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Research Article

Combining ability and heterosis for yield and its component traits in rice [*Oryza sativa* (L.)]

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Abstract
Investigation was carried out to determine combining ability and heterosis for yield and its component traits in rice. The material consisted of F_1 hybrids of 30 crosses developed by crossing 10 lines with three testers. The cross HPR 2639 X HPR 2143 is good specific combination for grain yield/plant, panicle length, spikelets/panicle, grains/panicle, biological yield/plant, days to 50% flowering and plant height. Another hybrid, HPR 2529 X HPR 1156 also shows high heterosis over standard check for grain yield/plant biological yield/plant, grain fertility and plant height.

Key words:
Rice, general combining ability, specific combining ability, heterosis

Introduction

Rice is an important staple food of almost half of the world population. Rice is grown worldwide over an area of 154 million hectares with total production of 672 million tonnes. Among rice growing countries, India has largest under rice in the world i.e. 36.9 million hectares and ranks second in production with 120.6 million tonnes. Rice is the staple food for more than 65 per cent of the people of India. Development of a new variety with high yield and quality parameters is the prime objective of all rice breeders. The first step in a successful breeding program is to select appropriate parents. Line x tester analysis provides a systematic approach for selection of appropriate parents and crosses superior in terms of traits. Exploitation of heterosis is primarily dependent on screening and selection of available germplasm that could produce better cross combinations.

Breeding strategies based on selection of hybrids require expected level of heterosis as well as the specific combining ability (*sca*). In breeding high yielding varieties of crop plant, the breeders often face the problem of selecting parents and crosses. Combining ability analysis is one of the powerful tools available to estimate the combining ability effects and aids in selecting the desirable parents and crosses for the exploitation of heterosis (Sarker *et al.* 2002; Muhammad *et al*. 2007). The ultimate objective of any crop improvement programme is to improve yield, which is a complex character and is dependent on a number of agro-morphological traits The degree of heterosis depends on the degree to which parental lines are related. With this background information, the present investigation was taken up to assess combining ability and heterosis in rice.

Material and methods

The experimental materials used for the present investigation consisted of F_1 hybrids of 30 crosses developed by crossing 10 lines/genotypes of rice *viz.*, HPR 2644, HPR 2604, HPR 2512, HPR 2555, HPR 2529, HPR 2373, HPU 741, HPR 2639, HPR 2589 and HPR 2653 with three testers *viz.*, HPR 1068, HPR 1156 and HPR 2143. All the lines used as female parents were crossed to each of the testers by hand pollination using the standard procedure of emasculation in a line x tester model at RWRC Malan, during *kharif*, 2011. During *kharif* 2012 the F_1's (30 hybrids along with parental lines (lines (10) + testers (3)) were evaluated in RBD with three replications at RWRC, Malan. In each replication entries (F_1's and parents) were grown in single row of 2m length with spacing of 20cm X 15cm transplanted as single seedling/hill. The data was recorded on five random competitive plants in each replication for all the traits studied except days to 50% flowering and days to maturity which were recorded on plot basis. The statistical analysis for analysis of variance as per Panse and Sukhatme (1985) and line x tester analysis as per Kempthorne (1957) were carried out using SPAR software of IASRI, New Delhi. Analysis of variance as per Panse and Sukhatme (1985), Combining ability analysis was carried out following the method of Kempthorne (1957) and the magnitude of heterosis was estimated in relation to better parent and standard check as per the standard method.

Results and discussion

Combining ability analysis helps in identifying potential parents either to be used in heterosis breeding or for isolation of transgressive segregents in the development of pure lines. The general and specific combining abilities were significant for all the characters, indicating the importance of both additive and non-additive genetic components. But it was found that there was a predominance of the non-additive genetic components for expression of different traits in the present set of materials. These results were in accordance with the findings of Singh and Kumar (2004), Rosamma and Vijayakumar (2005), Pradhan *et al.* (2006), Muhammad *et al.(*2007) and Hossain *et al.*(2009), emphasized grain yield/plant have high specific combining ability (*sca*) variance suggesting the predominance of non-additive genetic variance. The major role of non-additive gene effects in the manifestation of all the traits was confirmed by higher values of *sca* variance ($\sigma^2 sca$) than for *gca* variance ($\sigma^2 gca$), the ratio of ($\sigma^2 gca/\sigma^2 sca$) being less than one, and the degree of dominance $(\sigma 2A/\sigma 2D)^{1/2}$ being greater than one. These results indicate the preponderance of non-additive gene action in the expression of all the traits studied and suggest the feasibility of exploitation of non-additive genetic variation for traits through hybrid breeding. The importance of non-additive genes for expression of yield and its components have also been previously reported (Swamy *et al.*, 2003; Malani *et al.*, 2006; Dalvi and Patel, 2009; Saidaiah *et al.*, 2010 and Selvaraj *et al.*, 2011). Further, for grain quality parameters higher estimates of *sca* variances than *gca* variances has also been revealed by Vanaja *et al.* (2003) and Thakare *et al.* (2010). Investigation of *gca* effects revealed that among lines and testers were good general combiners for grain yield and the other traits. Hence, these good general combiners of males and females may be extensively used in future for hybrid rice breeding programme.

The scope of exploitation of hybrid vigour in rice for higher yield and the associated problems have been discussed by Stansel and Craigmiles (1966), Virmani *et al.* (1982) and Saravanam *et al.* (2006). Heterosis for the exploitation of non-additive gene action has been best exploited by chinese workers through the development of hybrids rice using cytoplasmic genetic male sterility. In conventional breeding approach which operates on additive gene action and additive x additive [i] type of gene interactions, the breeders interest is in the recombinants exhibiting transgressive segregates, which may produce promising genotypes as commercial cultivars in self-pollinated crops. A considerable attention has been paid to increase the yield potential by exploiting the heterosis from intervarietal hybrids of rice by identification of potential cross combinations with respect to grain yield and its related traits.

In present study estimation of general combining ability (*gca*) and specific combining ability (*sca*) for all the traits studied which showed that out of 10 lines HPR 2529 is good general combiner for panicle length, biological yield/plant, grain yield/plant, grain fertility, plant height and 1000-grain weight and the tester HPR 2143 is good general combiner for panicle length, spikelets/panicle, harvest index, grain length and L:B ratio whereas, HPR 1156 for grains/panicle, biological yield/plant, grain yield/plant and plant height. Among crosses HPR 2639 X HPR 2143 is good specific combination for grain yield/plant, panicle length, spikelets/panicle, grains/panicle, biological yield/plant, days to 50% flowering and plant height and the cross HPR 2653 X HPR 2143 is good specific combination for panicle length, grains/panicle, biological yield/plant, grain yield/plant, total tillers/plant, effective tillers/plant, 1000-grain weight and grain breadth.

Specific combining ability (*sca*) of a cross is the estimation and the understanding of the effect of non-additive gene action for a trait. Non-additive gene action of a trait is an indicator for the selection of a hybrid combination. Therefore, a highly significant *sca* effect is desirable for a successful hybrid breeding programme. List of heterotic crosses over standard check (%), good specific combinations and good general combiners for yield, phenological, physiological and grain quality traits are given in Table 1.

It was observed that significant positive heterosis exhibited by as many as ten crosses over better parent and seven crosses over standard check for grain yield/plant are given in Table 2. Heterosis over better parent for grain yield/plant ranged from -48.82 to 126.98 per cent. However, when compared with standard check, it ranged from -57.50 to 66.75 per cent. Cross combinations showing significant positive heterosis over the standard check were HPR 2529 X HPR 1156, HPR 2589 X HPR 1156, HPR 2639 X HPR 2143, HPR 2512 X HPR 1156, HPR 741 X HPR 2143 and HPR2529 X HPR 2143. These crosses expressed significant positive heterosis over standard check for grain yield/plant indicatingthus these crosses have the capability for hybrid rice production.These crosses parents (lines & testers) had good general cobining ability.

References

Dalvi, V.V.and Patel, D.V. 2009. Combining ability analysis for yield in hybrid rice. *Oryza,* 46(2): 97-102

Hossain, K.A., Akter, H.B., Ansari, A.and Rahman, M.M. 2009..Line x Tester analysis for yield and its related traits in rice (*Oryza sativa* L.). *Bangladesh J. Plant Breed. Genet.,* 22(2): 01-06

Jones, J.W. 1926. Hybrid vigour in rice. *J. American Society of Agron*., 18: 424-428

Kempthorne, O. 1957. An introduction of genetic statistics. John Wiley & sons, New York, p. 468-473

Malani, N, Sundaram, T., Ramakrishnan, S.and Saravanan S 2006. Prediction of hybrid vigour for yield attributes among synthesized hybrids in rice. *Res. J. Agric. Biol. Sci*., 2: 166-170

Muhammad, R., Cheema, A..A.and Muhammad, A. 2007 Line X tester analysis in Basmati rice. *Pakistan J. Bot*., 39(6): 2035-2042

Panse, V.G.and Sukhatme, P.V. 1985 Statistical Methods for Agricultural Workers. ICAR Publication, New Delhi, p. 145-152

Pradhan, S.K., Bose, L.K.and Meher, J. 2006. Studies on gene action and combining ability analysis in basmati rice. *J. Central European Agric*., 7(2): 267-272

Rosamma, C.A.and Vijayakumar, N.K .2005. Heterosis and combining ability in rice (*Oryza sativa L.*) hybrids developed for Kerala state. *Indian J. Genet. Plant Breed*., 65(2): 119-120

Saidaiah, P., Kumar, S.S.and Ramesha, M.S. 2010. Combining ability studies for development of new hybrids in rice over environments. *J. Agric. Sci.*, 2: 1-5

Sarker, U., Biswas, P.S., Prasad, B.and Khaleque, M.M.A. 2002. Heterosis and genetic analysis in rice hybrid. *Pakistan J. Biol. Sci.*, 5(1): 1-5

Selvaraj, C.I., Nagarajan, P., Thiyagarajan ,K., Bharathi, M.and Rabindran, R. 2011. Studies on heterosis and combining ability of well known blast resistant rice genotypes with high yielding varieties of rice (*Oryza sativa* L.). *Internat. J. Plant Breed. Genet*., 5(2): 111-129

Singh, N.K.and Kumar, A. 2004. Combining ability analysis to identify suitable parents for heterotic rice breeding. *Internat. Rice Res*., 29: 21-12

Stansel, J.W.and Craigmiles, J.P. 1966. Hybrid rice: Problems and potentials. *Rice J.*, 69(5): 14-15

Swamy, M.H., Gururaja, Rao M.R. and Vidyachandra, B. 2003. Studies on combining ability in rice hybrids involving new CMS lines. *Karnataka J. Agric. Sci*., 16 (2): 228-233

Saravanan K, Anbanandan V, Kumar PS (2006) Heterosis for yield and yield components in rice (*Oryza sativa* L.). *Crop Res. Hisar*, 31(2): 242-244

Thakare, I.S., Mehta, A.M., Patel, J.S.and Takle, S.R. 2010. Combining ability analysis for yield and grain quality traits in rice hybrids. *J. Rice Res*., 3: 1-5

Vanaja, T., Babu, L.C., Radhakrishnan, V.V.and Pushkaran ,K. 2003. Combining ability analysis for yield and yield components in rice varieties of diverse origin. *J. Tropical Agric*., 41: 7-15

Virmani, S.S., Aquico, R.C.and Khush, G.S. 1982. Heterosis breeding in rice (*Oryza sativa* L.). *Theor. Appl. Genet*., 63(4): 373-380

Table 1. Estimates for general combining ability (*gca*) effects of parents for yield and phenological traits

Traits	Panicle length	Spikelets/ panicle	Grains/ panicle	Biological yield/ plant	Grain yield/ plant	Grain fertility	Days to 50% flowering	Days to maturity
Lines								
HPR 2373	-1.41*	39.13*	43.01*	-1.82*	-1.59	4.07*	4.74*	0.56
HPR 2512	0.06	-1.02	4.01*	1.20	1.82*	3.50*	4.19*	0.11
HPR 2529	1.89*	1.18	12.81*	14.17*	8.05*	6.77*	4.19*	0.11
HPR 2555	0.07	-33.20*	-24.61*	- 7.32*	-4.14*	1.57	-4.37*	-0.11
HPR 2589	0.65	36.96*	30.09*	-3.49*	1.14	0.21	4.74*	0.22
HPR 2604	-0.25	39.23*	22.50*	11.59*	-1.50	-4.18*	-2.70*	0.11
HPR 2639	0.04	-24.94*	-47.00*	1.01	-2.22*	-15.92*	-1.03	0.22
HPR 2644	0.43	23.05*	12.57*	-3.96*	-0.33	-2.91*	-1.03	-0.22
HPR 2653	-0.97*	-44.47*	-29.56*	-10.38*	-3.74*	3.07*	-2.81*	-0.56
HPU 741	-0.50	-35.91*	-23.84*	-1.00	2.50*	3.82*	-5.92*	-0.44
SE (gi) ±	0.36	1.84	1.74	0.85	0.83	0.81	0.59	0.31
SE (gi-gj) ±	0.51	2.60	2.47	1.20	1.17	1.14	0.84	0.43
Testers								
HPR 1068	-0.96*	-28.06*	-22.04*	-6.16*	-2.93*	0.87	-0.18	-0.11
HPR 1156	-0.08	13.28*	14.32*	7.95*	2.78*	0.19	-0.11	0.22
HPR 2143	1.04*	14.79*	7.72*	-1.80*	0.14	-1.06*	0.29	-0.11
SE (gi) ±	0.20	1.01	0.95	0.46	0.45	0.44	0.32	0.17
SE (gi-gj) ±	0.28	1.42	1.35	0.66	0.64	0.63	0.46	0.24

* Significant at 5% level of significance

Table 2. List of heterotic crosses over standard check (%), good specificcombinations and good general combiners for various traits

Traits	Heterotic Crosses over standard check (%)	Good specific combination	Good general combiners
Panicle Length	HPR2529 X HPR 2143 (8.61)	HPR 2639 X HPR 2143	HPR 2529
	HPR2512 X HPR 2143 (8.43)	HPR 2512 X HPR 2143	HPR 2143
		HPU 741 X HPR 1068	
		HPR 2653 X HPR 2143	
Spikelets/panicle	HPR 2373 X HPR 1156 (21.25)	HPR 2639 X HPR 2143	HPR 2604
	HPR 2639 X HPR 2143 (20.69)	HPR 2604 X HPR 1068	HPR 2589
	HPR 2589 X HPR 1156 (17.57)	HPR 2589 X HPR 1068	HPR 2373
	HPR 2604 X HPR 1156 (10.49)	HPU 741 X HPR 1068	HPR 2143
Grains/panicle	HPR 2373 X HPR 1156 (48.71)	HPR 2639 X HPR 2143	HPR 2373
	HPR 2589 X HPR 1156 (27.48)	HPR 2373 X HPR 1156	HPR 2589
	HPR 2529 X HPR 2143 (18.32)	HPR 2604 X HPR 1068	HPR 2604
	HPR 2644 X HPR 1156 (18.21)	HPR 2653 X HPR 2143	HPR 1156
Biological yield/plant	HPR 2529 X HPR 1156 (84.86)	HPR 2639 X HPR 2143	
	HPR 2639 X HPR 2143 (58.84)	HPR 2529 X HPR 1156	HPR 2529
	HPR 2604 X HPR 1068 (38.28)	HPR 2653 X HPR 2143	HPR 2604
	HPR 2604 X HPR 1156 (36.20)	HPR 2604 X HPR 1068	HPR 1156
Grain yield/plant	HPR 2529 X HPR 1156 (66.75)	HPR 2604 X HPR 1068	
	HPR 2589 X HPR 1156 (33.19)	HPR 2639 X HPR 2143	HPR 2529
	HPR 2639 X HPR 2143 (22.91)	HPR 2653 X HPR 2143	HPU 741
	HPR 2512 X HPR 1156 (21.34)	HPR 2589 X HPR 1156	HPR 2512
			HPR 1156
Grain Fertility	HPR 2373 X HPR 1156 (22.69)	HPR 2639 X HPR 1068	HPR 2529
	HPR 2529 X HPR 1068 (21.77)	HPR 2373 X HPR 1156	HPR 2373
	HPU 741 X HPR 2143 (20.52)	HPU 741 X HPR 2143	HPU 741
	HPR 2512 X HPR 1068 (19.19)	HPR 2653 X HPR 1156	HPR 2512
Days to 50 (%) flowering	HPU 741 X HPR 1156 (-8.87)	HPR 2639 X HPR 2143	HPR 2373
	HPR 2555 X HPR 2143 (-7.51)	HPR 2653 X HPR 1068	HPR 2589
	HPU 741 X HPR 1068 (-6.83)	HPR 2555 X HPR 1068	HPR 2512
	HPR 2555 X HPR 1156 (-5.12)	HPU 741 X HPR 2143	HPR 2529
Plant Height	HPR 2529 X HPR 1156 (32.85)	HPR 2639 X HPR 2143	HPR 2529
	HPR 2639 X HPR 2143 (25.96)	HPR 2373 X HPR 1068	HPR 2555
	HPR 2529 X HPR 2143 (18.81)	HPR 2589 X HPR 1068	HPR 1156
	HPR 2555 X HPR 2143 (17.58)	HPU 741 X HPR 1156	
Total Tillers/plant	HPU 741 X HPR 2143 (26.67)	HPR 2512 X HPR 1068	HPU 741
	HPR2373 X HPR 1068 (23.03)	HPR 2653 X HPR 2143	HPR 2639
		HPU 741 X HPR 2143	HPR 2529

		HPR 2529 X HPR 1156	
Effective tillers/plant	HPU 741 X HPR 2143 (24.40)	HPR 2639 X HPR 1068	HPU 741
		HPR 2512 X HPR 1068	HPR 2639
		HPR 2653 X HPR 2143	HPR 2529
		HPU 741 X HPR 2143	
Harvest Index	HPR 2589 X HPR 2143 (12.85)	HPR 2639 X HPR 1068	HPR 2589
	HPU 741 X HPR 2143 (10.17)	HPR 2604 X HPR 1068	HPU 741
		HPR 2644 X HPR 1156	HPR 2143
1000- grain weight	HPR 2529 X HPR 1068 (19.31)	HPR 2639 X HPR 1068	HPR 2529
	HPR 2639 X HPR 1068 (14.44)	HPR 2653 X HPR 2143	HPR 2555
	HPR 2555 X HPR 1068 (12.05)	HPR 2653 X HPR 1156	HPU 741
	HPR 2529 X HPR 2143 (11.44)	HPR 2529 X HPR 1068	HPR 1068
Grain Length	HPR 2529 X HPR 2143 (3.28)	HPR 2639 X HPR 1156	HPR 2529
	HPR 2639 X HPR 1156 (2.50)	HPR 2604 X HPR 2143	HPR 2644
	HPR 2604 X HPR 2143 (0.88)	HPR 2653 X HPR 1068	HPU 741
		HPR 2639 X HPR 1068	HPR 2143
Grain Breadth	HPR 2555 X HPR 1068 (20.03)	HPR 2653 X HPR 2143	HPR 2555
	HPR 2529 X HPR 1068 (14.94)	HPR 2653 X HPR 1156	HPR 2589
	HPR 2589 X HPR 1068 (14.12)	HPR 2555 X HPR 1068	HPR 2529
	HPR 2589 X HPR 1156 (14.12)	HPU 741 X HPR 1068	HPR 1068
L:B Ratio	HPR 2653 X HPR 1068 (1.97)	HPR 2653 X HPR 1068	HPR 2644
		HPR 2639 X HPR 1156	HPR 2653
		HPR 2604 X HPR 2143	HPR 2639
		HPU 741 X HPR 2143	HPR 2143

Table 3. Details of promising hybrids and parents involved for grain yield

Heterotic Crosses	Heterosis for grain yieldover standard check (%)	gca of parents	
		Lines	Testers
HPR 2529 X HPR 1156	66.75*	8.05*	2.78*
HPR 2589 X HPR 1156	33.19 *	1.14	2.78*
HPR 2639 X HPR 2143	22.91*	-2.22*	0.14
HPR 2512 X HPR 1156	21.34*	1.82*	2.78*

*Significant at 5% level of significance; Standard Check Variety : HPR 2143