STUDIES ON HETEROSIS OF SOME MAINTAINER AND RESTORER LINES FOR CYTOPLASMIC MALE STERILE SYSTEM IN HYBRID RICE.

EL-MOWAFI, H.F[1] AND A.H. ABD EL-HADI[2]

1 Rice Res. Training Center (RRTC), Field Crops Research Institute, ARC, Egypt
2 Genetics. Dept.Fac. of Agric. Mansoura Univ., Egypt.

Abstract

This investigation was carried out to evaluate the manifestation of heterosis for eleven agronomic, yield and its components and panicle traits. Five parental lines were utilized to produce 20 hybrids, three of them were maintainer of the CMS lines, i.e.IR58025B, IR69625B, IR68886B. The other two parental lines were Egyptian varieties identified as good restorers viz. Giza 178R and Giza 182R.The hybrids were obtained in a complete diallel crosses of five lines evaluated for different traits. The highest heterosis values versus better parent (B.P.)% of 88.3% was regarded for grain yield plant^{-1} followed by panicles plant^{-1} (75.66%) and tillers plant^{-1} (69.38%). The highest mid-parants (M.P.)% heterosis values were observed for the same previous traits, respectively. On the other hand, the highest standard heterosis(S.H.)% of 83.8% was observed for tillers plant^{-1}, followed by grain yield plant^{-1} (80.42%) and panicles plant^{-1} (77.83%).

Evaluation of hybrids for heterosis breeding based on six considerations, mean performance B.P., M.P. and S.H.%, SCA and GCA effects of female or male parent indicated that out of 20 hybrids studied that Giza 178R x IR68886B, Giza 182R x IR68886B, Giza 182R x Giza 178R and the reciprocal hybrids Giza 178R x Giza 182R and IR68886B x Giza 178R were the most promising ones for grain yield plant^{-1} and most of the studied traits. The combinations involving the restorer lines Giza 178R and Giza 182R and the maintainer line IR68886B were the most promising ones for commercially exploit heterosis.

INTRODUCTION

Success of heterosis breeding in several self fertilizing species prompted scientists to study the prospects of its application in rice as well. With the serious limitations of strictly self fertilizing nature of rice and the absence of a useable form of male sterility, research continued, however, with no tangible results until the Chinese scientists surprised the world by releasing the first commercial hybrids in 1976. (Dwivedi *et al.,* 1998). These hybrids were capable of out yielding the best non-hybrid varieties by 25-30% (Lin & Yuan, 1980).

The need of further studies on heterosis and combining ability for yield and other agronomic traits as one of the important objectives of research for the development of acceptable hybrids,(Yuan and Virmani,1986). Therefore, the present study was suggested to study heterosis and some other genetic parameters for some economic characteristics on a complete diallel crosses of five rice varieties under Egyptian conditions.

MATERIALS AND METHODS

The genetic materials used in this investigation were five parental lines, three of them were IRRI lines used as maintainers in the international hybrid rice program, and the other two lines were Egyptian commercial varieties identified as good restorers .The parental lines and their most important information are presented in Table (1). Complete diallel crosses were made between the parental lines to obtain 20 F1 hybrids. All parental lines and their F_1 hybrids were evaluated in a randomized complete block design with three replications, at the Rice Research and Training Center Farm, Sakha Kafr El-Sheikh, Egypt in 2002 rice season. Each replicate consisted of 130 rows, where five rows were devoted to each parent, F_1 hybrid and the standard variety. The rows were five m. long with a spacing of 20 x 20 cm. Observations were recorded on 10 random plants for all the studied traits. These traits were agronomic traits i.e. heading date, plant height and tillers plant^{-1}, yield and its component traits i.e. grain yield plant^{-1}, panicles plant^{-1}, filled grains panicle^{-1} and 1000-grain weight, and panicle traits i.e. panicle length, panicle weight, spikelets panicle^{-1} and spikelets fertility %. Analysis of combining ability were done according to Method I Model I of Griffing (1956). Heterosis effects were expressed as percentage deviation versus better (high) parent (Heterobeltiosis), mid-parents (significant heterosis), and the standard check variety Giza 178R (standard heterosis).

Table 1. Parentage, origin and salient features of the maintainer and restorer lines used for the study

No.	Designation	Parentage	Origin	Salient features
1	IR58025B	IR48483A/8*PUSA 167-120-3-2//PUSA 167-120-3-2	IRRI	Indica type, late maturing, maintainer for the CMS line IR58025A line, extra long grain, low amylose content and strong aroma
2	IR68886B	-	IRRI	Indica type, late maturing, maintainer for the CMS line IR68886A, long grain, med. amylose content and strong aroma
3	IR69625B	-	IRRI	Indica type, med. early maturing, maintainer for the CMS line IR 69625A, med. grain type and med. amylose content
4	Giza 178 R	Giza 175/Milyang 49	Egypt	Indica-Japonica type, early maturing, short statured, tolerance to salinity, short grain, good grain quality, high yielder and good restorer for cytoplasmic male sterile lines(CMS).
5	Giza 182 R	Giza 181/IR39422-163-1-2//Giza 181	Egypt	Indica type, new released variety, early maturing, semi-dwarf, long grain, resistance to blast, high yielder and good restorer for cytoplasmic male sterile lines (CMS).

RESULTS AND DISCUSSION

Analysis of variances presented in Table 2 showed significant differences among the 25 genotypes (20 F_1 hybrids and their five parents) for all the studied traits. The crosses showed significant differences for all traits. In the same time, the parents showed significant values for all the studied traits except for grain yield plant^{-1} and panicle weight. The mean squares of parents vs crosses estimates, as an indication to average heterosis overall hybrids, were found to be highly significant for most of the studied traits.

Table 2. Analysis of variance and mean squares of genotypes, crosses, parents andparents vs crosses for all studied traits.

S.V.	d.F.	Agronomic traits			Yield and its component traits				Panicle traits			
		Heading date (days)	Plant height (cm)	Tillers plant^{-1}	Grain yield plant^{-1} (g)	Panicles plant^{-1}	Filled grains panicle^{-1}	1000-grain weight (g)	Panicle length (cm)	Panicle weight (g)	Spikelets panicle^{-1}	Spikelet fertility (%)
Reps.	2	4.222*	26.59*	0.1136	55.20	7.42	174.3	1.597*	0.682	1.121*	361.0*	14.53
Genotypes	24	58.08*	77.51*	77.97*	537.2*	66.65*	1272.7*	15.22*	5.742*	0.649*	2930.4*	188.3*
Crosses (C)	19	37.89*	55.94*	30.05*	404.6*	29.51*	1063.4*	15.27*	4.197*	0.523*	2617.9*	215.2*
Parents (P)	4	90.93*	103.6*	46.96*	18.65	50.23*	1310.3*	18.53*	6.349*	0.418	4088.2*	85.58*
PxC	1	310.2**	282.8**	1112.5**	5132.2**	838.01**	5099.3**	1.100*	32.66**	3.958**	4238.3**	88.22*
Error	48	0.9629	5.77	2.99	33.50	4.128	54.7	0.209	0.499	0.125	66.10	14.18

*, **: Significant at 0.05 and 0.01 levels of probability, respectively.

The mean performances of the five parental lines and their 20 F_1 hybrids including reciprocals for all the studied agronomic, yield and its components, and panicle traits are presented in Table 3.

It could be noticed that most of the F_1 hybrids mean values of the agronomic traits i.e. heading date, plant height and tillers plant^{-1} were tended to the direction of the earlier, taller and higher tillering parents. This finding suggested that earliness, tallness and the highest tillers plant^{-1} were dominant over lateness, the shortness and lowest tillers plant^{-1}, respectively. On the other hand, heading date of four hybrids, plant height of six hybrids and tillers plant^{-1} of one reciprocal hybrid were intermediate between the two parents involved.

Table 3. Mean performances of the five parental lines and their F_1 5 x 5 diallel analysis including reciprocal hybrids.

Genotype	Agronomic traits			Yield and its component traits				Panicle traits			
	Heading date (days)	Plant height (cm)	Tillers plant^{-1}	Grain yield plant^{-1} (g)	Panicles plant^{-1}	Filled grain panicle^{-1}	1000-grain weight (g)	Panicle length cm	Panicle weight (g)	Spikelets panicle^{-1}	Spikelet fertility (%)
IR58025B	104.33	100.33	30.44	43.19	29.64	175.93	20.61	24.07	4.20	230.60	76.35
IR68886B	107.67	104.33	27.57	41.97	25.98	153.60	23.81	25.40	4.12	206.73	74.36
IR69625B	97.00	101.27	30.44	43.25	21.75	126.28	24.42	22.60	3.93	148.27	85.38
Giza 178R	96.00	92.33	22.70	44.50	21.47	139.85	20.91	21.87	3.31	172.68	81.12
Giza 182R	95.67	90.93	20.80	38.02	19.50	126.53	26.51	22.33	3.60	146.53	86.43
IR58025B x IR68886B	102.33	104.80	36.33	55.39	33.08	156.67	20.14	25.33	4.47	245.00	63.82
IR68886B x IR58025B	103.33	109.40	36.33	61.60	33.25	153.73	22.79	26.13	4.30	236.53	65.09
IR58025B x IR69625B	94.00	103.67	37.67	63.07	30.20	165.13	25.40	26.33	4.30	180.67	91.44
IR69625B x IR58025B	100.33	105.11	29.57	45.78	27.03	164.93	24.87	23.13	4.37	183.48	89.94
IR58025B x Giza 178R	97.00	104.60	35.07	65.58	32.11	165.25	20.43	24.20	3.95	215.75	76.73
Giza 178R x IR58025B	94.00	104.27	31.87	66.14	30.80	171.60	21.25	23.07	4.66	186.27	92.19
IR58025B x Giza 182R	92.67	104.47	33.00	65.95	31.53	183.40	24.17	26.47	4.71	221.30	82.88
Giza 182R x IR58025B	95.67	93.13	32.03	57.76	30.67	120.47	25.28	23.60	3.69	141.20	85.55
IR68886B x IR9625B	95.00	110.33	34.41	67.33	33.17	149.07	25.15	24.40	4.20	192.67	77.58
IR69625B x IR68886B	93.67	104.63	30.98	54.42	29.00	164.93	24.97	25.07	4.52	183.80	89.86
IR68886B x Giza 178R	96.00	107.17	41.72	78.22	37.08	178.47	20.03	25.40	4.59	221.60	80.50
Giza 178R x IR68886B	92.33	104.40	39.77	80.28	38.18	212.60	20.00	25.67	5.29	254.40	83.60
IR68886B x Giza 182R	95.00	105.43	32.54	69.29	26.24	184.70	25.62	26.40	4.59	232.80	79.30
Giza 182R x IR68886B	93.67	106.60	36.13	79.03	32.97	177.53	26.35	26.53	5.35	222.60	79.73
IR69625B x Giza 178R	92.67	106.27	32.77	76.47	30.61	166.73	24.68	23.40	4.48	178.33	93.48
Giza 178R x IR69625B	94.00	100.80	35.02	73.74	33.53	170.13	23.34	23.40	4.34	183.67	92.56
IR69625B x Giza 182R	97.00	100.28	31.00	51.76	29.87	162.50	21.52	24.00	4.12	188.40	86.34
Giza 182R x IR69625B	91.00	101.20	32.69	68.10	30.59	159.00	27.08	25.07	4.34	170.47	93.25
Giza 178R x Giza 182R	91.33	97.93	38.45	78.64	37.71	157.50	24.23	25.47	3.92	188.00	83.74
Giza 182R x Giza 178R	90.00	95.27	33.77	74.15	32.88	136.73	24.48	25.00	3.89	168.20	81.23
C.D 5%	1.61	3.94	2.84	9.51	3.33	12.15	0.750	1.16	0.579	13.35	6.18
1%	2.15	5.26	3.79	12.68	4.45	16.20	1.0002	1.55	0.773	17.80	8.25

Concerning yield and its component traits, complete to over-dominance was observed in all or most of the hybrids towards the higher grain yield plant^{-1}, higher number of panicles plant^{-1}, higher number of filled grains panicle^{-1}. However, seven hybrids out ofshowed the dominance effects towards the heavier 1000-grain weight. On the other hand, the rest of the hybrids were intermediate between the parents involved for filled grains panicle^{-1} and 1000-grain weight. However, few crosses exhibited dominance effect towards the lower parents(one reciprocal hybrid for filled grains panicle^{-1} and five for 1000-grain weight) . With respect to panicle traits i.e. panicle length, panicle weight, spikelets panicle^{-1} and spikelet fertility percentage, panicle length and panicle weight in most of the F_1 hybrid values were longer and heavier than their two corresponding parents. These findings suggested the presence of overdominance for long and heavy panicle, over the short panicle and low panicle weight. For aforenamed traits, the rest of the hybrids were intermediate between the two parents involved. For spikelets panicle^{-1} and spikelet fertility percentage, out of 20 crosses, seven and ten crosses were intermediate to their respective parents for the spikelets panicle^{-1} and for spikelet fertility%, respectively. However, the F_1 means of the eleven hybrids for spikelets panicle^{-1} and eight for spikelet fertility % tended toward the highest parents, while one hybrid only for spikelets panicle^{-1} and two for spikelet fertility% were tended toward the lowest parents.

A range of heterosis over the better parent, mid-parents and standard variety Giza 178R was observed in hybrids of maintainer and restorer lines for agronomic, yield and its components and panicle traits (Table 4).

Table 4. A range of heterosis over the better parent, mid-parents and standard variety for all the studied traits.

Trait	Better parent heterosis (heterobeltiosis)		Mid-parent heterosis		Standard heterosis	
	%	No	%	No	%	No
Agronomic traits:						
Heading date(days)	A - 5.93 to 3.43	20	A -9.33 to 0.69	20	A - 6.25 to 7.63	20
	B 3.43	1	B -	-	B 4.51 to 7.63	3
	C - 1.92 to -5.93	13	C - 2.52 to -9.33	18	C -2.08 to -6.25	11
Plant height (cm)	A 2.42 to 17.23	20	A - 2.61 to 9.78	20	A 0.87 to 19.49	20
	B 4.45 to 17.23	17	B 3.97 to 9.78	16	B 6.06 to 19.49	18
	C -	-	C -	-	C -	-
Tillers plant^{-1}	A - 2.86 to 69.38	20	A 10.42 to 76.78	20	A 30.26 to 83.79	20
	B 12.38 to 6938	16	B 10.42 to 76.78	20	B 30.26 to 83.79	20
	C -	1	C -	-	C -	-
Yield and its components:						
Grain yield plant^{-1} (g)	A 5.85 to 88.30	20	A 5.92 to 97.60	20	A 2.88 to 80.42	20
	B 25.83 to 88.30	18	B 27.38 to 97.60	19	B 22.29 to 80.42	18
	C -	-	C -	-	C -	-
Panicles plant^{-1}	A -8.84 to 75.69	20	A 5.17 to 84.18	20	A 22.22 to 77.83	20
	B 12.42 to 75.69	12	B 15.39 to 84.18	19	B 22.22 to 77.83	20
	C -	-	C -	-	C -	-
Filled grains panicle^{-1}	A -31.52 to 38.41	20	A -20.34 to 44.90	20	A -13.86 to 52.02	20
	B 12.62 to 38.41	9	B 8.68 to 44.90	14	B -9.92 to 52.02	17
	C -10.95 to -31.52	3	C - 6.69 to -20.34	2	C - 13.86	1
1000-grain weight (g)	A -16.00 to 18.82	20	A- 15.47 to 12.84	20	A - 4.36 to 29.51	20
	B 4.01 to 18.82	2	B 3.00 to 12.84	10	B 8.94 to 29.51	14
	C - 3.36 to -16.00	10	C -9.32 to -15.47	4	C -3.68 to -4.36	3
Panicle traits						
Panicle length (cm)	A -4.15 to 14.06	20	A -0.86 to 15.25	20	A 5.49 to 21.31	20
	B 9.39 to 14.06	5	B 4.46 to 15.25	15	B 5.49 to 21.31	20
	C -	-	C -	-	C -	-
Panicle weight (g)	A -12.16 to 29.95	20	A -5.38 to 42.59	20	A 11.58 to 62.12	20
	B 28.49 to 29.95	2	B 15.42 to 42.59	9	B 17.61 to 62.12	19
	C -	-	C -	-	C -	-
Spikelets panicle^{-1}	A -38.77 to 27.06	20	A -25.12 to 34.11	20	A -18.23 to 47.32	20
	B 6.24 to 27.06	9	B 6.99 to 34.11	14	B 7.86 to 47.32	12
	C -6.44 to -38.77	7	C -7.62 to-25.12	2	C - 18.23	1
Spikelet fertility %	A -16.41 to 13.65	20	A -15.30 to 17.09	20	A -21.33 to 15.24	20
	B 7.89 to 13.65	4	B 7.54 to 17.09	8	B 10.77 to 15.24	7
	C -7.75 to -16.41	5	C-13.62 to -15.30	2	C - 19.76 to -21.33	2

A= Overall range B = Positive significant range C = Negative significant range

The summarised information on the number of hybrids showing significant heterosis and range of heterosis over B.P., M.P. and S.H.% are given in the same Table. Heterosis was observed for all studied traits but the magnitude was varied, according to the kind of hybrids and traits. The highest better parent heterosis of 88.30% was observed for grain yield plant^{-1} followed by panicles plant^{-1} (75.69%), tillers plant^{-1} (69.38%), filled grains panicle^{-1} (38.41%), panicle weight (29.95%) and spikelets panicle^{-1} (27.06%). The highest mid-parents heterosis of 97.60% was observed for grain yield plant^{-1} followed by panicles plant^{-1} (84.18%), tillers plant^{-1} (76.78%), filled grains panicle^{-1} (44.90%), panicle weight (42.59%), and spikelets panicle^{-1} (34.11%). The highest standard heterosis of 83.79% was observed for tillers plant^{-1} followed by grain yield plant^{-1} (80.42%), panicles plant^{-1} (77.83%), panicle weight (62.12%), filled grains panicle^{-1} (52.02%), spikelets panicle^{-1} (47.32%) and 1000-grain weight (29.51%). These results are in agreement with many authors, among them Patel *et al.* (1994), Dwividi *et al.* (1998), Mishra and Pandey (1998), Mamta *et al.* (1999), Rajesh and Singh (2000), El-Mowafi (2001), El-Refaee (2002), El-Mowafi and Abou Shousha (2003), El-Mowafi *et al.* (2003) and Hammoud (2004). They have also reported high heterosis for most of the studied traits under this investigation.

Tables 5,6 and 7 revealed undesirable positive or highly significant heterotic values towards tallness except the reciprocal hybrid Giza 182R x IR58028B for MP heterosis which showed insignificant and negative value. Similar results were obtained by El-Mowafi (1988), and El-Refaee (2002).

The magnitude of heterosis in F_1 hybrids is related not only to the performance of parents per se but also to the genetic diversity between two parents. Positive as well as negative B.P., M.P. and S.H.% were observed for all the traits (Tables 4, 5 and 6). Thirteen of the hybrids flowered earlier than their early parents. There were also instances of the hybrids flowering later than late parents but with no significant for the hybrids except only one. Among the earlier, the hybrid Giza 182R x Giza 178R exhibited highest significant heterosis of -5.93% over the better parent, -6.08% over mid parents and -6.25% over standard variety for earliness. Four other hybrids viz. Giza 178R x Giza 182 R, Giza 182R x IR69625B, Giza 178R x IR68886B and IR580258B x Giza 182R also manifested B.P., M.P. and S.H.% for earliness. As regards of plant height, it was found that the hybrids were mostly tall in height to be classified into either medium tall or tall types. Some hybrids were medium tall types, which with high grain yield would meet the dual purposes of straw and increased production in hybrid rice culture.

Table 5. Heterobeltiosis (B.P.) of F_1 hybrids for all the studied traits.

Hybrid	Agronomic traits			Yield and its component traits				Panicle traits			
	Heading date (days)	Plant height (cm)	Tillers plant^{-1}	Grain yield plant^{-1} (g)	Panicles plant^{-1}	Filled grain panicle^{-1}	1000-grain weight (g)	Panicle length (cm)	Panicle weight (g)	Spikelets panicle^{-1}	Spikelet fertility (%)
IR58025B x IR68886B	-1.92*	4.45*	19.35**	45.83**	11.57*	-10.95**	-15.41**	-0.27	6.40	6.24*	-16.41**
IR68886B x IR58025B	0.96	9.04**	19.35**	5.85	12.14*	-12.62**	-4.28**	2.87	2.36	2.57	-14.75**
IR58025B x IR69625B	-3.09**	3.33	23.75**	28.25*	1.85	-6.14	4.01*	9.39**	2.85	-21.65**	7.10
IR69625B x IR58025B	3.43**	4.77*	-2.86	42.63**	-8.84	-6.25	1.84	-3.90	4.02	-20.43**	5.34
IR58025B x Giza 178R	1.04	13.29**	15.21**	47.38**	8.33	-6.07	-2.29	0.54	-5.97	-6.44*	-5.41
Giza 178R x IR58025B	-2.08*	12.93**	4.70	48.63**	3.88	-2.46	1.63	-4.15	10.92	-19.22**	13.65**
IR58025B x Giza 182R	-3.13**	14.89**	8.41	57.14**	6.34	4.25	-8.83**	9.97**	12.12	-4.03	-4.11
Giza 182R x IR58025B	0.00	2.42	5.22	37.62**	3.44	-31.52**	-4.64**	-1.95	-12.16	-38.77**	-1.02
IR68886B x IR9625B	-2.06*	8.95**	24.84**	55.68**	27.71**	-2.95	2.99	-3.94	2.02	-6.80*	-9.13*
IR69625B x IR68886B	-3.43**	3.32	12.38*	25.83*	11.62	7.38	2.25	-1.30	9.79	-11.09**	5.25
IR68886B x Giza 178R	0.00	16.07**	51.32**	75.77**	42.72**	16.19**	-15.87**	0.00	11.49	7.19*	0.76
Giza 178R x IR68886B	-3.82**	13.07**	44.25**	80.40**	46.96**	38.1**	-16.00**	1.06	28.49**	23.06**	3.06
IR68886B x Giza 182R	-0.70	15.95**	18.03**	65.09**	1.00	20.25**	-3.36*	3.94	11.49	12.61**	-8.25*
Giza 182R x IR68886B	-2.09*	17.23**	31.05**	88.30**	26.90**	15.58**	-0.60	4.45	29.95**	7.68*	-7.75*
IR69625B x Giza 178R	-3.47**	15.09**	41.68**	71.84**	40.72**	19.22**	1.06	3.54	13.99	3.27	9.49*
Giza 178R x IR69625B	-2.08*	9.17**	51.40**	65.71**	54.09**	21.65**	-4.42**	3.54	10.43	6.36	8.41*
IR69625B x Giza 182R	1.39	10.28**	34.02**	19.68	37.27**	28.43**	18.82**	6.19	4.83	27.06**	-0.10
Giza 182R x IR69625B	-4.88**	11.29**	41.33**	57.46**	40.58**	25.66**	2.15	10.93**	10.43	14.97**	7.89*
Giza 178R x Giza 182R	-4.54**	7.69**	69.38**	76.72**	75.69**	12.62**	-8.60**	14.06**	8.86	8.87*	-3.11
Giza 182R x Giza 178R	-5.93**	4.77*	48.81**	66.63**	53.19**	-2.23	-4.66**	11.96**	8.02	-2.59	-6.02
C.D 5%	1.61	3.94	2.84	9.51	3.33	12.15	0.750	1.16	0.570	13.35	6.18
C.D 1%	2.15	5.26	3.79	12.68	4.45	16.20	1.0002	1.55	0.773	17.80	8.25

*, **: Significant at 0.05 and 0.01 levels of probability, respectively.

Table 6. Mid-parents heterosis (M.P.%) of F_1 hybrids for all the studied traits.

Hybrid	Agronomic traits			Yield and its component traits				Panicle traits			
	Heading date (days)	Plant height (cm)	Tillers plant^{-1}	Grain yield plant^{-1} (g)	Panicles plant^{-1}	Filled grain panicle^{-1}	1000-grain weight (g)	Panicle length (cm)	Panicle weight (g)	Spikelets panicle^{-1}	Spikelet fertility (%)
IR58025B x IR68886B	-3.46**	2.41	25.27**	45.93**	18.95**	-4.91	-9.32**	2.43	7.45	12.05**	-15.30**
IR68886B x IR58025B	-2.52**	6.91**	25.27**	5.92	19.56**	-6.69*	2.61	5.66**	3.36	8.17**	-13.62**
IR58025B x IR69625B	6.62**	2.85	40.66**	30.08**	17.51**	9.28*	12.84**	12.86**	5.84	-4.62	13.08**
IR69625B x IR58025B	-0.33	4.28*	10.42*	44.67**	5.17	9.15*	10.48**	-0.86	7.63	-3.14	11.23**
IR58025B x Giza 178R	-3.15**	8.58**	31.99**	49.58**	25.66**	4.66	-1.59	5.35*	5.33	6.99*	-2.54
Giza 178R x IR58025B	-6.15**	8.24**	19.95**	50.85**	20.50**	8.68*	2.36	0.43	24.27**	-7.62*	17.09**
IR58025B x Giza 182R	-7.33**	9.24**	28.80**	62.42**	28.33**	2127**	2.59	14.09**	20.77**	17.36**	1.83
Giza 182R x IR58025B	-4.33**	-2.61	25.01**	42.25**	24.83**	-20.34**	7.30*	1.72	-5.38	-25.12**	5.11
IR68886B x IR9625B	-7.16**	7.32**	35.78**	58.01**	39.00**	6.52	4.31**	1.67	4.48	8.55*	-2.87
IR69625B x IR68886B	-8.46**	1.78	22.21**	27.72**	21.49**	17.86**	3.57*	4.46*	12.44	3.55	12.51**
IR68886B x Giza 178R	-5.72**	8.99**	66.02**	80.92**	56.32**	21.64**	-10.42**	7.49**	23.72**	16.82**	3.55
Giza 178R x IR68886B	-9.33**	6.17**	58.26**	85.68**	60.96**	44.90**	-10.55**	8.63**	42.59**	34.11**	7.54*
IR68886B x Giza 182R	-6.56**	7.99**	34.57**	73.25**	15.39**	31.98**	1.83	10.64**	18.91**	31.80**	-1.36
Giza 182R x IR68886B	-7.87**	9.19**	49.42**	97.60**	44.99**	26.86**	4.73**	11.19**	38.60**	26.03**	-0.82
IR69625B x Giza 178R	-3.97**	9.78**	43.04**	74.29**	41.69**	25.30**	8.91**	5.26*	23.76**	11.13**	12.29**
Giza 178R x IR69625B	-2.59**	4.13*	52.86**	68.07**	55.16**	27.86**	3.00*	5.26*	19.89**	14.46**	11.18**
IR69625B x Giza 182R	0.69	4.35*	41.16**	27.38**	44.79**	28.56**	-15.47**	7.43**	9.57	27.81**	0.51
Giza 182R x IR69625B	-5.53**	5.31**	48.86**	67.59**	48.28**	25.79**	6.36**	11.62**	15.42*	15.65**	8.56**
Giza 178R x Giza 182R	-4.69**	6.87**	76.78**	90.60**	84.18**	18.25**	2.19	15.25**	13.62	17.79**	-0.03
Giza 182R x Giza 178R	-6.08**	3.97*	55.31**	79.71**	60.59**	2.66	3.25*	13.12**	12.75	5.39	-3.03
C.D 5%	1.39	3.42	2.46	8.23	2.89	10.52	0.649	1.005	0.502	11.56	5.35
C.D 1%	1.86	4.56	3.28	10.98	3.85	14.03	0.866	1.34	0.669	15.42	7.14

*, **: Significant at 0.05 and 0.01 levels of probability, respectively.

Table 7. Standard heterosis (S.H.%) of F_1 hybrids for all the studied traits.

Hybrid	Agronomic traits			Yield and its component traits				Panicle traits		
	Heading date (days)	Plant height (cm)	Tillers plant^{-1}	Grain yield plant^{-1} (g)	Panicles plant^{-1}	Filled grain panicle^{-1}	1000-grain weight (g)	Panicle length (cm)	Spikelets panicle^{-1}	Spike let fertility (%)
IR58025B x IR68886B	6.59**	13.50**	60.04**	41.74**	54.07**	12.03**	-3.68*	15.82**	41.88**	-21.33**
IR68886B x IR58025B	7.63**	18.49**	60.04**	2.88	54.87**	9.92*	8.94**	19.48**	36.97*	-19.76**
IR58025B x IR69625B	-2.08*	12.28**	65.95**	24.47*	40.66**	18.07**	21.47**	20.39**	4.62	12.72**
IR69625B x IR58025B	4.51**	13.85**	30.26**	38.44**	25.89**	17.93**	18.89**	5.76*	6.25	10.87**
IR58025B x Giza 178R	1.04	13.29**	54.49**	47.39**	49.60**	18.16**	-2.29	10.65**	24.94**	-5.40
Giza 178R x IR58025B	-2.08*	12.93**	40.39**	48.63**	43.45**	22.70**	1.63	5.49*	7.86*	13.66**
IR58025B x Giza 182R	-3.47**	13.15**	45.37**	48.21**	46.85**	31.14**	15.54**	21.03**	28.16**	2.17
Giza 182R x IR58025B	-0.34	0.87	41.10**	29.80**	42.85**	-13.86**	20.90**	7.91**	-18.23**	5.46
IR68886B x IR9625B	-1.04	19.49**	51.63**	51.32**	54.54**	6.59	20.28**	11.57**	11.57**	-4.36
IR69625B x IR68886B	-2.43**	13.32**	36.47**	22.29*	35.07**	17.93**	19.37**	14.63**	6.44	10.77**
IR68886B x Giza 178R	0.00	16.07**	83.79**	75.79**	72.71**	27.61**	-4.36*	16.14**	28.33**	-0.76
Giza 178R x IR68886B	-3.82**	13.07**	75.19**	80.42**	77.83**	52.02**	-4.35*	17.37**	47.32**	3.07
IR68886B x Giza 182R	-1.04	14.19**	43.35**	55.71**	22.22**	32.07**	22.52**	20.71**	34.81**	-2.24
Giza 182R x IR68886B	-2.43**	15.45**	59.16**	77.59**	53.56**	26.94**	25.97**	21.31**	28.91**	-1.71
IR69625B x Giza 178R	-3.47**	15.09**	44.36**	71.85**	42.62**	19.22**	18.03**	6.10*	3.27	15.24**
Giza 178R x IR69625B	-2.08*	9.17**	54.27**	65.71**	56.17**	21.65**	11.62**	6.10*	6.35	14.10**
IR69625B x Giza 182R	1.04	8.61**	36.56**	16.33	39.12**	16.19**	2.92	9.74**	9.10*	6.45
Giza 182R x IR69625B	-5.21**	9.61**	44.01**	53.04**	42.48**	13.69**	29.51**	14.63**	-1.28	14.95**
Giza 178R x Giza 182R	-4.86**	6.06**	69.38**	76.73**	75.69**	12.62**	15.83**	16.46**	8.87*	3.23
Giza 182R x Giza 178R	-6.25**	3.18	48.81**	66.63**	53.19**	-2.23	17.07**	14.31**	-2.59	0.13
C.D 5%	1.61	3.94	2.84	9.51	3.33	12.15	0.75	1.16	13.35	6.18
1%	2.15	5.26	3.79	12.68	4.45	16.20	1.00	1.55	17.80	8.25

*, **: Significant at 0.05 and 0.01 levels of probability, respectively

The most promising hybrids identified in this study were, Giza 178R x IR68886B for heading date, tillers plant^{-1}, grain yield plant^{-1}, panicles plant^{-1}, filled grains panicle^{-1}, panicle length, panicle weight and spikelets panicle^{-1}. Giza 182R x IR688886B with significant desirable heterosis for grain yield plant^{-1}, filled grains panicle^{-1}, 1000-grain weight, panicle length and panicle weight, Giza 182R x Giza 178R for heading date, plant height, grain yield plant^{-1} and panicles plant^{-1}. The reciprocal hybrid, Giza 178R x Giza 182R was promising for heading date, plant height, tillers plant^{-1}, grain yield plant and panicles plant^{-1}. However, the hybrid combination IR68886B x Giza 178R was promising for tillers plant^{-1}, grain yield plant^{-1}, panicles plant^{-1} filled grains panicle^{-1} and panicle weight. Moreover, the promising hybrid exceded others with significantly SCA effects for most of the studied traits.

Evaluation of hybrids for heterosis breeding based on six considerations, mean performance, heterobeltiosis (B.P.%), mid-parents heterosis (M.P.%), standard heterosis (S.H.%), SCA effects and GCA of male or female parent would be meaningful from this point of view out of 20 cross combinations, three direct hybrids named, IR68886B x Giza178R, IR69625B x Giza178R and Giza178R x Giza182R recorded significantly positive values and were most promising for all the above mentioned six considerations. The parents having higher GCA for one or both female and male parents exhibited high standard heterosis in hybrids. Some hybrids involving parents with lower SCA effects showed high negative standard heterosis. These results have been reported by Peng and Virmani (1990), Devaraj and Nadarajan (1996), Mishra and Pandey (1998), El-Refaee (2002) and El-Mowafi *et al.* (2003).

The combinations involving the restorer lines Giza 178R and Giza 182R and the maintainer line IR68886B revealed commercially heterosis.

The results indicated that the mean heterotic effects for grain yield plant^{-1} were significant and positive in 18 out of 20 hybrids, as deviation from the better parent value (Table 8). The highest estimates were detected for the direct hybrids and their reciprocal, hybrids, IR68886B x Giza 178R (75.77%) and their reciprocal hybrid Giza 178R x IR68886B (80.40%), IR68886B x Giza 182R (65.09%) and their reciprocal hybrid (88.30%) and Giza 178R x Giza 182R (76.72%) and their reciprocal hybrid Giza 182R x Giza 178R (66.63%). Moreover, significant and positive values of heterosis were estimated for 19 direct and reciprocal hybrids as deviation from the mid-parents values. It is clear from Table 7 that the highest heterotic effects over mid-parent were 97.60, 90.60, 85.68, 80.92 and 79.71% for Giza 182R x IR68886B (reciprocal), Giza 178R x Giza 182R, Giza 178R x IR68886B (reciprocal), IR68886B x Giza 178R and Giza 178R x Giza 182R, respectively.

Table 8. The mean performances,better parant (B.P.),mid- parant (M.P.) and standard heterosis (S.H.)%, SCA and GCA effects of female and male parents of F_1 hybrids for yield trait.

Hybrids	F_1	BP%	MP%	SH%	SCA	GCA of female parent	GCA of male parent
IR58025B x IR68886B	55.39	45.83**	45.93**	41.74**	0.53	-4.98**	1.20
IR68886B x IR58025B	61.602	5.85	5.92	2.88	-3.106	1.20	-4.98**
IR58025B x IR69625B	63.07	28.25*	30.08**	24.47*	0.69	-4.98**	-3.03**
IR69625B x IR58025B	45.78	42.63**	44.67**	38.44**	8.645**	-3.03**	-4.98**
IR58025B x Giza 178R	65.58	47.38**	49.58**	47.39**	2.62	-4.98**	6.48**
Giza 178R x IR58025B	66.14	48.63**	50.85**	48.63**	-0.277	6.48**	-4.98*
IR58025B x Giza 182R	65.95	57.14**	62.42**	48.21**	4.76**	-4.98**	0.33
Giza 182R x IR58025B	57.76	37.62**	42.25**	29.80**	4.095	0.33	-4.98**
IR68886B x IR9625B	67.33	55.68**	58.01**	51.32**	0.95	1.20	-3.03**
IR69625B x IR68886B	54.42	25.83*	27.72**	22.29*	6.455**	-3.03**	1.20
IR68886B x Giza 178R	78.22	75.77**	80.92**	75.79**	9.82**	1.20	6.48**
Giza 178R x IR68886B	80.28	80.40**	85.68**	80.42**	-1.032	6.48**	1.20
IR68886B x Giza 182R	69.29	65.09**	73.25**	55.71**	10.89**	1.20	0.33
Giza 182R x IR68886B	79.03	88.30**	97.60**	77.59**	-4.87*	0.33	1.20
IR69625B x Giza 178R	76.47	71.84**	74.29**	71.85**	9.91**	-3.03**	6.48**
Giza 178R x IR69625B	73.74	65.71**	68.07**	65.71**	1.365	6.48**	-3.03**
IR69625B x Giza 182R	51.76	19.68	27.38**	16.33	0.89	-3.03**	0.33
Giza 182R x IR69625B	68.10	57.46**	67.59**	53.04**	-8.167**	0.33	-3.03**
Giza 178R x Giza 182R	78.64	76.72**	90.60**	76.73**	7.85**	6.48**	0.33
Giza 182R x Giza 178R	74.15	66.63**	79.71**	66.63**	2.245	0.33	6.48**
C.D. 5%	9.506	9.506	8.23	9.51	3.428	1.902	1.902
1%	12.68	12.68	10.98	12.68	4.753	2.537	2.537

*, **: Significant at 0.05 and 0.01 levels of probability, respectively.

The results showed that significant and positive heterotic effects were regarded for 18 hybrids as deviation from the standard variety (Giza 178R). The highest heterotic effects were 80.42, 77.59, 76.73, 75.79 and 71.85% for Giza 178R x IR68886B (reciprocal cross), Giza 182R x IR68886B (reciprocal), Giza 178R x Giza 182R, IR68886B x Giza 178R and IR69625B x Giza 178R, respectively.

However, out of 20 hybrids, eighteen exhibited highly significant and positive heterotic effects relatively to the better, mid-parents and standard variety heterosis.

Significant heterosis for grain yield was reported by Mandel *et al.* (1990), Singh *et al.* (1991), Pandey *et al.* (1995), Rogbell and Subbaraman (1997), Vishawakarma *et al.* (1998), El-Mowafi (2001), El-Refaee (2002) and El-Mowafi *et al.* (2003).

REFERENCES

1. Devaraj, M. and N. Nadarajan, 1996. Evaluation of rice hybrids. Oryza, 33: 230-235.
2. Dwivedi, D.K., M.P. Pandy, S.K. Pandèy and Li Rongbai, 1998. Heterosis in inter and intraspecific crosses over three environments in rice. Euphytica. 99(3), 155-165.
3. El-Mowafi, H.F. 1988. Breeding studies on some traits of crosses and cultivated and induced rice lines. M.Sc. Thesis, Fac. of Agric., Tanta University, Kafr El Sheikh, Egypt.
4. El-Mowafi, H.F. 2001. Study on heterosis in hybrid rice under Egyptian conditions. Egypt. J. Appl. Sci., 16(2), 52-63.
5. El-Mowafi, H.F. and A.A. Abou Shousha, 2003. Combining ability and heterosis analysis of diverse CMS lines in hybrid rice. J. Agric. Res. Tanta Univ., 29(1): 106-127.
6. El-Mowafi, H.F., A.O. Bastawisi, M.I. Abo Youssef and F.U. Zaman, 2003. Exploitation of rice heterosis under Egyptian conditions. 10th National Conference of Agronomy, 7-10 Oct., 2003. Suez Canal Univ, Fac. of Environmental Agric. Sci., El-Arish (Under press).
7. El-Refaee, Y.Z.E. 2002. Genetical and biochemical studies on heterosis and combining ability in rice. M.Sc. Thesis, Fac. of Agric., Tanta Univ., Kafr El-Sheikh, Egypt.
8. Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. Austr. J. Bio. Sci. 9: 463-493.
9. Hammoud, S.A.A. 2004. Inheritance of some quantitative characters in rice (*Oryza sativa*, L.). Ph.D. Thesis, Fac. of Agric., Minufiya University, Egypt.

10. Lin, S.C. and L.P. Yuan, 1980. Hybrid rice breeding in China. Innovative Approaches to Rice Breeding. pp. 35-51. IRRI, Los Banos, Laguna Philippines.
11. Mamta, S., D.M. Maurya and M. Singh, 1999. Heterosis and inbreeding depression in rice for yield and yield components using CMS System .Oryza. 36: 1, 24-27.
12. Mandel, P.K., S. Saran and V.N. Sahai, 1990. Heterosis studies in hybrid rice. Indian Agric., 34(1): 47-50.
13. Mishra, M. and M.P. Pandey, 1998. Heterosis breeding in rice for irrigated sub-humid tropics in North India. *Oryza*, 35: 1, 8-14.
14. Pandey, M.P., J.P. Singh, S. Harpal and H. Singh, 1995. Heterosis breeding for grain yield and other agronomic characters in rice (*Oryza sativa* L.) Indian J. Genetic,, 55(4): 438-445.
15. Patel, S.R., N.M. Deasi and M.V. Kukadia, 1994. Heterosis for yield and yield contributing characters in upland rice. Huharat-Agric. Univ. Research Journal. 20: 1,162-163.
16. Peng, J.Y. and S.S. Virmani, 1990. Combining ability for yield and four related traits in relation to breeding in rice. Oryza 27: 1-10.
17. Rajesh, S. and R. Singh, 2000. Heterosis studies in rice using "WA" based CMS system for developing hybrids for eastern Uttar Pradesh. Annals of Agric. Res. 21(1): 79-83.
18. Rogbell, J.E. and N. Subbaraman, 1997. Line x tester analysis for combining ability in saline rice cultivars. Madras-Agricultural-Journal. 84: 1, 22-25.
19. Singh, N.K., N.B. Singh, P.B. Jha and V.K. Sharma, 1991. Heterosis and combining ability for yield and some component characters in rice. Crop Improvement. 18(2): 128-131.
20. Vishawakarma, DN., D.M. Maurya, S.K. Mishra, G.P. Verma and K.K.R. Rakesh, 1998. Heterosis studies in rice using CMS system. Annuals of Agricultural Research. 19: 4, 370-374.
21. Yuan, L.P. and S.S. Virmani, 1986. Status of hybrid rice research and development. Hybrid Rice Proceeding of the Int. Symp. On Hybrid Rice, 6-10 Oct. 1986, Changsha, Hinan, China, 7-24.

دراسات على قوة الهجين فى بعض السلالات الحافظة والمعيدة للخصوبة لنظام العقم الذكرى السيتوبلازمى فى الأرز الهجين

حمدى فتوح الموافى[١] ، أشرف حسين عبد الهادى[٢]

١ مركز البحوث و التدريب فى الأرز-معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – مصر
٢ قسم الوراثة – كلية الزراعة – جامعة المنصورة – مصر

تم تقييم عشرين هجينا من الأرز الناتج من تهجين خمس سلالات أبوية ثلاثة منها مستوردة حافظة للعقم الذكرى السيتوبلازمي الوراثي وهى السلالة اى ار ٥٨٠٢٥ بى ، السلالةاى‌ار ٦٨٨٨٦بى والسلالةاى‌ار ٦٩٦٢٥ بى والصنفان الأخران مصريان معيدان للخصوبة واللذان تنتج تقاوى الأرز الهجين وهما جيزه ١٧٨ار وجيزه ١٨٢ ار. وقد تم التهجين بينها بنظام الهجن الدورية الكاملة باستخدام طريقة جريفنج ١٩٥٦ للهجن والهجن العكسية لتقدير قوة الهجين فى إحدى عشرة صفة حقلية ومحصولية وصفات السنبلة .أجريت الدراسة بمرزعة مركز البحوث والتدريب فى الأرز بسخا-كفر الشيخ .

أظهرت الدراسة أن أعلى قوة هجين مقارنة بالأب الأفضل شوهدت فى صفات محصول النبات الفردي وكانت ٨٨,٣% يليها صفتي عدد السنابل وكذلك عدد الفروع الكلية فى النبات. بينما كانت أعلى قيم لقوةالهجين على أساس متوسط الأبوين فى صفات محصول النبات الفردي ٩٧,٦% يليها نفس الصفات السابقة. أما أعلى قوة هجين قياسية مقارنة أفضل الأصناف المحلية المنزرعة وهو الصنف جيزه ١٧٨ار فكانت ٨٣,٨% لصفة عدد الفروع الكلية للنبات يليها محصول الحبوب للنبات وعدد السنابل أيضا.

أظهر تقييم الهجن على أساس قوة الهجين باستخدام المقاييس الثلاث السابق الإشارة إليها بالإضافة إلى القدرة الخاصة على الائتلاف وكذلك القدرة العامة علي الائتلاف لكلا الأبوين باعتبارها تقديرات تعطى أهمية وراثية لقوة الهجين أظهر التقييم أن الهجن جيزه ١٧٨أر ×اى ار ٦٨٨٨٦بى، وجيزه ١٨٢ار × اى‌ار ٦٨٨٨٦بى ، جيزه ١٧٨ار × جيزه ١٨٢ ار و اى‌ار ٦٨٨٨٦ بى X جيزه ١٧٨ار هي أفضل الهجن التى يمكن استغلالها اقتصاديا عن طريق تهجين سلالتها العقيمة ذكريا مع الآباء الملقحة والتي تفوقت على الأصناف التجارية و كذلك استغلال بعض الهجن لتحسين السلالات الأبوية الحافظة للعقم الذكرى وذلك لبعض الصفات الاقتصادية الهامة.