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Quantitative and qualitative genetic analysis in segregating generation of high yielding rice cultivars

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ABSTRACT

Combining ability study on grain yield, various yield components and selected grain quality traits of 9 x 9 diallel mating design (excluding reciprocals) indicated predominance of additive gene action for all the traits except plant height, net-assimilation rate, biological yield, harvest index and protein content (%). The parent HPR2047, VL93-3613, JD8, VL93-6052 and HPR1164 were good general combiners for grain yield, its components and grain quality characters. On the basis of specific combining ability effects, the cross combinations HPR2047x JD8, China 988 x VL91-1754, HPR1164xVLDhan221 and HPR1164x HPR2047 are having high grain yield plant^{-1} and grain quality traits. These crosses and are suggested for isolation of high yielding transgresive segregants through pedigree method.

Key words: *combining ability, quantitative traits, qualitative, rice*

Breeding method for the improvement of a crop depends primarily on the nature and magnitude of gene action involved in the expression of quantitative and qualitative traits. Combining ability analysis helps in the identification of parents with high general combining ability (gca) effects and cross combinations with high specific combining ability (sca) effects. Additive and non-additive gene actions in the parents estimated through combining ability analysis may be useful in determining the possibility for commercial exploitation of heterosis and isolation of pure lines among the progenies of the heterotic F_2. The present study was conducted to get information on the combining ability and gene action of nine high yielding cultivars of rice for yield, its components and some qualitative traits.

MATERIALS AND METHODS

Nine diverse parents of rice *viz.*, HPR1164 (P_1), HPR2047 (P_2), China 988 (P_3), VL91-1754 (P_4), VL93-3613 (P_5), VL93-6052 (P_6), IR57893-08 (P_7), VLDhan221 (P_8) and JD8 (P_9) were crossed in diallel mating design (excluding reciprocals) during wet seasons of 2001 and 2002. The nine parents along with their 36 F_2s for evaluation were grown in randomized block design with three replications in the CSK, Himachal Pradesh Krishi Vishvavidyalaya, Palampur, India during wet season 2003. Twenty one days old seedlings of each parent and F_2s were transplanted with a spacing of 20 x 15cm. Three rows of each parent and five rows of each F_2s were raised. Single seedling hill^{-1} was transplanted and standard agronomical practices were followed to raise a healthy crop. Observations were recorded on five parental plants and 50 segregating plants on the following traits *viz.*, days to 50% flowering, days to maturity, plant height, leaf area index, dry matter, net-assimilation rate, harvest index, 100 grain weight, panicle length, biological yield, grain yield, grain length, grain breadth, grain length:breadth ratio, amylose content and protein content (Table1). Combing ability analysis was carried out following Method II and Model 1 of Griffing (1956).

RESULTS AND DISCUSSION

Analysis of variance for combining ability indicated that both additive as well as non-additive gene actions were involved for the characters under study (Table 1). The

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Table 1. Analysis of variance for combining ability for grain yield, its components and grain quality traits in F_2 generation of rice

Characters	Mean square due to		
	GCA 8	SCA 36	Error 160
Days to 50% flowering	77.73**	50.28**	1.51
Plant height	80.69**	91.63**	4.08
Leaf area index	0.46**	0.30**	0.0004
Dry matter	20.70**	12.43**	3.99
Net assimilation rate	1.41	4.02*	0.88
Length of panicle	4.86**	4.03**	0.47
Days to maturity	67.04**	47.45**.	1.25
Grain yield plant^{-1}	7.95**	3.55**	2.24
Biological yield plant^{-1}	111.95**	139.70**	3.88
Harvest index	39.54**	53.96**	5.52
100 grain weight	0.21**	0.08**	0.004
Grain length	0.40**	0.19**	0.020
Grain breadth	0.50**	0.008**	0.0007
L/B ratio	0.21**	0.05**	6.21
Amylose content	3.85**	0.06**	0.01
Protein content	0.33**	0.73**	0.04

estimated components of general combining ability (gca) variance was higher than specific combining ability sca variance for all the characters except plant height, net-assimilation rate (nar), biological yield plant^{-1}, protein content and harvest index indicating the predominance of additive gene action in the expression of all these characters which is highly heritable and fixable. Similar results were also reported by several workers for plant height (Lokaparkash *et al*., 1991), for days to 50% flowering (Ghosh, 1993).

HPR 2047 was found to be the best general combiner for grain yield plant^{-1}, whereas JD 8 was a good general combiner for yield components and grain quality traits like plant height, days to 50% flowering, biological yield plant^{-1}, days to maturity, grain length, grain breadth, length breadth ratio and protein content (Table 2). VL93-3613 was a good general combiner for plant height, days to 50% flowering, biological yield, harvest index, days to maturity, and net-assimilation rate. This study suggested that hybridization among the parents having good general combining ability for grain yield and important yield components would be useful in breeding programmes to provide desirable segregants for selection. Similar results were also reported by Sarma and Mani (2001). On the basis of gca effects, the parents VL93-6052, JD8 and VL93-3613 are good general combiners for most of the yield contributing and quality traits.

Maximum desirable sca effects were exhibited by cross combination of HPR2047 x VL91-1754 followed by VLDhan221xJD 8 for plant height (Table 3). The cross combinations VL91-1754xVL93-3613 and VL93-3613 xVLDhan221 exhibited maximum sca effects for early maturity followed by VLDhan221xJD8. The results on specific combining ability effects of cross combinations indicated that the cross HPR2047xJD8 was the best specific combination for grain yield plant^{-1} followed by China 988xVL91-1754. Cross combination VL93-6052 x VLDhan221 exhibited maximum sca effects for harvest index followed by HPR1164 x JD8. Maximum significant sca effects were exhibited by heterotic combinations HPR2047xVL93-6052 (19.70) and minimum by VL93-6052xVLDhan221 (4.12) for biological yield per plant. Maximum sca effect for panicle length was exhibited by the cross China 988xJD8 and VL93-3613 xIR57893-08 (each 2.98). Cross combination VL91-1754xIR57893-08 indicated maximum sca effects for 100-grain weight followed by HPR2047xVL93-6052. Cross combination HPR2047xJD8 exhibited maximum length breadth ratio. The cross combination China 988xVL91-1754 exhibited maximum amylose content. Maximum sca effect was exhibited by the cross combination IR57893-08xVLDhan221 followed by HPR2047xVL93-3613. Maximum sca effect was exhibited by cross combination HPR2047xJD8 for net assimilation rate. Maximum significant sca effect was exhibited by the cross combination HPR1164 xVL93-3613 followed by VL91-1754xVL93-3613 and VL93-3613 xVLDhan221 for dry matter.

The cross combination HPR2047xJD8 was also the best specific combination for biological yield, harvest index, net-assimilation rate, grain length and length breadth ratio. The cross combination China 988xVL91-1754 indicated high sca effects for biological yield per plant, harvest index, 100 grain weight, grain length, and length breadth ratio (Table 4). The study of the relationships of sca effects of crosses and gca effects of parents indicated that the sca combinations for grain yield viz.HPR2047xJD8, China 988xVL91-1754, HPR1164 xVLDhan221 and HPR1164 xHPR2047 involved good x average, average x average,

Table 2. Estimates of general combining ability (gca) effects for yield, its components and grain quality traits in F_2 generation of rice

Traits Genotypes	Plant height	Days to 50% flowering	Grain yield	Biological yield	Harvest index	Days to maturity	LAI	DM	PL	100grain weight	NAR	GL	GB	L/B ratio	AC	PC
HPR 1164 (P1)	3.70**	0.52	0.35	2.42**	-2.93**	0.38	0.11**	2.56**	-0.27	0.02*	-0.22	0.12**	0.06**	-0.03	0.37**	0.14*
HPR2047 (P2)	-1.70**	0.80*	1.37**	1.00	-0.02	0.67*	-0.20**	-0.45	-0.16	-0.25**	-0.26	-0.25**	-.12**	0.11**	-0.41**	-0.19**
China 988 (P3)	-1.89**	3.99**	0.09	-3.71**	1.25	3.84**	0.08**	-1.72**	-0.27	0.05**	0.07	-0.06	0.09**	-0.20**	-0.80**	-0.13*
VL91-1754 (P4)	4.82**	1.80**	0.34	-1.39*	1.21	1.66**	0.16**	0.80	1.49**	0.16**	0.49**	0.07	0.01**	0.00	0.38**	0.05
VL93-3613 (P5)	-1.35*	-3.10**	0.72	6.13**	1.73**	-3.25**	-0.21**	-0.67	-0.30	-0.04**	0.65*	-0.25**	-.01**	-0.11**	-0.14**	-0.14*
VL 93-6052 (P6)	0.23	-0.71*	-0.68	-2.36**	1.49*	-0.86**	0.36**	1.30*	0.28	0.13**	-0.30	0.19**	0.02**	0.07**	0.83**	0.13*
IR-57893-08 (P7)	-2.12**	2.69**	-1.33**	-2.95**	1.16	2.54**	0.03**	-1.58**	0.43*	0.13**	0.10	0.06	0.04**	-0.06**	-0.75**	-0.16**
VL-Dhan221 (P8)	1.10	-3.76**	-0.94*	-1.40*	-3.18**	-2.97**	-0.28**	-0.16	-0.44**	-0.04**	-0.33	-0.17**	-003**	-0.05*	0.65**	-0.02
JD-8(P9)	-2.78**	-2.23**	0.09	2.25**	-0.72	-2.01**	-0.05**	-0.08	-0.77**	-0.17**	-0.19	0.28**	-006**	0.28**	-0.13**	0.32**
S.E (gi)	0.57	0.34	0.42	0.55	0.66	0.31	0.0006	0.56	0.17	0.01	0.26	0.04	0.00	0.02	0.03	0.06
S.E (gi-gj)	0.86	0.52	0.63	0.83	0.31	0.46	0.0009	0.84	0.28	0.02	0.40	0.06	0.01	0.03	0.04	0.09
C.D.(gi) at5%	1.12	0.66	0.82	1.08	1.29	0.60	0.00	1.09	0.33	0.02	0.50	0.08	0.00	0.04	0.05	0.11

* Significant at 5 per cent probability ** Significant at 1 percent probability

LAI – leaf area index DM– dry matter, GL – grain length, GB – grain breadth, NAR – net assimilation rate , AC-amylose content, PC-protein content and PL – panicle length

Table 3. Estimates of specific combining ability effects for yield, its components and grain quality traits in F_2 generation

Crosses	PH	DTF -50%	GY	BY	HI	DTM	LAI	DM	PL	100 GW	NAR	GL	GB	L/B ratio	AC	PC
P_1xP_2	0.69	-6.04**	2.17*	15.26**	-3.22	-5.93**	-0.44**	-0.57	0.91	0.31**	-0.3	0	0.08**	-0.08	0.12	0.44**
P_1xP_3	0.61	-6.90**	-0.9	-5.87**	-1.54	-6.77**	-0.77**	0.54	1.37*	-0.02	-0.22	-0.01	-0.05*	0.08	0.04	0.19
P_1xP_4	2.61	-6.57**	-0.42	11.08**	-4.35*	-6.44**	-0.24**	2.5	-0.77	-0.34**	0.76	-0.24*	-0.11**	0.08	-0.38**	-0.66**
P_1xP_5	3.71**	0.5	1.44	10.33**	-6.52**	0.63	1.03**	6.55**	1.49*	0.06	0.04	-0.13	0.04*	-0.14*	0.54**	0.2
P_1xP_6	4.93**	12.57**	0.67	-11.77**	1.9	12.70**	0.75**	0.7	0.03	-0.21	-1.22	0.79**	0.04*	0.50**	-0.1	-0.08
P_1xP_7	3.54**	-4.32**	-1.08	3.03	6.69**	-4.19**	-0.44**	0.99	2.85**	0.21	0.27	0.25*	-0.05*	0.05	-0.17	-0.3
P_1xP_8	2.28	-0.94	2.41*	2.7	0.14	-1.73	-0.05**	3.77**	-1.43**	0.07	0.4	-0.49**	-0.08**	-0.11	-0.03	0.62**
P_1xP_9	7.92**	10.31**	-2.42	-12.43**	2.24	10.08**	-0.27**	0.55	1.98**	0.08	1.06	0	0.01	-0.06	-0.07	-0.61**
P_2xP_3	-6.72**	-2.02	-2.66	-7.64**	9.12**	-1.9	0.08**	4.00*	1	-0.19**	-0.94	-0.99**	-0.23**	-0.16*	-0.09	0.31
P_2xP_4	-15.01**	-1.9	-1.33	-3.98*	-0.25	-1.79	-0.36**	-4.27*	-1.05	-0.41	-1.75*	-0.61**	-0.01	-0.34**	0.24**	0.88**
P_2xP_5	-11.83**	5.14**	0.41	-19.24**	10.11**	5.26**	-0.15**	-5.43**	0.54	-0.09	-1.29	-0.13	0.11**	-0.30**	0.01	1.06**
P_2xP_6	-5.68**	1.43	0.64	19.70**	-6.47**	1.55	0.34**	-3.93*	1.98**	0.46**	-1.45	0.36**	0.01	0.18*	-0.03	0.27
P_2xP_7	17.34**	-0.21	0.43	5.48**	-8.39**	-0.1	1.02**	2.54	0.65	0.32**	3.03**	0.43**	0.06**	0.09	-0.20*	-0.66**
P_2xP_8	1.54	0.29	0.67	-10.87**	-2.01	-0.33	-0.07**	1.87	1.70**	0	2.80**	-0.15	0.05**	-0.20**	0.43**	-0.80**
P_2xP_9	13.01**	6.86**	5.91**	6.00**	10.70**	6.61**	-0.26**	3.69*	-0.23	-0.07	3.25**	0.37**	-0.08**	0.41**	-0.09	-0.23
P_3xP_4	4.28*	-1.01	2.63*	6.46**	4.48*	-0.88	-0.11**	-4.26*	-2.62**	0.22**	-1.06	0.58**	0.06**	0.19*	0.55**	0.62**
P_3xP_5	6.88**	4.61**	-0.06	7.43**	-0.21	4.74**	0.60**	-6.35**	0.23	0.34**	-2.87**	0.49**	-0.02	0.29**	-0.06	-0.22
P_3xP_6	3.31	-8.82**	1.74	-5.95**	4.17	-8.69**	-0.97**	-0.92	0.49	-0.03	2.11*	-0.61**	0.02	-0.34**	-0.07	-0.30**
P_3xP_7	0.21	3.63**	-0.37	11.86**	-10.00**	3.76**	-0.12**	-0.49	-1.67**	-0.19**	2.13*	-0.29**	0	-0.13	0.11	1.37**
P_3xP_8	2.62	4.99**	0.92	14.55**	-8.00**	4.20**	0	2.68	1.67**	0.38**	1.68*	1.02**	0.13**	0.28**	-0.33**	1.17**
P_3xP_9	6.60**	7.54**	0.77	-3.96**	2.44	7.30**	0.49**	2.28	2.98**	0.14**	0.63	0.01	0.27**	-0.47**	0.02	-0.21
P_4xP_5	-2.03	-11.00**	-0.4	-8.53**	6.05**	-10.87**	-0.68**	5.09**	2.36**	0	2.55*	-0.22	-0.05*	-0.02	0.12	-0.04
P_4xP_6	- 3.94*	1.14	-1.38	-8.37**	-9.58**	1.27	-0.60**	2.37	1.70**	0.27**	0.97	0.18	0.04*	0.02	0.15	-0.14
P_4xP_7	-6.93**	-8.45**	-0.74	0.83	-0.83	-8.32**	-0.06**	-2.44	-0.6	0.51**	-0.73	0.64**	0.09**	0.17*	-0.61**	-0.91
P_4xP_8	0.01	3.96**	1.23	-5.27**	8.59**	3.16**	-0.08**	-0.45	-1.07	0.25**	0.79	-0.07	-0.04*	0.05	0.06	1.58
P_4xP_9	21.09**	6.33**	-0.63	1.58	4.34*	6.10**	-0.18**	0.59	1.21	0.20**	0.54	0.06	0.03	-0.03	0.01	0.19
P_5xP_6	1.87	-8.21**	-2.74*	4.55*	-4.1	-8.08**	-0.52**	-2.85	-4.14**	-0.32**	-0.78	-0.38**	-0.09**	-0.04	-0.07	1.10*
P_5xP_7	14.63**	-5.78**	-0.24	2.56	9.12**	-5.65**	-0.53**	5.03**	0.51	0.30**	-1.27	0.67	0.06**	0.06	0.08	-0.01
P_5xP_8	15.99**	8.25**	0.31	33.88**	-14.98**	7.46**	-0.01	0.34	2.27**	0.20**	-1.80*	0.63**	0.03	0.28**	-0.14	-0.85**
P_5xP_9	-1.91	-7.18**	-0.64	21.40**	-11.15**	-7.41**	0.96**	2.35	-0.23	0.16**	-1.11	-0.36**	-0.06**	-0.08	-0.34**	1.26**
P_6xP_7	1.12	-5.20**	-1.84	-2.65	-2.56	-5.06**	0.09**	0.7	0.34	0.19**	0.51	0.11	0.02	0.02	0.42**	0.07
P_6xP_8	-5.08**	2.64*	-1.28	4.12**	18.71**	1.84	0.89**	2.88	0.76	-0.01	0.43	-0.39**	0.11**	-0.40**	-0.06	-1.12**
P_6xP_9	-9.80**	-8.29**	1.85	0.07	3.9	-8.52**	0.32**	2.49	-0.57	-0.27**	0.5	0.11	-0.11**	0.29**	0.13	0.64**
P_7xP_8	1.12	7.27**	0.91	-17.32**	-2.71	6.47**	0.29**	-3.22	1.23*	-0.06	0.77	-0.08	-0.02	0	-0.14	1.62**
P_7xP_9	-1.88	9.93**	-1.29	4.62**	0.44	9.70**	-0.38**	-3.42	2.80**	-0.13*	-0.77	0.04	0	-0.01	0.33**	0.22
P_8xP_9	-13.70**	-8.92**	-0.48	-6.58**	-2.57	-10.08**	-0.36**	-2.57	-2.88**	-0.27**	3.03	-0.44**	-0.06**	-0.13	0.22*	-0.03
S.E.(Sij)	1.85	1.12	1	1.8	2.14	1.01	0.02	1.82	0.62	0.05	0.85	0.12	0.02	0.07	0.09	0.2
S.E(Sij-ik)	2.72	1.65	2.01	2.65	3.17	1.5	0.03	2.69	0.92	0.08	1.26	0.18	0.03	0.12	0.14	0.29
S.E(Sij-L)	2.58	1.57	1.91	2.51	3	1.43	0.03	2.55	0.87	0.07	1.2	0.18	0.03	0.11	0.13	0.28
C.D ij) at 5%	3.63	2.19	1.96	3.53	4.19	1.97	0.04	3.56	1.21	0.09	0.92	0.23	0.04	0.13	0.17	0.39

P_1=HPR1164, P_2=HPR2047, P_3=China 988, P_4=VL91-1754, P_5=VL93-3613, P_6=VL93-6052, P_7=IR57893-08, P_8=VLDhan221 and P_9=JD8

Table 4. Best general combiners and specific combiners for different characters

Characters	Best general combiners	Best specific combiners
DFFL	P_5, P_8, P_9	$P_1xP_2, P_1xP_3, P_1xP_4, P_1xP_7, P_3xP_6, P_4xP_5, P_4xP_7, P_6xP_7, P_6xP_8, P_7xP_9, P_8xP_9$
PH	P_2, P_3, P_5, P_7, P_9	$P_2xP_3, P_2xP_4, P_2xP_5, P_2xP_6, P_4xP_5, P_4xP_6, P_6xP_8, P_6xP_9, P_8xP_9$
LAI	P_1, P_3, P_4, P_6, P_7	$P_1xP_5, P_1xP_6, P_2xP_5, P_2xP_7, P_3xP_9, P_5xP_7, P_6xP_7, P_6xP_8, P_6xP_9, P_7xP_8$
DM	P_1, P_6	$P_1xP_5, P_1xP_8, P_2xP_3, P_2xP_9, P_4xP_5, P_5xP_8$
NAR	P_4, P_5	$P_2xP_7, P_2xP_8, P_2xP_9, P_3xP_6, P_3xP_7, P_3xP_8, P_4xP_5$ P_5xP_6, P_5xP_7
LP	P_4, P_7	$P_1xP_3, P_1xP_5, P_1xP_7, P_1xP_9, P_2xP_6, P_2xP_7, P_3xP_8, P_3xP_9, P_4xP_5, P_4xP_6, P_5xP_6, P_5xP_7, P_5xP_8, P_5xP_9, P_7xP_8, P_7xP_9$
DTM	P_5, P_6, P_8, P_9	$P_1xP_2, P_1xP_3, P_1xP_4, P_1xP_7, P_3xP_6, P_4xP_5, P_4xP_7, P_5xP_8, P_6xP_7, P_6xP_9, P_8xP_9$
100GW	P_1, P_3, P_6, P_7	$P_1xP_2, P_2xP_6, P_2xP_7, P_3xP_4, P_3xP_8, P_3xP_9, P_4xP_6, P_4xP_7, P_4xP_8, P_4xP_9, P_5xP_6, P_5xP_7, P_5xP_9, P_6xP_7$
GY	P_2	$P_1xP_2, P_1xP_8, P_2xP_9, P_3xP_4$
BY	P_1, P_5, P_9	$P_1xP_2, P_1xP_4, P_1xP_5, P_2xP_6, P_2xP_7, P_2xP_9, P_3xP_4, P_3xP_5, P_3xP_7, P_3xP_8, P_5xP_6, P_6xP_9, P_7xP_8$
HI	P_5, P_6	$P_1xP_7, P_2xP_3, P_2xP_5, P_2xP_9, P_3xP_4, P_4xP_5, P_4xP_8, P_4xP_9, P_5xP_8, P_6xP_8$
GL	P_1, P_6, P_9	$P_1xP_6, P_1xP_7, P_2xP_6, P_2xP_7, P_2xP_8, P_2xP_9, P_3xP_4, P_3xP_8, P_4xP_7, P_5xP_6$
GB	P_2, P_5, P_9, P_8	$P_1xP_3, P_1xP_4, P_1xP_7, P_2xP_3, P_2xP_8, P_4xP_5, P_4xP_8, P_5xP_8, P_6xP_9, P_8xP_9$
L/B ratio	P_2, P_6, P_9	$P_1xP_6, P_2xP_6, P_6xP_8$
AC	P_1, P_4, P_6, P_8	$P_1xP_5, P_2xP_4, P_2xP_8, P_3xP_4, P_6xP_7, P_7xP_9, P_8xP_9$
PC	P_1, P_6, P_9	$P_1xP_2, P_1xP_8, P_2xP_4, P_2xP_5, P_3xP_4, P_3xP_7, P_3xP_8, P_5xP_6, P_6xP_9, P_7xP_8$

DFFL- days to 50% flowering, PH- Plant height, DM-Dry matter at 90 days after transplanting, NAR- net assimilation rate, LP- Length of panicle, DTM- Days to maturity, 100Gw- 100 grain weight, GY- grain yield per plant, BY- Biological yield per plant, HI- Harvest index, BL- Grain length, GB- Grain breadth, L/B ratio-Length breadth ratio, AC- Amylose content and PC- Protein content.

P_1=HPR1164, P_2=HPR2047, P_3=China 988, P_4=VL91-1754, P_5=VL93-3613, P_6=VL93-6052, P_7=IR57893-08, P_8=VLDhan221 and P_9=JD8

average x poor and average x good parents. The superiority of such crosses might be due to the concentration and interaction between favorable genes contributed by the parents. Reddy *et al*., (2002) also observed superiority of average x average combinations. The chances of getting good segregates in these crosses will depend on the additive genetic variance present in the good general combiner and the epistatic effects in the cross, provided both the types of genetic effects act in the same direction so as to maximize the desirable yield component.

Based on the result of the present study, it could be concluded that the parents HPR2047, VL91-1754 and JD8 were found to be good general combiners for grain yield and its components and should be exploited in hybridization programme. The crosses HPR2047xJD8, China 988xVL91-1754, HPR1164 xVLDhan221 and HPR1164 xHPR2047 exhibited desirable sca effects for grain yield along with majority of yield attributes and could be for isolated of high yielding pure lines through pedigree method of breeding.

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