COMBINING ABILITY ANALYSIS OF THE MAINTAINER AND RESTORER LINES FOR CYTOPLASMIC MALE STERILE (CMS) SYSTEM OF HYBRID RICE

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Abstract

Five cultivars of rice were crossed to obtain 20 F_1 hybrids, through diallel hybrid mating design. These cultivars included three introduced maintainers and two Egyptian restorers. Griffing's 1956 Method 1, Model 1 was employed for this purpose. The five parents and their 20 F_1S (including reciprocals) were grown in a randomized block design with three replications at RRTC farm, Sakha Kafr El-Sheikh, Egypt. Data were collected on 12 traits including agronomic, yield and its components and panicle traits. GCA and SCA were significant for all the studied traits except harvest index. GCA/SCA ratio was found to be greater than unity for heading date, plant height, harvest index, 1000-grain weight, panicle length, spikelets panicle^{-1} and spikelet fertility%. This finding indicates that additive and additive x additive types of gene action were of greater importance in the inheritance of these traits. On the other hand, GCA/SCA ratios were found to be less than unity for the rest of the studied traits, indicating that the non-additive type of gene action including dominance was of great importance in the inheritance of these traits.

The maintainer line IR68886B was the best general combiner for most of the studied traits followed by the restorer lines Giza 178R and Giza 182R. The hybrid combinations IR68886B x Giza 178R, IR68886B x Giza 182R and IR692625B x Giza 178R showed high SCA effects for the most studied traits and were considered as the best combinations. Thus, these hybrids could be useful for the hybrid rice program.

INTRODUCTION

Rice (*Oryza sativa,* L.) is the second largest crop grown in the world in terms of both area and production. It is cultivated over 148 million ha, with an annual production of 528 million tons. It is a major source of calories for about three billion people in Southeast Asia, Africa, and Latin American (Ahmed and Siddiq, 1998). Hybrid rice technology holds great promise to break the yield barrier and yield plateau in irrigated ecosystems and to contribute significantly towards meeting the rice demand anticipated in the 21st century.

Diallel analysis provided useful information about the nature of the genetic parameters. It also helps in identification of parental lines in terms of their combining ability in hybrid combinations. This may provide a dependable basis in selecting parents in a hybridization programme to get desirable segregants. The investigation being reported herein was undertaken with a view to estimate the general and specific combining ability effects as well as reciprocal effects of three introduced maintainer lines for CMS and two Egyptian restorer lines useful for hybrid rice breeding program.

MATERIALS AND METHODS

All possible hybrid combinations were made including reciprocals using five rice genotypes (Table 1) to obtain 20 F_1 hybrids. These genotypes included three introduced maintainers for CMS lines namely IR58025B, IR68886B and IR69625B and two Egyptian restorer lines (R), viz. Giza 178R and Giza 182R. All the 25 genotypes (20 F_1 hybrids and their five parents) were raised in a randomized complete blocks design with three replications with spacing of 20 cm between rows and 20 cm between plants during the summer season 2002 at the Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt. The recommended cultural practices were followed. Data were recorded on 10 randomly plants taken from each replication and the mean values were used for statistical analysis. Combining ability analyses were carried out according to method 1 and model 1 of Griffing (1956). The observations were recorded for 12 quantitative traits viz., agronomic traits (heading date, plant height and tillers plant),yield and its components traits (grain yield plant^{-1}, panicles plant^{-1}, harvest index %, filled grains panicle^{-1} and 1000-grain weight) and panicle traits (panicle length, panicle weight, spikelets panicle^{-1} and spikelet fertility %).

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, 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	Giza175/Milyang 49	Egypt	Indica-Japonica type, early maturing, short statured, tolerant to salinity, short grain, good grain quality, high yielder and good restorer for cytoplasmic male sterile lines CMS
5	Giza 182 R	Giza181/IR39422-163-1-2// Giza 181	Egypt	Indica type, new released variety, early maturing, semi-dwarf, long grain, resistant to blast, high yielder and good restorer for cytoplasmic male sterile lines (CMS)

RESULTS AND DISCUSSION

The analysis of variances were made for all the studied traits and the results are presented in Table (2).The results showed significant differences for all the studied traits. The hybrids as well as parents (maintainer and restorer liens) showed significant differences for all the studied traits except grain yield plant^{-1} and panicle weight for the parents.

Parent and hybrid mean squares showed highly significance and significance for all studied traits except harvest index %. The analysis of variances for combining ability showed highly significant differences due to both general and specific combining abilities for all the studied traits except harvest index %. This finding indicated the importance of both additive and non-additive genetic variances in the inheritance of the studied traits.

General combining ability/specific combining ability ratio was used to clarify the nature of the genetic variance. The ratio was found to be greater than unity for heading date, plant height, harvest index %, 1000-grain weight, panicle length, spikelets panicle^{-1} and spikelet fertility %. The obtained results indicated that the additive and additive x additive types of gene actions were of great importance in the inheritance of these traits. The selection procedures based on the accumulation of additive effects could be very successful in improving these traits. These results are in agreement with conclusions obtained by El-Mowafi (1988), Lokaprakash *et al.* (1991), Abd El-Hafez *et al.* (1992), El-Mowafi (1994), Dwivedi *et al.* (1999), El-Refaee (2002), and Hammoud (2004).

On the other hand, the GCA/SCA ratio of the other traits such as tillers plant^{-1}, grain yield plant^{-1}, panicles plant^{-1}, filled grains panicle^{-1} and panicle weight was found to be less than unity. This finding indicated that the non-additive type of gene action including dominance was of great importance in the inheritance of these traits. The results are in agreement with the those obtained by Banumathy and Prasad (1991) for filled grains panicle^{-1} and grain yield plant^{-1}(Lokaprakash *et* al. 1991, Lang and Buu 1992), Geetha *et al.* (1994) for grain yield plant^{-1} and panicles plant^{-1}, and Satyanarayana *et al.* (1998).

These results also, clearified that the mean squares of reciprocals were also significant for all the studied traits except harvest index trait (Table 2). Significant reciprocal effect for spikelets panicle^{-1} was as large as GCA but its contribution in grain yield plant^{-1} was substantial suggesting the need for careful choice of female parents. Maternal effects in some agronomic, yield and its components, and panicle traits have been observed by Sasmal and Banerjee (1986), El-Mowafi (1988) and (1994).

Table 2. Estimates of the mean square of ordinary analysis and combining ability analyses for all the 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}	Panicles plant^{-1}	Harvest index	Filled grains panicle^{-1}	1000-grain weight	Panicle length (cm)	Panicle weight (g)	Spikelets panicle^{-1}	Spikelet fertility (%)
Reps	2	4.222*	26.59*	0.1136$^{n.s}$	55.2$^{n.s}$	7.42$^{n.s}$	0.0116*	174.3$^{n.s}$	1.5970*	0.682$^{n.s}$	1.121*	361.0*	14.53$^{n.s}$
Genotypes	24	58.08*	77.51*	77.97*	537.2*	66.65*	0.0076*	1272.7*	15.220*	5.742*	0.649*	2930.4*	188.30*
Hybrids	19	37.89*	55.94*	30.05*	404.6*	29.51*	0.0084*	1063.4*	15.270*	4.197*	0.523*	2617.9*	215.2*
Parents	4	90.93*	103.6*	46.96*	18.65$^{n.s}$	50.23*	0.0042*	1310.3*	18.530*	6.34**	0.418$^{n.s}$	4088.2*	85.58*
PVS Hybrids	1	310.2**	282.8**	1112.5**	5132.2**	838.01**	0.0051$^{n.s}$	5099.3**	1.100*	32.660**	3.958**	4238.3**	88.22*
GCA	4	63.21**	83.30**	21.76**	193.7**	17.59**	0.0062$^{n.s}$	390.8**	17.750**	4.404**	0.244**	326.8**	005.7**
SCA	10	15.29**	17.12**	46.92**	304.0**	40.84**	0.0012$^{n.s}$	565.2**	2.950**	1.717**	0.280**	571.4**	45.10**
Reciprocal	10	5.892**	11.57**	6.752**	48.3**	5.44**	0.0024$^{n.s}$	296.6**	2.127**	1.115**	0.141**	468.3**	23.28**
Error	48	0.9629	5.773	2.994	33.5	4.128	0.0021	54.7	0.209	0.499	0.125	66.1	14.18
GCA/SCA		4.135	4.867	0.4638	0.637	0.431	5.255	0.69	6.017	2.565	0.871	5.7	4.56

*, ** : Significant at 5% and 1% probability levels, respectively.

n.s : Not significant

The estimates of genetic parameters viz., additive variance (σ^2A), dominance variance (σ^2D), environmental variance (σ^2E), genotypic variance ((σ^2G) and phenotypic variance (σ^2P), broad sense heritability (h^2_b%), narrow sense heritability(h^2_n%), relative importance of GCA % and relative importance of SCA% for all agronomic, yield and its components and panicle traits are presented in Table 3. It is clear that the estimates of the additive variance (σ^2A) and the relative importance of GCA% for plant height, harvest index%, 1000-grain weight, spikelets panicle^{-1} and spikelet fertility % were higher than the dominance variance (σ^2D) and relative importance of SCA% for these studied traits suggesting that these traits are largely governed by additive gene action. The importance of additive gene action for the inheritance of these traits are in agreement with the findings of El-Mowafi (1988) and (1994), Sharma and Koranne (1995), El-Mowafi (2001), El-Refaee (2002) and Hammoud (2004). On the other hand, higher estimates of dominance genetic variances and its relative magnitudes of SCA% were found to be greater than the additive variances for the rest of studied traits. These results indicated that dominance variance played a predominant role in the expression of the studied traits which are in agreement with the results reported by Mou and Lu (1991), Lang and Buu (1992), Lokaprakash *et al.* (1994), Satyanarayana *et al.* (1998), El-Mowafi (2001) and El-Mowafi *et al.* (2003).

High values of environmental component (σ^2E) were recorded for grain yield plant^{-1}, harvest index, filled grains panicle^{-1} and panicle weight, while the other estimates for the rest traits were normal but differed in magnitudes indicating that these traits were affected by the environmental component with different degrees.

Heritability values in broad sense were high for all the studied traits (Table 3) except harvest index, panicle length and panicle weight which were relatively low. This finding suggested that a major part of the phenotypic variance was due to environmental effect for harvest index % and panicle weight. In the same time, heritability estimates in the narrow sense were high for 1000-grain weight and spikelets panicle^{-1}, moderate for heading date, plant height and spikelet fertility % and low for the rest of the studied traits. These results are in agreement with those reported by Kumar and Chandrappa (1994), Mani *et al.* (1997), Rather *et al.* (1998), El-Refaee (2002), El-Mowafi *et al.* (2003) and Hammoud (2004).

Table (4) illustrated that the magnitude of GCA effects for the five parents. The results indicated that the acceptable magnitude was found in IR68886B for tillers plant^{-1}, filled grains panicle^{-1}, panicle length, panicle weight and spikelets panicle^{-1}, in Giza 178R for grain yield plant^{-1}, panicles plant^{-1} heading date, plant height, harvest index, filled grains panicle^{-1} and spikelet fertility %, in Giza 182R for heading date,

Table 3. The estimates of the genetic parameters, ($\sigma^2_A, \sigma^2_D, \sigma^2_G, \sigma^2_E, \sigma^2_P$, h^2_b, h^2_n%) and the relative importance of GCA and SCA for all studied traits.

Genetic parameters and R.I.G.C.A.% and SCA%	Agronomic traits			Yield and its component traits					Panicle traits			
	Heading date (days)	Plant height (cm)	Tillers plant^{-1}	Grain yield plant^{-1}	Panicles plant^{-1}	Harvest index %	Filled grains panicle^{-1}	1000-grain weight	Panicle length (cm)	Panicle weight (g)	Spikelets panicle^{-1}	Spikelet fertility (%)
Additive variance (σ^2A)	9.420	13.04	-5.54	-25.38	-5.096	0.0009	-41.03	2.928	0.5176	-0.0106	531.82	31.60
Dominant variance (σ^2D)	9.846	10.00	30.21	192.67	25.960	-0.0039	359.86	1.895	1.020	0.1571	361.42	26.56
Environmental variance (σ^2E)	0.963	5.773	2.99	33.53	4.128	0.0021	54.75	0.209	0.499	0.1246	66.10	14.18
Genotypic variance (σ^2G)	19.266	23.04	24.67	167.29	20.860	0.0029	318.83	4.823	1.538	0.1466	893.24	58.16
Phenotypic variance (σ^2P)	20.229	28.81	27.66	200.82	24.990	-0.0008	373.58	5.032	3.057	0.2712	959.34	72.34
Broad sense heritability ($h^2_{.b}$) %	95.24	79.96	89.19	83.30	83.480	3.571	85.34	95.85	50.30	54.05	93.11	80.40
Narrow sense heritability ($h^2_{.n}$) %	46.57	45.22	-20.02	-12.64	-20.390	-1.120	-10.98	58.19	16.93	-3.912	55.43	43.68
Relative importance of GCA%*	48.89	56.59	-22.44	-15.17	-24.420	31.35	-12.87	60.710	33.65	-7.24	59.54	54.33
Relative importance of SCA%**	51.10	43.41	122.44	115.17	124.420	-131.35	112.87	39.290	66.35	107.2	40.46	45.67

Relative importance of GCA = σ^2A/σ^2G and

Relative importance of SCA = σ^2D/σ^2G.

Table 4. Estimates of GCA effects of the five parents for agronomic, yield and its components, and panicle traits.

Parents	Agronomic traits			Yield and its component					Panicle traits			
	Heading date (days)	Plant height (cm)	Tillers plant^{-1}	Grain yield plant^{-1}	Panicles plant^{-1}	Harvest index	Filled grains panicle^{-1}	1000-grain weight	Panicle length (cm)	Panicle weight (g)	Spikelets panicle^{-1}	Spikelet fertility (%)
IR58025B	2.759**	0.653$^{n.s}$	0.644*	-4.98**	0.4416$^{n.s}$	-0.201**	2.3736$^{n.s}$	-0.9666**	0.0664$^{n.s}$	-0.0038$^{n.s}$	11.142**	-2.864**
IR68886B	2.627**	3.784**	1.705**	1.20$^{n.s}$	1.1376**	-0.027**	7.5596**	-0.2546**	0.9994**	0.2662**	24.288**	-6.078**
IR69625B	-0.94**	1.125**	-1.593**	-3.03**	-1.6024**	-0.002	-5.4324**	1.0634**	-0.5736**	-0.0368$^{n.s}$	-20.195**	5.623**
Giza 178R	-2.174**	-1.821**	0.754*	6.48**	1.2316**	0.019*	2.9406*	-1.4956**	-0.6386**	-0.1168*	-1.84n.s	1.729**
Giza 182R	-2.272**	-3.741**	-1.509**	0.33$^{n.s}$	-1.2084**	0.031**	-7.4414**	1.6534**	0.1464$^{n.s}$	-0.1088$^{n.s}$	-13.395**	1.59*
SE ($_{gi}$)	0.160	0.392	0.282	0.946	0.332	0.0075	1.1208	0.075	0.115	0.0576	1.328	0.615
SE ($_{gi-gj}$)	0.253	0.620	0.447	1.495	0.525	0.0119	1.910	0.118	0.182	0.0911	2.099	0.972
CD 5% ($_{gi}$)	0.3221	0.788	0.567	1.902	0.667	0.015	2.429	0.150	0.231	0.116	2.0670	1.236
CD 1% ($_{gi}$)	0.430	1.051	0.756	2.537	0.890	0.020	3.240	0.2001	0.308	0.154	3.562	1.649

*, ** : Significant at 5% and 1% levels of probability, respectively.

n.s : Not significant

plant height, harvest index%, 1000-grain weight and spikelet fertility %, in IR69625B for spikelet fertility %, heading date and 1000-grain weight, in IR58025B for spikelets panicle^{-1} and tillers plant^{-1} . The results of combining method proposed by Wang (1981) and El-Mowafi and Abou Shousha (2003) are shown in Table 5. Evaluation of the parents was made according to the ranking numbers of GCA and according to the total marks. As the results showed in this Table, the maintainer line IR68886B was the best general combiner followed by the restorer lines Giza rice (*O. sativa* Sinica). Zhejiang Agric. Sci., 5: 205-212.

In most of the high heterosis registering hybrid for different traits IR68886B or Giza 178R or Giza 182R was also one of the parents or both involved thus proved to be promising parents for high heterotic effect (Table 6). On the other hand IR69625B and IR58025B were poor general combiners for most of the traits. According to the mentioned results, hybrid combinations involved the parents IR68886B, Giza 178R and Giza 182R could be exploited more profitably in hybrid breeding programme, to develop parental lines(CMS, maintainer and restorer) with good traits. The hybrid combination IR68886B x Giza 182R showed high effects of SCA for heading date, tillers plant^{-1}, grain yield plant^{-1}, filled grains panicle^{-1}, 1000-grain weight, panicle length, panicle weight and spikelets panicle^{-1} followed by IR68886B x Giza 178R for heading date, tillers plant^{-1}, grain yield plant-^{1}, panicle plant^{-1}, filled grains panicle, panicle length panicle weight, spikelets panicle and spikelet fertility %. In the same time, the hybrid IR69625B x Giza 178R was the best for tillers plant^{-1}, grain yield plant^{1}, panicles plant^{-1}, filled grains panicle^{-1}, 1000-grain weight, panicle weight, spikelets panicle^{-1} and spikelet fertility%. These results are presented in Table 6. According to the results of the ranking numbers of SCA for ten hybrid combinations presented in Table (7), IR68886B x Giza 178R, IR68886B x Giza 182 R, and IR69625B x Giza 178R were the best combinations for most of the studied traits.

Table 5. comparison between the five parents using ranking numbers of GCA for the all studied traits.

Parents	Agronomic traits			Yield and its component trait					Panicle traits				Total	Overall rank
	Heading date (days)	Plant height (cm)	Tillers plant^{-1}	Grain yield plant^{-1}	Panicles plant^{-1}	Harvest index	Filled grains panicle^{-1}	1000-grain weight	Panicle length (cm)	Panicle weight (g)	Spikelets panicle^{-1}	Spikelet fertility (%)		
IR58025B	5	3	3	5	3	5	3	4	3	2	2	4	42	4
IR68886B	4	5	1	2	2	4	1	3	1	1	1	5	30	1
IR69625B	3	4	5	4	5	3	4	2	4	3	5	1	43	5
Giza 178R	2	2	2	1	1	2	2	5	5	5	3	2	32	2
Giza 182R	1	1	4	3	4	1	5	1	2	4	4	3	33	3

Table 6. Estimates of specific combining ability (SCA) for the 20 F_1 hybrids for al the studied traits.

Hybrids	Agronomic traits			Yield and its components					Panicle traits			
	Heading date (days)	Plant height (cm)	Tillers $plant^{-1}$	Grain yield plants	Panicles $plant^{-1}$	Harvest index	Filled grains $panicle^{-1}$	1000-grain weight	Panicle length (cm)	Panicle weight (g)	Spikelets $panicle^{-1}$	Spikelet fertility (%)
IR58025B x IR68886B	1.40**	0.305	1.350*	0.53	1.229*	-0.0387*	-15.664**	-0.835**	0.0906	-0.1662	9.337**	-9.501**
IR68886B x IR58025B	-0.500	-2.300*	0.000	-3.106	-0.085	0.265	1.470	-1.325**	-0.400	0.085	4.235	-0.635
IR58025B x IR69625B	-0.69**	0.24	4.938**	0.69	-0.581	-0.0037	7.158**	1.517**	0.6636**	0.0853	-4.870*	5.033**
IR69625B x IR58025B	-3.165**	-0.720	4.050**	8.645**	1.585	0.0535**	0.100	0.265	1.600**	-0.037	-1.405	0.750
IR58025B x Giza 178R	-1.12**	3.245**	-0.559	2.62	-0.569	0.0085	2.180	-0.219	-0.3664	0.1378	-4.290	2.697*
Giza 178R x IR58025B	1.500**	0.165	1.600*	-0.277	0.660	0.0315	-3.175	-0.410*	0.565	-0.354*	14.74**	-7.73**
IR58025B x Giza 182R	-2.36**	-0.470	0.749	4.76**	1.510*	0.0165	-3.928	0.517**	0.2486	0.0238	-12.49**	2.591*
Giza 182R x IR58025B	-1.500**	5.670**	0.485	4.095	0.430	-0.032	31.46**	-0.555**	1.435**	0.510**	40.05**	-1.335
IR68886B x IR9625B	-3.39**	0.213	-0.043	0.95	1.198*	0.0210	-6.057**	0.729**	-0.2644	-0.1582	-11.85**	1.277
IR69625B x IR68886B	0.665	2.850**	1.720*	6.455**	2.090*	-0.003	-7.930*	0.090	-0.335	-0.160	4.435	-6.140**
IR68886B x Giza 178R	-2.33**	1.464*	5.655**	9.82**	4.904**	0.0022	24.104**	-1.756**	0.6006**	0.5018**	19.55**	3.501**
Giza 178R x IR68886B	1.835**	1.385	0.975	-1.032	-0.550	-0.041*	-17.06**	0.015	-0.135	-0.350*	-16.40**	-1.550
IR68886B x Giza 182R	-2.06**	3.614**	1.508**	10.89**	-0681	0.0307	20.066**	1.065**	0.7456**	0.5238**	20.81**	1.104
Giza 182R x IR68886B	0.665	-0.585	-1.795*	-4.870*	-3.365**	-0.032	3.585	-0.365	-0.065	-0.380*	5.100	-0.2155
IR69625B x Giza 178R	0.07	1.873*	2.103**	9.91**	2.089**	0.0222	9.991**	0.921**	0.0386	0.2748*	7.037**	2.770*
Giza 178R x IR69625B	-1.000*	2.735**	-1.125	1.365	-1.455	0.003	-1.700	0.670**	0.00	0.070	-2.670	0.460
IR69625B x Giza 182R	1.17**	0.998	2.316**	0.89	2.684**	-0.0233	12.693**	-1.938**	0.3886	0.0873	17.03**	-0.316
Giza 182R x IR69625B	3.000**	-0.460	-0.845	-8.167**	-0.360	-0.035	1.750	-2.780	-0.535	-0.108	8.965**	-3.455*
Giza 178R x Giza 182R	-0.93**	-0.196	4.239**	7.85**	4.925**	0.0059	-9.315**	0.676**	1.1536	-0.1617	-2.663	-3.732**
Giza 182R x Giza 178R	0.665	1.330	2.335**	2.245	2.415**	-0.048	10.385**	-0.125	0.235	0.016	9.900**	1.255
C.D. 5% (sij)	0.219	1.421	1.023	3.428	1.202	0.0312	4.379	0.269	0.418	0.239	4.811	2.228
C.D. 1% (sii)	0.293	1.896	1.365	4.573	1.604	0.0416	5.841	0.359	0.558	0.319	6.418	2.972
*C.D. 5% (rij)	0.805	1.972	1.419	4.753	1.667	0.0378	6.074	0.374	0.579	0.289	6.673	3.090
** C.D. 1% (rij)	1.074	2.631	1.893	6.340	2.223	0.0504	8.102	0.499	0.772	0.386	8.901	4.122

Table 7. Comparison of specific combining ability effects for the hybrid combinations for all the studied traits.

Hybrids	Heading date (days)	Plant height (cm)	Tillers plant^{-1}	Grain yield plant^{-1}	Panicles plant^{-1}	Harvest index %	Filled grains panicles^{-1}	1000-grain weight	Panicle length (cm)	Panicle weight (cm)	Spikelets panicle^{-1}	Spikelet fertility%	Total	Rank
IR58025B x IR68886B	10	5	7	10	6	10	10	8	7	10	4	10	97	10
x IR69625B	7	4	5	9	9	8	5	1	3	6	8	1	66	5
x Giza 178R	5	9	10	6	8	5	6	7	10	4	7	4	81	9
x Giza 182 R	2	2	8	5	5	4	7	6	6	7	10	6	68	6
IR68886B x IR69625B	1	3	9	7	7	3	8	4	9	8	9	6	74	8
x Giza 178R	3	7	1	3	2	7	1	9	4	2	2	2	43	1
x Giza 182 R	4	10	6	1	10	1	2	2	2	1	1	7	47	2
IR69625B x Giza 178 R	8	8	4	2	4	2	4	3	8	3	5	3	54	3
x Giza 182R	9	6	3	8	3	9	3	10	5	5	3	8	72	7
Giza 178R x Giza 182R	6	1	2	4	1	6	9	5	1	9	6	9	59	4

REFERENCES

1. Abd El-Hafez, A.G., M.S. El-Keredy and H.E. El-Mowafi 1992. Genetic components and heritability in rice. Proc. 5th Conf. Agron., Zagazig Univ. 13-15 Spet., Egypt. (1): 216-225.
2. Ahmed, M.I. and E.A. Siddiq 1998. Hybrid cultivar development. S.S. banga and S.K. Banga (EDS), Copyright (C) 1998 Narosa Publishing House, New Delhi, India, Chapter (9): Rice-201-220.
3. Banumathy, S. and M.N. Prasad 1991. Studies on combining ability for development of new hybrids in rice. School of genetics, Tamil Nadu Agricultural University, Combature-6410003, India. Oryza 28 (439-442).
4. Dwivedi, D.K., M.P. Pandey, S.K. Pandey and L.I. Rongbai 1999. Combining ability over environments in rice involving Indica and tropical Japonica lines. Oryza, 36: 2, 104-107.
5. 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.
6. El-Mowafi, H.F. 1994. Studies on rice breeding. Ph.D. Thesis, Faculty of Agric., Kafr El-Sheikh Tanta University, Egypt.
7. El-Mowafi, H.F. 2001. Combining ability analysis for some cytoplasmic male sterile and restorer rice lines under Egyptian conditions. Egypt. J. Appl. Sci., 16(2): 25-51.
8. 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.
9. 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., Suez Canal Univ. Fac. of Environmental Agric. Sci., El-Arish : 133-159.
10. 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.
11. Geetha, S., A.P.M.K. Soundararaj, S. Palanisamy and A.A. Kareem 1994. Combining ability analysis and gene action relating to grain characters among medium duration rice genotypes. Crop Research Hisar. 7: 2, 239-242.
12. Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel hybriding system. Astr. J. Bio. Sci. 9: 463-493.

13. Hammoud, S.A.M. 2004. Inheritance of some quantitative traits in rice (*Oryza sativa,* L.). Ph.D. Thesis, Fac. of Agric., Minufiya University, Egypt.

14. Kumar, B.M.D. and H.M. Chandrappa 1994. Combining ability studies for yield and its components in rice. Mysore-Journal of Agricultural Sciences. 28: 3, 193-198.

15. Lang, N.T. and B.C. Buu 1992. Combining ability and heterosis for some physiological traits in rice: International Rice Research Newsletter. 18(1): 7-8.

16. Lokaprakash, R., G. Shivashankar , M. Mahadevappa, B.T.S. Gowda and R.S.Kulkarni 1994. Genetic components of variation in rice. Indian Journal of Genetic & Plant Breeding.

17. Lokaprakash, R., G. Shivashankar, M. Mahaderappa, B.T. Shankaregowda and R.S. Kulkami 1991. Combining ability for yield and its components in rice. Oryza 28(3): 319-322 (Cited From Rice Abstracts. 1995 Vol. 18, No. 1).

18. Mani, S.C., S.K. Verma and R.K. Sharma 1997. Genetic variability and trait association for panicle traits in basmati rice. Agricultural Science Digest Karnal. 17: 3, 155-157.

19. Mou, T.M. and X.G. Lu 1991. Combining ability and heterosis of agronomic traits in Indica PGMS and their hybrids. International Rice Research Newsletter 16(2): 8.

20. Rather, A.C., G.N. Mir and F.A. Sheikh 1998. Genetic parameters for some quantitative traits in rice. Advances in Plant Science, 11: 2, 163-166.

21. Sasmal, B. and S.P. Banerjee 1986. Combining ability for grain yield and other agronomic traits in rice. J. Agronomy and Crop Sci. (156): 18-23.

22. Satyanarayana, P.V., I. Kumar and M.S.S. Reddy 1998. Studies on combining ability and heterosis in rice. International Rice Research Notes, 23: 3, 10.

23. Sharma, R.K. and K.D. Koranne 1995. Line x tester analysis for yield and yield components in indica x japonica hybrids of rice. *Oryza,* 32: 234-238.

24. Wang, R.C. 1981. Preliminary studies on heterosis and combining ability in hybrid

تحليل القدرة على الائتلاف في بعض السلالات الحافظة للعقم والمعيدة للخصوبة لنظام العقم الذكرى السيتوبلازمى الوراثي في الأرز الهجين

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أجري التحليل الدوري لتعريف السلالات الأبوية والهجن الخاصة ببرنامج تربية الأرز الهجين من خلال تحليل القدرة على الائتلاف فى خمسة أصناف وَ سلالات أرز (ثلاثة حافظة للعقم الذكرى السيتوبلازمى وسلالتين معيدة للخصوبة ومنتجة للأرز الهجين).

استخدم في هذه التجربة طريقة جريفنج ١٩٥٦ الأولى ــ الموديل الأول (١) وتم زراعة الأباء والجيل الأول بما فيه الهجن العكسية في تجربة قطاعات كاملة العشوائية من ثلاث مكررات بمزرعة مركز البحوث والتدريب في الأرز بسخا ــ كفر الشيخ. أخذت البيانات على ١٢ صفة تشمل الصفات الحقلية وصفات المحصول ومكوناته وصفات السنبلة. أظهرت البيانات معنوية كل من تباين القدرة العامة والخاصة على الائتلاف لكل الصفات ماعدا صفة معامل الحصاد.

اتضح من النتائج الدور المهم للفعل المضيف للجين في وراثة صفات تاريخ التزهير ، طول النبات ، معامل الحصاد ، وزن الألف حبة ، طول السنبلة ، عدد السنيبلات/سنبلة ، والنسبة المئوية للخصوبة%. بينما تبين أيضا أهميه دور الفعل غير المضيف أو السيادى للجين في وراثة صفات عدد الفروع/نبات ، محصول الحبوب/نبات ، عدد السنابل/نبات ، عدد الحبوب الممتلئة/سنبلة ، ووزن السنبلة بالجرام.

أظهرت الدراسة أن السلالة المحافظة على بقاء السلالة العقيمة أىأر ٦٨٨٨٦ بي كانت أفضل السلالات في القدرة العامة على الائتلاف في غالبية صفات الدراسة يليها الصنف المعيد للخصوبة جيزة ١٧٨أر ، ثم الصنف المعيد للخصوبة جيزة ١٨٢ أر. اعتبرت على الجانب الأخر اعتبرت التراكيب الهجينية أىار ٦٨٨٨٦ بي ×جيزة ١٧٨ أر ، أىأر ٦٨٨٨٦ بي ×جيزة ١٨٢ أر ،أىأر ٦٩٦٢٥ بي × جيزة ١٧٨ أر أحسن الهجن في القدرة الخاصة على الائتلاف في معظم صفات الدراسة ويمكن الاستفادة منها في برنامج التربية لانتاج الأرز الهجين وكذلك تحسين السلالات الأبوية في النظام الثلاثي للعقم الذكرى السيتوبلازمى الوراثي والذي يشتمل على السلالة العقيمة CMS أو سلالة (A) والسلالة المحافظة والمبقية عليها (B) أو السلالة Maintainer والسلالة المعيدة للخصوبة (R) أو Restorer والتي تنتج الأرز الهجين المتفوق تجاريا في الصفات المختلفة خصوصا القدرة على التلقيح الخلطى.