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Studies on gene action and combining ability for yield and its component traits in rice (*Oryza sativa* L.)

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ABSTRACT
Combining ability in rice was studied in a set of 4 lines and 10 testers with their 40 hybrids. The analysis of variance indicated magnitude of gca variances was higher than sca variances for day to 50 per cent flowering, amylose content, protein content and L/B ratio for which predominance of additive gene action and magnitude of sca variance was higher than gca variance for remaining all other characters indicating predominance of non-additive gene action. Componantwise findings indicated that male parents like IET-20528, NVSR-20, GR-103 and GR-12 were good general combiner for yield and yield contributing traits, while female parents like GR-10 and IR-28 have good general combining ability for earliness and yield contributing traits. All the crosses having best specific combination for grain yield per plant were obtained either through average x poor and average x average parental combination.

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Key words : Combining ability, Gene action, Line x tester, Rice, Yield, Yield components

INTRODUCTION

The concept of combining ability plays a significant role in crop improvement, since it helps the breeder to determine the nature of gene action involved in the expression of quantitative characters of economic importance such as plant height, productive tillers per plant, length of the panicle, number of grains per panicle and grain yield per plant and to formulate the breeding procedure. It helps in the identification of best general combiners and specific combiners. Hence, present investigation was undertaken using line x tester analysis to estimate the combining ability for grain yield and yield contributing traits.

MATERIALS AND METHODS

The experimental plant material consisted of four females *viz.*, GR-10, IR-28, Lal kada and safed kada and ten testers *viz.,* GR-12, NVSR-20, IET-20152, IET-20528, IET-20533, IET-20538, IET-20560, IET-20567, GR-103 and IET-19419. They were crossed in line x tester fashion during summer 2007 to obtained 40 F_1s. All these hybrids along with their parents were evaluated in a Randomized Block Design with three replications during *Kharif*–2008 at National Agricultural Research Project Farm, NAU, Navsari. Each entry was planted in a single row consist of 15 plant in each row with a spacing 20 x 15 cm. The standard agronomical practices were followed to raise the experimental crop. Biometrical observations were recorded for ten yield and yield attributing traits *viz*., days to 50 % flowering, panicles per plant, panicle length, plant height, grains per panicle, grain yield per plant, 1000 grain weight, amylose content, protein content and L/B ratio. Observations were made on five randomly selected competitive plants per replication for 54 genotypes, comprising 40 hybrids and their 14 parents. The estimates of combining ability and variances were worked out according to the method outlined by Kempthorne (1957).

RESULTS AND DISCUSSION

The results obtained from the present investigation alongwith relevant discussion have been presented as under:

Analysis of variance:

The analysis of variance for combining ability (Table 1) revealed that general combining ability (gca) variances for females (s^2f) were significant for days to 50 per cent flowering, panicle length, amylose content and protein content, whereas general combining ability (gca) variances for males (s^2m) were significant for all the characters. On the other hand, specific combining ability (sca) variances for f x m interaction were also significant for all characters. The variance estimates for gca and sca suggested that both additive as well as non-additive gene

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Table 1 : Analysis of variance for combining ability for different characters in rice

Source of variation	d.f.	Days to 50 % flowering	Panicles per plant	Panicle length (cm)	Plant height (cm)	Grains per panicle	Grain yield per plant (g)	1000 grain weight (g)	Amylose content (%)	Protein content (%)	L/B ratio
Replication	2	3.967	0.007	0.481	0.712	0.381	1.374	0.035	0.090	0.0518	0.001
Female	3	620.932**	13.722	49.853*	387.019	56.078	0.807	6.942	17.300**	18.432**	0.093
Male	9	305.612**	41.868**	86.179**	1087.44**	2377.09**	265.460**	48.870**	70.770**	3.282*	3.393**
Female x male	27	46.983**	6.274**	10.987**	261.724**	331.748**	50.301**	7.838**	3.659**	1.077**	0.114**
Error	78	10.249	0.801	3.197	87.928	81.560	10.451	1.065	0.523	0.062	0.016
σ^2 f		19.131**	0.248	1.295*	4.176	9.189	1.649	0.0299	0.4547**	0.5785**	0.0007
σ^2 m		21.552**	2.966**	6.266**	68.809**	170.445**	17.929**	3.419**	5.592**	0.1837*	0.273**
σ^2 gca		19.823**	1.024**	2.715**	22.643**	42.135**	3.944**	0.955**	1.922**	0.4657**	0.077**
σ^2 sca		10.940**	1.832**	2.758**	65.153**	88.736**	13.869**	2.202**	0.994**	0.3347**	0.033**
σ^2 gca/ σ^2 sca		1.811	0.558	0.984	0.347	0.474	0.284	0.433	1.933	1.391	2.333

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

action were important in the inheritance of various traits. The magnitude of gca variances was higher than sca variances for day to 50 % flowering, amylose content, protein content and L/B ratio indicating the predominance of additive gene action. The magnitude of sca variances was higher than gca variances for remaining all other characters indicating predominance of non-additive gene action. This was further supported by low magnitude of s^2gca/ s^2sca ratios. These results were supported by the findings of Satyanarayana *et al.* (1998), Annadurai and Nadarajan (2001), Singh *et al.* (2005) and Panwar (2005).

Effects of general combining ability:

Nature and magnitude of combining ability effects provide guideline in identifying the better parents and their utilization. The overall summery of general combining ability effects of the parents (Table 2) revealed that among males IET-20528 was good general combiner for all the traits. NVSR-20 showed good gca effects for all the traits except L/B ratio. The male parent GR-103 also combines well for yield attributing traits. Also GR-12 showed good combining ability for days to 50 % flowering, panicle per plant, panicle length, 1000 grain weight and amylose content. On the other hand female parent GR-10 showed good general combining ability for days to 50 % flowering, panicle per plant, panicle length, 1000 grain weight, amylose content and L/B ratio, while IR-28 showed good general combining ability for days to 50 % flowering, panicle per plant, plant height, protein content and L/B ratio.

Componentwise findings indicated that male parents like IET-20528, NVSR-20, GR-103 and GR-12 were good general combiner for yield and yield contributing traits, while female parents like GR-10 and IR-28 have good general combining ability for earliness and other yield contributing characters. This could be considered as the best combining parent of the present study in yield attributes and hence could be utilize in the future breeding programme.

Effects of specific combining ability:

The magnitude of sca effects is of vital importance in selecting the cross combinations with higher probability of obtaining desirable transgressive segregants. In case of specific combining ability effects, none of the hybrid exhibited favourable sca effect for all the characters.

In the present study positive specific combining ability is desirable for all the characters except days to 50 % flowering and plant height. Significant specific combining ability in favourable direction was observed in many crosses (Table 3) for days to 50 % flowering (4), panicles

Table 2: Estimating general combining ability effects of parents for different characters in rice

Parents	Days to 50 % flowering	Panicles per plant	Panicle length (cm)	Plant height (cm)	Grains per panicle	Grain yield per plant (g)	1000 grain weight (g)	Amylose content (%)	Protein content (%)	L/B ratio
Females										
GR-10	5.56**	0.46**	1.79**	0.48	1.00	0.008	0.45*	0.92**	1.13**	0.049*
IR-28	1.59*	0.68**	0.03	5.04**	1.96	0.17	0.33	0.008	0.44**	0.048*
Lal kada	2.34**	0.70**	1.11**	1.13	0.85	0.21	0.57**	0.008	0.09	0.045*
Safed kada	4.81**	0.44**	0.71*	3.42*	0.11	0.05	0.22	0.93**	0.59**	0.052*
SE (gi)	0.68	0.16	0.30	1.48	1.47	0.53	0.20	0.15	0.04	0.02
SE (gi-gj)	0.97	0.22	0.42	2.10	2.09	0.76	0.28	0.21	0.07	0.02
Males										
GR-12	4.73**	1.19**	1.18*	2.16	5.04*	0.34	0.85**	0.57*	0.26**	0.51**
NVSR-20	6.05**	3.11**	5.91**	10.06**	24.34**	9.73**	3.77**	3.59**	0.39**	0.04
IET-20152	3.85**	0.07	0.02	3.80	1.35	0.07	0.66*	1.45**	0.42**	0.33**
IET-20528	3.23**	2.08**	1.90**	13.56**	16.40**	4.29**	1.98**	2.54**	0.23**	0.67**
IET-20533	0.04	1.30**	1.97**	1.22	8.61**	3.02*	1.13**	2.02**	0.36**	0.04
IET-20538	4.24**	1.64**	2.68**	6.42**	20.99**	6.02**	2.39**	1.79**	0.02	0.33**
IET-20560	4.30**	0.26	0.69	7.48**	4.41	2.70*	0.87**	3.72**	1.13**	0.12**
IET-20567	8.32**	2.87**	1.57**	16.55**	15.26**	5.10**	2.52**	2.49**	0.59**	8.38**
GR-103	3.84**	1.06**	0.18	9.29**	10.17**	2.63**	1.04**	1.72**	0.28**	0.88**
IET-19419	4.90**	1.44**	3.24**	7.21**	4.77*	0.08	1.41**	0.94**	0.38**	0.33**
SE (gi)	1.08	0.25	0.47	2.34	2.33	0.85	0.32	0.23	0.07	0.03
SE ((gi-gj)	1.53	0.36	0.67	3.32	3.30	1.20	0.45	0.33	0.11	0.04

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

r plant (7), panicle length (3), plant height (4), ains per panicle (6), grain yield per plant (7), 00 grain weight (5), amylose content (6), protein ntent (9) and L/B ratio (5). These results are tting support from the findings of Roy and andal (2001), Sinha *et al.*(2006), Sarial *et al.* 007), Singh *et al.* (2007) and Parihar and thak (2008).

Estimation of specific combining ability ect for days to 50 % flowering ranged from - 35 (GR-10 x IET-20560) to 6.64 (Lal kada x VSR-20) for this trait. The sca effect was nificant for nine crosses, of which four crosses owed significant negative sca effect for day to % flowering. Cross combination GR-10 x IET- 560 (-8.85) exhibited the maximum negative a effect, followed by Safed kada x NVSR-20 .78). Both these crosses are best specific osses for early flowering.

With regards to sca effect of crosses for nicles per plant sixteen hybrids attributed toward nificant sca effect for this trait, of which, seven brids showed significant positive sca effect. oss combination Safed kada x IET-20538 (2.45) hibited the maximum positive sca effect.

For panicle length sca effect of crosses, nine brids exhibited significant sca effect for this it. Three superior crosses *viz.*, Safed kada x T-20538 (4.21), IR-28 x IET-20528 (2.65) and l kada x IET-20567 (2.38), exhibited highly nificant positive sca effect.

Estimation of sca effect for plant height nged from -19.82 (GR-10 x IET-20560) to 17.40 afed kada x IET-20560). Nine hybrids showed nificant sca effect of which, four crosses picted significant negative sca effect for plant ight. The best three specific cross for arfness were GR-10 x IET-20560 (-19.82) lowed by cross, IR-28 x GR-103 (-18.69) and l kada x IET-20528 (-13.59).

As regards to sca effect for grains per nicle, fourteen hybrids attributed toward nificant sca effect for this trait of which, six brids showed significant positive sca effect. oss combination Lal kada x IET-20528 (18.45) hibited the maximum positive sca effect.

Estimation of sca effect for grain yield per nt ranged from -7.95 (Safed kada x GR-12) to 55 (Safed kada x IET-20538). Seventeen hybrids owed significant sca effect of which, seven brids attributed towards significant positive

Table 3 : Estimation of specific combining ability for different traits in rice

Crosses	DFF	PP	PL	PH	GP	GYP	TW	AC	PC	L/B ratio
GR 10 x GR 12	0.19	1.63**	0.90	1.15	2.17	5.43**	2.45**	-1.20*	-0.30	0.001
GR 10 x NVSR 20	-5.28*	-2.39**	-0.81	-4.24	2.15	1.31	-0.19	-0.52	0.04	-0.26**
GR 10 x IET 20152	5.29*	0.31	1.74	3.08	13.37**	2.57	0.72	-0.80	-1.18**	-0.06
GR 10 x IET 20528	2.74	-1.29*	-2.74**	12.30*	-6.80	0.55	0.10	0.21	0.82**	0.11
GR 10 x IET 20533	2.91	0.74	1.00	-0.21	4.79	1.15	0.56	2.00**	-0.21	0.53**
GR 10 x IET 20538	1.76	-1.19*	-1.83	-2.73	-2.46	-3.44*	-2.04**	-1.35**	-0.24	-0.27**
GR 10 x IET 20560	-8.85**	-0.01	0.10	-19.82**	2.10	0.92	-0.041	-0.59	1.32*	0.04
GR 10 x IET 20567	2.81	0.79	-0.63	4.14	2.02	-0.089	1.58*	1.18*	0.32*	0.08
GR 10 x GR 103	-0.81	-0.99	1.47	10.76*	-9.16	-2.007	-1.85**	1.23*	0.75**	-0.05
R 10 x IET 19419	-0.76	2.40**	0.79	-4.44	-8.17	-3.78*	-1.29*	-0.15	-1.33**	-0.11
IR 28 x GR 12	1.31	-0.65	0.28	5.31	6.76	1.19	-0.44	0.14	0.18	-0.05
IR 28 x NVSR 20	4.42*	-0.009	-0.55	1.06	-9.47*	1.90	0.22	1.34**	-0.13	-0.09
IR 28 x IET 20152	-2.17	1.35**	1.59	7.92	11.28*	6.17**	2.52**	0.43	0.71**	0.38**
IR 28 x IET 20528	-3.17	-0.02	2.65**	-5.91	-4.72	-3.65*	-0.32	0.04	-0.01	0.01
IR 28 x IET 20533	-4.01	-0.19	0.81	10.33*	5.03	0.94	0.79	-1.17*	0.07	-0.36**
IR 28 x IET 20538	0.47	-0.49	-1.16	-1.26	-3.51	0.50	0.99	-0.72	-0.05	0.007
IR 28 x IET 20560	4.49*	-1.97**	-2.57**	0.27	-10.00*	-5.31**	-2.16**	0.09	-0.37*	0.04
IR 28 x IET 20567	2.30	0.41	-1.78	2.46	-4.56	-3.49*	-1.23	-0.98*	-0.18	-0.10
IR 28 x GR 103	-3.02	0.48	0.73	-18.69**	13.75**	4.02*	0.89	0.87	-0.40*	0.12
IR 28 x IET 19419	-0.63	1.09*	0.005	-1.51	-4.56	-2.29	-1.27	-0.06	0.20	0.04
Lal kada x GR 12	-0.12	0.39	1.23	-4.72	3.28	1.33	0.66	-0.35	0.14	-0.035
Lal kada x NVSR 20	6.64**	1.83**	0.97	10.63*	3.08	0.17	0.71	-0.79	0.41**	0.19**
Lal kada x IET 20152	-1.60	-1.13*	-1.07	-5.06	-11.78*	-5.008**	-1.31*	0.13	-0.01	-0.16*
Lal kada x IET 20528	-2.17	1.66**	-0.19	-13.59**	18.45**	4.09*	0.02	-0.05	-0.36*	-0.09
Lal kada x IET 20533	0.28	-1.21*	-2.21*	-3.86	-13.28**	-4.97**	-2.01**	0.32	-0.06	-0.12
Lal kada x IET 20538	-1.91	-0.77	-1.31	4.78	-12.33*	-3.71*	-1.41*	0.37	0.09	0.20**
Lal kada x IET 20560	0.38	1.01	1.41	2.13	3.13	2.33	1.08	0.09	-0.28	0.002
Lal kada x IET 20567	0.24	-0.21	2.38*	2.87	7.11	3.52*	0.55	-0.84	-0.18	0.01
Lal kada x GR 103	-0.56	-0.22	-2.44*	4.89	-9.37*	-2.15	-0.03	0.37	-0.35*	-0.09
Lal kada x IET 19419	-1.16	-1.36**	0.75	1.92	11.71*	4.40*	1.72**	0.73	0.61**	0.10
Safed kada x GR 12	-1.37	-1.37**	-2.42*	-1.75	-12.21*	-7.95**	-2.67**	1.40*	-0.02	0.09
Safed kada x NVSR 20	-5.78**	0.57	0.39	-7.46	4.23	0.76	-0.75	-0.03	-0.32*	0.17*
Safed kada x IET 20152	-1.51	-0.53	-2.26*	-5.95	-12.87**	-3.74*	-1.93**	0.23	0.47**	-0.15*
Safed kada x IET 20528	2.60	-0.34	-0.10	7.21	-6.91	-0.98	0.19	-0.20	-0.44**	-0.03
Safed kada x IET 20533	0.81	0.66	0.39	-6.26	3.45	2.87	0.65	-1.15*	0.20	-0.03
Safed kada x IET 20538	-0.32	2.45**	4.21**	-0.77	18.31*	6.65**	2.45**	1.69**	0.20	0.06
Safed kada x IET 20560	3.96	0.98	1.06	17.40**	4.76	2.05	1.11	0.40	-0.65**	-0.09
Safed kada x IET 20567	-5.36*	-1.00	0.03	-9.48*	-4.57	0.06	-0.90	0.63	0.05	0.004
Safed kada x GR 103	4.41*	0.72	0.23	3.03	4.77	0.13	1.00	-2.48**	0.005	0.01
Safed kada x IET 19419	2.56	-2.13**	-1.54	4.03	1.02	1.68	0.84	-0.51	0.51**	-0.03

DFF= Days to 50% flowering, PP= Panicles per plant, PL= Panicle length (cm), PH= Plant height (cm), GP= Grains per panicle, GYP= Grain yield per plant (g), TW= 1000 grain weight, AC= Amylose content (%), PC= Protein content (%), L/B ratio= Kernel length/breadth ratio

direction for grain yield per plant. The best three specific crosses for grain yield per plant were Safed kada x IET-20538 (6.65) followed by cross, IR-28 x IET-20152 (6.17) and GR-10 x GR-12 (5.43).

Range of sca effect of hybrids varied from -2.67 (Safed kada x GR-12) to 2.52 (IR-28 x IET-20152) for

1000 grain weight. The best three specific crosses were IR-28 x IET-20152 (2.52) followed by cross, Safed kada x IET-20538 (2.45) and GR-10 x GR-12 (2.45) which exhibited maximum positive sca effect for 1000 grain weight.

Estimation of sca effect for amylose content ranged from -2.48 (Safed kada x GR-103) to 2.00 (GR-10 x IET-20533). Six crosses showed significant positive sca effect for amylase content. Cross, GR-10 x IET-20533 (2.00) exhibited maximum sca effect followed by Safed kada x IET-20538 (1.69) and Safed kada x GR-12 (1.40) for this trait.

Range of sca effect was varied from -1.18 (GR-10 x IET-20152) to 1.32 (GR-10 x IET-20560) for protein content. The best three specific crosses were GR-10 x IET-20560 (1.32) followed by cross, GR-10 x IET-20528 (0.82) and GR-10 x GR-103 (0.75) exhibited maximum positive sca effect for protein content.

For kernel L/B ratio sca effect ranged from -0.36 (IR-28 x IET-20533) to 0.53 (GR-10 x IET-20533). Ten hybrids showed significant sca effect of which, five hybrids attributed towards positive direction for this trait. Cross, GR-10 x IET-20533 (0.53) exhibited maximum sca effect followed by IR-28 x IET-20152 (0.38) and Lal kada x IET-20538 (0.20) for this trait.

By examining the summary from Table 2 and Table 3, it can be seen that all the crosses having best specific combination for grain yield per plant were obtained either through average x poor and average x average parental combination. This might be due to additive x dominance type of interaction with epistasis gene action and non-fixable genetic component for grain yield per plant. This indicated possibly to obtained desirable transgressive segregants and hybrid vigour from such crosses by adopting cyclic selection or biparental breeding programme.

The best specific combination *i.e.* Safed kada x IET-20538 also recorded the desirable significant sca effects for traits *viz.,* panicles per plant, panicle length, grains per panicle, 1000 grain weight and amylose content. The second best cross IR-28 x IET-20152 had desirable significant sca effects for panicles per plant, grains per panicle, 1000 grain weight, protein content and L/B ratio, whereas the third best cross GR-10 x GR-12 had desirable significant sca effects for panicles per plant and 1000 grain weight.

From this study, it is suggested that both additive and non additive gene actions were important in controlling various characters. Among males best combiners for yield and yield attributing traits were IET-20528, NVSR-20, GR-103 and GR-12 and among females GR-10 and IR-28 could be utilized in future breeding programme. The crosses *viz*., Safed kada x IET-20538, IR-28 x IET-20152 and GR-10 x GR-12 could be used for exploitation of heterosis for yield in F_1 generation.

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