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Analysis of gene action and combining ability for yield and its component characters in rice

R.K.Sharma* and S.C.Mani

Department of Genetics& Plant Breeding, Govind Ballabh University of Agriculture & Technology, Pantnagar 263 145, Uttarkhand, India

ABSTRACT

Eighteen hybrids generated from crossing six basmati lines with three tester parents were studied for combining ability for grain yield and its component characters. Additive gene action was predominant for flag leaf area, panicle length, grain weight panicle^{-1} and grain yield plant^{-1}while days to flowering, PBT plant^{-1}, grains panicle^{-1} exhibited preponderance of non-additive gene action. Kasturi, Basmati 5853 and Haryana Basmati 1 among the lines and Pant Dhan 11 among the testers emerged as good general combiner for various traits. Basmati C 622 x TN 1, Basmati. 5853 x Pant Dhan 11and Pusa Basmati 1 x T N 1 crosses were emerged as most promising.

Key words: Rice*, combining ability, gene action, grain yield and yield component*

The combining ability studies provide useful information for selection of high order parents and also elucidate the nature and magnitude of gene action involved in the expression of economically desirable traits. This, in turn, helps the breeder to choose the desirable parents for hybridization. The present study was undertaken to assess the nature of combining ability of traditionally grown tall and recently developed semi-tall varieties of *basmati* rice for yield and yield components through line x tester mating design proposed by Kempthorne (1957).

MATERIALS AND METHODS

Six diverse lines of *basmati* rice Basmati 370, Basmati C 622, Basmati 5853, (traditionally grown tall varieties), Kasturi, Pusa Basmati1, Haryana Basmati 1 (semi-tall improved varieties) were crossed with three non basmati tester parent viz., UPR 85-71-8-1, TN 1 and Pant Dhan 11 in line x tester design. Thirty-days old seedlings of 18 hybrids and their nine parents were transplanted in a well-puddled field using randomized block design with three replications. The crop was raised using standard and uniform agronomic practices. Observations were recorded on randomly selected five plants from each replication for panicle bearing tillers plant^{-1} (PBT plant^{-1}), flag leaf area (cm^2), panicle length (cm), grains panicle^{-1}, grain weight panicle^{-1} (g), harvest index (HI) and grain yield plant^{-1} and on plot basis for days to 50 % flowering using Standard Evaluation System of rice proposed by International Rice Research Institute. The estimates of combining ability and variances were worked out according to the method outlined by Kempthorne (1957).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the genotypes for all the characters understudy. Combining ability analysis (Table 1) reveled significance of mean squares due to lines (except PBT plant^{-1}), testers and line x testers (except panicle length and grain weight panicle^{-1}) for all the traits. Partitioning of combining ability variances into fixable or additive genetic variance and non-fixable or non-additive genetic variance indicated that both additive and non-additive gene actions play important role in expression of these traits.

Preponderance of additive gene action indicated by more than unity ratio between σ^2 gca and

Present address: [1]*Principal Scientist, Division of Genetics, IARI, Pusa, New Delhi-110012*

Table 1. Combining ability analysis for different characters

Character	Rep(2)	Lines(5)	Tester(2)	L x T(10)	Error(34)	σ^2 gca	σ^2 sca	σ^2gca/ σ^2 sca	Mean degree of dominance
Days to 50% flowering	28.125	876.950**	74 .016**	122.753**	10.659	26.13	37.36	0.70	1.20
PBT plant	1.130	5.807	16.963**	7.496*	3.109	0.29	1.45	0.20	2.24
Flag leaf area	21.761	330.189**	896.102**	104.459*	40.082	37.68	20.79	1.81	0.74
Panicle length	4.064	46.553**	16.100*	3.462	4.354	2.06	0.30	6.87	2.62
Grains panicle^{-1}	264.469	819.262*	2383.813**	1197.637**	221.287	29.92	325.45	0.09	3.30
Grain yield panicle^{-1}	0.264	0.649*	1.671*	0.367	0.222	0.06	0.05	1.20	0.91
Harvest index	0.028	0.029**	0.017**	0.070*	0.03)	0.01	0.01	1.00	1.00
Grain yield plant^{-1}	5.890	82.958	36.212**	18.024*	8.046	3.82	0.08	4.54	1.95

Figure in parenthesis represent the degree of freedom, *,** significant at 5 and 1 % probability, respectively

σ^2 sca for flag leaf area, panicle length, grain weight panicle^{-1} and grain yield plant^{-1}. The estimate of mean degree of dominance for these traits was less than one, which suggested partial dominance type of gene action. Similar results were reported by earlier workers for panicle length (Sharma *et al.*, 1996 and Lavanya, 2000); for grain weight panicle^{-1} (Bhanumathy and Prassad 1991), for flag leaf width (Sardana and Borethakur 1987) and for grain yield plant^{-1} (Kalamani and Sundaram, 1988). When additive effect forms the principal factor for genetic variance, use of pedigree method could be desirable. The estimate of σ^2 gca : σ^2 sca and mean degree of dominance were equal to unity for harvest index, suggested the equal importance of both additive and non-additive types of gene action and complete dominance. Under such condition, use of reciprocal recurrent selection would be more effective as suggested by Comstock *et al.* (1949). Higher estimates of σ^2 sca than respective σ^2 gca for days to flowering, PBT plant^{-1}, grains panicle^{-1} suggested the predominance of non-additive gene action and over dominance by more than unity estimates of mean degree of dominance. Kalita and Upadhaya (2000) for days to flowering and PBT plant^{-1} and Lavanya (2000) for grains panicle^{-1} reported similar results. Preponderance of non-additive genetic effects offers good scope for exploitation of hybrid vigour in improving these traits.

The estimates of GCA effects revealed wide differences among the parental lines for different traits and none of parental line was found good general combiners for all the traits (Table 2). Among the lines, Kasturi was found good general combiners for harvest index, grain weight panicle^{-1}, panicle length, flag leaf area and days to flowering. Basmati 5853 and Haryana Basmati.1 emerged good combiner for grain yield plant^{-1} and days to flowering. Basmati 5853 and Haryana Basmati.1 also turn out to be good general combiner for PBT plant^{-1} and HI, respectively. Basmati C 622 for flag leaf area and panicle length and Pusa Basmati 1 for days to flowering showed significant gca effects. Among testers, Pant Dhan 11 for grain yield plant^{-1}, HI, grain weight panicle^{-1}, flag leaf area and PBT plant^{-1} recorded significant gca effect in desired direction. High specific combining ability effects of hybrids (Table 3 and 4) resulted mostly from the dominance interaction effects. In present investigation, cross Basmati C 622 x TN 1 recorded the significant sca effects for grain yield plant^{-1} and days to flowering while cross Basmati 5853 x Pant Dhan11 showed significant positive sca effects for flag leaf area, panicle length, and grains panicle^{-1}. For grain yield panicle^{-1} and grains panicle^{-1} Pusa Basmati.1 x TN1 recorded positively significant sca effects. Three cross combinations *viz.*, Basmati 5853 x UPR 85-71-8-1, Basmati. 370 X UPR 85-71-8-1 and Basmati C 622 x Pant Dhan 11 showed negatively significant sca effects for days to flowering while Basmati. 370 x Pant Dhan 11 exhibited positively significant sca effects for HI.

Perusal of different crosses with significant sca effects and gca effects of respective parents involved revealed that only 50 per cent crosses have at least one parent possessing good general combining ability. This indicated the presence of additive x additive and/

Table 2. Estimates of gca effects of Line x Tester analysis for grain yield and associated traits

Parents	Days to 50% flowering	PBT plant^{-1}	Flag leaf area	Panicle length	Grains panicle^{-1}	Grain weight panicle^{-1}	Harvest index	Grain yield plant^{-1}
Lines								
Basmati C622	4.65**	-0.52	5.30*	1.46*	8.02	0.09	-0.06**	-1.94*
Kasturi	-4.13**	-0.85	9.68**	3.94**	11.46*	0.35*	0.06**	-0.04
Basmati 5853	-6.13**	1.37*	-1.81	-0.88	-5.76	0.23	-0.01	4.398*
Haryana Basmati 1	-5.19**	-0.19	-4.95*	-2.06**	1.35	-0.09	0.07**	2.73**
Pusa Basmati.1	-6.69**	0.30	4.23	-1.50*	14.98**	-0.36*	-0.02	-3.55**
Basmati 370	18.20**	0.48	4.00	-0.97	-0.09	-0.21	-0.05**	-1.50
SE(gi)	1.09	0.56	2.16	0.69	4.96	0.16	0.02	0.95
SE(gi-gi)	1.54	0.79	3.06	0.98	7.01	0.20	0.03	1.35
Testers								
Plant Dhan 11	-0.02	0.81*	8.12**	0.92	4.91	0.29*	0.02*	1.64*
TNI	-2.02	0.26	-3.49*	-0.97	-13.15**	-0.32**	0.02*	0.89
UPR85-71-8-1	2.04	-1.07**	-4.63	0.04	8.24*	0.03	-0.04**	-0.74
SE(gi)	0.77	0.40	1.53	0.49	3.51	0.11	0.01	0.17
SE(gi-gi)	1.09	0.56	2.16	0.69	4.96	0.16	0.02	0.95

*,** significant at 5 and 1 % probability, respectively

Table 3. Parents showing the significant general combining ability effects

Character	Lines	Testers
Days to50% flowering	Kasturi, Basmati 5853, Haryana Basmati 1, Pusa Basmati 1	TN1
PBT plant^{-1}	Basmati 5853	Pant Dhan 11
Flag leaf area	Basmati C622, Kasturi	Pant Dhan 11
Panicle length	Basmati C622, Kasturi	-
Grain weight panicle^{-1}	Kasturi	Pant Dhan 11
Harvest index	Kasturi, Haryana Basmati 1	Pant Dhan 11, TN1
Grain yield plant^{-1}	Bas 5853, Haryana Basmati 1	Pant Dhan 11

Table 4. Hybrid combinations with significant specific combining ability effects

Character	Hybrid combinations
Days to50 % flowering	Basmati C 622 x Pant Dhan 11, Basmati C622 x TN 1, Basmati 5853 x UPR85-71-8-1, Basmati 370 x UPR 85-71-8-1
PBT plant^{-1}	Basmati 5853 x TN 1
Flag leaf area	Basmati 5853 x Pant Dhan 11
Panicle length	Basmati. 5853 x Pant Dhan 11
Grains panicle^{-1}	Basmati 5853 x Pant Dhan 11, Pusa Basmati 1 x TN 1
Grain yield panicle^{-1}	Pusa Basmati 1 x TN1
Harvest index	Basmati 370 x Pant Dhan 11
Grain yield plant^{-1}	Bas. C622 x TN 1

or additive x dominance genetic interaction in sizeable amount in these crosses. The remaining crosses involved average or poor general combiners as their parents indicated that sca effect of crosses does not depend upon gca effects of their parental lines. Sharma *et al.* (1996) also reported similar results. It might be due to differential expression of component traits in specific genetic background or may be due to complementary type of gene action, which can result in strong transgressive segregants for the desired traits due to segregation of genes with strong potentials and their specific buffers (Langham, 1961). In such crosses where non-additive gene effects played a predominant role in association with additive components the recurrent selection or reciprocal recurrent selection may be used.

No correspondence between the *per se* performance of parents and crosses with gca effects of parents and sca effects of crosses suggested that *per se* parental or hybrid performance did not necessarily correspond with gca and sca effects. Singh and Gupta (1970) observed that it is possible that favoured direction of the expression of a character is due to complex interaction among genes, which may express recessively in certain background and dominantly in others. Dick and Shattuck (1990) opined that epistatic gene action might result upon hybridization, responsible for the F_1 performance. Thus the present studies showed the importance of additive and non-additive gene action for grain yield and associated characters. Kasturi, Basmati 5853 Haryana Basmati1 Pant Dhan11 as emerged as good general combiners for yield and yield components, thus, crossing programme involving these parents, coupled with rigorous selection for desired traits should be taken up to generate the desirable genotypes.

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