Combining ability for yield and physical characters in rice

M. Venkatesan*, Y. Anbuselvam, R. Elangaimannan and P. Karthikeyan

Department of Agricultural Botany, Faculty of Agriculture, Annamalai University, Annamalai Nagar – 608 002, Tamilnadu, India

ABSTRACT

Combining ability for ten quantitative and physical characters in rice was studied through Line × Tester analysis involving eight lines and four testers. The mean squares of variance for Line × Tester interaction was significant for all the characters except grain length and grain breadth. The combining ability analysis revealed non-additive gene action governing the characters viz., days to first flower, plant height, panicles plant^{-1}, grain yield plant^{-1} and grain L/B ratio. Predominance of GCA variance was recorded for days to first flower, plant height, grains panicle^{-1} and grain yield plant^{-1}. Among the parents, the lines AD 95137, AD 95157 and MDU 5 and testers ADT 36, ADT 43 and IR 50 were good combiners for grain yield and most of the yield component characters studied. Hence, crosses involving these parents were identified as suitable for recombination breeding.

Key words: *General combining ability, specific combining ability*

The potentiality of the hybrids have been well demonstrated in China, Korea and Japan. Some selected hybrids have given an yield increase of more than 30% over the existing hybrids with fairly high yield levels (Yuan, 1994). Further improvement in parental lines will give a steady increase in hybrid yield (Ikehashi *et al*., 1994). Introgression of genes between these genetically distinct varieties was greatly hampered in the past due to problem of hybrid sterility, but it has now become feasible with identification of wide compatibility gene(s) (Ikehashi and Araki, 1984).

Breeding methods to improve a genetic traits are largely determined by the combining ability and nature of gene action. Among the different methods suggested for studying combining ability, Line X Tester is an important one to find out the combining ability of the parents and hybrids with rapidity and confidence (Singh and Chaudhary, 1985). The present investigation was undertaken with the objective of studying the combining ability of rice cultivars for yield and physical quality characters.

MATERIALS AND METHODS

The material for the present study comprised of 8 lines viz., AD95128 (L_1), AD 95134 (L_2), AD 95137 (L_3), AD 95157 (L_4), AD 97230 (L_5), ASD 8 (L_6), ASD 17 (L_7), and MDU 5 (L_8); four testers viz., ASD 16(T_1), ADT 36 (T_2), ADT 43(T_3) and IR 50 (T_4). All the parents and hybrids were raised in randomized block design with three replications, adopting the spacing of 30 × 20cm during 1993 at Plant Breeding Farm, Faculty of Agriculture, Annamalai University. Twenty two days old seedlings were transplanted at the rate of one seedling hill^{-1}, for each entry 20 plants were maintained. Recommended cultural and need based plant protection measures were followed. Observations were recorded on days to first flower, plant height, number of panicles plant^{-1}, panicle length, number of grains panicle^{-1} test weight, grain yield plant^{-1}, grain length, grain breadth and grain L/B ratio. Standard statistical procedures were followed for analysis of variance of combining ability (Kempthorne, 1957).

RESULTS AND DISCUSSION

The analysis of variance for combining ability (Table 1) revealed significant differences among the lines, testers and Line × Tester interaction for all the characters except grain length and grain breadth, suggesting the importance of both additive and non-additive gene action in the inheritance of the characters

Table 1. Analysis of variance for combining ability (Line x Testers method)

Source of variation	df	Days to first flower	Plant height	No. of panicles plant^{-1}	Panicle length	No. of grains panicle^{-1}	Test weight	Grain yield plant^{-1}	Grain length	Grain breadth	Grain L/B ratio
Replication	2	191.6449	23.9403	75.4295	6.6784	8.9261	12.0405	52.4155	0.7727	0.2139	28.1472
Line (L)	7	285.234**	1098.2608**	218.4158**	17.0796**	1175.9605**	17.9135**	628.6469**	1.8009	0.4913	21.2212**
Tester (T)	3	102.8438**	63.2917**	70.4204**	5.3816**	11.3021**	3.6628**	61.2504**	2.7252	0.2334	32.5363**
L X T	21	45.9224**	58.1104**	81.7346**	78.4311**	351.8091**	3.5378**	85.9669**	0.6915	0.1530	28.4939**
Error	86	22.0248	17.3963	5.5547	75.4625	15.8676	2.3444	7.4657	0.2440	0.0470	20.0874
σ^2gca		1.1833	4.6773	0.5916	-0.4158	3.0433	0.0647	2.3876	0.0092	0.0017	-0.0249
σ^2sca		7.9659	13.5714	25.3933	0.9896	111.9805	0.3978	26.1670	0.1325	0.0353	2.8021
σ^2 gca/σ^2sca		0.1485	0.3446	0.0230	-0.4201	0.0271	0.1626	0.0912	0.0694	0.0481	-0.0160

* Significant at 5% level.
** Significant at 1% level.

studied. The significant mean squares due to LineTesters showed importance of specific combining ability effects for the expression of those characters in the crosses indicating that the materials selected were desirable for successful breeding programme. The non-significant mean squares due to LineTesters for grain length and grain breadth might be due to lack of genetic diversity among lines and testers. The estimates of SCA and GCA and their ratios revealed the predominance of SCA for days to first flower, plant height, panicles plant^{-1}, grain yield plant^{-1} and grain L/B ratio. This indicated a predominantly non additive type of genetic component governed by SCA variance to obtain high yielding combination. (Ramalingam *et al.*, 1993). The estimates of general combining ability effects of lines and testers (Table 2) revealed that the lines *viz.*, AD 95137 (L_3), AD 95157 (L_4) MDU 5 (L_8) and the testers namely; ADT 36 (T_2), ADT 43 (T_3) and IR 50 (T_4) were good combiners for grain yield and yield component characters. The desirable *gca* effect of lines AD 95 128 (L_1) and AD 97230 (L_5) for earliness and Ad 95134 (L_2) and ASD 16 (T_1) for late flowering were the better general combiners. AD 95128 (L_1), AD 95134 (L_2), 95137 (L_3) and MDU 5 (T_4), had desirable *gca* for short plant stature. It is worthwhile to mention here that the selection of parents for days to first flower and plant height depends on the target environment of the breeder.

As late and tall varieties are preferred to low land ecosystem, the genotypes like AD 95 137 (L_3), AD 95157 (L_4), AD 97230 (L_5), ASD 8(L_6), ASD 17 (L_7) and MDU 5 (L_8) among lines; ADT 43 (T_3) and IR 50 (T_4) among testers were good combiners for number of panicles plant^{-1}. In respect of panicle length, AD 95137 (L_3) and MDU 5 (L_8) among lines and ADT 36 (T_2), ADT 43 (T_3) and IR 50 (T_4) among testers showed significant positive *gca*. AD 95137 (L_3), AD 95157 (L_4) and MDU 5 (L_8) among females and ADT 36 (T_2), ADT 43 (T_3) and IR 50 (T_4) among males showed positive and significant *gca* effect for grains panicle^{-1}, grain yield plant^{-1} and grain length. As regards to test weight, AD 95128 (L_1), AD 95 137 (L_3) and MDU 5 (L_8) in lines and ADT 36 (T_2) and IR 50 (T_4), in testers exhibited desirable negative significant *gca* for test weight. AD 95157 (L_4) and ADT 36 (T_2) were best for grain breath line ASD 8 (I_6) and tester MDU 5 (T_4) were test for L/B ratio.

Table 3. Specific combining ability (SCA) of hybrids

Hybrids	Days to first flower	Plant height	No. of panicles	Panicle length	grains panicle^{-1}	Test weight	Grain yield	Grain length	Grain breadth	Grain L/B ratio
L_1x T_1	3.10	-1.60	-0.32	3.72**	-4.60*	-0.76	-0.65	0.24	-0.22	0.83
L_1x T_2	-1.58	0.93	2.11	-4.01**	-4.21	0.22	-2.18	0.12	0.07	0.55
L_1 x T_3	-3.44	-6.03*	-0.91	-0.82	-3.07	0.99	2.17	-0.35	0.24	0.16
L_1 x T_4	1.92	6.71**	-0.88	1.11	11.89**	-0.45	0.67	-0.00	-0.10	-1.54
L_2 x T_1	4.56	0.60	-1.68	-4.10**	-5.63*	1.60	-3.45*	0.43	-0.12	0.88
L_2 x T_2	-1.84	3.32	2.52	6.66**	4.87*	-0.02	1.13	-0.39	-0.09	0.46
L_2 x T_3	2.02	0.54	1.34	-4.67**	5.69*	-0.29	3.74*	0.18	0.15	0.46
L_2 x T_4	-8.43**	-4.47	-2.18	2.11	-4.93*	-1.29	-1.42	-0.22	0.06	-1.79
L_3 x T_1	0.39	2.08	-4.20**	1.64	25.14**	0.39	1.70	-0.39	0.01	0.30
L_3 x T_2	-2.60	2.75	4.71**	2.98*	4.66*	-1.21**	9.79**	0.76**	-0.32*	1.42
L_3 x T_3	4.06	0.54	9.41**	6.66**	5.76*	-2.03**	-5.23**	-0.06	0.03	0.43
L_3 x T_4	-1.84	-5.37	-4.51**	-3.99**	-6.23**	1.43	-6.25	-0.32	0.27*	-2.16
L_4 x T_1	5.53**	-1.37	3.06*	-0.65	6.67**	-1.36	-1.84	-1.11**	0.26*	-0.37
L_4 x T_2	-2.21	0.16	2.22	1.97	0.31	0.08	2.69	0.22	-0.03	0.77
L_4 x T_3	-1.86	-3.18	4.16**	5.43**	11.45**	0.99**	4.55**	0.57*	-0.17	1.02
L_4 x T_4	-1.46	4.39	2.13	1.05	4.17	0.55	0.99	0.32	-0.07	-1.40
L_5 x T_1	0.77	2.72	0.06	-3.32**	-2.32	-0.79	-0.07	0.57*	-0.13*	0.89
L_5 x T_2	0.32	-0.04	4.59**	3.37**	4.74*	0.90	5.41**	-0.46	0.27	0.10
L_5 x T_3	-0.26	3.73	-4.86**	2.61*	-5.84*	0.86	-1.59	0.11	-0.00	0.61
L_5 x T_4	-0.82	-6.41**	0.22	-2.65*	3.42	0.82	-3.75*	-0.22	-0.10	-1.60
L_6 x T_1	2.73	2.29	-5.68**	4.92**	-5.27*	0.96	-3.06	0.47	-0.31*	-3.02
L_6 x T_2	-4.34	-5.79*	-5.11**	-4.98**	-7.85**	0.05	-3.50*	-0.31	0.19	-3.87
L_6 x T_3	-1.20	-3.37	4.66**	-0.09	8.42**	-0.99	5.41**	0.03	0.04	-4.40
L_6 x T_4	2.81	6.87**	6.14**	0.15*	4.71*	-0.03	1.15	-0.18	0.08	11.30**
L_7 x T_1	-3.47	-2.35	1.35	-3.31**	-4.38	0.56	0.53	-0.00	-0.02	0.57
L_7 x T_2	-1.80	-148	-3.07	8.27**	0.40	0.45	-3.19*	-0.01	-0.04	0.30
L_7 x T_3	0.29	6.05*	2.92*	-5.02**	6.50**	-0.89	2.91	-0.19	0.01	0.68
L_7 x T_4	4.98	-2.22	-1.19	0.06	-2.52	-0.13	-0.25	0.20	0.05	-1.54
L_8 x T_1	-5.87*	-2.37	7.40**	1.10	-9.89	-0.61	-1.24	-0.21	0.51**	-0.07
L_8 x T_2	-2.64	0.15	2.54	1.03	0.41	0.07	2.33**	0.08	-0.02	0.28
L_8 x T_3	0.39	1.72	-11.39**	6.77**	-6.00*	1.44	-11.95**	-0.29	-0.31*	1.05
L_8 x T_4	-2.83	0.50	5.54**	3.84**	9.48**	-0.99**	8.86**	0.53**	-0.19	-1.26

* Significant at 5% level. ** Significant at 1% level.

Table 2. General combining ability (GCA) of parents

Parents		Days to first flower	Plant height	No. of panicles	Panicle length	grains panicle^{-1}	Test weight	Grain yield	Grain length	Grain breadth	Grain L/B ratio
Lines	L_1	-5.93**	-16.04**	-5.55**	0.32	-14.53**	-1.35**	-8.47**	-0.52**	-0.01	-0.17
	L_2	3.89**	-6.16**	-1.50*	-0.89	-0.94	-0.51	-1.58*	-0.07	0.06	-0.59
	L_3	-1.44	-2.89*	2.87*	3.58**	16.33**	-1.01**	1.98*	0.39*	-0.08	-0.37
	L_4	-0.55	-0.49	2.43**	2.65	11.01**	1.10**	9.81**	0.62**	-0.40**	0.35
	L_5	-0.17	-0.43	2.82**	-1.80	-8.35**	2.18**	-4.06**	-0.04	0.05	-0.62
	L_6	-5.23**	17.32**	3.95**	1.65	-0.52	0.83	-3.95**	-0.27	0.26**	3.16*
	L_7	0.14	5.71**	2.06**	-0.09	-1.18	-0.57	-5.26**	-0.29*	0.20**	-0.87
	L_8	0.29	1.99	7.66**	3.25	6.12**	-1.10*	11.52**	0.47**	-0.07	-0.35
Testers	T_1	1.74	1.80*	-2.30	0.35	0.93	0.44	-1.00	-0.32**	0.12*	-0.79
	T_2	-0.82	0.56	0.58	2.39*	10.53**	-1.05**	1.92**	0.47**	-0.11*	-0.25

Specific combining ability (*sca*) effects was estimated for all the 32 hybrids for ten characters (Table 3). High estimates of *sca* effects for grain yield was recorded for six out of 32 hybrids. The hybrid L_8T_4 (MDU 5 IR 50) combined positive and significant *sca* effects for six yield component characters namely, number of panicles plant^{-1}, number of grains panicle^{-1}, panicle length, test weight, grain yield plant^{-1} and grain length. The hybrids L_3L_2 (AD 95137ADT 36) and L_4 T_3 (AD 95157 ADT 43) hybrids were worth mentioning, combined desirable significant *sca* effects for seven and six yield component traits, *viz.*, number of panicles plant^{-1}, panicle length, number of grains panicle^{-1}, test weight, grain yield plant^{-1}, grain length and grain breadth. Similar findings were reported by Bindhan Roy and Mandal (2001).

The hybrids *viz.*, L_4 T_2 (AD 95157 ADT 36), L_4 T_4 (AD 95157 IR 50) and L_8 T_2 (MDU 5 ADT 36) recorded non-significant *sca* effects for all the character namely days to first flower, plant height, number of panicles plant^{-1}, panicle length, number of grains panicle^{-1}, test weight, grain yield plant^{-1}, grain length, grain breadth and grain L/B ratio. Hence, these three crosses recording high mean, non-significant *gca* and high heterosis were found suitable for recombination breeding. These crosses may be utilized for recombination breeding for improvement of this trait, as they had atleast one parent with negative *gca* effect and hybrids with significant *sca* effects. This result was supported by Meenakshi and Amirthadevarathinam (1999). It was observed that crosses with significant *sca* effects, were due to the combinations of parents, both of which were good or poor general combiners. Depending upon the nature of gene actions and the combining abilities of parents and crosses, suitable breeding procedure such as pedigree or heterosis breeding or biparental mating in F_2 and selection in later generation will have to be adopted in selective crosses or for characters in varietal improvement work.

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