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Heterosis and Inbreeding Depression for Morpho-Physiological Traits in Rice [*Oryza sativa* L.]

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ABSTRACT

Highly significant and positive heterosis over mid parent and better parent was recorded for grain yield per plant and its related traits in crosses viz., GURJARI x IR-28, NAUR-1 x DANTESHWARI and GAR-13 x RP BIO- 226. Crosses which depicted significant and positive heterosis for grains yield per plant also exhibited significant and positive heterosis for its components traits like grains per panicle, panicle length and test weight, which indicated that heterotic effect for grain yield per plant was mainly due to manifestation of heterosis in yield components. The crosses which exhibited heterosis for grain yield per plant, yield contributing traits and physiological traits also depicted significant inbreeding depression which revealed association between heterotic effects and inbreeding depression.

Key words: *Heterosis, Inbreeding depression, Rice*

INTRODUCTION

Rice belongs to the genus: Oryza, family: Gramineae (Poaceae) and tribe: Oryzeae. The cultivated rice plant (*Oryza sativa* L.) is an important annual, self pollinated, diploid (2n=2x=24) cereal crop species1,3. Rice is life" was the famous theme of International Year of Rice, 2004 denoting its overwhelming importance as an item of food and commerce. Rice remains a staple food for the majority of the world population. More than two thirds of the world relies of the nutritional benefit of rice. Rice, the world's most important cereal crop, is the primary source of food and calories for about half of the mankind2. In India, rice grown in 42.75 million hectares during 2013 with production of 105.24 million tonnes and productivity of 2462 kg per hectare4. In Gujarat, rice is cultivated 7.01 lakh hectares with production of 15.41 lakh tonnes and productivity of 2198 kg per hectare4. The heterosis expresses the superiority of F1 hybrid over its parents in term of yield and other traits. On the other hand, the inbreeding depression reflects on reduction or loss in vigour, fertility and yield as a result of inbreeding.

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The magnitude of heterosis helps in the identification of potential cross combinations to be used in conventional breeding programme to enable create wide array of variability in segregating generations. The knowledge of heterosis accompanied by the extent of inbreeding depression in subsequent generations is essential for maximum exploitation of such heterosis by adopting appropriate breeding methodology.

MATERIAL AND METHODS

The experimental materials consisted of 7 parent's *viz.*, Gurjari, IR-28, NAUR-1, Danteshwari, GAR 13, RP-Bio-226 and Pusa Sugandha-5 as detailed in Table 3.1. These entries collected from Regional Rice Research Station (RRRS), Navsari Agricultural University, Vyara.

Table 1: Details of the genotypes used for this study (source: R.R.R.S., N.A.U., Vyara)

Particulars	Gurjari	IR-28	NAUR-1	Danteshwari	GAR-13	RP BIO-226	Pusa Sugandha-5
Parentage Pedigree	Asha x Kranti	IR-833-6-1-1-1 x IR-1561-1491/IR1737	GR-4 x IET 1705	Samridhi x IR 8608-298	GR-11 x IET – 14726	Samba Mahsuri x 4/SS1113	Pusa 3 A x Haryana Basmati-1
Days to flowering	90-95	80-85	90-100	80-85	105-108	110-112	98-100
Plant height (cm)	100-115	100-105	117-125	90-95	127-133	100-105	105-110
Productive tillers per plant	7-8	8-10	7-8	6-7	8-10	10-12	7-8
Panicle length (cm)	22-24	20-22	28-30	20-22	26-28	19-21	26-28
Grains per panicle	120-150	80-110	140-170	120-150	200-230	130-160	150-180
100 seed weight	2.7-2.8	2.25-2.30	2.3-2.5	2.4-2.6	1.5-1.6	1.4-1.6	2.6-2.65
Grain L-B Ratio	3.68-3.70	3.90-3.93	3.45-3.48	4.65-4.68	3.35-3.38	3.60-3.65	4.80-4.82
Grain yield (kg/ha)	5000-8000	5000-5500	5500-7000	4500-5000	5500-6500	5000-5500	5500-6500

Generation mean analysis helps us in understanding the performance of the parents used in crosses and potential of crosses to be used either for heterosis exploitation or pedigree selection. The seeds of F1 of each cross developed during kharif-2013 at Regional Rice Research Station, Navsari Agricultural University, Vyara. F1's along with their parents were grown during summer-2014, where fresh F1's and back crosses were developed. Parental lines and F1's plant were selfed during the same season to obtain seeds of parental lines and F2's.The experimental material consisting of four families, each having six generations (P1, P2, F1, F2, BC1 and BC2) was grown in nursery during kharif 2014 at Navsari. The experimental material was planted in compact family block design with three replications, whereas, different generations viz., P1, P2, F1, F2, BC1 and BC2 of each family represented individual experimental unit within family. The individual replication was represented by four family blocks, one row each of P1, P2 and F1, four rows each of F2 and two rows of BC1 and BC2 generations. Total 10 plants were accommodated in each row.

RESULTS AND DISCUSSION

Exploitation of hybrid vigour in commercial crop is more significant when judged in relation to better parent or other hybrids rather than with mid-parental mean (average heterosis). Fonseca and Patterson5 emphasized the utilization of hybrid vigour in express of the better parent for the production of commercial hybrids and coined the term "Heterobeltiosis". The estimates of heterotic effects in the present study revealed that the magnitude of heterosis was in general low to medium for most of characters. In case of grain yield per plant three out of four crosses viz., GURJARI x IR-28, NAUR-1 x DANTESHWARI and GAR-13 x RP BIO-226 displayed highly significant average heterosis and heterobeltiosis in desired direction. It was further observed that the cross combination who had significant relative heterosis or heterobeltiosis for grain yield per plant in general, occupied significant relative heterosis or heterobeltiosis for productive tillers per plant, grain length, grain breadth, grains per panicle, chlorophyll content, photosynthetic rate, harvest index and test weight. The heterotic effects for grain yield per plant and its related traits was also reported by Cheema *et al.*[9], Ram[21], Khan *et al.*[14], Mishra *et al.*[18], Sarker *et al.*[24], Agrawal[6], Alam *et al.*[7], Joshi *et al.*[13], Reddy[22], Verma *et al.*[29], Raju *et al.*[20], Veni *et al.*[28], Faiz *et al.*[11], Singh[26], Kumar *et al.*[15], Allah *et al.*[8], Roy *et al.*[23], EL-Namaky et al, Kumar *et al.*[16], Soni and Sharma[27], Latha *et al.*[17], Sharma *et al.*[25], Yadav *et al.*[30], Ghara *et al.*[12] and Mohamed[19]. The magnitude of mean performance of F2 populations for grain yield per plant showed significant inbreeding depression in all the crosses studied but two crosses viz., NAUR-1 x DANTESHWARI and GAR-13 x PUSA SUGANDHA-5 showed negative value of inbreeding depression revealed the possibility of getting desirable transgressive segregants. The significantly negative relative heterosis for days to flowering was depicted by all the crosses while significantly negative heterobeltiosis for days to flowering was depicted by NAUR-1 x DANTESHWARI. The significantly negative inbreeding depression for days to flowering found NAUR-1 x DANTESHWARI and GAR-13 x RP BIO- 226. Similar findings were reported by Joshi *et al.*[13] and Soni and Sharma[27]. For plant height, crosses GAR-13 x RP BIO- 226 and GAR-13 x PUSA SUGANDHA-5 exhibited significant relative heterosis and heterobeltiosis in negative direction. For panicle length, all the crosses exhibited relative heterosis in desired direction, while two crosses GURJARI x IR-28 and GAR-13 x PUSA SUGANDHA-5 had significantly positive heterobeltiosis. These results are in accordance with the findings of Joshi *et al.*[13], Soni and Sharma27 and EL-Namaky *et al.*[10]. The crosses, GURJARI x IR-28, NAUR-1 x DANTESHWARI and GAR-13 x RP BIO-226 manifested significant and positive relative heterosis and heterobeltiosis for grain yield per plant also showed significant inbreeding depression. This indicated that degree of inbreeding depression expressed by the F2 populations was somewhat related to the amount of heterosis in F1 for grain yield per plant. For grains per panicle, all the crosses exhibited significant relative heterosis in positive direction except GAR-13 x RP BIO- 226 while two crosses GURJARI x IR-28 and GAR-13 x USA SUGANDHA-5 exhibited significant heterobeltiosis in positive direction. For harvest index, all the crosses exhibited significant relative heterosis in positive direction while two crosses GURJARI x IR-28 and GAR-13 x PUSA SUGANDHA-5 exhibited significant heterobeltiosis in positive direction. These results are in accordance with the findings of Faiz *et al.*[11], Singh[26], Roy *et al.*[23], EL-Namaky *et al.*[10], Sharma *et al.*[25], Yadav *et al.*[30] and Mohamed[19]. For grain length, all the crosses exhibited significant relative heterosis in positive direction except GAR-13 x RP BIO- 226 while two crosses GURJARI x IR-28 and NAUR-1 x DANTESHWARI exhibited significant heterobeltiosis in positive direction. For grain breadth, all the crosses exhibited significant relative heterosis in positive direction while two crosses GAR-13 x RP BIO- 226 and GAR-13 x PUSA SUGANDHA-5 exhibited significant heterobeltiosis in positive direction and negative significant in NAUR-1 x DANTESHWARI. For L-B ratio, all the crosses exhibited significant relative heterosis and heterobeltiosis in negative direction. These results are in accordance with the findings of Kumar *et al.*[16]. For chlorophyll content at panicle initiation stage, GAR-13 x RP BIO-226 and GAR-13 x PUSA SUGANDHA-5 crosses exhibited significant relative heterosis in positive direction while GAR-13 x RP BIO-

226 exhibited significant heterobeltiosis in positive direction. For chlorophyll content at flowering stage, all the crosses exhibited significant relative heterosis in positive direction except GAR-13 x RP BIO- 226 while GAR-13 x PUSA SUGANDHA-5 exhibited significant heterobeltiosis in positive direction. For photosynthetic rate at panicle initiation stage, all the crosses exhibited significant relative heterosis in positive direction except NAUR-1 x DANTESHWARI while GURJARI x IR-28 and GAR-13 x RP BIO-226 exhibited significant heterobeltiosis in positive direction. Photosynthetic rate at the flowering stage was lower than that at the panicle initiation stage in all the parents and hybrids, Heterosis for photosynthetic rate was higher at the panicle initiation stage then that at the flowering stage except GURJARI x IR-28. Inbreeding depression was significant and positive for chlorophyll content and photosynthetic rate in most of the crosses. These results are in accordance with the findings of Khan *et al.*[14] and Allah *et al*[8]. For days to flowering, cross GAR-13 x RP BIO-226 exhibited negative inbreeding depression whereas crosses viz., GURJARI x IR-28 and NAUR-1 x DANTESHWARI showed positive inbreeding depression. More chance of getting desirable transgressive segregants for earliness in crosses which expressed significantly positive inbreeding depression. This cross might be useful for getting dwarf stature in segregating generations. For grains per panicle and 100 seed weight all the crosses expressed significantly positive inbreeding depression, these suggested the least chances of getting transgressive segregants in desired direction in these crosses. In general, most of the crosses, those who exhibited positive inbreeding depression for yield components like productive tillers per plant, panicle length, test weight, grains per panicle also exhibited positive inbreeding depression for grain yield per plant. This revealed that the expression of heterosis and inbreeding depression for grain yield per plant was dependent on its attributing traits. The results are matching with the results of Joshi *et al*[13]. Reddy[22], Veni *et al.*[28] and Yadav *et al.*[30].

Table 2: Relative Heterosis (RH %), heterobeltiosis (HB %) and inbreeding depression (ID %) for morphological characters in four crosses in rice

Characters	Gurjari × IR – 28			NAUR- 1 × Danteshwari			GAR-13 × RP-Bio-226			GAR –13 ×Pusa sungadha 5		
	RH (%)	HB (%)	ID (%)	RH (%)	HB (%)	ID (%)	RH (%)	HB (%)	ID (%)	RH (%)	HB (%)	ID (%)
Days to flowering	-2.10**	4.70**	6.00**	-2.81**	8.33**	6.07**	-5.34**	-3.35**	-8.5**	-4.51**	-1.55	0.90
Plant height (cm)	-0.46	3.97**	-1.57	4.10**	-6.33**	12.00**	4.79**	5.95**	1.60	-7.73**	-3.62**	-6.00**
Panicle length (cm)	4.17**	0.86**	1.80	6.85**	-9.60**	7.70**	8.69**	-5.27**	8.90**	9.46**	7.95**	11.70**
Productive tillers per plant	-2.34	-7.95**	9.30**	-6.81**	-17.30**	1.70	-4.78**	-14.99**	-22.90**	-0.39	-8.84**	12.50**
Grains per panicle	60.89**	28.34**	18.38**	8.05**	-3.06	12.00**	-0.10	-14.16	7.40*	31.79**	19.82**	24.70**
100 seed weight	22.25**	9.55**	15.49**	5.03**	2.62	11.80**	20.53**	12.34**	7.50**	-1.87	-19.25**	6.60**
Grain length (mm)	2.46**	1.58**	2.59**	5.39**	4.55**	2.60**	1.08	0.78	0.40	7.82**	-5.56**	11.70**
Grain breadth (mm)	12.52**	0.83	12.8**	12.30**	-1.68*	5.40**	9.39**	4.68**	6.70**	7.99**	1.90*	0.60
Grain L:B ratio	-10.07**	-18.94**	-11.90**	-8.14**	-20.13**	-2.90**	-7.78**	-11.99**	-6.70**	-11.82**	-26.56**	0.60
Grain yield per plant (g)	22.18**	8.92**	23.90**	24.27**	10.33**	-10.70**	27.65**	11.20**	16.80**	3.77	-2.88	-7.5**
Straw yield per plant (g)	6.18**	-0.66	12.00**	6.08*	-7.93**	-5.20*	2.55	-4.21*	11.30**	-15.21**	-16.81**	-12.10**
Harvest Index (%)	8.40**	5.32**	7.5**	9.62**	7.75	-2.90	13.49**	8.50	3.50**	11.63**	6.13**	1.90

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