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RESEARCH **P**APER

Study of combining ability using CMS line in hybrid rice (*Oryza sativa* L.)

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Combining ability revealed higher specific combining ability variance than their respective general combining ability variances indicating the predominance of non-additive gene effects indicated relevance of heterosis breeding for improving the yield and yield contributing attributes. Among the testers high GCA was recorded in Sarjoo 52 and Narendra Usar 3 for harvest index, grain yield plant^{-1}, days to 50% flowering (earliness), plant height (dwarf stature), panicle bearing tillers plant^{-1} and biological yield. Among the female parental lines, IR 58025 was observed as a good general combiner only for seedling height, panicle length, spikelets panicle^{-1}, test weight, biological yield palnt^{-1}. Cross between IR 688897A X Sarjoo 52 , IR 58025 A X 21-2-5-B-1-1, IR 58025 A X Narendra Usar 3 and IR 58025 A X IR 71829-3R-73-1-2-B shown favorable *per se* performances and higher significant positive SCA effects in related to grain yield plant^{-1}.These combinations proved to be good hybrids based on CMS system in rice.

Key words : Combining ability, Line x tester, Rice hybrids

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INTRODUCTION

Rice is one of the most important crop plants in the world and is the main nutritional staple food for approximately of the world's population Therefore, increasing its productivity is of high importance in breeding programs. Reduced plant height, oderate tillering, large and compact panicles, increased kernel number per panicle, increased thousand kernel weight and higher yield are the most important rice characters to be improved in breeding programmes. Since some rice hybrids show heterosis, it subsequently result to production yields which is to higher than inbred varieties and finding a better cross combination is of high importance. Line × tester analysis is used to evaluate the general and specific combining ability of various lines and to estimate gene effects and it is useful in deciding the relative ability of female and male lines to produce desirable hybrid combinations.

To full-fill the demand of increasing population, developing new high yielding hybrids and improved lines/ varieties along with stable performance in different agro climatic is a big challenge. Genetic improvement depends on the availability high magnitude of genetic variability in germplasm. The most common, easy and effective means for developing/identifying new hybrids or line is by utilizing cytoplasmic genetic male sterility (CMS) technique in the hybrid breeding programme is fruitful. The development and use of hybrid rice varieties on commercial scale utilizing CMS - fertility restoration system has now proved to be one of the plausible milestones in the history of rice improvement. The hybrid rice technology now in operation, aims at yield augmentation through higher exploitable heterosis levels. With the moto of increasing interest in exploitation of heterosis in rice, there is an urgent need to make available various CMS lines and good restoration capability lines for combining ability tests. nicking ability in self-pollinated crops and at the same time elucidate the nature and

magnitude of gene actions involved, provides to the breeder about insight of nature and relative magnitude of fixable and non-fixable genetic variances *i.e.* Due to dominance or epistatic components. Hence, this study provides useful information for the selection of donor parents for effective breeding programme. Such informations are required to design efficient breeding programmes for rapid dynamic and strategic crop improvement for quantitative along with qualitative nature of traits.

RESEARCH METHODOLOGY

Plant materials :

The experimental material for this investigation comprised of 2 CMS lines *viz*., IR 68897 A and IR 58025 A possessing "wild abortive" (WA) cytoplasm as lines (females), 20 diverse rice varieties/genotypes as testers (males) and 40 crosses obtained through crossing in a "line × tester" mating design (Kempthorne, 1957). These diverse elite strains were selected from the collection of genetic stock available in Rice Section of the Department of Genetics and Plant Breeding, N.D. University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad. The resulting set of 40 F_1's along with their 22 parents were evaluated in Randomized Complete Block Design with three replications during *Kharif,* 2010. All the recommended cultural practices were followed to raise a good crop. The experimental data collected on ten characters *i.e.* days to 50% flowering, flag leaf area, plant height, panicle bearing tillers plant^{-1}, panicle length, spikelets panicle^{-1}, grain yield plant^{-1}, test weight, biological yield plant^{-1} and harvest index .

Statistical analysis :

Data were recorded on five randomly selected plants from parents and F_1 s plant samples. The combining ability analysis was carried out following line × tester mating design outlined by Kempthorne (1957) and further elaborated by Arunachalam (1974).

RESEARCH FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

General combining ability:

Estimates of GCA effects showed that it was difficult to choose a good combiner for all the traits as the combining ability effects were not consistent for all the yield components. It might possible due to low negative association of characters. The GCA effects of parent have been presented in Table 1. It is noted that top two males, NDRK 5095 and NDRK 5013 proved the best general combiner for seedling height and number of

Table 1 : Estimates of general combining ability effects (GCA) of parent (males and females) for 13 characters in rice

Parental lines	Seedling height (cm)	Number of leaves per seedling	Days to 50% flowering	Flag leaf area (cm^2)	Plant height (cm)	Panicle bearing tillers per plant
Male						
IR 70023-4B-R-12-3-1-1-B	1.204**	-0.266*	1.189	1.811**	7.465**	-1.607**
IR 61920-3B-22-2-1	-2.885**	0.423**	-0.478	5.231**	5.088**	-1.118**
PNL 1-8-5-17-2	3.571**	0.090	3.522**	1.778**	-3.963**	0.326
NDRK 5095	8.604**	0.446**	-0.033	-0.044	3.465**	-0.363
NDRK 5056	-1.896**	-0.243	-4.256**	-1.233**	-2.624**	0.859**
NDRK 5086	2.004**	0.134	-1.033	-0.722	-1.079*	0.882**
NDR 9830119	-2.418**	-0.310*	-1.033	3.400**	2.099**	-0741*
NDRK 5013	5.648**	0.312*	-1.033	-1.122**	2.432**	-2.918**
CST 7-1	-1.374**	0.112	-0.033	2.311**	-11.190**	-0.629
21-2-5-B-1-1	-0.174	0.290*	-1.811	2.836**	5.965**	0.259
IR 64	-1.385**	0.001	0.744	-3.756**	-3.924**	-1.918**
NDR 9830148	2.671**	0.290*	-0.589	-2.867**	7.699**	-2.529**
CSRC(S) 14-1-4-0	-4.363**	-0.354**	-1.922	0.200	9.354**	-1.896**
PNL 5-8-1-7-21	-1.574**	-0.110	-1.478	-0.911*	-6.657**	0.548
IR 72048-B-R-2-2-2-1-B	0.204	-0.354**	2.078*	-1.328**	0.332	1.726**
IR 71829-3R-73-1-2-B	-4.485**	-0.332*	2.856**	-3.933**	-2.213**	1.348**
NDRK 5094	1.537**	0.134	3.967**	2.300**	-2.668**	-1.163**

Contd.…….. Table 1

Contd…….. Table 1

92-H 51-4	-0.074	-0.177	1.300	6.789**	2.376**	-0.518
Narendra Usar 3	-0.152	-0.154	3.078**	0.360	-3.613**	1.171**
Sarjoo 52	-4.663	0.068	-5.033**	-6.478**	-8.346	8.282**
SE (gi)	0.3145	0.1290	1.0066	0.3923	0.4974	0.3202
SE (gi-gj)	0.4448	0.1825	1.4235	0.5548	0.7034	0.4528
CD (1%)	0.8234	0.3378	2.6354	1.0272	1.3022	0.8383
CD (5%)	0.6228	0.2555	1.9933	0.7769	0.9850	0.6341
Female						
IR 688897A	-2.379**	0.088	-2.239**	-1.449**	-4.410**	1.036**
IR 58025 A	4.174**	-0.156**	0.611	3.276**	10.444**	-0.646**
PUSA 6A	-1.794**	0.068	1.628**	-1.827**	-6.304**	-0.389**
SE (gj)	0.1218	0.0500	0.3899	0.1519	0.1926	0.1240
SE (gi-gj)	0.1723	0.0707	0.5513	0.2149	0.2724	0.1754
C.D. (P=0.01)	0.3189	0.1308	1.0207	0.3978	0.7133	0.3247
C.D. (P=0.05)	0.2412	0.0990	0.7720	0.3009	0.5395	0.2456

Contd…….. Table 1

Table 1 contd…..

Parental lines	Panicle length (cm)	Spikelets per panicle	Spikelet fertility (%)	Test weight (g)	Biological yield per plant (g)	Harvest index (%)	Grain yield per plant (g)
Male							
IR 70023-4B-R-12-3-1-1-B	2.271**	-39.333**	2.212*	-3.181**	-35.216**	-7.287**	-18.016**
IR 61920-3B-22-2-1	-0.507	-13.667**	-1.922*	-3.081**	22.084**	-5.045**	-14.907**
PNL 1-8-5-17-2	-3.129**	-6.089	3.167**	0.053	-23.612**	5.736**	-0.601
NDRK 5095	3.226**	-22.889**	0.812	1.408**	-14.350**	0.049	-4.512**
NDRK 5056	-0.318	16.669**	7.189**	-2.003**	3.128	2.126*	5.401**
NDRK 5086	-2.085**	-0.889	-9.499**	-0.503*	4.306*	-6.025**	-7.232**
NDR 9830119	1.759**	28.111**	9.045**	-1.459**	38.306**	-5.230**	3.079*
NDRK 5013	-0.341	-18.311**	-17.788**	3.108**	-33.850**	-8.081**	-18.872**
CST 7-1	-1.318**	-5.356	3.734**	0.630**	4.750*	0.800	1.479
21-2-5-B-1-1	-0.141	22.111**	3.123**	1.408**	3.573	6.673**	14.093**
IR 64	-3.041**	-4.622	8.545**	-0.347	-23.794**	0.937	-5.503**
NDR 9830148	1.193**	-17.533**	-5.855**	0.130	-32.672**	-7.074**	-17.194**
CSRC(S) 14-1-4-0	-0.052	6.667	-3.799**	1.303**	2.850	-2.415*	-6.092**
PNL 5-8-1-7-21	-1.429**	2.667	6.223**	0.253	-2.627	5.296**	6.735**
IR 72048-B-R-2-2-2-1-B	3.782**	7.155	1.712	-0.322	9.517**	3.707**	7.975**
IR 71829-3R-73-1-2-B	-0.274	2.444	-5.944**	-1.807**	-9.261**	-1.682	-1.327
NDRK 5094	-0.496	-2.311	8.556**	2.453**	-13.841**	6.743**	4.673**
92-H 51-4	-0.274	10.044*	-14.688**	-0.081	38.028**	-6.353**	-4.079**
Narendra Usar 3	0.204	37.355**	7.656**	-0.403*	15.862**	6.999**	18.410**
Sarjoo 52	0.971**	-2.222	-2.477**	2.441**	46.817**	10.128**	36.490**
SE (gi)	0.3497	4.9879	0.8664	0.1996	1.8941	0.9988	
SE (gi-gj)	0.4945	7.0539	1.2253	0.2822	2.6786	1.4125	
C.D. (P=0.01)	0.9155	13.0590	2.2685	0.5225	4.9589	2.6150	
C.D. (P=0.05)	0.6925	9.8774	1.7158	0.3952	3.7508	1.9779	
Female							
IR 688897A	-0.839***	-12.472***	0.541	-0.340***	-17.209***	3.153***	-0.385
IR 58025 A	1.546***	8.161***	-2.189***	0.308***	27.975***	-4.738***	0.958
PUSA 6A	-0.706***	4.311*	1.649***	0.032	-10.765***	1.585***	-0.574
SE (gj)	0.1354	1.9318	0.3356	0.0773	0.7336	0.3868	05593
SE (gi-gj)	0.1915	2.7320	0.4746	0.1093	1.0374	0.5471	0.7909
C.D. (P=0.01)	0.3546	5.0577	08786	0.2023	1.9206	1.0128	1.4642
C.D. (P=0.05)	0.2682	3.8255	06645	0.1530	1.4527	07660	1.1075

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 2: Estimates of specific combining ability effects (SCA) of hybrids for 13 characters in rice

Hybrids	Seedling height (cm)	Number of leaves seedling^{-1}	Days to 50% flowering	Flag leaf length (cm)	Plant height (cm)	Panicle bearing tillers plant^{-1}
IR 688897A X IR 70023-4B-R-12-3-1-1-B	-0.987	0.446*	-2.206	-1.151	-6.804**	-0.991
IR 688897A X IR 61920-3B-22-2-1	0.835	0.290	-5.872**	-4.011**	-6.693**	-1.213*
IR 688897A X PNL 1-8-5-17-2	-1.821**	0.223	-6.539**	1.016	0.273	-0.191
IR 688897A X NDRK 5095	-3.454**	-0.466*	-0.650	1.171	-0.804	0.031
IR 688897A X NDRK 5056	0.779	0.223	0.239	1.527*	3.151**	-0.924
IR 688897A X NDRK 5086	1.479**	0.046	0.017	0.649	-1.893*	-0347
IR 688897A X NDR 9830119	-0.698	0.223	1.017	-2.307**	-3.671**	0.742
IR 688897A X NDRK 5013	3.502**	-0.199	-3.983*	1.416*	-6.071**	-0.080
IR 688897A X CST 7-1	-6.809**	-0.332	1.017	0.871	7.551**	-0.302
IR 688897A X 21-2-5-B-1-1	-2.143**	0.157	1.461	-1.235	-1.938*	-1.458**
IR 688897A X IR 64	-6.798**	-0.488*	-1.428	-1.051	6.284**	1.587**
IR 688897A X NDR 9830148	0.146	-0.557*	4.906**	1.660*	-3.338**	1.631**
IR 688897A X CSRC(S) 14-1-4-0	5.179**	0.601**	-0.094	-1.840**	-1.027	1.431*
IR 688897A X PNL 5-8-1-7-21	-0.676	-0.310	-1.206	1.771*	5.018**	0.053
IR 688897A X IR 72048-B-R-2-2-2-1-B	7.546**	0.001	3.572*	3.271**	3.662**	0.209
IR 688897A X IR 71829-3R-73-1-2-B	0.235	-0.021	2.461	0.827	-2.093*	0.187
IR 688897A X NDRK 5094	-0.787	-0.021	4.683**	-2.540**	3.862**	-0.436
IR 688897A X 92-H 51-4	1.091*	-0.043	3.550	-2.362**	-4.016**	0.053
IR 688897A X Narendra Usar 3	-1.032	-0.399	-3.094	0.447	3.307**	0.631
IR 688897A X Sarjoo 52	4.413**	0.446*	2.350	1.871	5.240**	-0.613
IR 58025 A X IR 70023-4B-R-12-3-1-1-B	-2.141**	-0.178	-0.389	1.424*	7.678**	0.491
IR 58025 A X IR 61920-3B-22-2-1	-1.252*	-0.867**	6.278**	8.204**	10.256**	1.668**
IR 58025 A X PNL 1-8-5-17-2	3.159**	0.600**	7.611**	-3.476**	-5.828**	-0.909
IR 58025 A X NDRK 5095	0.859	0.578*	-3.500*	-1.921**	6.745**	-0.554
IR 58025 A X NDRK 5056	-0.907	-0.133	-1.944	-0.798	-7.300**	1.957**
IR 58025 A X NDRK 5086	0.326	-0.178	-5.833**	-0.976	7.289**	1.935**
IR 58025 A X NDR 9830119	-3.918**	-0.333	-2.833	5.902**	3.245**	-1.176*
IR 58025 A X NDRK 5013	4.948**	1.044**	4.500*	-3.576**	7.978**	-1.732**
IR 58025 A X CST 7-1	8.971**	-0.022	-3.500*	-2.987**	-10.266**	1.379*
IR 58025 A X 21-2-5-B-1-1	5.771**	0.200	-2.389	1.366*	4.378**	2.357**
IR 58025 A X IR 64	11.215**	0.889**	-0.278	1.124	-8.733**	-2.598**
IR 58025 A X NDR 9830148	2.326**	0.067	-1.278	-1.432*	5.511**	-2.521**
IR 58025 A X CSRC(S) 14-1-4-0	-10.707**	-1.156**	0.722	4.168**	2.456**	-1.554**
IR 58025 A X PNL 5-8-1-7-21	3.571**	0.467*	0.611	-3.721**	-11.200**	-1.265*
IR 58025 A X IR 72048-B-R-2-2-2-1-B	-8.541**	-0.422	4.389*	-2.437**	-5.855**	-0.509
IR 58025 A X IR 71829-3R-73-1-2-B	1.082*	-0.044	0.278	-2.565**	4.356**	2.068**
IR 58025 A X NDRK 5094	-1.874**	0.022	0.500	4.335**	-5055**	-0.421
IR 58025 A X 92-H 51-4	-1.329*	0.067	-3.167	4.446**	8.900**	0.268
IR 58025 A X Narendra Usar 3	-2.318**	-0.222	3.389	-4.125**	-6.444**	0.846
IR 58025 A X Sarjoo 52	-9.241**	-0.378	-5.167**	-2.954**	-8.111**	0.268
PUSA 6A X IR 70023-4B-R-12-3-1-1-B	3.128**	-0.268	2.594	-0.273	-0.874	0.501
PUSA 6A X IR 61920-3B-22-2-1	0.417	0.577*	-0.406	-4.193**	-3.563**	-0.455
PUSA 6A X PNL 1-8-5-17-2	-1.339**	-0.823**	-1.072	2.460**	5.554**	1.101*
PUSA 6A X NDRK 5095	2.594**	-0.112	4.150*	0.749	-5.940**	0.523
PUSA 6A X NDRK 5056	0.128	-0.290	1.706	-0.728	4.149**	-1.033
PUSA 6A X NDRK 5086	-1.806**	0.132	5.817**	0.327	-5.396**	-1.588**
PUSA 6A X NDR 9830119	4.617**	0.110	1.817	-3.595**	0.426	0.434**
PUSA 6A X NDRK 5013	-8.450**	-0.846**	0.517	2.160**	-1.907*	1.812**
PUSA 6A X CST 7-1	-2.161**	0.354	2.483	2.116**	2.715**	-1.077
PUSA 6A X 21-2-5-B-1-1	-3.628**	-0.357	0.978	-0.131	-2.440**	-0.899
PUSA 6A X IR 64	-4.417**	-0.401	1.706	-0.073	2.449**	1.012
PUSA 6A X NDR 9830148	-2.472**	0.510*	-3.628*	-0.228	-2.174*	0.889
PUSA 6A X CSRC(S) 14-1-4-0	5.528**	0.554*	-0.628	-2.328**	-1.429	0.123
PUSA 6A X PNL 5-8-1-7-21	-2.894**	-0.157	0.594	1.949**	6.182**	1.212*
PUSA 6A X IR 72048-B-R-2-2-2-1-B	0.994	0.421	-7.661**	-0.834	2.193*	0.301
PUSA 6A X IR 71829-3R-73-1-2-B	-1.317*	0.066	-2.739	1.738*	-2.263**	-2.255**
PUSA 6A X NDRK 5094	2.661**	-0.001	-7.183**	-1.795**	1.193	0.856
PUSA 6A X 92-H 51-4	0.239	-0.023	-0.183	-2.084**	-4.885**	-0.322
PUSA 6A X Narendra Usar 3	3.350**	0.621**	-0.294	3.678**	3.138**	-1.477**
PUSA 6A X Sarjoo 52	4.828**	-0.068	-2.817	1.083	2.871**	0.345
SE (Sij)	0.545	0.224	1.744	0.680	0.862	0.555
SE (Sij-Skl)	0.7704	0.3160	2.4656	0.9610	1.2183	0.7843
C.D. (P=0.01)	2.0169	0.8274	6.4554	2.5161	3.1898	2.0534
C.D. (P=0.05)	1.5255	0.6258	4.8827	1.9031	2.4126	1.5531

Table 2 ……

Contd….Table 2

Hybrids	Panicle length (cm)	Spikelets per panicle	Spikelet fertility (%)	Test weight (g)	Biological yield per plant (g)	Harvest index (%)	Grain yield per plant (g)
IR 688897A X IR 70023-4B-R-12-3-1-1-B	-0.394	43.583**	7.248**	1.329**	18.254**	6.545**	10.283**
IR 688897A X IR 61920-3B-22-2-1	1.151	32.583**	4.515**	1.962**	-46.713**	7.803**	8.167**
IR 688897A X PNL 1-8-5-17-2	1.206*	22.339*	4.259**	-1.471**	27.263**	-2.098	5.874*
IR 688897A X NDRK 5095	0.384	10.139	4.048**	-1.026**	5.087	1.952	2.732
IR 688897A X NDRK 5056	0.695	-31.752**	1.471	-1.582**	0.743	-8.821**	-12.995**
IR 688897A X NDRK 5086	-1.072	6.139	2.559	-2.115**	-15.535**	4.140*	0.305
IR 688897A X NDR 9830119	-0.449	-19.528*	-1.318	-0.726*	-26.502**	2.628	-2.760
IR 688897A X NDRK 5013	-1.616**	15.561	0.782	-0.360	9.587**	2.129	3.605
IR 688897A X CST 7-1	-1.772**	-28.728**	-8.341**	-1.882**	-46.746**	-0.795	-17.553**
IR 688897A X 21-2-5-B-1-1	-1.583*	-20.194*	-4.129**	-1.626**	-10.635**	-9.539**	-20.446**
IR 688897A X IR 64	0.251	-14.128	1.782	3.596**	27.865**	4.665**	13.363**
IR 688897A X NDR 9830148	-0.616	27.450**	-1.418	0.318	21.776**	6.462**	11.927**
IR 688897A X CSRC(S) 14-1-4-0	0.295	-8.417	2.826	-0.554	-11.746**	5.800**	5.992*
IR 688897A X PNL 5-8-1-7-21	-0.294	-11.417	6.863**	0.496	0.698	-3.364	-5.575*
IR 688897A X IR 72048-B-R-2-2-2-1-B	1.462*	-16.239	-12.385**	0.070	-18.346**	-3.699*	-11.802**
IR 688897A X IR 71829-3R-73-1-2-B	0.751	1.806	-15.729**	-3.644**	-7.668*	-10.803**	-18.400**
IR 688897A X NDRK 5094	-0.627	-0.772	-1.563	1.096**	12.645***	-1.442	0.614
IR 688897A X 92-H 51-4	3.351**	-9.128	18.715**	3.829**	1.876	2.141	11.438**
IR 688897A X Narendra Usar 3	-0427	-8.439	-2.596	-0.815*	11.543**	-3.671	-3.637
IR 688897A X Sarjoo 52	-0.694	9.139	6.137**	3.107**	46.554**	-0.033	18.869**
IR 58025 A X IR 70023-4B-R-12-3-1-1-B	1.054	-52.384**	-8.622**	-2.919**	-32.563**	-8.138**	-15.014**
IR 58025 A X IR 61920-3B-22-2-1	0.199	-30.717**	-5.355**	-4.952**	109.470**	-17.616**	-12.730**
IR 58025 A X PNL 1-8-5-17-2	-2.479**	-19.228*	7.823**	1.114**	-42.168**	8.547**	-2.483
IR 58025 A X NDRK 5095	0.899	-22.161*	-9.155**	1.025**	-14.763**	-7.207**	-12.038**
IR 58025 A X NDRK 5056	-0.157	-0.046	3.801*	2.170**	-21.508**	13.643**	14.108**
IR 58025 A X NDRK 5086	1.270*	-24.161**	-18.044**	3.817**	-26.419**	-0.002	-6.285*
IR 58025 A X NDR 9830119	0.699	13.505	2.678	1.359**	16.848**	-0.978	0.950
IR 58025 A X NDRK 5013	1.932**	-21.006*	3.512*	0.659	-40.597**	1.297	-7.212**
IR 58025 A X CST 7-1	1.843**	33.905**	7.256**	3.270**	76.737**	0.452	26.717**
IR 58025 A X 21-2-5-B-1-1	3.532**	35.172**	8.401**	2.625**	26.314**	13.512**	35.624**
IR 58025 A X IR 64	-2.434**	29.372**	2.712	-7.152**	-33.052**	-9.604**	-18.747**
IR 58025 A X NDR 9830148	1.266*	-24.117**	18.378**	-1.164**	-27.908**	-2.250	-8.503**
IR 58025 A X CSRC(S) 14-1-4-0	-1.823**	6.616	-8.544**	0.998**	29.777**	-11.699**	-10.665**
IR 58025 A X PNL 5-8-1-7-21	-1.552*	25.283**	5.167**	-0.286	-2.286	-0.363	1.375
IR 58025 A X IR 72048-B-R-2-2-2-1-B	-1.657**	26.261**	10.345**	1.199**	37.570**	-0.428	14.062**
IR 58025 A X IR 71829-3R-73-1-2-B	0.599	-5.495	17.067**	6.394**	13.481**	18.674**	33.050**
IR 58025 A X NDRK 5094	2.554**	31.994**	3.234*	-0.286	-15.846**	6.656**	6.084*
IR 58025 A X 92-H 51-4	-5.534**	-14.628	-40.322**	-6.086**	27.525**	-17.804**	-31.112**
IR 58025 A X Narendra Usar 3	-0.079	32.661**	4.267**	2.970**	-2.241	12.590**	22.293**
IR 58025 A X Sarjoo 52	-0.179	-20.828*	-4.599**	-4.808**	-78.363**	0.718	-29.474**
PUSA 6A X IR 70023-4B-R-12-3-1-1-B	-0.661	8.800	1.373	1.590**	14.310**	1.593	4.731
PUSA 6A X IR 61920-3B-22-2-1	-1.349*	-1.867	0.840	2.990**	-62.757**	9.812**	4.562
PUSA 6A X PNL 1-8-5-17-2	1.273*	-3.111	-12.082**	0.357	14.905**	-6.449**	-3.391
PUSA 6A X NDRK 5095	-1.283*	12.022	5.107**	0.001	9.676**	5.254**	9.307**
PUSA 6A X NDRK 5056	-0.538	31.798**	-5.271**	-0.588	20.765**	-4.822**	-1.113
PUSA 6A X NDRK 5086	-0.205	18.022*	15.484**	-1.755**	41.954**	-4.138*	5.980*
PUSA 6A X NDR 9830119	-0.249	6.022	-1.360	-0.632	9.654**	-1.650	1.809
PUSA 6A X NDRK 5013	-0.316	5.445	-4.293**	-0.299	31.010**	-3.426	3.607
PUSA 6A X CST 7-1	-0.072	-5.178	1.084	-1.388**	-29.990**	-0.343	-9.164**
PUSA 6A X 21-2-5-B-1-1	-1.949**	-14.978	-4.271**	-0.999**	-15.679**	-3.973*	-15.178**
PUSA 6A X IR 64	2.184**	-15.244	-4.493**	3.557**	5.187	4.940**	5.385*
PUSA 6A X NDR 9830148	-0.649	-3.333	-16.960**	0.846*	6.132	-4.212*	-3.424
PUSA 6A X CSRC(S) 14-1-4-0	1.528*	1.800	5.718**	-0443	-18.024**	5.899**	4.674
PUSA 6A X PNL 5-8-1-7-21	1.806**	-13.867	1.696	-0.210	1.587	3.728*	4.200
PUSA 6A X IR 72048-B-R-2-2-2-1-B	0.195	-10.022	2.040	-1.269**	-19.224**	4.127*	-2.260
PUSA 6A X IR 71829-3R-73-1-2-B	-1.349*	3.689	-1.338	-2.750**	-5.813	-7.871**	-14.651**
PUSA 6A X NDRK 5094	-1.927**	-31.222**	-1.671	-0.810*	3.201	-5.213**	-6.698**
PUSA 6A X 92-H 51-4	2.184**	23.756**	21.607**	2.257**	-29.402**	15.663**	19.674**
PUSA 6A X Narendra Usar 3	0.506	-24.222	-1.671	-2.155**	-9.302**	-8.919**	-18.665**
PUSA 6A X Sarjoo 52	0.873	11.689	-1.538	1.701**	31.810**	-0.685	10.605**
SE (Sij)	0.606	8.639	1.500	0.346	3.281	1.730	2.501
SE (Sij-Skl)	0.8566	12.2177	2.1223	0.4888	4.6395	2.4465	3.5371
C.D. (P=0.01)	2.2426	31.9878	5.5566	1.2798	12.1468	6.4053	9.2605
C.D. (P=0.05)	1.6962	24.1945	4.2028	0.9680	9.1874	4.8448	7.0044

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 3 : Ranking of five desirable parent on the basis of *per se* performance and GCA effects for 10 characters in rice

Characters	Desirable parent based on *per se* performance	Best general combiners	Best parent based on *per se* performance and GCA effects
Seedling height (cm)	NDRK 5095	NDRK 5095	NDRK 5095
	Narendra Usar 3	NDRK 5013	
	NDR 9830148	IR 58025 A	
	92-H 51-4	PNL 1-8-5-17-2	PNL 1-8-5-17-2
	PNL 1-8-5-17-2	NDR 9830148	NDR 9830148
Number of leaves per Seedling		NDRK 5095	NDR 9830148
	IR 58025 A	IR 61920-3B-22-2-1	
	IR 688897A	NDRK 5013	
	IR 64	NDR 9830148	
	NDR 9830148	21-2-5-B-1-1	
Days to 50% flowering	IR 688897A	Sarjoo 52	Sarjoo 52
	IR 58025 A	NDRK 5056	IR 688897A
	NDRK 5013	IR 688897A	
	PNL 1-8-5-17-2	CSRC(S) 14-1-4-0	
	Sarjoo 52		
Flag leaf area (cm^2)	92-H 51-4	92-H 51-4	92-H 51-4
	PNL 1-8-5-17-2	IR 61920-3B-22-2-1	
	21-2-5-B-1-1	CSRC(S) 14-1-4-0	
	Narendra Usar 3	NDR 9830119	
	NDRK 5095	IR 61920-3B-22-2-1	
Plant height (cm)		CST 7-1	
	IR 58025 A	Sarjoo 52	
	IR 688897A	PNL 5-8-1-7-21	IR 688897A
	IR 71829-3R-73-1-2-B		
	CST 7-1	IR 688897A	
Panicle bearing tillers per plant	IR 688897A	Sarjoo 52	Sarjoo 52
	Sarjoo 52	IR 72048-B-R-2-2-2-1-B	IR 72048-B-R-2-2-2-1-B
		IR 71829-3R-73-1-2-B	
	IR 58025 A	Narendra Usar 3	
	IR 72048-B-R-2-2-2-1-B	IR 688897A	IR 688897A
Panicle length (cm)	IR 72048-B-R-2-2-2-1-B	IR 72048-B-R-2-2-2-1-B	IR 72048-B-R-2-2-2-1-B
	92-H 51-4	NDRK 5095	NDRK 5095
	NDRK 5095	IR 70023-4B-R-12-3-1-1-B	IR 70023-4B-R-12-3-1-1-B
	IR 70023-4B-R-12-3-1-1-B	NDR 9830119	
	Sarjoo 52	IR 58025 A	
Spikelets $panicle^{-1}$	IR 58025 A	Narendra Usar 3	Narendra Usar 3
	NDR 9830119	NDRK 5094	
		21-2-5-B-1-1	
	Narendra Usar 3	NDRK 5056	
	IR 688897A	92-H 51-4	
Spikelet fertility (%)	Sarjoo 52	NDR 9830119	
	IR 688897A	NDRK 5094	
	IR 58025 A	IR 64	
		Narendra Usar 3	
	CSRC(S) 14-1-4-0	NDRK 5056	
Test weight (g)	IR 688897A	NDRK 5094	
	Sarjoo 52	21-2-5-B-1-1	
	IR 58025 A	NDRK 5013	NDRK 5013
	NDRK 5013	NDRK 5095	
		21-2-5-B-1-1	
Biological yield per plant (g)	Sarjoo 52	Sarjoo 52	Sarjoo 52
	PNL 5-8-1-7-21	NDR 9830119	
	Narendra Usar 3	92-H 51-4	92-H 51-4
	92-H 51-4	IR 58025 A	
	NDRK 5094	IR 61920-3B-22-2-1	
Harvest index (%)	IR 58025 A	Sarjoo 52	Sarjoo 52
	IR 688897A	Narendra Usar 3	
	Sarjoo 52	21-2-5-B-1-1	
		PNL 1-8-5-17-2	
	PNL 5-8-1-7-21	PNL 5-8-1-7-21	PNL 5-8-1-7-21
Grain yield per plant	Sarjoo 52	Sarjoo 52	Sarjoo 52
(g)	PNL 5-8-1-7-21	Narendra Usar 3	PNL 5-8-1-7-21
	Narendra Usar 3	21-2-5-B-1-1	Narendra Usar 3
	92-H 51-4	IR 72048-B-R-2-2-2-1-B	
	NDRK 5094	PNL 5-8-1-7-21	

Table 4: Ranking of five desirable hybrids on the basis of *per se* performance and SCA effects for 10 characters in rice

Characters	Desirable parent based on *per se* performance	Desirable crosses based on SCA	Common crosses based on *per se* performance and SCA
Seedling height (cm)	IR 58025 A X NDRK 5013 (47.400)	IR 58025 A X IR 64 (11.215)	IR 58025 A X IR 64
	IR 58025 A X IR 64 (46.633)	IR 58025 A X CST 7-1 (8.971)	IR 58025 A X CST 7-1
	IR 58025 A X NDRK 5095 (46.267)	IR 688897A X IR 72048-B-R-2-2-2-1-B (7.546)	
	IR 58025 A X CST 7-1 (44.400)	IR 58025 A X 21-2-5-B-1-1 (5.771)	
	IR 58025 A X PNL 1-8-5-17-2 (43.533)	PUSA 6A X CSRC(S) 14-1-4-0 (5.528)	
Number of leaves per Seedling	IR 58025 A X NDRK 5013 (4.933)	IR 58025 A X NDRK 5013 (1.044)	IR 58025 A X NDRK 5013
	PUSA 6A X IR 61920-3B-22-2-1 (4.800)	IR 58025 A X IR 64 (0.889)	
	PUSA 6A X NDR 9830148 (4.600)	PUSA 6A X Narendra Usar 3 (0.621)	
	IR 58025 A X NDRK 5095 (4.600)	IR 58025 A X PNL 1-8-5-17-2 (0.600)	IR 58025 A X NDRK 5095
	IR 688897A X IR 61920-3B-22-2- (4.533)1	IR 58025 A X NDRK 5095 (0.578)	
Days to 50% flowering	IR 58025 A X Sarjoo 52 (91.333)		
	IR 688897A X IR 61920-3B-22-2-1 (92.333)		IR 688897A X IR 61920-3B-22-2-1
	IR 688897A X NDRK 5013 (93.667)	IR 688897A X PNL 1-8-5-17-2 (-6.539)	
	IR 688897A X NDRK 5056 (94.667)	IR 688897A X IR 61920-3B-22-2-1 (-5.872)	
	IR 58025 A X NDRK 5086 (94.667)	IR 58025 A X NDRK 5086	IR 58025 A X NDRK 5086
Flag leaf area (cm^2)	IR 58025 A X IR 61920-3B-22-2-1 (50.533)	IR 58025 A X IR 61920-3B-22-2-1 (8.204)	IR 58025 A X IR 61920-3B-22-2-1
	IR 58025 A X 92-H 51-4 (48.333)	IR 58025 A X NDR 9830119 (5.902)	IR 58025 A X 92-H 51-4
	IR 58025 A X NDR 9830119 (46.400)	IR 58025 A X 92-H 51-4 (4.446)	IR 58025 A X NDR 9830119
	IR 58025 A X NDRK 5094 (43.733)	IR 58025 A X NDRK 5094 (4.335)	IR 58025 A X NDRK 5094
	IR 58025 A X CSRC(S) 14-1-4-0 (41.467)	IR 58025 A X CSRC(S) 14-1-4-0 (4.168)	IR 58025 A X CSRC(S) 14-1-4-0
Plant height (cm)		IR 58025 A X PNL 5-8-1-7-21 (-11.200)	
		IR 58025 A X CST 7-1 (-10.266)	
	IR 58025 A X CST 7-1 (87.800)	IR 58025 A X IR 64 (-8.733)	IR 58025 A X CST 7-1
		IR 58025 A X Sarjoo 52 (-8.111)	
		IR 58025 A X NDRK 5056 (-7.300)	
Panicle bearing tillers per plant	IR 688897A X Sarjoo 52 (22.800)	IR 58025 A X 21-2-5-B-1-1 (2.357)	
		IR 58025 A X IR 71829-3R-73-1-2-B (2.068)	IR 58025 A X IR 71829-3R-73-1-2-B
	IR 58025 A X Sarjoo 52 (22.000)	IR 58025 A X NDRK 5056 (1.957)	
	IR 58025 A X IR 71829-3R-73-1-2-B (16.8667)	IR 58025 A X NDRK 5086 (1.935)	IR 58025 A X NDRK 5086
	IR 58025 A X NDRK 5086 (16.2667)		
Panicle length (cm)	IR 58025 A X NDRK 5095 (31.267)	IR 58025 A X 21-2-5-B-1-1 (3.532)	IR 58025 A X 21-2-5-B-1-1
	IR 58025 A X 21-2-5-B-1-1 (30.533)	IR 688897A X 92-H 51-4 (3.351)	
	IR 58025 A X IR 70023-4B-R-12-3-1-1-B (30.467)	IR 58025 A X NDRK 5094 (2.554)	
	IR 688897A X IR 72048-B-R-2-2-2-1-B (30.000)		
	IR 58025 A X NDR 9830119 (29.600)		
Spikelets $panicle^{-1}$	IR 58025 A X Narendra Usar 3 (285.733)	IR 688897A X IR 70023-4B-R-12-3-1-1-B (43.583)	IR 58025 A X Narendra Usar 3
	IR 58025 A X 21-2-5-B-1-1 (273.000)	IR 58025 A X 21-2-5-B-1-1 (35.172)	IR 58025 A X 21-2-5-B-1-1
	IR 58025 A X NDR 9830119 (257.333)	IR 58025 A X CST 7-1 (33.905)	
	IR 58025 A X IR 72048-B-R-2-2-2-1-B (249.133)	IR 58025 A X Narendra Usar 3 (32.661)	
		IR 688897A X IR 61920-3B-22-2-1 (32.583)	
Spikelet fertility (%)	IR 688897A X IR 64 (92.333)	PUSA 6A X 92-H 51-4 (21.607)	
	IR 58025 A X NDR 9830148 (91.800)	IR 688897A X 92-H 51-4 (18.715)	IR 58025 A X NDR 9830148
	IR 688897A X IR 70023-4B-R-12-3-1-1-B (91.467)	IR 58025 A X NDR 9830148 (18.378)	
	IR 58025 A X IR 72048-B-R-2-2-2-1-B (91.333)	IR 58025 A X IR 71829-3R-73-1-2-B (17.067)	
	IR 58025 A X Narendra Usar 3 (91.200)	PUSA 6A X NDRK 5086 (15.484)	

Contd…..Table 4

Contd….. Table 4

Test weight (g)	IR 688897A X Sarjoo 52 27.800)	IR 58025 A X IR 71829-3R-73-1-2-B (6.394)	IR 58025 A X IR 71829-3R-73-1-2-B
	IR 58025 A X IR 71829-3R-73-1-2-B (27.487)	IR 58025 A X NDRK 5086 (3.829)	
	IR 58025 A X 21-2-5-B-1-1 (26.933)	IR 688897A X 92-H 51-4 (3.810)	
	IR 58025 A X CST 7-1 (26.800)	IR 688897A X IR 64 (3.596)	IR 58025 A X CST 7-1
	IR 58025 A X NDR 9830119 (26.667)	IR 58025 A X CST 7-1 (3.270)	
Biological yield per plant (g)	IR 58025 A X IR 61920-3B-22-2-1 (297.000)	IR 58025 A X IR 61920-3B-22-2-1 (109.470)	IR 58025 A X IR 61920-3B-22-2-1
	IR 58025 A X CST 7-1 (246.933)	IR 58025 A X CST 7-1 (76.737)	IR 58025 A X CST 7-1
	IR 58025 A X 92-H 51-4 (231.000)	IR 688897A X Sarjoo 52 (46.554)	IR 688897A X Sarjoo 52
	IR 58025 A X NDR 9830119 (220.600)	IR 58025 A X IR 72048-B-R-2-2-2-1-B (37.570)	
	IR 688897A X Sarjoo 52 (213.633)	IR 58025 A X CSRC(S) 14-1-4-0 29.770)	
Harvest index (%)	IR 58025 A X 21-2-5-B-1-1 (49.143)	IR 58025 A X IR 71829-3R-73-1-2-B (18.674)	IR 58025 A X 21-2-5-B-1-1
	IR 58025 A X Narendra Usar 3 (48.547)		IR 58025 A X Narendra Usar 3
	IR 688897A X Sarjoo 52 (46.943)	IR 58025 A X NDRK 5056 (13.643)	
	IR 58025 A X IR 71829-3R-73-1-2-B (45.950)	IR 58025 A X 21-2-5-B-1-1 (13.512)	IR 58025 A X IR 71829-3R-73-1-2-B
		IR 58025 A X Narendra Usar 3 (12.590)	
Grain yield per plant (g)	IR 688897A X Sarjoo 52 (100.2933)	IR 58025 A X 21-2-5-B-1-1 (35.624)	IR 688897A X Sarjoo 52
	IR 58025 A X 21-2-5-B-1-1 (95.993)	IR 58025 A X IR 71829-3R-73-1-2-B (33.050)	IR 58025 A X 21-2-5-B-1-1
		IR 58025 A X CST 7-1 (26.717)	
	IR 58025 A X Narendra Usar 3 (86.980)	IR 58025 A X Narendra Usar 3 (22.293)	IR 58025 A X Narendra Usar 3
	IR 58025 A X IR 71829-3R-73-1-2-B (78.000)	IR 688897A X Sarjoo 52 (18.869)	IR 58025 A X IR 71829-3R-73-1-2-B

leaves seedling^{-1}; Sarjoo 52 and NDRK 5056 for days to 50% flowering (earliness); 92-H 51-4 and IR 61920-3B-22-2-1 for flag leaf area; CST 7-1 and Sarjoo 52 for plant height (dwarf stature); Sarjoo 52 and IR 72048-B-R-2-2-2-1-B for panicle bearing tillers plant^{-1}; IR 72048-B-R-2-2-2-1-B and NDRK 5095 for panicle length; Narendra Usar 3 and NDR 9830119 for spikelets panicle^{-1}; NDR 9830119 and NDRK 5094 for spikelet fertility; NDRK 5013 and NDRK 5094 for test weight; Sarjoo 52 and NDR 9830119 for biological yield; Sarjoo 52 and Narendra Usar 3 for harvest index and grain yield plant^{-1}. Similar findings are also reported by Singh and Kumar (2004); Rosamma and Vijayakumar (2005); Priyanka *et al.* (2014) and Dorosti and Monajjem (2014).

Among the female parental lines, IR 58025 was observed as a good general combiner only for seedling height, panicle length, spikelets panicle^{-1}, test weight, biological yield palnt^{-1}. Whereas, IR 688897 A was good combiner for panicle bearing tillers plant^{-1} and harvest index. These findings are supported by Saleem *et al.* (2010), Patial *et al.* (2016) and Prasad *et al.* (2013) also reported IR 58025 A as good general combiner for seedling vigour.

The GCA effects together with relative *per se* performance is useful for selecting desirable parent with favourable genes for different component of yield. The *per se* performance of the parent and their GCA effects for all the characters (Table 3) were almost in close correspondence which indicates that the *per se* performance of the parent for these traits could possibly be taken as a criterion for selection of parent

Specific combining ability effects :

In the present investigation, none of the 40 hybrids manifested consistently high SCA effects for all the characters. Ghosh (1993) and Dwivedi *et al.* (1999) also observed that no specific combination was desirable for all the traits they studied. The sca effects of parent have been presented in Table 2. The present findings reveled that cross IR 58025 A x 21-2-5-B-1-1, IR 58025 A x IR 71829-3R-73-1-2-B, IR 58025 A x CST 7-1, IR 58025 A x Narendra Usar 3 and IR 688897A x Sarjoo 52 exhibited

high SCA effects for grain yield plant^{-1}. The effect of IR 58025 A x CST 7-1 for grain yield was due to desirable SCA effect of seedling height, plant height, spikelets panicle^{-1}, test weight and biological yiled plant^{-1}. The common crosses based on *per se* performance and SCA effects for all the characters (Table 4) were also in close correspondence. Similar pattern of association between SCA effects for grain yield plant^{-1} with other yield attributing traits were reported by Hasan *et al.* (2013); Adilakshmi and Reddy (2012); Adilakshmi and Upendra (2014) and Dorosti and Monajjem (2014) have suggested that about 20-30% standard heterosis may be considered sufficient to offset the extra cost of hybrid seeds. The favourable *per se* performances and higher significant positive SCA effects in related to grain yield plant^{-1} were found in hybrid IR 688897A X Sarjoo 52, IR 58025 A X 21-2-5-B-1-1, IR 58025 A X Narendra Usar 3 and IR 58025 A X IR 71829-3R-73-1-2-B. These combinations proved to be good hybrids based on CMS system in rice.

LITERATURE CITED

Adilakshmi, D. and Reddy, P.R. (2012). Combining ability analysis for yield components and physiological traits in rice. *Internat. J. Plant Sci.*, **7** : 295-300.

Adilakshmi, D. and Upendra, A. (2014). Combining ability analysis for quality and nutritional traits in rice. *Internat. J. Farm Sci.*, **4**(2): 15-23.

Arunachalam, V. (1974). The fallacy behind the use of modified line x tester design. *Indian J. Genet*, **34**(2): 200-207.

Dorosti, H. and Monajjem, S. (2014). Gene action and combining ability for grain yield and yield related traits in rice (*Oryza sativa* L.). *J. Agric. Sci.*, **9**:100-108.

Dwivedi, D.K., Pandey, M.P., Pandey, S.K. and Li, R. (1999). Studies on screening and genetics of wide compatibility in rice. *Indian J. Genet*., **53**: 1-14.

Ghosh, A. (1993). Combining ability for yield and its related traits in upland rice. *Oryza*, **30** : 275-279.

Hasan, M.J., Kulsum, U.K., Lipi, L.F. and Shamsuddin, A.K.M. (2013). Combining ability studies for developing new rice hybrids in Bangladesh. *Bangladesh J. Bot.*, **42**(2): 215-222.

Kempthorne, O. (1957). *An introduction to genetical statistics* (Ed.). John Wiley and Sons, Inc. New York, USA.

Patial, M., Pal, D. and Kumar, J. (2016). Combining ability and gene action studies for grain yield and its component traits in barley (*Hordeum vulgare* L.) *SABRAO J. Breed. Genet.*, **48** (1) : 90-96.

Prasad, S., Verma, O.P., Treepathi, N., Ashish and Yadav, P.K. (2013). Combining ability for yield and its contributing traits in rice (*Oryza sativa* L.) under salt affected soil. *Internat. J. Sci. & Res.*, **6** : 1050-1054.

Priyanka, K., Jaiswal, H.K. and Waza, S.A. (2014). Combining ability and heterosis for yield, its component traits and some grain quality parameters in rice (*Oryza sativa* L.). *J. Appl. & Natural Sci.*, **6** (2): 495-506.

Rosamma, C.A. and Vijayakumar, N.K. (2005). Heterosis and combining ability in rice (*Oryza sativa* L.). *Indian J. Genet.*, **65**(2): 119-120.

Saleem, M.Y., Mirza, J.I. and Haq, M.A. (2010). Combining ability analysis for yield and related traits in basmati rice (*Oryza sativa* L.). *Pak. J. Bot.*, **42**(1): 627-637.

Singh, N.K. and Kumar, Anand (2004). Combining ability analysis to identify suitable parents for heterotic rice hybrid breeding. *Internat. Rice Res. Notes*, **29**(1): 21-22.