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COMBINING ABILITY FOR QUALITY TRAITS IN RICE (*ORYZA SATIVA* L.)

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Abstract

Combining ability analysis helps in the evaluation of inbreds in terms of their genetic value and in the selection of suitable parents for hybridization. It also helps in the identification of superior cross combinations. Combining ability analysis for yield and grain quality traits was carried out in rice through line x tester mating design of 50 hybrids developed by crossing five females with 10 male lines along with parents. The results were indicative of predominance of non additive gene action for all the quality traits studied. This showed the possibilities of improvement of these traits through heterosis breeding. Based on the *gca* effects of parents, the lines IR 68886A, IR 68885A and IR 68897A and the testers ADT 42, ACK 03002, CO 43, ASD 19 and ASD 16 were the best parents for improvement of quality traits besides grain yield. The hybrid combinations, IR 68886A X White ponni, IR 68897A X ADT 42, IR 58025A X ASD 18, IR 58025A X CO 43, IR 58025A X ACK 03002, IR 68885A X ADT 43, IR 68886A X ADT 41 and IR 68897A X ASD 19 were recorded highest *sca* effects would be suitable for exploiting heterosis for improving quality in rice genotypes.

Key words : Rice, quality, combining ability.

Introduction

Rice is important cereal crop in the world. More than half of the world's population depends on rice for calories and protein, especially in developing countries. By the year, 2025 about 756 million tones of rice grain, which is 70 per cent, more than the current production, will be needed to meet the growing demand (Duwayri *et al.,* 1999). For a systematic breeding programme, it is essential to identify the parents and crosses for further genetic improvement. The combining ability studies of the parents provide information which helps in the selection of better parents for effective breeding. Combining ability analysis also provides information on additive and dominance variance. It's role is important to decide parents, crosses and appropriate breeding procedure to be followed to select desirable segregants (Salgotra *et al*., 2009). Even though many studies have been made on the combining ability for yield and component traits in rice, information on combining ability for kernel quality traits is limited. Hence, an attempt was made to study the combining ability of kernel quality characters in rice through line x tester analysis.

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Materials and Methods

Five exotic male sterile lines *viz*., IR 58025A, IR 62829A, IR 68885A, IR 68886A and IR 68897A (Lines) were crossed with ten testers such as ACK 03002, ADT 39, ADT 41, ADT 42, ADT 43, ASD 16, ASD 18, CO 43, ASD 19 and White ponni. All the 15 parents were raised thrice at an interval of 15 days to ensure synchronization in flowering for the purpose of hybridization in the field during *Kharif* 2003 at Agricultural College and Research Institute, Killikulam, TNAU. Seeds from fifty cross combinations along with 15 parents were raised in Randomized Block Design with 3 replication during rabi 2004. Recommended fertilizer dose and agronomic packages were adopted. Observations were recorded such as L/B ratio (mm), water uptake (g), kernel elongation (cm), volume expansion (ml), alkali value, amylose content (%) and gel consistency (mm). The combining ability analysis was carried out as per the method described by Kempthorne (1957).

Results and Discussion

The variance due to lines and testers and the interaction between lines and testers were significant for all the quality characters. Combining ability analysis revealed that both *gca* and *sca* variances were important

Table 1 : Analysis of variance for combining ability.

Source	df	L/B ratio (mm)	Water uptake (g) (cm)	Kernel elongation (ml)	Volume expansion (cm)	Alkali value (%)	Amylose content (mm)	Gel consi-stency	Grain yield (g)
Replication	2	0.00017	0.00012	0.00003	0.00014	0.00161	0.01064	0.33220	0.03365
Hybrids	49	0.39831**	0.18153**	0.00662**	0.15551**	1.43080**	2.72615**	199.66712**	1017.98029**
Line	4	0.73104**	0.10004**	0.00072**	0.39555**	2.76952**	3.70797**	163.06520**	2241.51656**
Tester	9	1.22962**	0.30677**	0.00655**	0.43227**	0.68723**	3.98354**	933.10133**	519.94488**
L × T	36	0.15351**	0.15927**	0.00729**	0.05965**	1.46795**	2.30271**	20.37545**	1006.54066**
Error	128	0.00007	0.00004	0.00002	0.0005	0.00003	0.01982	0.01960	0.16622
GCA	-	0.0036	0.0003	0.0004	0.0014	-0.0005	0.0063	2.6502	0.1691
SCA	-	0.2168	0.0612	0.0017	0.0915	0.5499	1.0726	110.8029	417.766.
GCA: SCA	-	0.0166	0.0049	0.0017	0.0153	-0.0009	0.0058	0.0239	0.0004

Table 2 : *gca* effects of parents for quality traits in rice.

Parents	L/B ratio (mm)	Water uptake (g)	Kernel elongation (cm)	Volume expansion (ml)	Alkali value (cm)	Amylose content (%)	Gel consi-stency (mm)	Grain yield (g)
IR 58025A	-0.1594**	-0.0179**	-0.0042**	-0.0645**	0.2420**	-0.3200**	-3.6167**	14.4284**
IR 62829A	-0.1771**	0.0748**	0.0061**	-0.0839**	-0.0580**	-0.1197**	-0.6833**	-8.2176**
IR 68885A	0.1389**	-0.0019	-0.0059**	0.1335**	-0.3080**	0.0660*	2.5367**	-3.7316**
IR 68886A	0.1296**	0.0268**	0.0028**	0.1012**	0.3820**	-0.2027**	1.2000**	-3.0069**
IR 68897A	0.0679**	-0.0819**	0.0011	0.1161**	-0.2580**	0.5763**	0.5633**	0.5177**
ACK 03002	-0.3521**	0.0305**	0.0331**	-0.1899**	0.1020**	0.6247**	2.5667**	-6.2056**
ADT 39	-0.1981**	-0.0469**	-0.0169**	0.1561**	0.3980**	-0.3513**	-14.3600**	-7.2376**
ADT 41	0.3259**	-0.0322**	-0.0122**	0.0921**	-0.1180**	-0.4733**	-8.3667**	5.1997**
ADT 42	0.2606**	0.2498**	0.0158**	0.1108**	-0.1180**	-0.3933**	7.9733**	1.2371**
ADT 43	-0.1427**	-0.2309**	-0.0315**	0.1795**	0.1820**	-0.6353**	3.4200**	7.7597**
ASD 16	-0.3761**	0.2125**	0.0311**	-0.0365**	0.0020	-0.2327**	7.8533**	-4.1443**
ASD 18	0.2913**	-0.0882**	-0.0062**	-0.2605**	-0.1180**	-0.2420**	0.3000**	-5.7389**
CO 43	0.3673**	-0.0995**	0.0025*	-0.0105**	0.2820**	0.5500**	1.7200**	5.9584**
ASD 19	-0.1294**	0.0285**	-0.0042**	0.1741**	0.2820**	0.5453**	-8.8133**	-2.9776**
White ponni	-0.0467*	-0.0235**	-0.0109**	-0.2152**	-0.0980**	0.6140**	7.7067**	6.1491**

for inheritance of various traits studied. It further revealed the importance of additive and non additive types of gene action. The variance due to *sca* was of greater in magnitude than *gca* variance for all quality characters indicating non – additive gene action for these characters (Table 1). Preponderance of non- additive gene action was reported by Ganesan (1995), Sarawgi *et al*. (1991), Sood *et al*. (1983), Vivekandan and Giridharan (1997), Vanaja *et al*. (2003), Mohan Andre Savery and ganesan (2003), Jagadeesan and Ganesan (2006), Anandakumar *et al*. (2004) and Saravanan *et al*. (2006).

The parents having high *gca* effects could be useful since the *gca* effect is due to additive gene action and is fixable. Hence the parents were evaluated based on *per se* performance and *gca* effects (table 2). Among the lines studied, IR 68886A was a good combiner for L/B ratio, water uptake, kernel elongation, volume expansion and gel consistency. The parent IR 68885A was a good combiner for L/B ratio, volume expansion, amylase content and gel consistency and IR 68897A was also good combiner for L/B ratio, volume expansion, amylose content and gel consistency. Among the testers studied, ADT 42 highest *gca* effects for L/B ratio, water uptake, kernel elongation, volume expansion and gel consistency. The parent CO 43 was also good combiner for L/B ratio, kernel elongation, alkali value, amylose content and gel consistency. While the parent ACK 03002 was good combiner for water uptake, kernel elongation, Alkali value, Amylose content and gel consistency. ASD 19 was also

Table 3 : Estimates of specific combining ability (*sca*) effects for quality traits in rice.

Hybrids	**L/B ratio (mm)**	**Water uptake (g)**	**Kernel elongation (cm)**	**Volume expansion (ml)**	**Alkali value (cm)**	**Amylose content (%)**	**Gel consist-ency (mm)**	**Grain yield (g)**
IR 58025A x ACK 03002	0.0840**	0.1825**	-0.0038	0.0718**	0.3580**	-0.3733**	1.4631**	-31.7110**
IR 58025A x ADT 39	-0.0732**	-0.1201**	0.0128**	-0.0441**	0.8580**	0.3093**	-3.4772**	2.3809**
IR 58025A x ADT 41	-0.2839**	-0.0781**	-0.0684**	0.0365**	-0.4220**	0.3146**	0.4301**	38.8369**
IR 58025A x ADT 42	0.1647**	0.0565**	0.0302**	0.2212**	-0.4220**	-0.8693**	-3.9431**	3.6996**
IR 58025A x ADT 43	-0.1586**	0.0205**	0.0108**	0.1658**	-0.2220**	-0.4733**	1.3100**	18.6836**
IR 58025A x ASD 16	0.0014*	-0.3094**	-0.0218**	-0.1481**	-0.5420**	0.0906	1.100**	-21.5924**
IR 58025A x ASD 18	0.3340**	0.2078**	0.0062**	0.0658**	0.4780**	0.1200	3.8971**	-25.2177**
IR 58025A x CO 43	0.2614**	0.3225**	0.0768**	-0.3274**	0.1780**	0.2913**	3.3432**	28.2582**
IR 58025A x ASD 19	-0.0319**	-0.0954**	0.0035	0.0378**	-0.8220**	0.3626**	0.5772**	-2.2924**
IR 58025A × White ponni	-0.2979**	-0.1868**	-0.0464**	-0.0794**	0.5580**	0.2273**	-4.7100**	-11.0457**
IR 62829A x ACK 03002	0.3450**	0.0198**	-0.0741**	-0.0721**	0.6580**	1.0163**	-1.5032**	1.8282**
IR 62829A x ADT 39	0.2477**	-0.0528**	0.0092**	-0.0114**	-0.3420**	-0.0076	5.6901**	7.0935**
IR 62829A x ADT 41	0.1237**	-0.0774**	0.0078**	-0.0041	-0.1220**	0.1143	1.3972**	4.6295**
IR 62829A x ADT 42	-0.3009**	0.1972**	-0.0668**	-0.1861**	-0.2220**	-0.5596**	-2.1772**	4.6789**
IR 62829A x ADT 43	-0.1042**	0.1212**	0.0138**	-0.1381**	-0.4220**	0.2896**	-2.6572**	19.4495**
IR 62829A x ASD 16	0.0190**	-0.1654**	0.1178**	0.1812**	0.7580**	-1.0663**	-4.2901**	-1.9330**
IR 62829A x ASD 18	-0.3282**	-0.1314**	-0.0174**	-0.1114**	0.8780**	-0.0636	0.7632**	-8.1850**
IR 62829A x CO 43	-0.0176**	0.5765**	0.0065**	0.1752**	-0.5220**	1.1110**	-0.4572**	-11.2624**
IR 62829A x ASD 19	-0.1809**	-0.1014**	-0.0068**	0.1638**	0.4780**	-0.9043**	-0.0902	-0.2664
IR 62829A x White ponni	0.1964**	-0.3861**	0.0098**	0.0032	-0.1420**	0.0703	3.3231**	-16.0330**
IR 68885A x ACK 03002	-0.2109**	0.1198**	-0.0454**	0.1172**	-0.0920**	0.8306**	0.3100**	-1.5010**
IR 68885A x ADT 39	0.0384**	-0.0494**	0.0478**	0.0678**	-0.5920**	-1.1366**	0.3371**	-10.5357**
IR 68885A x ADT 41	0.0010*	-0.0374**	0.0198**	-0.0048	-0.8720**	-0.0346	-1.6231**	-23.1730**
IR 68885A x ADT 42	-0.0836**	-0.1594**	0.0085**	0.1432**	0.1280**	-0.1120	-0.1632*	-17.6504**
IR 68885A x ADT 43	-0.0102*	-0.1021**	0.0325**	0.0845**	0.7280**	0.0906**	4.4571**	-21.1130**
IR 68885A x ASD 16	0.1197**	0.1445**	-0.0268**	-0.1394**	0.0080**	0.7280**	-0.1100**	6.0975**
IR 68885A x ASD 18	-0.1542**	-0.0048	-0.0121**	0.0245**	0.1280**	1.6973**	-2.5901**	24.8922**
IR 68885A x CO 43	-0.1436**	-0.3834**	-0.0448**	-0.0654**	0.7280**	-1.0346**	-1.8100**	-7.4917**
IR 68885A x ASD 19	0.1730**	0.0685**	0.0152**	-0.2268**	-0.2720**	-1.0700**	1.2572**	4.0509**
IR 68885A x White ponni	0.2704**	0.4038**	0.0052*	-0.0008	0.1080**	0.0413	-0.0635	46.4242**
IR 68886A x ACK 03002	-0.1049**	-0.3388**	0.0525**	-0.0681**	0.2180**	-0.8506**	1.6131**	22.5242**
IR 68886A x ADT 39	-0.1156**	0.1785**	-0.0908**	-0.0074	0.7180**	-0.5213**	-0.8603**	1.7595**
IR 68886A x ADT 41	0.0504**	0.2205**	0.0778**	-0.0101**	0.3380**	0.1906	-0.4874**	-7.7944**
IR 68886A x ADT 42	0.0757**	-0.1148**	0.0198**	-0.2054**	-0.5620**	0.1366	2.7732**	9.0615**
IR 68886A x ADT 43	-0.0742**	-0.1008**	-0.0128**	-0.1741**	0.1380**	0.4593**	-1.440**	-7.7077**
IR 68886A x ASD 16	-0.2209**	0.1192**	-0.0421**	0.1552**	0.3180**	-0.9800**	1.1932**	8.4162**
IR 68886A x ASD 18	0.0450**	0.0632**	-0.0308**	-0.0474**	-0.5620**	0.0093	-1.4872**	-9.8690**
IR 68886A x CO 43	-0.0276**	-0.0921**	0.0298**	0.1692**	-0.9620**	0.1706*	-0.8402**	-9.2130**
IR 68886A x ASD 19	-0.0076*	-0.0934**	-0.0101**	0.1745**	-0.0620**	1.2153**	-1.9071**	-2.3237**
IR 68886A x White ponni	0.3797**	0.1585**	0.0065**	0.0138**	0.4180**	0.1700*	1.4402**	-4.8837**
IR 68897A x ACK 03002	-0.1132**	0.0165**	0.0708**	-0.0488**	-1.1420**	-0.6230**	-1.8832**	8.8596**
IR 68897A x ADT 39	-0.0972**	0.0438**	0.0208**	-0.0048	-0.6420**	1.3563**	-1.6900**	-0.7284**
IR 68897A x ADT 41	0.1087**	-0.0274**	-0.0371**	-0.0174**	1.0780**	-0.5850**	0.2831**	-12.4990**
IR 68897A x ADT 42	0.1440**	0.0205**	0.0082**	0.0272**	1.0780**	1.4043**	3.5100**	0.2102
IR 68897A x ADT 43	0.3474**	0.0612**	-0.0444**	0.0618**	-0.2220**	-0.3663**	-1.6702**	-9.3124**
IR 68897A x ASD 16	0.081**	0.2112**	-0.0271**	-0.0488**	-0.5420**	1.2276**	2.0972**	9.0116**
IR 68897A x ASD 18	0.1034**	-0.1348**	0.0542**	0.0685**	-0.9220**	-1.7630**	-0.5832**	18.3796**
IR 68897A x CO 43	-0.0726**	-0.4234**	-0.0684**	0.0485**	0.5780**	-0.5383**	-0.2372**	-0.2910**
IR 68897A x ASD 19	0.0474**	0.2218**	-0.0018	-0.1494**	0.6780**	0.03963**	0.1632**	0.8316**
IR 68897A x White ponni	-0.4586**	0.0105**	0.0248**	0.0632**	0.0580**	0.5090**	0.0100	-14.4617**

Table 4 : Promising hybrids selected based on *gca* and *sca* effects.

Character	Best hybrids	*sca* effects	*gca* effects	
L/B Ratio(mm)	IR 68886A X White ponni	0.379**	0.129**	-0. 177**
	IR 62829A X ACK 03002	0.345**	-0. 046*	-0. 352**
Water uptake(g)	IR 62829A X CO 43	0.576**	0.074**	-0.001
	IR 68885A X White ponni	0.403**	-0.099**	-0.023**
Kernel elongation (cm)	IR 62829A X ASD 16	0.117**	0.006**	0.002**
	IR 68886A X ADT 41	0.077**	0.031**	-0.012**
Volume expansion (ml)	IR 58025A X ADT 42	0.221**	-0.064**	-0.083**
	IR 62829A X ASD 16	0.181**	0.110**	-0.036**
Alkali value (cm)	IR 68897A X ADT 41	1.07**	-0.258**	-0.258**
	IR 68897A X ADT 42	1.07**	-0.118**	-0.118**
Amylose content (%)	IR 68897A X ADT 42	1.40**	0.576**	0.576**
	IR 68897A X ADT 39	1.35**	-0.393**	-0.351**
Gel consistency (mm)	IR 62829A X ADT 39	5.69**	-0.683**	2.53**
	IR 68885A X ADT 43	4.45**	-14.36**	3.42**

good combiner for water uptake, volume expansion, alkali value and amylose content. Among the parents, IR 68886A, IR 68885A, IR 68897A, ACK 03002, ADT42, CO43, ASD 19 and ASD 16 were the best, since they possessed significant and desirable *gca* effects for more than three quality character. Therefore, it may be concluded that crosses involving these parents would result in the identification of superior segregants with favourable genes for quality traits.

The specific combining ability (*sca*) is considered to be the best criterion for the selection of superior hybrids. The two cross combinations IR 68886A x white ponni and IR 68897A × ADT 42 recorded favourable *sca* effects for all the quality traits such as L/B ratio, water uptake, kernel elongation, volume expansion, Alkali value, Amylose content and gel consistency. The hybrids IR 58025 A x ASD18 and IR 58025A x CO43 showed desirable *sca* effects for six traits.

The next best significant hybrids IR 58025A x ACK 03002, IR 68885A x ADT43, IR 68886A x ADT 41 and IR 68897A x ASD 19 recorded positive *sca* effects for five quality characters (table 3).

Among the fifty hybrids, twenty five hybrids recorded positive significant *sca* effects for L/B ratio, water uptake and Alkali value. Twenty seven hybrids recorded positive significant value for kernel elongation. Twenty three hybrids showed positive *sca* effects for volume expansion and twenty two hybrids recorded significant positive *sca* effects for gel consistency.

The criterion for the selection of hybrids for recombination breeding is that the parents should have significant *gca* effects and the hybrids with non-significant *sca* effects. The hybrids selected based on *gca* and *sca* effects presented in (table 4). The following hybrids *viz.,* IR 62829A × Co 43, IR 62829A × ASD 16, IR 68886A × ADT 41, IR 68897A × ADT 42, IR 68897A × ADT 39 and IR 68885A × ADT 43 possessed positive significant *sca* effects with any one of the parents possess positive *gca* effects. These hybrids identified for heterosis breeding, which combine grain quality traits. These results are in conformity with the earlier findings of Kumar *et al.* (2007), Singh *et al.* (1993) and Sarma *et al.* (2007).

From this study, it is observed that the *sca* variance was higher in magnitude than *gca* variance for all characters, indicating the predominance of non-additive gene action. This showed the possibilities of improvement of these traits through heterosis breeding. The testers having high *gca* effects, to restore the fertility of male sterile lines and produce the fertile hybrids. Among the parents, IR 68886A, IR 68885A, IR 68897A, ADT 42, CO 43, ACK 03002 and ASD 19 and cross combinations IR 62829A × CO43, IR 68886A × ADT 41, IR 68897A × ADT 42, IR 68885A × ADT 43 could be exploited beneficially in rice breeding programme by adopting appropriate breeding strategy in order to evolve high yielding with high quality hybrid varieties.

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