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HETEROSIS AND INBREEDING DEPRESSION IN UPLAND RICE CROSSES

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ABSTRACT

F_1 heterosis over midparent (MP) and better parent (BP) and F_2 inbreeding depression (ID) were studied in 8 crosses of rice for grain yield/plant and its four component traits, i.e., plant height, effective tillers/plant, filled grains/panicle and 1000-grain weight. Highly significant and positive heterosis for grain yield over MP and BP was expressed by four hybrids and, invariably followed by ID in F_2. Such high grain yield heterosis was due to additive heterotic effect of one or more component traits. In all the cases, heterosis for number of effective tillers was observed to be the major contributor and number of filled grains/panicle to a lesser extent, to grain yield heterosis. High heterosis accompanied by high ID for effective tillers/plant and filled grains/panicle indicate that nonadditive gene effects govern the inheritance of these traits. Since the hybrid vigour was not of retentive nature, as indicated by high ID in F_2 for grain yield, it can be exploited only in F_1.

Key words: Heterosis, inbreeding depression, *Oryza sativa* L.

Commercial exploitation of heterosis in rice is already a profitable proposition. The knowledge about extent of heterosis for a trait, accompanied by the extent of decline in vigour in the subsequent generations manifested by inbreeding depression would be desirable for its exploitation by adopting appropriate breeding methodology. We report the results on heterosis and inbreeding depression in eight rice crosses.

MATERIALS AND METHODS

Eight F_1s were obtained from 9 diverse rice cultivars as parents using Prabhavati as female parent and 8 others as male parents. Prabhavati is semidwarf while the rest belong to different plant height and maturity groups. During the summer season, a part of F_1 seed along with parents was sown to obtain seed for F_2. The final experiment was laid out in split plot design with 3 replications during the ensuing rainy season by direct seeding. Each row

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was 2.2 m long. Spacing between 2 rows was 30 cm and between plants 10 cm. Fertilizer application with 100 kg N + 50 kg P_2O_5/ha was done and the required agronomic practices and plant protection measures were adopted. Ten random plants in all other generations, and 50 in the F_2 populations of each cross in a replication were used to record observations on grain yield and four important yield contributing characters. Percentage heterosis over the midparent (MP) and better parent (BP) was estimated for F_1 hybrids as per [1, 2]. Likewise, inbreeding depression in F_2 over F_1 was calculated according to [3].

RESULTS AND DISCUSSION

Estimates of heterosis over MP and BP and ID of F_2s over F_1s for five quantitative traits are presented in Table 1. The magnitude and direction of MP and BP heteroses varied substantially from cross to cross and from character to character. The mean heterosis was higher for number of effective tillers/plant, followed by grain yield/plant. Moderate heterosis over MP and very low or negative BP heterosis was observed for the remaining characters, i.e., plant height, number of filled grains/panicle and 1000-grain weight. However, negative BP heterosis observed for plant height is desirable for developing short statured hybrids. The average ID over all the crosses was favourable for plant height, low for 1000-grain weight, and moderate for filled grains/panicle. The ID was high for effective tillers and grain yield/plant.

For plant height, MP heterosis was significantly positive in all the crosses except in Prabhavati x RPA 5929 (nonsignificant) and ranged from 0.01 to 18.71%. However, BP heterosis was negative and significant in most of the F_1s which was desirable with the range of – 18.74%

Table 1. Heterosis over midparent, better parent and inbreeding depression of different crosses in rice

Cross	Heterosis (%)		Inbreeding depression (%)
	MP	BP	
Plant height			
Prabhavati x Ambemohor Local	6.2**	– 5.1**	2.3
Prabhavati x Punjab 1	18.7**	6.1**	10.3
Prabhavati x IET 8573	7.7	– 5.4**	2.1
Prabhavati x RPA 5929	0.0	– 13.4**	3.8
Prabhavati x Dee-geo-woo-gen	14.3**	– 9.8**	7.9
Prabhavati x CRM mutant	7.6**	– 18.7**	3.0
Prabhavati x Pusa 33	10.0**	– 9.5**	0.5
Prabhavati x Basmati 370	16.2**	6.7**	17.6
Average	10.1	– 6.1	5.9
Number of effective tillers/plant			
Prabhavati x Ambemohor Local	– 6.6	– 15.6**	– 8.3
Prabhavati x Punjab 1	100.9**	61.2**	47.2
Prabhavati x IET 8573	67.8**	13.2**	36.4
Prabhavati x RPA 5929	39.1**	– 1.6	33.5
Prabhavati x Dee-geo-woo-gen	54.0**	6.1	31.9
Prabhavati x CRM mutant	36.6**	4.5	12.3
Prabhavati x Pusa 33	76.4**	28.5**	34.0
Prabhavati x Basmati 370	74.6**	42.0**	39.2
Average	55.3	17.3	28.3

(Contd.)

(Prabhavati x CRM mutant) to 6.71% (Prabhavati x Basmati 370). Almost all the crosses, which expressed significant negative BP heterosis in F_1, also showed favourable ID in their F_2s, indicating their short stature. Therefore, selection for short statured plants in all these cross combinations would be effective even in F_2 and subsequent generations. Negative BP heterosis for this trait was also reported earlier.

The magnitude of heterosis was highest for number of effective tillers/plant. Significantly positive MP and BP heterosis was expressed in four hybrids with equally high ID, the highest being in F_1 of Prabhavati x Punjab 1 (100.9 and 61.2% over MP and BP, respectively). The observation of heterosis for this trait by [4, 5] were also similar. Virmani et al. [6], however, reported negative heterosis for tiller number though the yield was not affected due to increased number of spikelets per unit area. Average ID was highest for this attribute. High heterosis in each case was followed by equally higher magnitude of ID, as was also observed by [7].

In respect of number of filled grains/panicle, the MP heterosis was positive in all the F_1s and highly significant in six F_1 hybrids. The BP heterosis was either nonsignificantly positive or negative except in the F_1s of the crosses Prabhavati x Dee-geo-woo-gen (12.40%) and Prabhavati x Basmati 370 (23.1%) with high ID

Table 1 (contd.)

Cross	Heterosis (%) MP	Heterosis (%) BP	Inbreeding depression (%)
Number of filled grains/panicle			
Prabhavati x Ambemohor Local	6.5	−0.2	1.6
Prabhavati x Punjab 1	12.7**	−8.2	10.9
Prabhavati x IET 8573	13.4**	2.2	6.6
Prabhavati x RPA 5929	15.0**	−3.2	8.7
Prabhavati x Dee-geo-woo-gen	37.7**	12.4**	16.5
Prabhavati x CRM mutant	10.3	−17.6**	−0.9
Prabhavati x Pusa 33	14.1**	−1.8	13.5
Prabhavati x Basmati 370	22.2**	23.1**	20.0
Average	16.5	0.9	9.6
1000-grain weight			
Prabhavati x Ambemohor Local	0.7	−2.0	2.1
Prabhavati x Punjab 1	6.9**	−6.3**	4.5
Prabhavati x IET 8573	10.0**	3.7	3.0
Prabhavati x RPA 5929	5.8**	−1.0	0.7
Prabhavati x Dee-geo-woo-gen	8.7**	−1.8	−5.9
Prabhavati x CRM mutant	4.9	−17.0**	−0.4
Prabhavati x Pusa 33	10.6**	−0.8	4.9
Prabhavati x Basmati 370	5.1*	−7.6**	2.8
Average	6.6	−4.1	1.5
Grain yield/plant			
Prabhavati x Ambemohor Local	8.2	0.2	1.6
Prabhavati x Punjab 1	126.2**	68.9**	52.7
Prabhavati x IET 8573	99.3**	28.4**	37.6
Prabhavati x RPA 5929	0.1	−33.5**	4.2
Prabhavati x Dee-geo-woo-gen	6.1	−40.6**	9.4
Prabhavati x CRM mutant	2.7	−39.6**	14.1
Prabhavati x Pusa 33	93.3**	18.0**	38.4
Prabhavati x Basmati 370	127.8**	55.8**	54.6
Average	58.0	7.2	26.6

*,**Significant at 5% and 1% levels, respectively.

of 16.5 and 20.0%, respectively. Virmani et al. [6] reported similar results for this character.

For 1000-grain weight, average negative BP heterosis of lower magnitude was observed. Such low heterosis for this attribute was reported earlier [8]. However, the ID observed was minimum, indicating less reduction in the mean value of F_2 over F_1. The cross Prabhavati x Dee-geo-woo-gen could be utilized for improving this trait as ID observed was desirable (negative) in the F_2.

Heterotic expression over MP and BP for grain yield was highly significant in four F_1 hybrids, the highest being in the F_1 of the cross Prabhavati x Punjab 1 (126.2 and 68.9%, respectively) with high (52.7%) ID in F_2. Significantly high heterosis in all the four crosses was invariably accompanied by high ID. The average ID was high, i.e., 26.6% (the least ID, which is desirable, was observed in the cross Prabhavati x Ambemohor Local, though it expressed least heterosis).

The inheritance of grain yield in rice is a complex trait and is dependent on several component traits. In the present investigation, none of the crosses showed heterosis for seed yield alone. In the cross Prabhavati x Basmati 370, highly significant and positive heterotic effect of grain yield was due to the cumulative effect of highly significant positive heterosis of all the quantitative traits studied, except for 1000-grain weight. Similarly in the crosses Prabhavati x Punjab 1 and Prabhavati x Pusa 33, it was due to the additive heterotic effect of two traits, and in the F_1 of the cross Prabhavati x IET 8573, it was due to only one trait. In all the F_1s of these four crosses, the high grain yield heterosis was due to the additive effects of number of effective tillers/plant to a larger extent and number of filled grains/panicle to a smaller extent. Grafius [9] was of the opinion that heterosis for grain yield is the resultant of interaction of simultaneous increase in the expression of heterosis of its individual components. High MP and BP heteroses in some rice crosses were reported from earlier studies [4, 5, 7]. In almost all the cases, high grain yield and its components were invariably accompanied by high and positive ID in their F_2 which may be due to dominance gene action in controlling heterosis for the various traits [2, 7, 8].

Since the vigour was not of retentive nature, as indicated by high percentage of ID in F_2 for grain yield and its most important component traits, it is suggested that heterosis can be best exploited in hybrid breeding.

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