J.Agric.Chem.and Biotechn., Mansoura Univ.Vol. 9 (1): 43- 50, 2018

Superiority for Agronomic and Yield Traits in Hybrid Rice Under Normal and Saline Conditions

El-Mowafi, H. F.[1]; A. H. Abd El-Hadi[2] and S. A. I. Soltan[3]
[1]Rice Res. Dept., Hybrid Rice Component, Field Crops Res. Inst., ARC, Egypt
[2]Genetics Dept., Fac. of Agriculture, Mansoura University
[3]Field Crops Res. Inst., ARC, Egypt.

ABSTRACT

Forty two rice hybrids were produced using six CMS lines and seven restorers following line x tester mating design. This study aimed to find out to the best hybrid combinations in respect of their superiority over the best inbred check variety, for agronomic and yield traits under normal and saline soil conditions.Hybrids with a yield advantage over the highest yielding check variety or over the hybrid check variety were considered as promising. Among 42 hybrid rice combinations evaluated ten under normal soil conditions and eight under saline soil conditions were most promising with mean performance of grain yield ranging from 5.60 ton/fed. for 58025A/GZ5121R to 6.18 ton/fed. for IR69625A/Giza 178R (EHR1) under normal soil condition. Mean performance of grain yield of best promising hybrids under saline condition ranging from 3.22 ton/fed. for IR69625A/PR1 to 3.34 ton/fed. for IR69625A/GZ5121R. The yield advantage over best local check variety was ranged from 1.10 ton/fed. to 1.68 ton/fed. under normal soil condition and ranged from 0.28 ton/fed. to 0.40 ton/fed. under saline soil conditions. Standard heterosis (SH%) or superiority % estimates ranged from 24.44 to 37.33% under normal soil condition and ranged from 9.52 to 13.60% under saline condition for above mentioned hybrids. The hybrid rice combination IR69625A/GZ5121R recorded the highest yield over the best hybrid check variety EHR1 under saline soil conditions.

INTRODUCTION

Exploitation of heterosis has played a significant role in increasing productivity and production of several crops over the world.

Availability of suitable pollination control systems and the extent of outcrossing between female and male parents, existence of exploitable level of heterosis and feasibility of hybrid seed production on large scale are the key factors determining the success of commercial exploitation of heterosis in any crop (El-Mowafi *et al*., 2005).

Among the many genetic approaches being explored to break the yield barrier in rice, hybrid rice technology appears to be the most feasible and readily adoptable one. China has successfully demonstrated usefulness of hybrid rice to meet increased demands of rice (Ilyas Ahmed *et al*., 2001).

Hybrid rice technology is one of innovative break through that can further increase rice production leading to food security and reduction of poverty in Egypt. Hybrid rice varieties can out yield conventional cultivars by at least 20-25% under the same input levels. Hence, this technology can be used to break the current yield plateau in rice (El-Mowafi *et al.*, 2005).

It was indicated that ST screening in the field under salt stress combined with selections of yield and its related traits in normal irrigated condition for introgression line populations with an elite restorer background will efficiently improve the ST of restorer lines, stronger heterosis as compared with the hybrids derived from Minghui86 and the two corresponding sterile lines (Zhanglu *et al*., 2012).

The hybrid H-639 showed desirable and superiority for number of panicles per hill, days to heading and 1000-grain weight. Hybrids H-631, H-637, H-661, H-640, and H-653 were observed to be the best hybrids over the standard check BRRI dhan28 due to desirable and significant superiority values for yield and most of their yield component traits (Biswash and Haque, 2015 and El-Mowafi *et al*., 2015).

The aim of the present study is to estimate superiority or standard heterosis (economic heterosis) for some agronomic and yield traits in F_1 hybrids developing using male sterility-fertility restoration system using cytoplasmic male sterile lines (CMS) and Egyptian restorer lines and both normal and saline soil conditions.

MATERIALS AND METHODS

The present investigation was conducted during the years 2011 and 2012 at Sakha and El-Sirw Farm Stations under both normal and saline soil conditions, respectively. The experimental material consisted of 13 parental lines (six cytoplasmic male sterile lines "CMS" and seven restorer "R" lines) and their 42 F_1 hybrid rice combinations (Table 1). The resulting 42 F_1 hybrid combinations along with 13 parents were grown in complete randomized block design in three replications under both normal and saline soil conditions during summer season of 2012 (Table 2).

Thirty day old seedlings with single plant hill^{-1} were transplanted in 14 rows in 5 m row length with inter and intra row spacing of 20 and 20 cm, respectively. All the recommended agronomic and plant protection practices were uniformly followed throughout the crop grow period for raising ideal crop stand. In each entry, ten plants were selected randomly from each replication and biometrical observations were recorded on agronomic traits, days to heading (day), plant height (cm), tillers plant^{-1}, spikelets panicle^{-1}, panicle length (cm), yield and its components, panicles plant^{-1}, filled grains panicle^{-1}, spikelets fertility (%), and 1000-grain weight. Ten guarded rows (10 m^2) were harvested from each entry in each replication to determine grain yield (ton/fed.).

Estimation of superiority or standard heterosis effects (over the best inbred check variety, Giza 178 and hybrid check Egyptian hybrid 1 "EHR1" were calculated for the studied traits.

Table 1. Cytoplasmic male sterile and restorer lines used in this study.

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 HRB program	Egypt
2. PR2	New restorer line developed by HRB program	Egypt
3. PR3	New restorer line developed by HRB program	Egypt
4. Giza 178R	Restorer and tolerance to salinity	Egypt
5. Giza 182	Restorer of Indica type	Egypt
6. Gz5121R	Restorer and tolerance 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.**

The superiority or standard heterosis was determined as the increase of the F_1 hybrid mean over its check inbred or hybrid variety, as follows

$$\text{Superiority or standard heterosis (SH\%)} = \frac{\bar{F}_1 - \overline{check\ variety}}{\overline{check\ variety}} x100$$

Appropriate L.S.D. values were calculated to test the significance of the heterosis effects for check variety according to the following formula, suggested by Wyanne *et al*. (1970).

$$\text{LSD for check variety} = t_{0.05,0.01}\sqrt{\frac{2MSe}{r}}$$

RESULTS AND DISCUSSION

Estimates of superiority or standard heterosis effects for agronomic traits

The standard heterosis (superiority) is especially important because the hybrid to be released is expected to outperform the existing superior local variety or hybrid check (El-Mowafi *et al*., 2005). The data for superiority (standard heterosis in 42 hybrid rice combinations under both normal and saline soil conditions for agronomic traits are presented in Tables (3 and 4).

Days to heading

The hybrids Pusa 3A/GZ6296R; Pusa 6A/Giza 182R; Pusa 6A/GZ6296R; IR58025A/GZ6296R; IR69625A/Gz6296R; IR70368A/ Gz6296R and IR68902A/Gz6296R were the earliest flower with significant negative superiority over check inbred and hybrid variety, Giza 178 and EHR1, respectively under both normal and saline soil conditions. These findings indicated that heterosis effects can be used to get earliness in rice hybrids (El-Mowafi, 2001; El-Mowafi *et al*., 2005; El-Mowafi *et al*., 2015 and Abd El-Hadi *et al*., 2016).

Plant height

Data in Table 3 reveals most of hybrid rice combinations to exhibit undesirable positive and highly significant superiority (heterotic) over Giza 178 variety check values towards tallness, except one hybrid under normal soil condition and 10 under saline soil condition with highly significant negative estimates over check inbred and hybrid variety, respectively. Estimates of heterosis under both conditions showed that 13 crosses were highly significant negative estimates over EHR1 for the same trait. The hybrid rice combinations IR58025A/GZ6296R and IR68902A/GZ6296R showed significant and highly significant negative superiority (heterotic) effects relating inbred check Giza 178 and the hybrid check EHR1 under both normal and saline soil conditions.

Tillers plant^{-1}

Data revealed that superiority (standard heterosis) was positive and significant in four hybrids under normal soil condition and six hybrid rice combinations under saline soil condition over best inbred check variety Giza 178R for tillers plant^{-1}. However, superiority (standard heterosis over the hybrid variety EHR1) was significant and positive in four hybrids only under normal soil condition. The highest heterotic effects over inbred check variety Giza 178R were Pusa 6A/Giza 182R (10.941%), IR58025A/Giza 178R (6.791%), IR58025A/GZ5121R (4.151%), and IR70368A/Giza178R (2.264%) under normal soil condition. While, the hybrid rice combinations IR69625A x Giza 178R (9.763%), Pusa 6A/Giza 178R (4.691%), IR58025A/GZ5121R (5.941%), IR68902A/ Giza 178R (5.472%) and IR68902A/GZ5121R (2.141%) gave the highest heterotic effects values over the best check variety Giza 178 under saline conditions (Soltan, 2007; Vennila *et al*., 2011; Reddy *et al*., 2012 and Pratap *et al*., 2013;).

Table 3. Estimates of heterosis for days to heading, plant height (cm) and tillers plant^{-1} under both normal and saline soil conditions (Sakha and El-Sirw).

	Hybrid combinations	Days to heading				Plant height (cm)				Tiller plant^{-1}			
		SH over Giza 178		SH over EHR1		SH over Giza 178		SH over EHR1		SH over Giza 178		SH over EHR1	
		N	S	N	S	N	S	N	S	N	S	N	S
1	Pusa 3A x PR1	-0.333^{NS}	1.912**	0.997^{NS}	-1.287^{NS}	10.431**	7.013**	1.863^{NS}	2.346*	-21.512**	-20.981**	-18.432**	-29.841**
2	x PR2	-0.993^{NS}	0.002^{NS}	0.329^{NS}	-0.319^{NS}	12.961**	7.722**	3.699**	3.020**	-16.602**	-27.821**	-13.332**	-37.126**
3	x PR3	1.641**	0.971^{NS}	2.990**	0.648^{NS}	9.692**	8.771**	1.183^{NS}	4.027**	-21.512**	-21.572**	-18.431**	-30.360**
4	x Giza 178	2.301**	2.261**	3.659**	1.936**	9.391**	7.012**	0.904^{NS}	2.346*	-23.401**	-24.302**	-20.392**	-32.793**
5	x Giza 182	0.000^{NS}	0.321^{NS}	2.661**	0.000^{NS}	5.661**	-1.051^{NS}	-2.540*	-5.366**	-25.661**	-34.194**	-22.751**	-41.581**
6	x Gz5121R	4.591**	5.181**	5.980**	4.839**	2.021^{NS}	1.051^{NS}	-5.890**	-3.352**	-24.913**	-19.473**	-21.961**	-28.500**
7	x Gz6296R	-7.871**	-10.041**	-6.648**	-10.326**	-2.022^{NS}	-12.632**	-9.620**	-16.440**	-17.363**	-22.803**	-14.122**	-31.461**
8	Pusa 6A x PR1	-7.211**	-1.300^{NS}	-6.309**	-1.616*	10.401**	7.021**	1.835^{NS}	-3.020**	-27.816**	-7.615**	-8.632**	-17.981**
9	x PR2	-6.231**	-0.333^{NS}	-4.984**	-0.648^{NS}	9.393**	8.771**	0.904^{NS}	4.027**	-5.192**	-19.612**	-21.181**	-28.620**
10	x PR3	-5.241**	0.321^{NS}	-3.987**	0.000^{NS}	9.092**	10.870**	0.624^{NS}	5.696**	-8.091**	-15.821**	-15.292**	-25.261**
11	x Giza 178	-1.311^{NS}	-0.971^{NS}	0.00^{NS}	-1.287^{NS}	6.360**	4.911**	-1.863^{NS}	0.332^{NS}	-4.531**	4.691**	-0.782^{NS}	-7.041**
12	x Giza 182	-5.901**	-3.561**	-4.655**	-3.871**	4.650**	-5.621**	-3.475**	-9.735**	10.941**	-16.741**	-7.451**	-26.070**
13	x Gz5121R	2.633**	2.580**	3.987**	2.255**	0.000^{NS}	-0.705^{NS}	-7.760**	-5.034**	-9.812**	-7.162**	-6.272**	-17.571**
14	x Gz6296R	-7.541**	-7.131**	-6.309**	-7.423**	-1.411^{NS}	-12.992**	-9.065**	-16.782**	-6.422**	-10.353**	-2.742**	-20.402**
15	IR58025A x PR1	-0.333^{NS}	6.151**	0.987^{NS}	5.807**	11.721**	7.012**	3.047**	2.346*	-12.082**	-22.342**	-20.391**	-31.052**
16	x PR2	-2.292**	1.291^{NS}	-0.997^{NS}	0.968^{NS}	10.711**	7.012**	2.115*	2.346*	-26.042**	-21.121**	-23.142**	-29.961**
17	x PR3	-3.281**	-0.333^{NS}	-1.993**	-0.648^{NS}	9.091**	10.170**	0.624^{NS}	5.366**	-21.881**	-21.301**	-18.822**	-30.121**
18	x Giza 178	1.971**	2.261**	3.319**	1.936**	6.361**	10.171**	-1.891^{NS}	-2.346*	6.791**	-10.942**	-3.143**	-20.931**
19	x Giza 182	-1.971**	-1.620*	-0.668^{NS}	-1.936**	2.021^{NS}	-7.731**	-5.897**	-11.750**	-16.221**	-23.852**	-12.943**	-32.390**
20	x Gz5121R	1.972**	2.261**	3.319**	0.319^{NS}	-0.711^{NS}	0.351^{NS}	-8.411**	-4.027**	4.151**	5.941**	-0.392^{NS}	-6.480**
21	x Gz6296R	-7.211**	-4.531**	-5.980**	-4.839**	-2.733**	-15.101**	-10.281**	-18.796**	-6.681**	-15.652**	-3.137**	-25.101**
22	IR69625A x PR1	-2.621**	0.651^{NS}	-1.326^{NS}	-0.967^{NS}	17.783**	11.222**	8.637**	6.373**	-13.211**	-13.822**	-9.803**	-23.481**
23	x PR2	-2.620**	-2.591**	-1.326^{NS}	-2.903**	16.472**	10.173**	7.426**	5.090**	-6.042**	-10.941**	-2.351**	-20.930**
24	x PR3	-1.973**	-1.622*	-0.660^{NS}	-1.936**	12.121**	10.873**	3.419**	6.041**	-1.892**	-1.051^{NS}	1.960**	-12.150**
25	x Giza 178	-1.313^{NS}	0.32^{N2S}	0.000^{NS}	0.000^{NS}	8.382**	4.561**	0.000^{NS}	0.000^{NS}	-4.152**	9.763**	0.000^{NS}	0.000^{NS}
26	x Giza 182	-1.972**	-0.333^{NS}	-0.667^{NS}	-0.653^{NS}	8.382**	-7.731**	0.000^{NS}	-11.751**	-10.561**	-6.522**	-7.062**	-14.831**
27	x Gz5121R	1.971**	2.581**	3.319**	2.255**	6.671**	1.402^{NS}	-1.612^{NS}	-3.021**	-3.391**	3.832**	0.392^{NS}	-5.401**
28	x Gz6296R	-6.231**	-3.881**	-4.983**	-4.190**	0.000^{NS}	-16.152**	-7.761**	-19.800**	-6.411**	-8.212**	-2.750**	-16.311**
29	IR70368A x PR1	0.662^{NS}	1.611*	1.993**	1.287^{NS}	12.420**	7.373**	3.699**	2.688*	-9.433**	-3.652**	-5.881**	-12.211**
30	x PR2	0.981^{NS}	1.291^{NS}	2.322**	0.968^{NS}	14.441**	9.821**	5.561**	5.034**	-10.943**	-8.661**	-7.451**	-16.781**
31	x PR3	1.641**	-0.330^{NS}	2.990**	-0.648^{NS}	11.411**	11.221**	2.795**	6.373**	-3.392**	-1.371*	0.392^{NS}	-10.137**
32	x Giza 178	1.971**	1.611*	3.319**	1.287^{NS}	6.362**	4.560**	-1.891^{NS}	0.000^{NS}	2.264**	0.464^{NS}	6.275**	-8.475**
33	x Giza 182	-0.981^{NS}	1.940**	0.329^{NS}	1.616*	0.611^{NS}	-6.670**	-7.202**	-10.740**	-9.431**	-12.311**	-5.881**	-20.111**
34	x Gz5121R	3.943**	3.881**	5.312**	3.550**	6.361**	6.322**	-1.891^{NS}	1.681^{NS}	-7.551**	-1.961**	-3.921**	-10.680**
35	x Gz6296R	-7.542**	-5.511**	-6.309**	-5.810**	3.642**	-8.782**	-4.407**	-12.760**	-3.021**	-9.263**	0.784^{NS}	-17.321**
36	IR68902A x PR1	1.971**	2.911**	3.319**	2.584**	13.742**	7.373**	4.911**	2.688*	-25.282**	-26.582**	-22.350**	-33.112**
37	x PR2	1.642**	2.581**	2.990**	2.260**	12.733**	9.120**	3.978**	4.354**	-24.152**	-23.994**	-21.176**	-30.701**
38	x PR3	0.983^{NS}	1.611*	2.322**	1.287^{NS}	10.711**	10.171**	2.115*	5.306**	-22.642**	-19.432**	-19.608**	-26.591**
39	x Giza 178	-0.655^{NS}	3.550**	0.668^{NS}	3.223**	6.361**	2.451*	-1.891^{NS}	-2.013^{NS}	-1.132^{NS}	5.472**	2.745**	-3.905**
40	x Giza 182	-1.974**	2.262**	-0.668^{NS}	1.936**	0.611^{NS}	-2.111^{NS}	-2.202*	-6.373**	-7.551**	-9.711**	-3.922**	-17.740**
41	x Gz5121R	2.303**	5.181**	3.658**	4.616**	2.321*	0.351^{NS}	-5.618**	-4.027**	-4.531**	2.141**	-0.784^{NS}	-6.938**
42	x Gz6296R	-5.902**	-3.881**	-4.655**	-4.140**	-2.401*	-15.791**	-8.134**	-19.46**	1.132^{NS}	-6.982**	5.098**	-15.247**
LSD 0.05		1.391	1.301	1.39	1.301	2.030	2.241	2.032	2.241	1.194	1.203	1.194	1.203
LSD 0.01		1.501	1.730	1.50	1.732	2.601	2.982	2.601	2.982	1.589	1.600	1.589	1.600

***, ** significant at 0.05 and 0.01 levels, respectively**
N = Normal soil, S = Saline soil

Spikelets panicle^{-1}

Data in Table 4 indicated that the estimates of superiority (standard heterosis) over the best check variety Giza 178 were positive significant and highly significant in 41 hybrids under normal soil condition and 39 hybrids under saline soil condition.

The highest estimates of superiority (SH%) over inbred check variety Giza 178 were recorded for the hybrids Pusa 3A/PR3 (65.093%); Pusa 6A/PR3 (62.512%); Pusa 6A/Giza 178R (61.022%); Pusa 6A/PR1 (60.692%) and Pusa 6A/Giza 182 (60.522%) under normal soil condition and the hybrids Pusa 6A/PR3 (52.395%); Pusa 6A/Giza 178 (50.569%); Pusa 6A/PR1 (47.472%); Pusa 3A/PR3 (46.401%) and Pusa 6A/PR2 (45.264%) under saline soil condition. On the basis of superiority over hybrid check EHR1; 28 hybrids under normal soil condition and 18 hybrids under saline soil condition had positive significant and highly significant estimates. The highest estimates were observed for the hybrids Pusa 3A/PR3 (37.222%); Pusa 6A/PR3 (35.071%); Pusa 6A/Giza 178R (33.832%); Pusa 6A/PR1 (33.572%) and Pusa 6A/Giza 182R (33.432%) under normal soil condition and the hybrids Pusa 6A/PR3 (25.95%); Pusa 6A/Giza 178 (24.090%); Pusa 6A/PR1 (21.538%); Pusa 3A/PR3 (20.656%) and Pusa 6A/PR2 (19.719%) under saline soil condition (Adedze *et al*., 2012; Patil *et al*., 2012 and Abdelkhalik, 2015).

Table 4. Estimates of heterosis for spikelets per panicle and panicle length (cm) under both normal and saline soil conditions (Sakha and El-Sirw)

Hybrid combinations	Spikelets/panicle				Panicle length (cm)			
	SH over Giza 178		SH over EHR1		SH over Giza 178		SH over EHR1	
	N	S	N	S	N	S	N	S
1 Pusa 3A x PR1	56.601**	40.803**	30.161**	16.042**	11.021**	19.905**	6.920**	-0.276^{NS}
2 x PR2	47.792**	36.033**	22.851**	12.111**	9.692**	22.275**	5.649**	1.695**
3 x PR3	65.093**	46.401**	37.222**	20.656**	13.563**	21.327**	9.374**	0.907*
4 x Giza 178	43.641**	40.288**	19.393**	15.617**	2.951**	8.531**	-0.863**	-9.736**
5 x Giza 182	31.782**	28.361**	9.533*	5.788*	5.491**	3.602**	1.591**	-13.835**
6 x Gz5121R	24.373**	26.000**	3.373^{NS}	3.842^{NS}	2.950**	-1.090**	-0.866**	-17.738**
7 x Gz6296R	44.731**	32.709**	20.292**	9.372**	3.353**	4.408**	-0.474**	-13.165**
8 Pusa 6A x PR1	60.692**	47.472**	33.573**	21.538**	11.872**	24.645**	7.744**	3.666**
9 x PR2	54.793**	45.264**	28.662**	19.719**	11.711**	25.592**	7.583**	4.454**
10 x PR3	62.512**	52.395**	35.071**	25.595**	12.842**	27.346**	8.672**	5.912**
11 x Giza 178	61.022**	50.569**	33.832**	24.090**	2.701**	17.062**	-1.092**	-2.641**
12 x Giza 182	60.522**	41.117**	33.422**	16.301**	6.583**	8.673**	2.641**	-9.618**
13 x Gz5121R	9.162*	15.967**	-9.273*	-4.427^{NS}	0.811**	3.175**	-2.921**	-14.190**
14 x Gz6296R	34.343**	26.936**	11.661**	4.614^{NS}	3.511**	8.389**	-0.311^{NS}	-9.854**
15 IR58025A x PR1	48.753**	36.769**	23.630**	12.718**	18.492**	15.639**	14.111**	-3.823**
16 x PR2	39.220**	29.030**	15.722**	6.339*	18.491**	18.341**	14.111**	-1.577**
17 x PR3	53.241**	39.465**	27.373**	14.939**	17.241**	19.099**	12.912**	-0.946*
18 x Giza 178	29.771**	31.706**	7.871*	8.545**	6.290**	7.109**	2.372**	-10.918**
19 x Giza 182	20.091**	15.806**	-0.193^{NS}	-4.559^{NS}	1.451**	2.038**	-2.293**	-15.136**
20 x Gz5121R	16.920**	21.338**	-2.822^{NS}	0.000^{NS}	6.422**	-1.279**	2.492**	-17.895**
21 x Gz6296R	44.521**	33.579**	20.131**	10.088**	15.063**	3.318**	10.811**	-14.072**
22 IR69625A x PR1	34.441**	26.154**	11.742**	3.969^{NS}	12.562**	21.185**	8.392**	0.788*
23 x PR2	32.586**	20.334**	10.200*	-0.827^{NS}	9.533**	22.275**	5.483**	1.695**
24 x PR3	31.784**	23.124**	9.534*	1.472^{NS}	16.272**	25.261**	11.980**	4.178**
25 x Giza 178	20.313**	21.338**	0.000^{NS}	0.00^{NS}	3.841**	20.237**	0.000^{NS}	0.000^{NS}
26 x Giza 182	7.052^{NS}	-5.973*	-11.02**2	-22.50**8	7.350**	9.336**	3.383**	-9.066**
27 x Gz5121R	10.970**	7.177**	-7.766*	-11.670**	1.825**	18.626**	-1.943**	-1.340**
28 x Gz6296R	22.586**	25.017**	1.889^{NS}	3.032^{NS}	6.783**	15.972**	2.842**	-3.548**
29 IR70368A x PR1	37.734**	28.094**	14.479**	5.568*	14.741**	21.943**	10.491**	1.419**
30 x PR2	30.259**	21.873**	8.267*	0.441^{NS}	15.143**	22.417**	10.892**	1.813**
31 x PR3	39.524**	24.234**	15.967**	2.387^{NS}	20.272**	26.872**	15.822**	5.518**
32 x Giza 178	21.621**	22.876**	1.087^{NS}	1.268^{NS}	6.383**	21.469**	2.451**	1.025**
33 x Giza 182	11.977**	-4.033^{NS}	-6.929^{NS}	-20.90**9	9.891**	9.479**	5.833**	-8.948**
34 x Gz5121R	20.898**	7.625**	0.486^{NS}	-11.301**	5.452**	20.237**	1.563**	0.000^{NS}
35 x Gz6296R	31.627**	25.237**	9.404*	3.214^{NS}	7.752**	19.763**	3.771**	-0.394^{NS}
36 IR68902A x PR1	43.279**	24.328**	19.088**	2.464^{NS}	16.961**	17.393**	12.642**	-2.365**
37 x PR2	44.141**	24.769**	19.805**	2.828^{NS}	18.892**	20.853**	14.501**	0.512^{NS}
38 x PR3	41.332**	25.351**	17.469**	3.308^{NS}	21.522**	20.379**	17.032**	0.118^{NS}
39 x Giza 178	21.278**	16.836**	0.802^{NS}	-3.710^{NS}	6.382**	9.336**	2.451**	-9.066**
40 x Giza 182	15.913**	-8.027**	-3.657^{NS}	-24.201**	10.211**	2.227**	6.142**	-14.978**
41 x Gz5121R	10.006**	9.853**	-8.567*	-9.465**	8.112**	-1.564**	4.122**	-18.132**
42 x Gz6296R	32.954**	10.234**	10.506**	-9.151**	8.521**	4.123**	4.511**	-13.402**
LSD 0.05	7.740	4.834	7.740	4.834	0.473	0.727	0.473	0.727
LSD 0.01	10.354	6.468	10.354	6.468	0.614	0.966	0.614	0.966

***, ** significant at 0.05 and 0.01 levels, respectively**
N = Normal soil, S = Saline soil

Panicle length

As evident from Table 4 of the 42 hybrid rice combinations as many as all 42 under normal soil condition and 39 under saline soil condition showed highly significant and positive superiority (SH) over check variety Giza 178. The highest values were recorded for IR68902A/PR3 (21.522%); IR70368A/PR3 (20.272%); IR68902A/PR2 (18.892%); IR58025A/PR1 (18.492%) and IR58025A/PR2 (18.492%) under normal condition and the hybrids; Pusa 6A/PR3 (27.346%); IR70368A/PR3 (26.872%); Pusa 6A/PR2 (25.592%); IR69625A/PR3 (25.261%) and Pusa 6A/PR1 (24.645%) under saline soil condition. The superiority (SH) over hybrid check (EHR1) for panicle length was significant and highly significant in 33 combinations under normal soil condition and 12 combinations under saline soil condition. The highest heterotic effects over hybrid check were IR68902A/PR3 (17.032%); IR70368A/PR3 (15.822%); IR68902A/PR2 (14.501%); IR58025A/PR1 and IR58025A/PR2 (14.111%) under normal soil condition. On the other hand, the highest heterotic effects over hybrid rice check EHR1 for panicle length under saline soil condition were Pusa 6A/PR3 (5.912%); IR70368A/PR3 (5.518%); Pusa 6A/PR2 (4.451%) and IR69625A/PR3 (4.178%) (El-Mowafi, 2001; Soltan, 2007; Adedze *et al.*, 2012; Zayed *et al.*, 2012 and Zhanglu *et al.*, 2012).

Estimates of superiority heterosis for yield and its components

Panicles plant^{-1}

As seen in Table 5 significant and highly significant negative (undesirable) estimates of superiority (SH) over check variety Giza 178 for panicles plant^{-1} is recorded in 39 hybrids under normal soil condition and 32 hybrids under saline soil condition. The superiority over check variety Giza 178 (SH) was highly significant and positive in only one hybrid combination under normal soil conditions and eight hybrids under saline soil conditions.

Table 5. Estimates of heterosis for panicles plant^{-1}, filled grains panicle^{-1} and spikelets fertility % under both normal and saline soil conditions (Sakha and El-Sirw).

Hybrid combinations	Panicles plant^{-1}				Filled grains panicles^{-1}				Spikelets fertility %			
	SH over Giza 178		SH over EHR1		SH over Giza 178		SH over EHR1		SH over Giza 178		SH over EHR1	
	N	S	N	S	N	S	N	S	N	S	N	S
1 Pusa 3A x PR1	-21.440**	-21.293**	-19.111**	-28.022**	59.651**	43.431**	17.737**	12.822**	1.922**	1.160^{NS}	-9.564**	-3.455**
2 x PR2	-16.861**	-26.201**	-14.392**	-32.512**	52.302**	39.784**	12.321**	9.953**	3.031**	2.452**	-8.580**	-2.222*
3 x PR3	-23.811**	-23.772**	-21.542**	-30.292**	69.811**	56.879**	25.235**	23.401**	2.866**	7.242**	-8.727**	2.344**
4 x Giza 178	-25.942**	-20.231**	-23.744**	-27.051**	46.313**	47.554**	7.901**	16.065**	1.851**	4.133**	-9.626**	-0.629^{NS}
5 x Giza 182	-26.063**	-16.692**	-23.865**	-36.152**	37.141**	20.363**	1.138^{NS}	-5.323*	4.092**	-6.202**	-7.638**	-10.481**
6 x Gz5121R	-24.753**	-16.692**	-22.523**	-36.151**	26.942**	30.527**	-6.381*	2.670^{NS}	2.087**	2.452**	-9.417**	-2.223*
7 x Gz6296R	-17.652**	-22.871**	-15.203**	-29.117**	46.493**	37.640**	8.038**	8.267**	1.215^{NS}	3.883**	-10.192**	-0.865^{NS}
8 Pusa 6A x PR1	-11.961**	-7.711**	-9.349**	-15.603**	65.812**	48.124**	22.283**	16.514**	3.184**	1.161^{NS}	-8.444**	-3.454**
9 x PR2	-24.201**	-18.332**	-21.952**	-28.361**	60.911**	41.841*	18.665**	11.571**	3.927**	-3.101**	-7.785**	-7.526**
10 x PR3	-18.671**	-12.843**	-16.171**	-20.293**	72.612**	51.227**	27.300**	18.954**	6.215**	-0.522^{NS}	-5.755**	-5.062**
11 x Giza 178	-4.073**	5.492**	-1.222*	-3.532**	78.320**	52.334*	31.511**	19.825**	10.731**	1.162^{NS}	-1.747*	-3.453**
12 x Giza 182	-11.841**	-21.661**	-9.233**	-28.361**	64.623**	33.665**	21.407**	5.139*	2.629**	-6.202**	-8.936**	-10.487**
13 x Gz5121R	-9.483**	-1.742*	-6.792**	-10.145**	17.633**	24.123**	-13.249**	-2.366^{NS}	7.747**	6.333**	-4.395**	1.485^{NS}
14 x Gz6296R	-6.202**	-12.682**	-3.415**	-20.145**	39.153**	25.851**	2.622^{NS}	-1.006^{NS}	3.573**	-0.133^{NS}	-8.099**	-11.693**
15 IR58025A x PR1	-23.806**	-24.464**	-21.545**	30.921**	56.483**	28.721**	15.398**	1.251^{NS}	5.189**	-5.303**	-6.665**	-9.626**
16 x PR2	-26.451**	-15.644**	-24.273**	-22.85**	50.012**	24.443**	10.628**	-2.114^{NS}	7.748**	-2.712**	-4.395**	-7.154**
17 x PR3	-22.111**	-14.792**	-19.792**	-22.083**	61.973**	35.082**	19.452**	6.255**	5.696**	-1.421^{NS}	-6.215**	-5.923**
18 x Giza 178	-5.926**	-7.923**	-3.233**	-15.792**	35.482**	34.157**	-0.089^{NS}	5.527*	4.363**	1.552^{NS}	-7.398**	-3.081**
19 x Giza 182	-16.191**	-27.101**	-13.694**	-33.332**	28.044**	5.454*	-5.573^{NS}	-17.051**	6.604**	-9.822**	-5.409**	-13.932**
20 x Gz5121R	-2.495**	8.982**	0.406^{NS}	-0.337^{NS}	28.294**	28.980**	-5.311^{NS}	1.455^{NS}	7.823**	5.812**	-2.553**	0.992^{NS}
21 x Gz6296R	-5.922**	-22.733**	-3.132**	-29.321**	44.755**	30.951**	6.748*	3.005^{NS}	0.153^{NS}	-1.421^{NS}	-11.133**	-5.923**
22 IR69625A x PR1	-12.523**	-17.012**	-9.919**	-24.106**	47.182**	33.725**	8.546**	5.187*	9.469**	6.332**	-2.867**	1.482^{NS}
23 x PR2	-5.252**	-13.891**	-2.440**	-21.261**	43.040**	26.206**	5.489^{NS}	-0.727^{NS}	7.866**	5.432**	-4.290**	0.622^{NS}
24 x PR3	-1.066^{NS}	3.169**	1.869**	-5.651**	44.604**	29.965**	6.643*	2.229^{NS}	9.705**	6.721**	-2.658**	1.853*
25 x Giza 178	-2.882**	9.350**	0.000^{NS}	0.000^{NS}	35.596**	27.131**	0.000^{NS}	0.000^{NS}	12.700**	3.622**	0.000^{NS}	-1.111^{NS}
26 x Giza 182	-10.146**	-14.580**	-7.481**	-21.882**	16.024**	-7.468**	-14.43**4	-27.21**5	8.373**	-1.031^{NS}	-3.840**	-5.552**
27 x Gz5121R	-1.974**	5.969**	0.926^{NS}	-3.091**	21.541**	14.347**	-10.365**	-10.055**	9.505**	6.331**	-2.836**	1.482^{NS}
28 x Gz6296R	-5.132**	-15.108**	-2.322**	-22.367**	29.788**	25.938**	-4.284^{NS}	-0.938^{NS}	5.861**	-0.132^{NS}	-6.069**	-4.693**
29 IR70368A x PR1	-7.106**	-4.015**	-4.344**	-12.223**	48.749**	35.886**	9.699**	6.887**	7.983**	5.431**	-4.185**	0.624^{NS}
30 x PR2	-10.383**	-10.037**	-7.724**	-17.732**	39.627**	28.747**	2.973^{NS}	1.271^{NS}	7.158**	4.262**	-4.918**	-0.494^{NS}
31 x PR3	-1.856**	-1.057^{NS}	1.057^{NS}	-9.517**	52.111**	32.489**	12.179**	4.215^{NS}	9.045**	6.331**	-3.244**	1.495^{NS}
32 x Giza 178	4.619**	2.641**	7.724**	-6.135**	36.855**	30.147**	0.928^{NS}	2.373^{NS}	12.500**	5.433**	-0.178^{NS}	0.623^{NS}
33 x Giza 182	-9.199**	-14.263**	-6.501**	-27.541**	20.475**	-4.728*	-11.15**2	-25.05**9	7.583**	-0.390^{NS}	-4.541**	-4.932**
34 x Gz5121R	-8.109**	0.898^{NS}	-5.691**	-7.729**	28.110**	15.056**	-5.521^{NS}	-9.498**	5.932**	5.432**	-6.006**	0.629^{NS}
35 x Gz6296R	-4.619**	-15.108**	-1.789**	-22.367**	33.157**	26.491**	-1.798^{NS}	-0.503^{NS}	1.144^{NS}	1.162^{NS}	-10.254**	-3.450**
36 IR68902A x PR1	-23.961**	-30.302**	-21.712**	-36.232**	55.268**	19.412**	14.507**	-6.071**	8.337**	-2.711**	-3.872**	-7.152**
37 x PR2	-24.991**	-23.402**	-22.763**	-29.952**	56.071**	23.172**	15.099**	-.3114^{NS}	8.255**	-1.421^{NS}	-3.945**	-5.923**
38 x PR3	-23.023**	-17.961**	-20.73**	-24.971**	55.026**	24.296**	14.329**	-2.230^{NS}	9.705**	-0.391^{NS}	-2.658**	-4.931**
39 x Giza 178	0.071^{NS}	7.924**	3.659**	-1.304*	31.118**	18.003**	-3.303^{NS}	-7.179**	8.101**	0.263^{NS}	-4.081**	-4.322**
40 x Giza 182	-7.501**	-14.263**	-4.761**	-21.593**	23.439**	-13.759**	-8.966**	-32.164**	6.486**	-6.462**	-5.514**	-10.732**
41 x Gz5121R	-3.948**	5.283**	-1.097^{NS}	-3.722**	21.612**	10.899**	-10.313**	-12.768**	10.531**	-0.132^{NS}	-1.925**	-4.691**
42 x Gz6296R	-4.860**	-9.297**	-2.033**	-17.051**	37.253**	10.432**	1.222^{NS}	-13.135**	3.219**	-1.422^{NS}	-8.413**	-5.921**
LSD 0.05	1.222	1.298	1.222	1.298	5.831	4.341	5.831	4.341	1.315	1.683	1.315	1.683
LSD 0.01	1.625	1.727	1.625	1.727	7.801	5.808	7.801	5.808	1.760	2.252	1.760	2.252

***, ** significant at 0.05 and 0.01 levels, respectively**
N = Normal soil, S = Saline soil

The highest value was for the hybrid IR70368A/Giza 178R 4.619% under normal soil condition and the highest values were for the hybrids IR69625A/Giza 178R (9.350%); IR58025A/GZ5121R (8.982%); IR68902A/ Giza 178 (7.924%); IR69625A/ GZ5121R (5.969%) and Pusa 6A/Giza 178R (5.492%) under saline soil condition. In addition; highly significant positive heterotic effects were computed for only three hybrid combinations namely IR70368A/Giza 178R (7.724%); IR68902A/Giza 178R (3.659%) and IR69625A/PR3 (1.869) under normal soil condition and only one hybrid namely IR58025A/PR1 (30.921%) under saline soil condition on the basis of superiority (Zayed *et al*. 2012; Abdelkhalik, 2015; El-Mowafi *et al.*, 2015 and El-Badawy, 2016).

Filled grains panicle^{-1}

Data in Table 5 revealed that all 42 hybrid combinations under normal soil condition and 38 hybrids under saline soil condition showed significant and positive SH values over the check variety Giza 178. The range of superiority for filled grains panicle^{-1} was 16.024 to 78.320% under normal soil condition for the hybrids IR69625A/Giza 182R and Pusa 6A/Giza 178R, respectively. While, the range of standard heterosis over Giza 178 check variety under saline soil condition was 5.545 to 56.879% for the hybrids IR58025A/Giza 182R and Pusa 3A/PR3, respectively.

Data indicated that 21 and 14 hybrids under both normal and saline soil conditions, respectively showed significant and positive SH values or superiority over hybrid check variety.

Among hybrids, the estimates of heterosis ranged from 6.643 to 31.511% under normal soil condition for the hybrids IR69625A/PR3 and Pusa 6A/Giza 178R, respectively. On the other hand, the superiority over hybrid check variety EHR1 under saline soil condition ranged from 5.187 to 23.401% for the hybrids IR69625A/PR1 and Pusa 3A/PR3, respectively (El-Mowafi *et al*., 2015; Veeresha *et al*., 2015 and Abd El-Hadi *et al*., 2016).

Spikelets fertility%

As revealed in this study highly significant positive standard heterosis or superiority over check variety Giza 178 was observed for spikelet fertility% in 39 and 17 hybrids under both normal and saline soil conditions, respectively. However, significant and highly significant positive estimates were observed for spikelet fertility % over hybrid check variety EHR1 in only two namely Pusa 3A x PR3 with a value of 2.344% under saline soil condition and IR69625A/PR3 with a value of 1.851%.

The superiority over inbred check variety Giza 178 was highly significant positive in 39 and 17 hybrids under both normal and saline soil conditions, respectively. However, the superiority was ranged from 1.851% for Pusa 3A/Giza 178R to 12.700% for IR69625A/Giza 178R under normal soil condition and ranged from 2.452% for Pusa 3A/PR2 and Pusa 3A/Gz5121R to 6.721 for the hybrid IR69625A/PR3 under saline soil condition. The remaining hybrid showed negatively significant or insignificant superiority over check's inbred and hybrid varieties. Similar results were obtained by El-Mowafi (1994), Abd El-Hadi and El-Mowafi (2005), El-Mowafi *et al.* (2005), and El-Mowafi *et al.* (2015).

1000-grain weight

Data in Table 6 revealed significant positive superiority (SH) for 1000-grain weight measured as deviation from the inbred check variety Giza 178 and hybrid check variety EHR1 under both normal and saline conditions. Moreover, significant positive heterotic effects were found as deviation from check variety Giza 178 for all 42 hybrids and 41 hybrids under both normal and saline conditions, respectively. These estimates ranged from 12.175% for the hybrid IR70368A/PR3 to 31.884% for IR70368A/PR1 under normal condition and ranged from 8.954% for IR68902A/Giza 182R to 33.38% for IR69625A/PR1 under saline soil condition. On the other side, significant positive values of superiority over hybrid check variety EHR1 were estimated in 32 and 16 hybrid rice combinations under both normal and saline soil condition, respectively. These estimates ranged from 0.544% for Pusa 3A/Giza 182R to 32.113% for IR70368A/PR3 under normal soil conditions and ranged from 0.811% for IR58025A/PR3 to 8.205% for IR69625A/PR3 under saline soil condition. Significant superiority under both normal and saline soil conditions was also detected by El-Mowafi (1994), Abd El-Hadi and El-Mowafi (2005), El-Mowafi *et al.* (2005), El-Mowafi *et al.* (2015) and Abd El-Hadi *et al.* (2016).

Table 6. Estimates of heterosis for 1000-grain weight (g) and grain yield (ton/fed.) traits under both normal and saline soil conditions (Sakha – El-Sirw).

Hybrid combinations	1000-grain weight (g)				Grain yield (ton/fed)			
	SH over Giza 178		SH over EHR1		SH over Giza 178		SH over EHR1	
	N	S	N	S	N	S	N	S
1 Pusa 3A x PR1	21.636**	14.793**	3.272**	-7.194**	12.527**	-8.044**	-18.015**	-17.762**
2 x PR2	22.545**	12.142**	4.044**	-9.333**	17.543**	-15.332**	-14.353**	-24.281**
3 x PR3	24.264**	17.891**	5.512**	-4.692**	24.740**	-7.693**	-9.112**	-17.455**
4 x Giza 178	15.193**	7.652**	-2.193**	-12.971**	11.415**	-6.812**	-18.823**	-16.663**
5 x Giza 182	18.412**	4.991**	0.544*	-15.111**	8.443**	-15.435**	-20.991**	-24.371**
6 x Gz5121R	21.955**	11.695**	3.544**	-9.692**	-4.132**	-4.634**	-30.151**	-14.710**
7 x Gz6296R	27.712**	17.741**	8.433**	-4.843**	9.934**	-0.683**	-19.902**	-11.185**
8 Pusa 6A x PR1	24.584**	12.140**	5.784**	-9.334**	26.142**	3.882**	-8.092**	-7.102**
9 x PR2	24.135**	11.843**	5.392**	-9.581**	26.141**	-5.211**	-8.095**	-15.233**
10 x PR3	27.393**	26.544**	8.161**	2.302**	27.693**	10.562**	-6.961**	-1.134**
11 x Giza 178	20.414**	17.991**	2.233**	-4.615**	24.142**	10.122**	-9.553**	-1.522**
12 x Giza 182	25.892**	12.093**	6.892**	-9.371**	17.033**	-5.211**	-14.722**	-15.235**
13 x Gz5121R	22.313**	24.191**	3.852**	0.401^{NS}	21.034**	7.293**	-11.811**	-4.055**
14 x Gz6296R	23.811**	20.345**	5.123**	-2.710**	23.033**	5.451**	-10.363**	-5.691**
15 IR58025A x PR1	20.542**	25.394**	2.351**	1.372**	23.250**	0.240**	-10.192**	-10.362**
16 x PR2	19.778**	20.043**	1.695**	-2.951**	22.142**	1.332**	-11.001**	-9.383**
17 x PR3	23.177**	24.692**	4.583**	0.811*	24.583**	3.883**	-9.222**	-7.091**
18 x Giza 178	14.421**	16.291**	-2.854**	-5.972**	18.811**	3.300**	-13.435**	-7.612**
19 x Giza 182	19.096**	-13.081**	1.122**	7.553**	10.595**	-9.401**	-19.421**	-18.981**
20 x Gz5121R	13.745**	14.093**	-3.433**	-7.764**	24.363**	4.904**	-9.392**	-6.183**
21 x Gz6296R	19.864**	17.390**	1.774**	-5.092**	22.142**	6.132**	-11.003**	-5.092**
22 IR69625A x PR1	29.072**	33.385**	9.591**	7.841**	23.475**	9.543**	-10.031**	-2.044**
23 x PR2	27.853**	30.082**	8.553**	5.174**	25.925**	10.352**	-8.252**	-1.311**
24 x PR3	30.708**	33.833**	10.972**	8.205**	29.032**	11.241**	-5.599**	-0.522**
25 x Giza 178	17.783**	23.692**	0.000^{NS}	0.000^{NS}	37.244**	11.822**	0.000^{NS}	0.000^{NS}
26 x Giza 182	27.165**	23.641**	7.972**	-0.043^{NS}	20.141**	-9.063**	-12.461**	-18.671**
27 x Gz5121R	22.727**	26.993**	4.205**	2.672**	22.812**	13.865**	-10.522**	1.833**
28 x Gz6296R	27.440**	29.791**	8.208**	4.933**	19.923**	8.411**	-12.621**	-3.052**
29 IR70368A x PR1	31.884**	30.082**	11.981**	5.173**	23.033**	-3.950**	-10.362**	-14.105**
30 x PR2	30.936**	27.941**	11.172**	3.434**	24.474**	-3.513**	-10.033**	-13.714**
31 x PR3	12.175**	32.035**	32.113**	6.752**	24.145**	2.182**	-9.551**	-8.622**
32 x Giza 178	21.772**	25.143**	3.394**	1.175**	28.142**	10.791**	-6.632**	-0.911**
33 x Giza 182	27.037**	23.796**	7.863**	0.083^{NS}	15.704**	-8.623**	-15.691**	-18.280**
34 x Gz5121R	25.393**	30.231**	6.477**	5.292**	22.364**	4.772**	-10.844**	-6.314**
35 x Gz6296R	28.036**	27.544**	8.701**	3.114**	24.145**	0.581**	-9.553**	-10.057**
36 IR68902A x PR1	14.201**	19.540**	-3.042**	-3.351**	12.812**	-11.444**	-17.791**	-20.805**
37 x PR2	14.204**	17.692**	-3.045**	-4.852**	15.263**	-9.745**	-16.022**	-19.280**
38 x PR3	21.185**	20.141**	2.891**	-2.873**	20.594**	-5.992**	-12.143**	-15.931**
39 x Giza 178	12.340**	17.743**	-4.621**	-4.817**	20.813**	-3.411**	-11.972**	-13.624**
40 x Giza 182	13.973**	8.954**	-3.233**	-11.923**	9.931**	-8.623**	-19.905**	-18.281**
41 x Gz5121R	13.795**	16.391**	-3.394**	-5.892**	17.691**	-1.122**	-14.241**	-11.571**
42 x Gz6296R	16.921**	13.492**	-0.731**	-8.245**	20.812**	0.000^{NS}	-11.971**	-10.575**
LSD 0.05	0.458	0.613	0.458	0.613	0.128	0.128	0.128	0.128
LSD 0.01	0.614	0.920	0.614	0.820	0.171	0.171	0.171	0.172

***, ** significant at 0.05 and 0.01 levels, respectively**
N = Normal soil, S = Saline soil

Grain yield (ton/fed.)

Data in Table 6 emphasized on estimates of superiority over check variety Giza 178 revealed significant and positive estimates for 41 and 21 hybrids under both normal and saline soil conditions, respectively. The highest estimate of 37.244% was obtained for IR69625A/Giza 178R (EHR1), followed by IR69625A/PR3 (29.032%), IR70368A/Giza 178R (28.142%) then Pusa 6A/PR3 (27.693%) under normal soil condition. On the other hand, the highest estimate of 13.865% was obtained for the hybrid IR69625A/GZ5121R followed by IR69625A/Giza 178R, IR69625A/PR3, IR70368A/Giza 178R and Pusa 6A/PR3 with a values of 11.822%, 11.241%, 10.791% and 10.562%, respectively under saline soil condition. Only the hybrid rice combination IR69625A/GZ5121R gave a significantly positive superiority over the best hybrid check variety EHR1 with a value of 1.83% under saline soil condition. (El-Mowafi, 1994; Abd El-Hadi and El-Mowafi, 2005; Soltan, 2007; Vanisree *et al*., 2011; Zayed *et al*., 2015 and Abd El-Hadi *et al*., 2016).

Best hybrid combinations

Evaluation of hybrid combinations for heterosis breeding based on mean performance and standard heterosis under both normal and saline soil conditions (Tables 7 and 8) would be meaningful from this point of view. Out of 42 hybrid combinations, ten under normal soil condition and eight under saline recorded significant superiority over check variety Giza 178.

Table 7. Best hybrid rice combinations for grain yield along with their yield advantage (ton/fed.) and standard heterosis % under normal soil condition.

Hybrid combination	Grain yield (ton/fed.)	Yield advantage (ton/fed.)		SH%	
		Over Giza 178	Over EHR1	Over Giza 178	Over EHR1
IR69625A/Giza 178R (EHR1)	6.18	1.68	-	37.33	-
IR69625A/PR3	5.81	1.31	-	29.11	-
IR70368A x Giza 178R	5.77	1.27	-	28.22	-
Pusa 6A/PR3	5.75	1.25	-	27.77	-
Pusa 6A/PR2	5.69	1.19	-	26.44	-
Pusa 6A/PR1	5.68	1.18	-	26.22	-
IR69625A/PR2	5.67	1.17	-	26.00	-
Pusa 3A/PR3	5.62	1.12	-	24.88	-
IR58025A/PR3	5.61	1.11	-	24.66	-
IR58025A/GZ5121R	5.60	1.10	-	24.44	-
Giza 178 (Inbred CK)	4.50				
EHR1 (Hybrid CK)	6.18				

Table 8. Best hybrid rice combinations for grain yield along with their yield advantage (ton/fed.) and standard heterosis % under saline soil condition.

Hybrid combination	Grain yield (ton/fed.)	Yield advantage (ton/fed.)		SH%	
		Over Giza 178	Over EHR1	Over Giza 178	Over EHR1
IR69625A/GZ5121R	3.34	0.40	0.06	13.60	1.83
IR69625A/Giza 178R (EHR1)	3.28	0.34	-	11.56	-
IR69625A/PR3	3.27	0.33	-	11.22	-
Pusa 6A/PR3	3.25	0.31	-	10.54	-
IR70368A/Giza 178	3.25	0.31	-	10.54	-
IR69625A/PR2	3.24	0.30	-	10.20	-
Pusa 6A/Giza 178R	3.23	0.29	-	9.86	-
IR69625A/PR1	3.22	0.28	-	9.52	-
Giza 178 (Inbred CK)	2.94				
EHR1 (Hybrid CK)	3.28				

Hybrids with yield advantage of >1.0 ton/fed. under normal soil condition over the highest yielding check variety, Giza 178 were recorded as promising combinations. Among the ten best selected hybrids, mean performance for grain yield ton/fed. ranged from 5.60 ton/fed. for IR58025A/GZ5121R to 6.18 ton/fed. for IR69625A/Giza 178 R (EHR1) under normal soil condition. The yield advantage over best local check, Giza 178 ranged from 1.10 ton/fed. EHR1 to 1.68 ton/fed. with superiority (SH%) of 24.44 to 37.33%. However, the eight selected hybrids under saline soil condition, mean performance of grain yield was ranged from 3.22 ton/fed. for IR69625A/PR1 to 3.34 ton/fed. for IR69625A/GZ5121R with yield advantage of 0.28 ton/fed. to 0.40 ton/fed. and superiority of 9.52 to 13.60%.

The hybrid rice combination IR69625A/ GZ5121R recorded higher yield over the best hybrid check variety EHR1 under saline soil conditions. Which is in agreement with the results of El-Mowafi (1994), Soltan (2007) and Zayed *et al.* (2015) under both normal and saline soil conditions.

REFERENCES

Abd El-Hadi, A.H. and H.F. El-Mowafi (2005). Combining ability analysis of the maintainer and the restorer for cytoplasmic male sterile (CMS) system of hybrid rice. Egypt. J. Agric. Res., 83(5A): 183-196.

Abd El-Hadi, A.H.; H.F. El-Mowafi and O.A. Badawy (2016). Genetic behavior and cluster analysis of some floral traits affecting cross breeding in the production of hybrid rice seed. J. Agric. Chem. and Biotechn., Mansoura Univ., 7(6); 163-168.

Abdelkhalik, A.F. (2015). Heterosis and combining ability for development of new basmatic hybrid rice. J. Plant Breed. 19(7): 2165-2175, Egypt.

Adedze, Y.M.; E. Andrew; Z. Sisong; S. Demba; H. Fen; H. Wnchuang; X. Ghuosheng and J. Deming (2012). Identification of interspecific grain yield heterosis between two cultivated rice species *Oryza saiva* L. and *Oryza glaberrima* Steud, Australian J. of Crop Science, AJCS, 6(11): 1558-1564.

Biswash, R. and M. Haque (2015). Estimation of superior of exotic hybrids of rice over check varieties in Bangladesh. A.M. Euras. J. Agric. & Environ. Sci., 15(3): 659-663.

El-Badawy, D.A. (2016). Genetic and molecular studies on fertility restoration ability of hybrid rice. Ph.D. Thesis, Fac. Agric., Mansoura Univ., Egypt.

El-Mowafi, H.F. (1994). Breeding studies on salt tolerance rice. Ph.D. Thesis, Fac. Agric., Kafr El-Sheikh, Tanta Univ., Egypt.

El-Mowafi, H.F. (2001). Combining ability analysis for some cytoplasmic male sterile and restorer lines under Egyptian conditions. Egypt. J. Appl. Sci., 16(2): 25-51.

El-Mowafi, H.F.; A.M. Reda; R.M. Abdallah and E.F.A. Arafat (2015). Combining ability analysis for agronomic and yield attributing traits in hybrid rice. J. Plant Breed., 19(7): 2195-2219.

El-Mowafi, HF.; A.O. Bastawisi; M.I. Abou Youssef and F.U. Zaman (2005). Exploitation of rice heterosis under Egyptian conditions. Egyptian J. Agric. Res., 83(5A): 143-166.

Ilyas Ahmed, A.; S. Singh; B.C. Viraktamath; M.S. Ramesha and C.H.M. Vijaya Kumar (2001). Development and use of hybrid rice technology-lessons learnt from the Indian experiences. International Rice Commission Newsletter, 46: 75-83.

Patil, S.r.; R.D. Vashi; P.P. Patil and P.G. Varpe (2012). Heterosis for yield and its components in rice (*Oryza sativa,* L.). Agricultural Science Digest., 32(2): 11-117.

Pratap, N. R. Shekhar; P.K. Singh and S.K. Soni (2013). Combining ability, gene action and heterosis using CMS lines in hybrid rice (*Oryza sativa* L.). International Quarterly J. of Life Sciences, 8(4): 1521-1528.

Reddy, M.R.; C.S. Raju; D. Sravani; T.D. Reddy and G.N. Reddy (2012). Heterosis for yield and kernel size in aromatic rice (*Oryza sativa* L.). India. Annals of Biological Research, 3(6): 2662-2666.

Soltan, S.A. (2007). Genetic and biochemical studies on rice (*Oryza sativa* L.) under salinity conditions. M.Sc. Thesis, Fac. Agic., Kafrelsheikh Univ., Egypt.

Vanisree, S.; C.S. Raju; P.N. Reddy; M. Sreedhar and L. Krishna (2011). Heterosis and gene effects for grain yield and physiological traits in rice (*Oryza sativa,* L.). J. Res., ANGRAU, 39(4): 1-5.

Veeresha, B.A.; N.G. Hanamaratti and P.M. Salimath (2015). Heterosis and combining ability studies for yield and productivity traits in rice: a review. International J. of Current Agricultural Res., 4(5): 120-125.

Vennila, S.; Y. Anbuselvam and K. Palaniraja (2011). Heterosis studies for yield and its components in rice (*Oryza sativa* L.). International J. of Recent Scientific Res., 2(9): 261-262.

Wyanne, J.C.; D.A. Emery and P.W. Rice (1970). Combining ability estimates in (*Arachis hypogea* L.). II. Field performance of F_1 hybrids. Crop Sci., 10(6): 713-715.

Zayed, B.A.; R.A. El-Namaky; Y.Z. El-Refaee and S.E.M. Sedeek (2012). Comparative study on hybrid and inbred rice under drought and saline stresses. J. Plant Production, Mansoura Univ., 3(1): 91-108, Egypt.

Zayed, B.A.; T.F. Metwally; S.M. Bassiouni and E.S. Naeem (2015). Performance of some rice cultivars under saline and sodic conditions. Egypt. J. Agric. Res., 93, 2(B): 518-527.

Zhang, Lu.B.; P.X. Biao; Z. Jian; C. Kai; Z. Qiang; X.J. Long; P.X. Biao and L. Kang (2012). Performance of restorer lines with salt tolerance in whole growth period under normal irrigated condition and development of hybrid rice with salt tolerance (Chinese). China, 38(10): 1782-1790.

التفوق فى الصفات الخضرية والمحصولية للأرز الهجين تحت ظروف الأراضى العادية والملحية

حمدى فتوح الموافى[1] ، أشرف حسين عبد الهادى[2] و سعيد عبد الغنى سلطان[3]

[1]مركز البحوث والتدريب فى الأرز ، معهد بحوث المحاصيل الحقلية ، مصر

[2]قسم الوراثة ، كلية الزراعة ، جامعة المنصورة

[3]معهد بحوث المحاصيل الحقلية ، مركز البحوث الزراعية ، مصر

أجرى هذا البحث على 42 تركيب وراثى هجين تم إنتاجها بإستخدام ستة سلالات عقيمة الذكر سيتوبلازميا (CMS) IR58025A, Pusa 6A, Pusa 3A, استخدمت كأمهات IR68902A, IR70368A, IR69625A مع سبعة سلالات معيدة للخصوبة أو ملقحات PR3, PR2, PR1, Giza 178, Giza 182, GZ5121R, GZ6296R واستخدم فيها نظام التزاوج السلالة × الكشاف (L x T) وذلك باتباع نظام الثلاث سلالات فى الأرز الهجين فى حقل إنتاج التقاوى للأرز الهجين تحت ظروف العزل. وتم زراعة الآباء والهجن الناتجة فى الحقل باستخدام تصميم القطاعات الكاملة العشوائية فى ثلاث مكررات تحت ظروف الأراضى العادية بسخا (كفرالشيخ) والملحية بالسرو (دمياط) فى موسم زراعة الأرز 2012. وكان الهدف من تلك الدراسة تحديد التراكيب الوراثية المتفوقة أو المتميزة للصفات الخضرية والمحصولية مقارنة بالصنف جيزة 178 والصنف الهجينى [هجين مصر 1 (EHR1)] تحت ظروف الأراضى العادية والملحية. أظهرت النتائج تفوق وزيادة فى المحصول مقارنة بالصنف القياسى جيزة 178، ومن تقدير التفوق فى المحصول مقارنة بالاصناف القياسية اتضح أنه من بين هذه الهجن عشرة هجن أعطت قيم تراوحت من 5.60 طن/فدان إلى 6.18 طن/فدان تحت ظروف الأراضى العادية ومن هذه الهجن IR58025A x GZ5121R (5.6 طن/فدان) ، IR69625A x Giza 178R (EHR1) (6.18 طن/فدان) حيث تفوقت عن باقى الهجن والصنف جيزة 178. أوضحت النتائج أيضا تفوق فى المحصول لثمانية هجن تحت ظروف الأراضى الملحية والتى تراوحت من 3.22 طن/فدان للهجينIR69625A x PR1 إلى 3.34 طن/فدان للهجين IR69625A x GZ5121R.وكانت الزيادة أو التفوق للمحصول مقارنة بالصنف جيزة 178 قد تراوحت من 1.10 طن/فدان إلى 1.68 طن/فدان تحت ظروف الأراضى العادية ، وكانت من 0.28 طن/فدان إلى 0.40 طن/فدان تحت ظروف الأراضى الملحية. تفوقت بعض الهجن عن هجين مصرى 1 (EHR1) حيث تراوحت نسبة التفوق من 24.44 إلى 37.33% تحت ظروف الأراضى العادية و تحت ظروف الأراضى الملحية وتراوحت النسب من 9.52% إلى 13.60% وكان أفضل الهجن هو الهجين IR69625A x GZ2521R وتفوق على الهجين المصرى 1 EHR1 تحت ظروف الأراضى الملحية