279**	1.333**	-4.7794*	1.119^{NS}	-1.672**	0.756^{NS}	-0.173^{NS}	-1.614**	0.116*	0.047^{NS}
9	x PR2	-1.510**	-0.873^{NS}	-4.3683*	-1.314^{NS}	-1.306*	-1.628**	-0.186^{NS}	-1.155**	0.050^{NS}	-0.159**
10	x PR3	-0.855^{NS}	-0.584^{NS}	-0.6238^{NS}	0.733^{NS}	-0.1167^{NS}	-1.478*	-0.177^{NS}	0.613**	-0.039^{NS}	0.126**
11	x Giza 178	0.439^{NS}	0.849^{NS}	29.1039**	5.983**	0.7278^{NS}	-0.661^{NS}	0.374*	0.449*	-0.117*	0.056^{NS}
12	x Giza 182	0.473^{NS}	-0.451^{NS}	27.1706**	18.285**	-2.0944**	0.650^{NS}	0.495**	0.186^{NS}	-0.002^{NS}	0.008^{NS}
13	x GZ5121R	-0.188^{NS}	-0.689^{NS}	-28.263**	-10.188**	0.8444^{NS}	2.383**	0.083^{NS}	1.185**	0.012^{NS}	-0.024^{NS}
14	x GZ6296R	0.362^{NS}	0.416^{NS}	-18.241**	-14.619**	1.6167**	-0.022^{NS}	-0.415**	0.335^{NS}	-0.019^{NS}	-0.052^{NS}
15	IR58025A x PR1	-1.126*	-1.001*	0.9683^{NS}	-6.558**	-0.1627^{NS}	-2.516**	0.078^{NS}	1.034**	0.109*	0.009^{NS}
16	x PR2	-1.482**	1.094*	-0.8206^{NS}	-6.672**	1.737**	-0.933^{NS}	0.005^{NS}	0.476*	-0.011^{NS}	0.101*
17	x PR3	-1.126*	-0.117^{NS}	3.2905^{NS}	-3.172*	-0.7405^{NS}	-1.683**	0.041^{NS}	0.227^{NS}	-0.054^{NS}	-0.002^{NS}
18	x Giza 178	-0.568^{NS}	-0.851^{NS}	-12.282**	-0.271^{NS}	-2.863**	1.501*	0.205^{NS}	0.107^{NS}	-0.238**	-0.076^{NS}
19	x Giza 182	-0.032^{NS}	-0.650^{NS}	-5.4151*	0.417^{NS}	1.0818^{NS}	-0.555^{NS}	0.143^{NS}	-0.733**	-0.163**	-0.047^{NS}
20	x GZ5121R	2.174**	2.177**	5.7516**	10.208**	2.4206**	3.445**	-0.333*	-0.841**	0.287**	-0.022^{NS}
21	x GZ6296R	1.024*	-0.65^{NS}	8.5071**	6.049**	-1.474*	0.739^{NS}	-0.140^{NS}	-0.270^{NS}	0.069^{NS}	0.037^{NS}
22	IR69625A x PR1	-0.574^{NS}	-0.034^{NS}	1.4302^{NS}	5.503**	0.5754^{NS}	1.994**	0.369*	0.456*	-0.092*	0.091*
23	x PR2	1.571**	-0.439^{NS}	2.9079^{NS}	1.647^{NS}	-1.0579^{NS}	0.910^{NS}	0.189^{NS}	0.315^{NS}	-0.052^{NS}	0.174**
24	x PR3	1.893**	1.416**	-7.6143**	-2.827^{NS}	-0.2357^{NS}	0.360^{NS}	0.103^{NS}	-0.114^{NS}	-0.061^{NS}	0.023^{NS}
25	x Giza 178	-0.979*	0.549^{NS}	1.4135^{NS}	-2.129^{NS}	1.3087*	-0.923^{NS}	-0.650**	-0.588**	0.384**	-0.017^{NS}
26	x Giza 182	-0.813^{NS}	-0.151^{NS}	-8.787**	-8.262**	-0.3135^{NS}	0.455^{NS}	0.328*	0.320^{NS}	0.053^{NS}	-0.228**
27	x GZ5121R	-0.007^{NS}	-0.256^{NS}	9.6468**	-0.450^{NS}	-0.7413^{NS}	-0.945^{NS}	-0.278^{NS}	-0.429^{NS}	0.009^{NS}	0.046^{NS}
28	x GZ6296R	-1.090*	-1.084*	1.0024^{NS}	6.518*	0.4643^{NS}	-1.851**	-0.062^{NS}	0.039^{NS}	-0.242**	-0.088^{NS}
29	IR70368A x PR1	0.721^{NS}	1.171**	-0.6651^{NS}	5.649**	0.7802^{NS}	1.575*	0.533**	-0.072^{NS}	-0.002^{NS}	-0.079^{NS}
30	x PR2	0.199^{NS}	0.465^{NS}	-6.1873**	2.242^{NS}	-0.1865^{NS}	1.025^{NS}	0.413*	0.020^{NS}	-0.048^{NS}	-0.006^{NS}
31	x PR3	1.621**	0.787^{NS}	-1.2429^{NS}	-2.261^{NS}	0.6690^{NS}	0.708^{NS}	-0.037^{NS}	-0.342^{NS}	-0.167**	-0.017^{NS}
32	x Giza 178	0.849^{NS}	-0.546^{NS}	-1.1151^{NS}	-1.000^{NS}	2.6135**	-0.542^{NS}	-0.227^{NS}	-0.162^{NS}	0.085^{NS}	0.179**
33	x Giza 182	-0.651^{NS}	0.087^{NS}	-6.8151**	-7.446**	0.4913^{NS}	0.636^{NS}	-0.158^{NS}	0.482*	-0.033^{NS}	0.011^{NS}
34	x GZ5121R	-1.712**	-1.052*	14.5849**	-1.991^{NS}	-2.3032**	-1.264*	-0.145^{NS}	0.353^{NS}	0.100*	0.006^{NS}
35	x GZ6296R	-1.028*	-0.913^{NS}	1.4405^{NS}	4.807**	-2.0643**	-2.137**	-0.379*	-0.279^{NS}	0.065^{NS}	-0.092^{NS}
36	IR68902A x PR1	-1.712**	-2.687**	4.3539*	-1.566^{NS}	0.6802^{NS}	-1.602**	-0.513**	0.187^{NS}	-0.178**	-0.121**
37	x PR2	-1.667**	-0.959*	12.798**	7.621**	0.3468^{NS}	0.348^{NS}	-0.422*	0.339^{NS}	-0.144**	-0.011^{NS}
38	x PR3	-1.912**	-1.303**	-1.3905^{NS}	0.097^{NS}	0.8357^{NS}	-0.502^{NS}	0.407*	-0.356^{NS}	-0.053^{NS}	-0.079^{NS}
39	x Giza 178	1.683**	1.563**	-13.3294**	-3.202*	-1.5198*	0.248^{NS}	0.545**	0.723**	0.036^{NS}	-0.059^{NS}
40	x Giza 182	1.616**	1.197*	-6.7960**	6.054**	-0.8421^{NS}	0.959^{NS}	-0.187^{NS}	-0.119^{NS}	-0.015^{NS}	0.189**
41	x GZ5121R	1.255**	0.891^{NS}	1.30397^{NS}	5.040**	1.1968*	-1.274*	0.147^{NS}	-0.051^{NS}	0.165**	0.011^{NS}
42	x GZ6296R	0.738^{NS}	1.297**	3.0595^{NS}	-1.935^{NS}	-0.6976^{NS}	1.821**	0.022^{NS}	-0.724**	0.189**	0.070^{NS}
LSD 0.05		0.873	0.928	4.123	3.069	1.153	1.189	0.324	0.433	0.090	0.090
LSD 0.01		1.168	1.241	5.516	4.107	1.542	1.593	0.433	0.580	0.121	0.121

***, ** significant at 0.05 and 0.01 levels of probability and NS not significant**
N = Normal S = Saline soil

The hybrid rice combinations, Pusa 6A/PR1 (-4.357) and Pusa 3A/PR2 (-1.659) gave the highest and lowest SCA negative values under saline soil conditions. With respect to tillers plant^{-1} 11 and 13 hybrid rice combinations showed significant effects in the desired direction for the trait under both normal and saline soil conditions, respectively. For spikelets panicle^{-1}. Ten and ten hybrids had superior SCA effects, 13 and eight hybrids for panicle length, 11 and 10 hybrids for panicles plant^{-1}, 10 and 12 for filled grains panicle^{-1}, 8 and 8 for spikelets fertility %, ten and nine hybrids under both normal and saline soil conditions for 1000-grain weight, 10 and 7 hybrids for grain yield under normal and saline soil conditions, respectively were superior SCA effects. For grain yield (ton/fed.), the highest estimates were obtained for the hybrids, IR69625A/Giza 178R (0.384), Pusa 3A/PR3 (0.375), and IR58025A/GZ5121R (0.287) under normal soil. However, the highest estimates for yield characters under saline soil were recorded for the hybrid rice combinations, IR68902A/Giza 182R (0.189), IR70368A/Giza 178R (0.179), IR69625A/PR2 (0.174), Pusa 3A/GZ6296R (0.126) and IR58025A/PR2 (0.101) which is in agreement with the results of Mishra *et al*. (1990), El-Mowafi (1994), Soltan (2007) and Zayed *et al*. (2015) under both normal and saline conditions, Sharma, (2006); Pratap *et al*. (2013); Latha *et al*. (2013); Abdelkhalik, (2015); and El-Mowafi *et al*., (2015) under normal condition.

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تحليل القدرة على التآلف للأرز الهجين تحت ظروف الأراضى العادية والملحية

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أجريت هذه الدراسة على 42 تركيب هجينى ناتجة من التهجين بنظام تزاوج السلالة فى الكشاف (L x T) فى حقل انتاج التقاوى للأرز الهجين تحت ظروف العزل ، استخدم فيها ستة سلالات عقيمة الذكر سيتولازميا CMS من طرز مختلفة والتى تم الحصول عليها من مصادر العقم الذكرى السيتوبلازمى ذو الإجهاد البرى (WA) مع سبعة سلالات معيدة للخصوبة او كشافات وذلك بإتباع نظام الثلاث سلالات فى الأرز الهجين. تم زراعة الآباء والهجن الناتجة فى تجربة قطاعات كاملة العشوائية فى ثلاث مكررات تحت ظروف الاراضى العادية بمحطة البحوث الزراعية بسخا والأراضى الملحية بمحطة البحوث الزراعية بالسرو. وقد اختبرت هذه الهجن مع أبائها لعشرة صفات زراعية ومحصولية لقدرتها على التآلف ، وقد أتضح من جدول تحليل التباين والقدرة العامة على التآلف وجود اختلافات عالية المعنوية للتراكيب الوراثية للصفات الزراعية والمحصولية بإستثناء محصول الحبوب (طن/فدان) تحت ظروف الأراضى العادية والملحية. وخلصت الدراسة أن السلالة العقيمة الذكر سيتوبلازميا Pusa 6A (CMS) والسلالة IR69625A وكذلك السلالات الأبوية المعيدة للخصوبة الملقحة PR3 وجيزة 178 هما الأفضل فى القدرة العامة على التآلف لمعظم الصفات المدروسة تحت ظروف الدراسة ، كما أظهرت الدراسة أنه من بين 42 تركيب وراثى أرز هجين التى تم تقييمها أعطت خمسة هجن مبشرة متوسط أداء جيد وقدرة خاصة على الإئتلاف متفوقة على الصنف التجارى المقارن جيزة 178 وهجين مصرى 1 للمحصول تحت ظروف الأراضى الملحية وهذه الهجن هى:

IR68902A x Giza 182R; IR70368A x Giza 178R; IR69625A x PR2; Pusa 3A x GZ6296R; IR58025A x PR2.