COMIBINING ABILITY ANALYSIS IN HYBRID RICE

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ABSTRACT

This research was planned to estimate the general and specific combining ability effects of Egyption lines to be evaluated in the rice breeding program. Fifteen hybrids were produced from a partial diallel crosses mating design among six lines, according to Griffing's1956 method 2 model 2. The six parents and their 15 F_1 S were grown in a randomized complete block design with three replications at RRTC farm, Sakha kafr EL-sheikh , Egypt . Data were collected on 11 traits including agronomic, yield and its components, panicle traits and floral traits. Both GCA and SCA were found to be significant for all the studied traits except anther width and panicle length. This indicates the importance of both additive and non-additive genetic variances in determining the inheritance of most of these studied traits. The GCA/SCA ratio shows the importance of additive genetic variance in the inheritance of most traits studied .

INTRODUCTION

Rice is an important food crop, as it is a primary food source for more than half of the world's population**.** However, the population of rice consumers is continuing to increase and the demand for rice is also going up due to improved living standards, particularly in Africa. Hybrid rice has proven to be an effective and economic way to increase rice production output. It is estimated to obtain about 15-20% higher yield just by growing hybrids instead of the common varieties (Virmani *et al.*,1993). Hybrid rice is successfully cultivated in China and gives more than 30% yield advantage over conventional rice varieties. This technology has enabled China to increase its rice production by nearly 200 milion tons from 1976 to 1991 (Yuan,1994).

Combining ability is a measure of gene action of both additive and non-additive genetic variation. The general combining ability (GCA) effects largely involve additive gene effects, whereas, specific combining ability (SCA) represents only non-additive gene action including dominance. The presence of non-additive genetic variance offers scope for exploration of heterosis (Yadav *et al.,* 1999). To develop hybrid rice with higher yield, better grain quality and multi-resistance, it would be very important to breed CMS lines with good combining ability.

MATERIALS AND METHODS

A Partial diallel crosses mating design was carried out among six rice genotypes (Table 1) To obtain 15 F_1 crosses. These genotypes included four introduced maintainers; IR58025B, Pusa 3B and 6B and the two Egyptian restorers; Giza 178R and Giza 5121R. All the 21 genotypes (15 F1 hybrids and their six parents) were raised in a randomized complete block design of

three replications with spacing of 20 cm rows and 20 cm between plants during the summer season 2008 at Rice Research and Training Center (RRTC) ,Sakha ,Kafr El-sheikh, Egypt . The recommended cultural practices were followed. Data were recorded on ten to twenty five randomly plants taken from all replications and the mean values were used for statistical analysis. Combining ability analyses were carried out according to method 2(model 2) of Griffing (1956). The observations were recorded for 11 quantitative traits viz, agronomic traits (days to heading and plant height), yield and its component traits (grain yield plant^{-1}, 1000-grain weight (g), filled grain panicle^{-1} and spikelets fertility) panicle traits (panicle length and panicle weight) and floral traits (anther length and anther width).

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

No	Genotype	Origin	Parantage	Salient features
1	Giza 178R	Egypt (Indica-Japonica type)	Giza 175/Miliang49	Early maturing, short stature, short grain, good grain quality and good restorer for CMS lines and high yielder.
2	GZ5121-R	Egypt (Indica type)	GZ1368S-5-4/LA110//Milyang49	Medium maturing, semi dwarf, short grain, good grain quality and good restorer for CMS lines and high yielder.
3	IR58025B	IRRI	IR48483A/8*PUSA167-120-3-2/PUSA167-120-3-2	Indica type, late maturing ,maintainer for the CMS line IR58025A line ,extra long grain ,low amylase content and strong aroma
4	IR69625B	IRRI	⎯⎯	Indica type, med .early maturing, maintainer for the CMS line IR69625A, med grain type and med. amaylose content
5	BUSA 3B	Egypt -IRRI	IR58025B/Pusa Basmati 1	Indica type, late maturing, maintainer for CMs line Busa 3A, Extra long grain type, aromatic and high amaylose content
6	BUSA 6B	Egypt -IRRI	IR58025B/Pusa Basmati 2	Indica type, late maturing, maintainer for CMs line Busa 6A, Extra long grain type, aromatic and high amaylose content

RESULTS AND DISCUSSION

The magnitude of genotypic variations and analysis of variance:

In the growing season of 2008, all genotypes were evaluated to determine the magnitude of genotypic variations among each other. The genotypes included 21 entries (six parents and 15 F1half diallel crosses excluding the reciprocal crosses).

The analyses of variances were made on the all studied traits viz., agronomic yield and its components, panicle and floret traits and results are presents in Table (2). This data also presentes the partitioning of the total

variance among genotypes into general combining ability (GCA) and specific combining ability (SCA) for the studied traits.

All genotypes were also subjected to statistical analysis of variance for five yield and its components traits, two panicle traits and floral traits. The results are also presented in Table (2).

The results of analysis of variances revealed the presence highly significant differences among the 21 genotypes of all traits except for anthers width. similar results were previously obtained by Awd-Allah(2006),El-Diasty *et al.* (2008), Abd El-Hadi *et al.* (2009) and Bagheri and Jelodar (2010) and Reda(2011).

Mean Performance:

The mean performance of the six parental lines and their 15 cross combinations for the eleven studied traits are presented in Table(3). The mean performance of the studied traits varied from cross combination to another. For days to heading, the FI mean value of four crosses were towards the lower parents (early flowering parents), while one cross only tended to the higher parents (late flowering parents). The mean of the rest (10 crosses) were intermediate between the two parents involved.

With respect to plant height, the desirable mean values towards short stature were found in four crosses. Complete to overdominance was observed in most crosses towards the taller parents, higher productive tillers plants $^{-1}$, heavier 1000- grain weight, higher filled grain panicle $^{-1}$, higher rate of spikelet fertility, higher grain yield plant^{-1}, longer panicle, heavier panicle weight and longer anther.

Some crosses combinations exhibited dominance effect towards the lower parents viz, for spikelet (three crosses), and for anther width (two crosses).

However, the rest of the hybrid combinations showed intermediate mean values between the parents involved for all studied characters.

Analysis of combining ability variances:

Statistical analysis was done using method 2, Model 2 of Griffing (1956).

Table (2) revealed highly significant differences for the mean square values of general combining ability (GCA) and specific combining ability (SCA) for days to heading , plant height , panicles plant^{-1}, grain yield plant^{-1}, 1000- grain weight (gm), panicle weight(gm), field grains panicles^{-1} , spikelet fertility % and anther length traits . This indicates the importance of both additive and non –additive genetic variance in determining the inheritance of most studied traits.

The relative importance of each gene was determined using GCA /SCA. The GCA/SCA ratios were found to be in favour of additive genetic variance in the inheritance of most traits. This indicates the importance of additive genetic variance. therefore, it could be concluded that selection procedures based on the accumulation of additive effect would be successful in improving traits with cytoplasmic male sterile lines and restoring ability genes transfer.

2

3

Similar results were obtained by El Mowafi *et al.* (2005), Abd-El Hadi and El Mowafi (2005), Abd-El Hadi *et al.* (2009), El-Diasty *et al.* (2008) bagheri and Jelodar (2011), Rahimi *et al.* (2010) and Saidaiah *et al* (2010).

Estimation of general combining ability effect:

Table (4) illustrates the magnitude of GCA effects for the six parents. The restorer variety Giza 178R is the best combiner for days to heading, plant height, grain yield plant^{-1} and panicle length. The restorer line GZ 5121R is the best combiner for panicle weight and anther width traits. The line IR 69625B is the best combiner for days to heading, 1000-grain weight, spikelet fertility% and anther width. While, IR 58025B is the best combiner for panicles plant^{-1}, filled grains panicle^{-1} , panicle length and panicle weight traits . The line Pusa 3B is the best combiner for panicle and anther length, while line Pusa 6B is the best combiner for plant height and anther traits.

Estimation of specific combining ability effects (SCA):

The results presented in Table(5), indicate that the traits depend not only on GCA but also on the SCA.

The SCA effects were important for the crosses GZ 5121R × Pusa 6B for days to heading, GZ 5121R × IR 58025 B for days to heading and filled grains panicle $^{-1}$,Giza 178R × IR 58025B for plant height and 1000-grain weight, Giza 178R × IR 69625B for grain yield plant^{-1} and 1000-grain weight , Giza 178R × Pusa 3B ,and Giza 178R × Pusa 6B for panicle length and 1000-grain weight, GZ 5121R × IR 69625B for grain yield plant^{-1},panicles plant $^{-1}$,panicles plant^{-1} and1000-grain weight , IR 58025 B × Pusa 3B for panicles plant^{-1} and anther length , IR 58025B × Pusa 6B for grain yield plant $^{-1}$, panicles plant^{-1},panicle weight ,filled grains panicle $^{-1}$ spikelet fertility % and anther width and Pusa 3B × Pusa 6B for grain yield plant^{-1}. All these crosses showed highly significant values of SCA effects.

The data in Table (5) indicated that among 15 cross combinations, GZ 5121R × IR 58025 B × Pusa 6B were the best specific combinations for grain yield plant^{-1} which is the most important trait.

4

5

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القدرة علي الائتلاف في بعض هجن الأرز الهجين.

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تم إنتاج خمسة عشر هجينا من تهجين نصف دوري بين ست سلالات من الأرز . استخدم في التحليل الإحصائي لهذه التجربة طريقة جريفنج 1956 الثانية ،النموذج الثاني.حيث تمت زراعة الآباء والجيل الأول في تجربة قطاعات كاملة العشوائية من ثلاث مكررات بمزرعة مركز البحوث و التدريب في الأرز بسخا- كفر الشيخ.

أخذت البيانات علي 11 صفة تشمل الصفات الحقلية و صفات المحصول والسنبلة والصفات الزهرية .

ولقد أظهرت البيانات معنوية كل من تباين القدرة العامة و الخاصة علي الائتلاف لكل الصفات ماعدا صفة عرض المتك و صفة طول السنبلة .

اتضح من النتائج أهمية كل من الفعل التجميعي و الفعل السيادي للجين في وراثة معظم الصفات. ولقد تبين من النسبة بين تباين القدرة العامة و الخاصة علي الائتلاف أن التباين الوراثي التجميعي له الدور الأهم في وراثة معظم الصفات المدروسة.

قام بتحكيم البحث

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Table 2 . Estimates of the mean square of ordinary analysis and combining ability analyses for all the studied traits.

s.o.v	d.f	Agronomic character		Yield and its component					Panicle character		Floral Trait	
		Days to heading (days)	Plant height (cm)	Panicles plant^{-1}	1000-grain weight (g)	Filled grains panicle^{-1}	Spikelet fertility %	Grain yield plant^{-1} (g)	Panicle length (cm)	Panicle Weight (g)	Anther length	Anther width
Reps	2	0.39	1.67	0.45	0.29	52.81	5.764	2.96	0.78	0.018	0.0011	0.0029**
Genotypes	20	69.94**	61.73**	17.95**	6.61**	1664.04**	18.659**	17.95**	8.94**	1.369**	0.1356**	0.0034
GCA	5	73.20**	27.44**	20.21**	5.80**	1311.21**	7.877**	20.21**	6.95	0.294**	0.1305**	0.0041**
SCA	15	6.68**	18.29**	1.24	1.0**	302.50**	5.667**	1.24	1.66**	0.510**	0.0168**	0.0002
Error	40	1.27	2.90	0.66	0.17	31.21	6.428	0.66	0.35	0.054	0.0057	0.0004
GCA/SCA ratio		1.66	0.20	4.20	0.76	0.557	0.203	4.20	0.63	0.070	1.4028	0.057

*,**significant at 0.05 and 0.01 levels, respectively.

Table 3. Mean performance for all studied traits:

Genotype	Agronomic character		Yield and its component					Panicle characters		Floral Traits	
	Days to heading (days)	Plant height (cm)	Panicles plant^{-1}	1000-grain weight (g)	Filled grains panicle^{-1}	Spikelet fertility %	Grain yield plant^{-1} (g)	Panicle length (cm)	Panicle Weight (g)	Anther length	Anther width
Parents:											
Giza 178R	101.53	96.10	23.17	21.47	178.27	91.91	39.27	23.23	3.60	1.57	0.44
GZ 5121R	108.30	93.20	24.60	26.07	140.17	92.92	33.17	21.00	3.68	1.53	0.48
IR 69625B	99.33	103.10	20.57	27.42	135.87	97.54	34.85	23.03	3.16	1.74	0.44
IR 58025B	116.10	105.47	26.00	23.24	194.00	86.87	30.20	25.13	3.69	1.70	0.37
Pusa 3B	110.50	102.70	17.07	23.33	170.17	95.37	24.19	24.63	2.76	2.07	0.40
Pusa 6B	107.50	95.73	20.77	23.37	173.70	91.23	36.99	22.03	3.06	2.04	0.35
Hybrid combinations:											
Giza 178R × GZ 5121R	105.50	101.63	25.50	24.80	192.97	95.68	44.28	24.40	4.38	1.85	0.46
Giza 178R ×IR 69625B	99.43	107.80	22.97	26.80	184.77	92.56	49.07	26.03	4.48	1.90	0.42
Giza 178R ×IR58025B	106.77	99.87	24.83	24.93	215.00	92.83	37.84	26.87	4.38	1.80	0.37
Giza 178R × Pusa 3B	105.53	107.50	20.43	24.63	191.20	91.58	36.76	27.47	4.37	2.13	0.41
Giza 178R × Pusa 6B	104.17	105.80	22.87	25.17	198.97	90.07	40.51	26.30	4.67	2.03	0.38
GZ 5121R ×IR 69625B	100.60	100.10	25.73	28.31	154.27	94.97	41.14	22.23	4.30	1.78	0.44
GZ 5121R ×IR58025B	105.87	109.20	26.27	24.83	217.30	93.01	30.81	24.67	5.15	1.70	0.39
GZ 5121R × Pusa 3B	104.60	107.27	21.73	25.08	183.53	90.69	28.13	23.83	5.02	1.91	0.44
GZ 5121R × Pusa 6B	100.43	101.83	22.70	25.13	189.30	88.05	39.75	23.17	4.49	1.74	0.42
IR 69625B ×IR58025B	108.87	109.87	23.77	25.35	178.07	91.52	31.13	25.57	3.95	1.81	0.39
IR 69625B × Pusa 3B	106.07	106.23	20.60	25.80	173.00	93.35	29.10	25.50	4.05	2.16	0.42
IR 69625B × Pusa 6B	103.60	100.73	22.33	.25.12	189.33	92.80	39.69	23.80	4.13	2.08	0.39
IR 58025B × Pusa 3B	117.43	106.07	24.50	24.88	218.57	95.07	26.57	26.17	5.14	2.18	0.39
IR 58025B × Pusa 6B	110.40	101.00	25.67	24.19	224.83	94.01	42.69	26.20	5.02	2.10	0.37
Pusa 3B×Pusa6B	107.20	105.00	19.87	24.67	193.50	92.40	20.91	25.80	3.91	2.29	0.39
LSD 0.05			1.34	0.69	9.22	4.18	3.17	0.97	0.38	0.124	0.033
0.01			1.79	0.92	12.33	5.60	4.24	1.30	0.51	0.166	0.044

Table 4: Estimates of GCA effects for all studied traits:

Parent	Agronomic character		Yield and its component					Panicle character		Floral Trait	
	Days to heading (days)	Plant height (cm)	Panicles plant^{-1}	1000-grain weight	Filled grains panicle^{-1}	Spikelet fertility %	Grain yield plant^{-1} (g)	Panicle length (cm)	Panicle Weight (g)	Anther length	Anther width
Giza 178R	-2.326*	-0.908	0.286	-0.700*	5.064	-0.200	4.331**	0.647	0.045	-0.065	0.009
GZ 5121R	-1.185	-1.954	1.311	0.677	-10.153*	0.012	-0.237	-1.507**	0.197	-0.167**	0.031
IR 69625B	-3.293**	1.108	-0.514	1.421**	-18.469**	1.515	0.935	-0.394	-0.239	-0.020	0.013
IR 58025B	4.744**	1.858	2.049**	-0.524	17.856**	-0.994	-2.863	0.922	0.236	-0.048	-0.026
Pusa 3B	2.344*	1.925	-2.422**	-0.392	0.151	0.712	-5.313**	0.710	-0.140	0.180**	-0.001
Pusa 6B	-0.285	-2.029	-0.710	-0.482	5.551	-1.045	3.149	-0.378	-0.099	0.120	-0.026
SD	1.86	2.812	1.34	0.69	9.22	4.18	3.17	0.97	0.38	0.124	0.033

*,**significant at 0.05 and 0.01 levels, respectively.

Table 5: Estimates of SCA effect for all studied traits.

Hybrid	Agronomic character		Yield and its component					Panicle character		Floral Trait	
	Days to heading (days)	Plant height (cm)	Panicles plant^{-1}	1000-grain weight	Filled grains panicle^{-1}	Spikelet fertility %	Grain yield plant^{-1} (g)	Panicle length (Cm)	Panicle Weight (g)	Anther length	Anther width
Giza 178R x GZ 5121R	2.857**	1.343	0.954	-0.157	12.495**	3.280	4.133*	0.637	-0.020	0.174**	0.011
xIR 69625B	-1.101	4.448**	0.245	1.099**	12.612**	-1.349	7.751**	1.158*	0.513**	0.074	-0.007
xIR58025B	-1.805	-4.236**	-0.451	1.178**	6.520	1.428	0.319	0.675	-0.063	-0.002	-0.026
x Pusa 3B	-0.639	3.331*	-0.380	0.739*	0.424	-1.525	1.693	1.487**	0.304	0.107	-0.003
x Pusa 6B	0.624	50585**	0.341	1.368**	2.791	-1.274	-3.019	1.408**	0.562**	0.067	-0.010
GZ 5121R xIR 69625B	-1.076	-2.207	1.987**	1.232**	-2.671	0.846	1.987**	-0.488	0.177	0.059	-0.010
xIR58025B	-3.847**	60143**	-0.042	-0.306	24.037**	1.404	-0.042	0.629	0.558**	0.006	-0.022
x Pusa 3B	-2.714**	4.143**	-0.105	-0.188	7.974	-2.625	-0.105	0.008	0.805**	-0.014	0.004
x Pusa 6B	-4.251**	2.664	-0.851	-0.046	8.341	-3.513	-0.851	0.429	0.233	-0.122	0.002
IR 69625B xIR58025B	0.761	3.748*	-0.717	-0.523	-6.880	-1.596	-0.717	0.417	-0.209	-0.036	0.000
x Pusa 3B	0.861	0.048	0.587	-0.205	5.758	-1.469	0.587	0.562	0.268	0.89	-0.001
x Pusa 6B	1.024	-1.498	0.608	-0.802*	16.691**	-0.267	0.608	-0.050	0.303	0.072	-0.002
IR 58025B x Pusa 3B	4.190**	-0.869	1.924**	0.817*	14.999**	2.765	1.924**	-0.087	0.879**	0.136*	0.005
x Pusa 6B	-0.214	-1.982	1.379*	0.216	15.866**	3.458	1.379*	1.033*	0.724**	0.120	0.016
Pusa 3BxPusa6B	-1.014	1.952	0.049	0.564	2.237	0.141	0.049	0.846	-0.013	0.081	0.007
SD	1.86	2.81	1.349	0.69	9.22	4.18	1.34	0.970	0.38	0.124	0.033

*,** significant at 0.05 and 0.01 levels, respectively.