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Heterosis for morpho-physiological and qualitative traits in rice

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ABSTRACT

The extent of heterosis was studied in a set of 36 hybrids generated from a 9 x 9 diallel mating design excluding reciprocals involving nine promising genotypes HPR1164, HPR2047, China 988, VL91-1754, VL93-3613, VL93-6052, IR57893-08, VL Dhan221 and JD8 of diverse nature maintained in pure form. Out of 36 hybrids, twelve showed significant heterosis for majority of the traits identified. In general, the estimates of heterosis values were low for quality traits when compared with yield and morpho-physiological traits. Nine hybrids exhibited positive and significant heterosis over standard check but seven over better parents for grain yield plant^{-1}. Standard heterosis and heterobeltiosis for grain yield ranged from 14.12 to 65.32% and 22.59 to 65.32%, respectively. The hybrid HPR 2047xJD8 which recorded 65.32% higher grain yield over both better parent and standard check was identified as the best hybrid for exploiting hybrid vigor. In order of merit (standard heterosis) HPR 2047xJD8 (65.32%), VL93-3613 x IR 57893-08 (60.05%) and VL93-6052 x VL Dhan (54.94%) were recorded to be the three best performing hybrids for grain yield plant^{-1}. The higher yield by these hybrids could be due to more panicle length, netassimilation rate, leaf area index, dry matter, harvest index and 100 grain weight. These crosses may be used in future breeding programmes for development of high yielding hybrids and varieties. The cross combinations VL91-1754 x VL93-3613 VL91-1754 xJD8 and VL93-3613xJD8 recorded desirable heterosis over both better parent and standard check for grain quality as well as grain yield plant^{-1}.

Key words: : *rice, diallel, heterobeltiosis, standard heterosis*

The hybrid technology, a modern approach to enhance the genetic yield potential has been widely acclaimed and established in various crops. China was the first country where yield barrier in semi dwarf inbred rice was broken by rice hybrids which gave 20-25% more yield than conventional inbred varieties (Virmani *et al.,* 1982). Parental combination's giving high heterosis to produce transgressive segregants along with higher magnitude of exploitable hybrid vigor is the pre-requisite for making a break through in yield. Such exploitations are very much needed to increase the yield level with better adaptability. Hence, the present study was undertaken to assess the extent of heterosis and to identify best cross combinations on the basis of yield and quality for future utilization in breeding programmes.

MATERIALS AND METHODS

Nine diverse genotypes of rice viz., HPR1164, HPR2047, China 988, VL91-1754, VL93-3613, VL93-6052, IR57893-08, VLDhan221 and JD8 were crossed in all the possible combinations in a diallel fashion excluding reciprocals at the Experimental Farm of Choudhary Sarwan Kumar, Himachal Pradesh Krishi Vishvavidyalaya, Palampur during wet seasons of 2001 and 2002. In the wet season of 2003, all the 36 hybrids along with parents and standard check were raised in randomized block design with three replications. Single row of each parent and hybrid was 3m measured with 20 x 15cm, row to row and plant to plant spacing, respectively. Fertilizers were applied at the rate of 90N:45P_2O_5:30K hectare^{-1} as recommended. Nitrogen was applied in three splits 50% as basal, 25% at tillering and 25% at panicle initation stage. The recommended cultural practices were followed. Observations were recorded on 10 randomly selected plants of parents and 25 plants of hybrids on the following traits viz., days to 50% flowering, plant height, length of panicle, days to maturity, grain yield plant^{-1}, biological yield plant^{-1}, leaf area index, dry matter, 100 grain weight, net assimilation rate grain length, grain breadth, length breadth ratio and harvest index. The percent heterosis over better parent and standard heterosis were calculated following Turner (1953).

RESULTS AND DISCUSSION

The analysis of variance mean squares for all the 14 characters indicated sufficient genetic diversity among the genotypes. Commercial exploitation of hybrid vigor is feasible only if the vigor is in excess of prevailing commercial check and better parent. Superiority of hybrid over mid parent is of no importance since it does not offer any advantage over the better parent.

One of the major objectives in plant breeding is to get higher grain yield plant^{-1}, therefore, emphasis was given in the present study for heterosis over better parent and standard check. The hybrids recorded 22.59 to 65.32% heterobeltiosis and -14.12 to 65.32% for economic heterosis for grain yield plant^{-1}. The cross combinations HPR2047xJD8, VL93-6052xVL Dhan 221 and VL93-3613xJD8 recorded the highest potential for grain yield plant^{-1} along with desirable heterosis for net assimilation rate, dry matter, days to maturity, harvest index, days to fifty percent flowering and 100 grain weight, respectively (Table1). Pandey *et al.* (1995) reported very high estimates of heterosis for grain yield in rice. Rest of the hybrids had recorded negative values. Parkash and Mahadevappa (1989) attributed low grain yield of F_1 was due to spikelet sterility. This could be the reason for most of the hybrids not showing significant heterosis for grain yield plant^{-1}. Maximum desirable heterosis for days to fifty percent flowering was observed in the hybrid VL Dhan 221xJD8 (-14.03%) compared to the standard check and 14.56% by hybrid VL93-3613xIR57893-08 on better parent along with yield and most of the yield attributing traits. Out of twelve hybrids, the single hybrid VL93-3613xIR57893-08 (-14.56% &-13.79%) (Table 2) revealed desirable heterobeltiosis and standard heterosis. Some of the crosses manifested significant positive heterobeltiosis, while others exhibited low negative values, probably due to the varying extent of genetic diversity between parents of different crosses for the component characters. Early flowering in hybrids had been reported by Lokaparkash *et al.* (1992) and Patil *et al.* (2003). Shorter plant type is an important character of hybrid to withstand lodging. Cross combinations exhibited desirable heterosis for plant height are China 988xVL91-1754 (-17.71%) and HPR1164x JD8 (-9.16%) over both better parent and standard check, respectively. Luat *et al.* (1985) and Rao *et al.* (1996) also observed negative heterosis for plant height. For days to maturity, only three hybrids (VL93-3613xIR57893-08, VL93-6052 x VL93-3613 and VL93-3613xIR57893-08) had exhibited significant negative standard heterosis but heterobeltiosis by only two hybrids (China 988xVL91-1754) and VL93-3613xIR57893-08). Hybrids VL93-3613xIR57893-08 and VL93-3613xIR57893-08 indicated maximum heterobeltiosis and standard heterosis (10.88%) and (-10.46%), respectively. Similar results were also reported by Cheema *et al.* (1988). Three crosses exhibited significant standard heterosis for harvest index. Maximum standard heterosis was exhibited by VL93-3613xIR57893-08 to an extent of 33.29% while, only the hybrid HPR1164x JD8 (36.54%) exhibited heterobeltiosis. However, a hybrid with greater panicle length is desirable since the spikelets attached to its primary and secondary branches would increase proportionality with the enhancement of panicle length. Five hybrids manifested significant and positive heterosis over both better parent and standard check. Maximum heterobeltiosis and standard heterosis were observed in VL93-3613xIR57893-08 (27.64% and 33.77%), respectively. Heterobeltiosis and standard heterosis ranged from (-19.34% to 27.64%) and (15.89% to 33.77%). These findings are in accordance with the findings of Janardhanan et al. (2001). The cross combination VL93-3613 xJD8 exhibited maximum heterobeltiosis (51.93%) and standard heterosis (71.01%) for grain weight (Table 1). Maximum heterobeltiosis and standard heterosis were exhibited for biological yield by two hybrids IR57893-08xJD8x VL Dhan221x JD8 (91.08% and 88.95%) and (70.70% and 68.79%), respectively. Heterbeltiosis and standard heterosis were observed to (-58.93 to 167.88%) and (22.93 to 167.88%), respectively for leaf area index. Maximum heterbeltiosis and standard heterosis for net assimilation rate were exhibited by hybrid VL93-3613 xJD8 (256.41%) and VL91-1754 xVL93-3613 (352.56%).

The long slender to extra long slender type is most preferred grain type. In this study, out of 12 crosses

Table1. Estimate of Heterosis over Better Parent (BP) and Standard Check (SC) in rice

Crosses	DTM		GY		BY		HI		100GW		GL		L\B ratio	
	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC
P2xP5	10.64**	10.64**	-11.06	2.47	-25.90**	-25.90**	-15.88**	12.74	15.02	29.46**	19.17**	16.56	2.5	1.50**
P2xP9	12.60**	2.49	65.32**	65.32**	-22.78**	-22.78**	36.54**	-0.91	0.42	13.04*	-26.77**	-1.22	-20.43**	-17.04**
P3xP4	-5.01**	0.73	22.59**	33.24**	-10.53	-9.13	-27.15	13.92	-17.34**	8.21	-11.44**	7.97	-4.57	-16.29**
P3xP7	-2.92	2.92	6.5	4.94	33.49**	8.9	-25.95**	-5.82	16.66**	42.02**	7.13	14.11	10.08**	-7.01*
P4xP5	3.49*	4.19	6.48	7.36	23.14	3.92	-4.24	28.35**	16.97**	53.14**	9.33*	25.15**	1.42	-11.02**
P4xP9	14.90**	4.57*	20.62	31.09**	20.47*	22.36**	-18.27**	-12.28	15.12**	50.72**	1.91	26.99**	-13.94**	-10.27**
P5xP7	-10.88**	-10.28**	38.91**	60.05**	7.19	-7.82**	-0.55	33.29**	22.74**	38.16**	0.96	12.26	1.78	-14.03**
P5xP9	6.34**	-3.2	27.61**	47.03**	-6.14	-7.19	-13.98**	15.36	51.93**	71.01**	1.5	23.92**	-11.53**	-7.76*
P6xP8	16.08**	5.15**	53.51**	54.94**	17.7	6.39	10.47	23.27**	-10.16	41.06**	1.58	14.11*	6.12	-4.51
P6xP9	-1.18	-10.05**	22.59**	23.73**	21.19**	19.83*	-1.87	9.49	-14.91**	21.25**	-14.89**	9.81	-16.58**	-14.03**
P7xP9	11.32**	1.33	26.09**	24.78**	91.08**	88.95**	-43.34**	-27.94**	22.74**	38.16**	-6.01	14.72	-11.53**	-7.76*
P8xP9	-1.15	-10.46**	-9.18	-14.12**	70.70**	68.79**	-12.56	-12.79	13.08**	29.46**	-13.52**	6.74	-12.50**	-8.77**
SE±	2.09	2.09	1.23	1.23	3.72	3.72	3.39	3.39	0.11	0.11	0.29	0.14	0.12	0.12

PH = plant height, DTM= days to maturity, LAI= leaf area index, DM= dry matter, DFL= days to 50% flowering, NAR= net assimilation rate, PL= panicle length, 100GW =100 grain weight, GL= grain length; 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

Table2. Estimate of Heterosis over Better Parent (BP) and Standard Check (SC) in rice

Crosses	PH		DFL		LAI		DM		NAR		PL		GB	
	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC
P2xP5	7.99**	7.99*	14.26**	14.26**	167.88**	167.88**	1.6	1.6	-73.95**	1.28	10.58	15.89*	3.82**	16.56
P2xP9	-9.16*	-9.16**	20.60**	3.34	15.97**	53.21**	71.39**	71.39**	256.41**	256.41**	18.59*	18.59*	16.77	-1.22
P3xP4	-17.71**	-10.59**	-6.59**	0.98	-58.93**	20.18	19.08**	34.73**	-27.11**	40.17**	-11.05	17.11*	-10.2	7.97
P3xP7	26.44**	12.16**	-3.85	3.92	12.77**	134.86**	2.7	-7.73	8.58**	83.76**	15.61*	20.33**	-5.1	14.11
P4xP5	-1.96	6.51	4.67*	5.62**	-42.31**	68.80**	47.19**	66.53**	16.37**	352.56**	-17.61**	8.48	7.93*	25.15**
P4xP9	-6.41	1.69	23.87**	6.13**	-52.66**	38.53**	-24.84**	-14.30*	-46.44**	2.99**	-8.45	20.54**	9.52**	26.99**
P5xP7	18.64**	1.35	-14.56**	-13.79**	-46.44**	-10.09	157.75**	112.92**	-10.65**	247.43**	27.64**	33.77**	-0.54	12.26
P5xP9	12.55**	-3.73	11.69**	-4.29*	27.77**	68.80**	129.03**	68.41**	-81.86**	29.48**	19.40**	25.14**	10.38**	23.92**
P6xP8	13.47**	20.76**	30.88**	6.91**	-27.75**	50.45**	30.33**	46.38**	-11.47**	28.63**	7.29	25.54**	-4.12	14.11*
P6xP9	-5.34	0.73	0.96	-13.48**	-40.96**	22.93*	50.39**	68.91**	67.64**	143.58**	-19.34**	-5.62	-7.73	9.81
P7xP9	33.46**	14.15**	18.78**	1.78	-33.87**	11	20.43	1.87	64.87**	148.71**	19.78**	23.45**	1.63	14.72
P8xP9	-5.23	-5.34	5.24	-14.03**	67.36**	121.10**	58.06**	35.28**	406.89**	25.64**	3.39	8.99	-1.13	6.74
SE±	3.83	3.83	2.14	2.1	0.12	0.12	1.15	1.15	0.08	0.08	1.5	1.5	0.14	0.14

PH = plant height, DTM= days to maturity, LAI= leaf area index, DM= dry matter, DFL= days to 50% flowering, NAR= net assimilation rate, PL= panicle length, 100GW =100 grain weight, GL= grain length, P2-HPR2047, P5-VL93-3613, P9-JD8, P4-VL91-1754, P3-China988, P7-IR57893-08, P6-Vl93-6052, and Dhan221

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 very few manifested positive heterosis for grain length. Two hybrids, exhibited heterobeltiosis while three hybrids exhibited standard heterosis. Maximum heterobeltiosis was recorded by cross combination HPR2047xVL93-3613 (19.17%) and standard heterosis by cross VL91-1754xVL93-3613 (25.15%) For grain breadth, no hybrids exhibited significant negative heterobeltiosis or standard heterosis. Maximum heterbeltiosis and standard heterosis were exhibited by HPR2047xJD8 (-20.43%) and (-17.04%), respectively for grain length breadth ratio. In respect of length breadth ratio, three hybrids showed poor manifestation of heterosis for grain quality traits was observed by Singh and Singh (1985). Viveklanandan and Giridharan (1995) also observed poor heterosis for grain length breadth ratio. HPR2047xJD8could be isolated for possessing standard heterosis for grain breadth and length breadth ratio.

The hybrid HPR2047xJD8 which recorded 65.32% high grain yield over both better parent and standard check was identified as the best hybrid for exploiting hybrid vigor. In order of merit (standard heterosis)HPR2047xJD8 (65.32%), VL93-6052xIR57893-08 (60.05%) and VL93-6052xVL Dhan 221 (54.94%) were recorded to be the three best performing F_1 hybrids for grain yield plant^{-1}. The higher yield by these hybrids could be due to more panicle length, net assimilation rate, leaf area index, dry matter, harvest index and 100 grain weight and these crosses may be used in future breeding programmes for development of high yielding hybrids and varieties. Considering both yield and quality together, VL 93-3613x JD8 hybrid exhibited significant heterosis for grain yield as well as for important quality characteristics in the desirable range. Hence, it needs further testing in replicated trails over locations for stability in performance prior to commercial exploitation.

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