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COMBINING ABILITY ANALYSIS FOR GRAIN YIELD AND ITS COMPONENT CHARACTERS IN RICE (*ORYZA SATIVA* L.)

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Abstract

The present investigation was carried out in rice involving 7 lines (STBN 12-14, IVT 1235, STBN 3, STBN 2, MTU 1001, IVT 1208 and STBN 13-11) and 3 testers (ADT 45, IR 50 and IR 66) to identify the best combining parents and nature of gene action in association with yield and its component traits in rice. The parents were mated in the L × T method. The resultant twenty one hybrids were evaluated for ten characters *viz.,* days to 50 per cent flowering, plant height at maturity, number of tillers per plant, number of productive tillers per plant, panicle length, number of grains per panicle, flag leaf length, flag leaf breadth, thousand grain weight, grain yield per plant. The performance of lines, testers and their hybrids were evaluated with the biometrical model given by Kempthorne (1957). The variance due to line × tester and hybrids were significant for all the ten characters of interest. The variance due to SCA was higher than the corresponding variance due to GCA for all the ten characters studied.

Key words: Rice, combining ability, *gca* effects, *sca* effects

Introduction

Rice (*Oryza sativa* L.) is the essential staple food for more than 65% of the people, also plays a key role in food security and it provides employment and livelihood security to 70% of Indian population. India is the second largest producer of rice in the world after china. It occupies the second place after wheat in terms of land cultivated and production and feeds about half of the world's population. It is the main resource for millions of people in Asia. In the world, annual production of rice is of 74, 09, 61, 445 tonnes with a yield of 55.11 tonnes/ha. It is grown in atleast 114 countries and many people are engaged in rice cultivation around the world. The quality of rice varieties are usually determined based on its various quantitative and qualitative traits.

In India, rice cultivated in an area of 44.5 million hectares and the annual rice production is about 131.9 million tonnes as per FAO stat. Division, 2015. In Tamil Nadu, rice is cultivated in an area of 17.23 lakh hectares with the production of 51.678 lakh tonnes and productivity of 2.965 tonnes per hectare. By the year of 2025, about 756 million tonnes of paddy, which is 70 percent more than the current production, will be needed to meet the growing demand. For the succession in a breeding programme, the method of parent selection for hybridization is considered as a basic factor. Here, line x tester technique which was developed by Kempthorne (1957) is used. It is an extensively used technique for screening the germplasm on the basis of GCA and SCA variances and effects, which is useful in deciding the relative ability of female and male lines to produce desirable hybrid combinations.

Materials and Methods

The present investigation was carried out at the Plant

Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, during the year 2017. The biological materials used for this study comprised of ten genotypes, out of which seven genotypes were used as lines and three genotypes were used as testers. The details of the parental materials are STBN 12-14 (L_1), IVT 1235 (L_2), STBN-3 (L_3), STBN-2 (L_4), MTU 1001 (L_5), IVT 1208 (L_6), STBN 13-11(L_7), ADT 45 (T_1), IR 50 (T_2), IR 66(T_3). Staggered sowing of parents was taken up during thaladi season.

The seeds were sown in raised nursery beds at ten days interval for synchronizing in flowering. In the crossing block, twenty five days old seedlings were transplanted at the rate of two seedlings per hill with the spacing of 30cm between the rows and 20 cm within the rows. Crosses were made between seven female and three male parents in line x tester fashion and totally 21 cross combinations were obtained by adopting hand emasculation and artificial pollination. The inflorescence is covered with a butter paper cover prior to anthesis, kept undisturbed till the flower opening completed.

The experimental materials consisted of twenty one hybrids along with their ten parents were raised in the nursery and transplanted in rows spacing of 30cm between rows and 20cm between plants. Twenty five days old seedlings per hill was maintained. The row length of 3 m was maintained for each genotype. The experiment was laid out in a randomized block design with three replications. Recommended cultural practices and need based plant protection measures were also adopted to raise the crop.

The observations taken for the hybrids and the parents were subjected to line × tester analysis and the general combining ability effects of parents and specific combining ability effects of different crosses were worked out. The combining ability variance analysis was based on the method developed by Kempthorne (1957).

Results and Discussion

The analysis of variance due to parents and hybrids for ten characters were carried out and are presented in Table 1. The variance due to lines and testers were significant for all the characters studied. The variance due to line × testers and hybrids were also significant for all traits. The results of the present study indicated that existence of significant differences among the lines, testers and hybrids. The variances due to SCA were greater than GCA for the characters *viz.,* days to 50 per cent flowering, plant height at maturity, number of tillers per plant, number of productive tillers per plant, panicle length, number of grains per panicle, flag leaf length, flag leaf breadth, thousand grain weight, and grain yield per plant (Table 2). These findings showed that these traits were predominantly controlled by non-additive gene action. The results are in the corroboration with the findings of Narasimhan *et al.,* (2007) and Satheesh Kumar *et al.,* (2010). These characters could be improved by delaying the selection to the later segregating generations until the dominance and epistatsis disappear and resorting to inter-mating of segregants followed by recurrent selection. In addition, diallel type mating could also be adopted to get elaborative results. Selective mating design as suggested by Jensen (1970) can also be adopted. It will promote more recombination.

Three out of Seven lines recorded negative significant *gca* effects for days to 50 per cent flowering. It was maximum with L_7 followed by L_1 and L_4. Among the testers T_1 recorded negative significant gca effects. Seven out of 21 cross combinations showed negative significant *sca* effects. It was maximum with $L_1 \times T_3$ followed by $L_2 \times T_3$ and $L_4 \times T_1$. The first cross combination involved female parent with negative significant *gca* effects and male parent with positive significant gca effects. It indicated the non-additive gene effects. Singh (1998) reported significant *gca* effects for flowering in poppy. The second cross combination involved both the parents with positive significant *gca* effects. It may indicate the presence of additive and additive × additive gene effects. The third cross combinations involved both parent with negative significant *gca* effects. It may indicate the presence of non-additive gene action of additive × dominance type. Similar findings are also reported by Palaniraja *et al.,* (2011).

In plant height at maturity, four out of seven lines recorded negative significant *gca* effects. It was maximum with L_7 followed by L_5. Only one tester (T_2) registered negative significant *gca* effects. Altogether nine hybrids registered negative significant *sca* effects. Maximum negative *sca* effects were recorded in $L_6 \times T_2$ followed by $L_4 \times T_1$. The first cross had both female and male parents with negative gca effects. It may indicate the presence of non-additive and additive × dominance gene effects. Similar results are also reported earlier by Palaniraja *et al.,* (2011). The second cross combination had both the parents with positive significant *gca* effects. It may indicate the presence of epistatic interaction between *gca* effects of the parents. Our findings are confirmed by the earlier reports of Dalvi and Patel (2009).

Three out of seven lines recorded positive significant *gca* effects for number of tillers per plant. Maximum *gca* was observed in L_4 followed by L_6 and L_7. Only one tester (T_1) registered positive significant *gca* effects for this character. Twelve out of twenty one hybrids had positive significant *sca* effects. It was maximum in $L_6 \times T_2$ followed by $L_2 \times T_1$ and $L_7 \times T_3$. The first cross combination had female parent with positive significant gca effects and male parent with non- significant gca effects. It may indicate the presence of dominance and epistasis. Similar results are also reported earlier by Roy and Senapati *et al.,* (2014). The reverse was true for the second cross combination. It may indicate the presence of dominance and epistasis. The third cross combination had female parent with positive significant *gca* effects and male parent with negative significant *gca* effects. It may indicate the dominance effect between the *gca* effects of the parents. Palaniraja *et al.,* (2011) had also reported the similar findings for this trait.

For number of productive tillers per plant three out of seven lines showed positive significant *gca* effects. It was maximum with L_7 followed by L_1 and L_3. One tester (T_1) recorded negative significant gca effects. Four out of 21 cross combinations recorded positive significant *sca* effects. It was maximum with $L_7 \times T_3$ followed by $L_2 \times T_2$ and $L_4 \times T_1$. The first cross combination had female parent with positive significant *gca* effects and male parent with non significant *gca* effects. This probably due to the contribution of dominant gene from one parent and recessive genes from other parent, result high *sca* effects due to dominance and may also be to epistatic effects. This cross combination promotes the maximum expression of another. It may be catalyst, synergist, stimulalator and may be complementary. Similar results are also reported earlier by Satheesh kumar *et al.,* (2004). The second cross combination had female parent with negative significant *gca* effects and male parent with non significant gca effects. It may indicate the presence of dominance and epistasis. The third cross combinations had both female and male parent with negative significant *gca* effects. It may be due to the presence of non-additive gene action of additive × dominance type. Similar results are also reported earlier by Ritheesh Balan (2005).

Three lines had positive significant gca effects for panicle length. It was maximum with L_6 followed by L_1 and L_7. None of the testers recorded positive significant *gca* effects. Three out of twenty one cross combinations registered positive significant *sca* effects. It was maximum with $L_3 \times T_1$ followed by $L_6 \times T_3$ and $L_5 \times T_3$. The first cross combination had female parent with non significant *gca* effects and male parent with negative significant *gca* effects. It may indicate the presence of dominance and epistatsis. The second cross combinations had female parent with positive significant *gca* effects and male with non significant *gca* effects. The third cross combination had female parent with negative significant *gca* effects and male parent with non significant *gca* effects. It may indicate the presence of dominance and epistasis.. Similar results are also reported earlier by Damodar Raju *et al.,* (2014).

In number of grains per panicle, three out of seven lines had positive significant *gca* effects. It was maximum with L_1 followed by L_6 and L_2. Two testers had positive significant *gca* effects for this character. It was maximum with T_2 followed by T_1. Twelve out of 21 cross combinations had positive significant *sca* effects. It was maximum with $L_5 \times T_3$ followed by $L_4 \times T_1$ and $L_1 \times T_1$. The first cross combination had both female parent and male parent with negative significant gca effects. It may indicate the presence of dominance and epistasis. The second cross combination had female parent with negative significant gca effects and male parent with positive significant *gca* effects. The third cross combination involved both the parents with positive significant *gca* effects. It may indicate the presence of additive and additive × additive gene effects. Similar results are also reported earlier by Roy and Senapathi (2012).

Table 1: Analysis of variance

S. No.	Characters	HybridsDf=20	LinesDf=6	TestersDf=2	Line × TesterDf=12	ErrorDf=60
1.	Days to 50 per cent flowering	27.51**	83.49**	30.11**	25.83**	1.32
2.	Plant height at maturity	189.76**	888.04**	47.79**	233.83**	0.44
3.	Number of tillers per plant	35.45**	195.94**	36.92**	51.55**	0.17
4.	Number of productive tillers per plant	9.75**	31.46**	2.05*	7.42**	0.93
5.	Panicle length	19.39**	1.46*	24.10**	5.65**	1.33
6.	Number of grains per panicle	723.34**	2285.65**	2617.75**	569.68**	0.37a
7.	Flag leaf length	35.42**	164.44**	49.05**	36.56**	0.11
8.	Flag leaf breadth	0.06**	0.06**	0.02*	0.03**	0.004
9.	Thousand grain weight	8.74**	60.65**	70.02**	6.33**	0.04
10.	Grain yield per plant	94.59**	275.35**	94.37**	86.44**	0.09

*significant at 5% level, **significant at 1% level

Table 2: Estimation of combining ability variance

S. No.	Characters	GCA	SCA	GCA/SCA
1.	Days to 50 per cent flowering	0.0438	8.15	0.0005
2.	Plant height at maturity	-1.1474	77.74	-0.0148
3.	Number of tillers per plant	-0.4193	17.11	-0.0245
4.	Number of productive tillers per plant	0.0606	2.39	0.0253
5.	Panicle length	0.3580	1.23	0.2908
6.	Number of grains per panicle	4.0015	189.73	0.0211
7.	Flag leaf length	-0.0296	12.14	-0.0002
8.	Flag leaf breadth	0.0008	0.0093	0.8602
9.	Thousand grain weight	0.0627	2.09	0.0299
10.	Grain yield per plant	0.2123	28.79	0.0007

None of the lines and testers had positive significant *gca* effects for flag leaf length. Nine out of 21 cross combinations had positive significant *sca* effects. It was maximum with $L_3 \times T_3$ followed by $L_7 \times T_1$ and $L_2 \times T_2$. The first and third cross combinations had female parent with non significant *gca* effects and male parent with negative significant *gca* effects. The second cross combination had female and male parents with non significant *gca* effects. It may indicate the presence of dominance and epistasis. Similar results are also reported earlier by Rahimi *et al.,* (2010).

For Flag leaf breadth, two out of seven lines had positive significant *gca* effects. Only one tester (T_3) registered positive significant *gca* effects. Four out of twenty one cross combinations had positive significant *sca* effects. It was maximum with $L_3 \times T_2$ and $L_4 \times T_3$ followed by $L_6 \times T_1$. The first cross combination had female parent with positive significant *gca* effects and male parent with non significant *gca* effects. It may indicate the presence of dominance and epistasis. The second cross combination had female parent with negative significant *gca* effects and male parent with positive significant *gca* effects. It indicated the non-additive gene effects. The third cross comibination had female parent with negative significant *gca* effects and male parent with non significant gca effects. It may indicate the presence of dominance and epistasis. Similar results are also reported earlier by Rahimi *et al.,* (2010).

Three out of seven lines had positive significant *gca* effects for thousand grain weight. It was maximum with L_6 followed by L_7 and L_3. Two testers recorded

Table 3: Estimates of combining ability effects for grain yield and its contributing characters in rice

S. No.	Characters Genotypes/ hybrids	Days to 50% flowering (days)	Plant height at maturity (cm)	Number of tillers per plant (Nos.)	Number of productive tillers per plant (Nos.)	Panicle length (cm)	Number of grains per panicle (Nos.)	Flag leaf length (cm)	Flag leaf breadth (cm)	Thousand grain weight (g.)	Grain yield per plant (g)
1	L_1	-1.28**	-0.36	-0.94	1.55**	1.51**	16.26**	2.05	0.25**	0.04	4.16**
2	L_2	2.18**	7.04**	0.26	-1.41**	0.38	5.16**	0.13	-0.05**	-1.09	5.14**
3	L_3	0.67	-1.29**	1.27	1.10**	-2.34	-1.17**	1.80	0.07**	0.1**	1.28**
4	L_4	-0.89*	3.69**	0.74**	-0.83**	-2.95**	-17.21**	2.20	-0.06**	-0.88**	-0.21**
5	L_5	-0.49	-3.35**	-2.38**	-0.42*	-1.56**	-10.19**	-2.34	-0.02	-0.24**	-2.58**
6	L_6	1.17**	-0.71**	0.55**	-1.56**	3.51**	11.23**	-0.51	-0.10**	0.85**	-2.14**
7	L_7	-1.36**	-5.02**	0.49**	1.56**	1.44**	-4.08**	-3.33	-0.10**	0.81**	-5.65**
8	T_1	-2.09**	0.74**	0.34**	-0.36**	-0.77*	0.33*	0.48	-0.02	1.16**	-0.90**
9	T_2	1.32**	-1.51**	0.07	0.16	0.23	1.49**	-0.32**	-0.01	0.16**	1.32**
10	T_3	0.77**	0.78**	-0.41**	0.20	0.54	-1.82**	-0.16*	0.03**	-1.33**	-0.42**
11	$L_1 \times T_1$	1.19	1.33**	2.84**	1.30*	-0.27	10.32**	-0.88**	0.02	-0.25*	6.65**
12	$L_2 \times T_1$	3.00**	6.34**	3.45**	-0.7	-0.26	10.07**	1.38**	0.01	1.30**	-4.26**
13	$L_3 \times T_1$	2.42**	-5.44**	0.14	0.28	2.56**	-8.07**	-3.68**	-0.14**	-0.43**	0.23
14	$L_4 \times T_1$	-3.22**	-11.42**	2.71**	1.66**	0.27	11.79**	-1.63**	-0.04	0.88**	-3.05**
15	$L_5 \times T_1$	1.86**	4.94**	1.74**	-1.65**	-1.55*	-27.37**	-1.76**	-0.06	1.10**	-1.82**
16	$L_6 \times T_1$	-2.82**	1.74**	-6.21**	0.47	-0.27	4.64**	2.15**	0.14**	-1.74**	-2.05**
17	$L_7 \times T_1$	-2.43**	2.51**	-4.67**	-1.31*	-0.48	-1.39**	4.42**	0.06	-0.86**	4.30**
18	$L_1 \times T_2$	2.45**	5.13**	-0.62*	-0.42	0.91	-11.05**	1.81**	-0.02	-1.15**	-6.26**

Table 4: Estimates of combining ability effects for grain yield and its contributing characters in rice (Contd.).

S. No.	Characters Genotypes/ hybrids	Days to 50% flowering (days)	Plant height at maturity (cm)	Number of tillers per plant (Nos.)	Number of productive tillers per plant (Nos.)	Panicle length (cm)	Number of grains per panicle (Nos.)	Flag leaf length (cm)	Flag leaf breadth (cm)	Thousand grain weight (g.)	Grain yield per plant (g)
19	$L_2 \times T_2$	0.35	-1.71**	1.69**	1.84**	0.64	2.07**	4.18**	0.03	-0.74**	5.28**
20	$L_3 \times T_2$	-1.99**	1.48**	1.38**	-0.25	-1.67*	1.71**	-1.01**	0.17**	0.47**	3.14**
21	$L_4 \times T_2$	-0.34	12.11**	-5.17**	-1.75**	0.13	-0.82*	0.05	-0.14**	-1.19**	3.58**
22	$L_5 \times T_2$	-1.74*	-1.77**	-2.78**	0.84	0.15	6.04**	0.97**	-0.07	-0.61**	4.04**
23	$L_6 \times T_2$	0.53	-15.37**	4.24**	0.89	-1.26	5.41**	-1.89**	-0.11**	2.02**	-6.39**
24	$L_7 \times T_2$	0.74	0.13	1.26**	-1.14*	1.11	-3.35**	-4.12**	-0.0	2.14**	-3.38**
25	$L_1 \times T_3$	-3.64**	-6.46**	-2.22**	-0.88	-0.64	0.74*	-0.93**	0.00	1.40**	-0.39*
26	$L_2 \times T_3$	-3.34**	-4.63**	-5.14**	-1.09	-0.38	-12.14**	-5.56**	-0.04	-0.56**	-1.02**
27	$L_3 \times T_3$	-0.43	3.96**	-1.52**	-0.03	-0.89	6.36**	4.68**	-0.03	0.91**	-3.37**
28	$L_4 \times T_3$	3.56**	-0.69	2.46**	0.09	-0.40	-10.97**	1.59**	0.17**	0.30**	-0.53**
29	$L_5 \times T_3$	-0.12	-3.17**	1.04**	0.80	1.40*	21.33**	0.78**	0.13**	-0.49**	-2.22**
30	$L_6 \times T_3$	2.28**	13.63**	1.97**	-1.36*	1.53**	-10.06**	-0.26	-0.33	-0.28*	8.44**
31	$L_7 \times T_3$	1.70*	-2.64**	3.41**	2.45**	-0.63	4.74**	-0.30**	-0.06	-1.28**	-0.91**
SE for lines		0.3907	0.2598	0.1524	0.1646	0.4660	0.2362	0.1175	0.0170	0.0690	0.0696
SE for testers		0.2558	0.1701	0.0998	0.1078	0.3051	0.1546	0.0770	0.0111	0.0451	0.0455
SE for hybrids		0.6767	0.4501	0.2640	0.2851	0.8071	0.4091	0.2036	0.0294	0.1194	0.1205

*significant at 5% level, **significant at 1% level

positive significant *gca* effects. It was maximum with T_1 followed by T_2. Nine out of twenty one cross combinations had positive significant *sca* effects. It was maximum with $L_7 \times T_2$ followed by $L_6 \times T_2$ and $L_1 \times T_3$. The first and second cross combinations had female parent and male parent with positive significant *gca* effects. It may indicate the presence of additive and additive × additive gene effects. The third cross combinations had female parent with positive significant *gca* effects and male parent with negative significant *gca* effects. It may indicate the dominance effect between the *gca* effects of the parents. Similar results are also reported earlier by Kolom *et al.,* (2014).

In Grain yield per plant, three out of seven lines had positive significant *gca* effects. It was maximum with L_2 followed by L_1 and L_3. Only one tester T_2 registered positive significant *gca* effects. Seven out of twenty one cross combinations had positive significant *sca* effects. It was maximum with $L_6 \times T_3$ followed by $L_1 \times T_1$ and $L_2 \times T_2$. The first cross combination had both female and male parent with negative significant *gca* effects. It may indicate the presence of epistatic interaction between the *gca* effects of the parents. The second cross combinations had female parent with positive significant *gca* effects and male with negative significant *gca* effects. It indicated the presence of dominance effect between the *gca* effects of the parents. The third cross combination had both female and male parent with positive significant *gca* effects. It may indicate the presence of additive and additive × additive *gca* effects of the parents. Similar results are also reported earlier by Patel *et al.,* (2015).

Based on *gca* effect, the line L1 and the tester T1 ranked first since they had significant gca for days to 50 per cent flowering, plant height at maturity, number of tillers per plant, panicle length, number of grains per panicle, thousand grain weight, grain yield per plant. The line L3 was considered as the next best for days to 50 per cent flowering, plant height at maturity, number of productive tillers per plant, panicle length, number of grains per panicle, thousand grain weight, grain yield per plant. Based on *sca* effect*,* the hybrid $L_2 \times T_2$ was adjudged as the best for six out ten characters studied namely, plant height at maturity, number of tillers per plant, number of productive tillers per plant, number of grains per panicle, flag leaf length, flag leaf breadth, grain yield per plant. The next hybrid $L_6 \times T_3$ followed by $L_1 \times T_1$ recorded high *sca* effect for grain yield per plant.

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