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Heterosis for Yield and its Component Traits in Intra and Inter Sub Specific Crosses in Rice (*Oryza Sativa* L.)

Key words : Heterosis, Indica, Japonica, Rice.

Rice is an important food crop in India accounting for 30% of the total cropped area. The expression of heterosis depends on the genetic diversity of the parental lines used. Renhua et al., (1998) and Li et al., (1998) reported that genetic diversity between parents within limits has profound influence on magnitude of heterosis for yield and other traits. Heterosis breeding is an important genetic tool for yield enhancement (30 to 400%) and other quantitative and qualitative characters in crops (Srivastava, 2000). Standard heterosis for yield ranging from 16 to 63 % was reported by Rutger and Shinjyo (1980) and from 29 to 45 % by Yuan *et al*., (1994). In practical breeding programme, standard heterosis would alone be taken into consideration for selection of hybrids rather than mid and better parental heterosis. The cross combination of indica / japonica hybrids would be expected to produce high magnitude of heterosis. Inter sub specific hybrids showed increased hybrid vigour in total dry matter and spikelet number. Hence, development of indica / japonica hybrids, assumes greater significance in realizing higher magnitude of heterosis, which is prerequisite for widespread adoption of hybrid rice technology. The present study aims to evaluate the yield and its component traits in crosses of japonica / indica, japonica / japonica and indica / indica.

The experimental material comprised of four japonica lines (Betagomblin, Gedonzipetan, Mazila and Orumundakan) and three indica lines (MLT-278, Kavya and BPT-5204) of rice. Crosses were made among the seven parents in all possible combinations excluding reciprocals. The resulting 21 F_1 hybrids were evaluated in a randomized block design with three replications at Regional Agricultural Research Station, Warangal during *Kharif,* 2008. Each plot consisted of single row of 3 m length with a spacing of 20 cm between rows and 15 cm between plants. All the recommended cultural practices were followed to obtain normal growth of the crop. Observations were recorded on five plants from each replication for eight traits *viz*., days to 50% flowering, plant height (cm), number of productive tillers per hill, pollen fertility (%), panicle length (cm), number of filled grains per panicle, spikelet sterility (%) and yield per plant (g). The mean data was analysed following Griffings (1956) to estimate heterosis. Heterosis was measured as per cent increase of F_1 over the mid parent, better parent and standard variety (BPT-5204).

The analysis of variance indicated significant differences among the genotypes for yield and its component traits. Estimates of per cent heterosis over mid parent, better parent and standard check for yield and component traits in rice was presented in Table-1. Heterosis for days to 50% flowering revealed that the japonica / japonica cross, Betagomblin / Orumundakan recorded superior heterotic effect for three types of heterosis might results in evolving early duration hybrids. Sixteen hybrids showed significant negative standard heterosis for days to 50% flowering. Four hybrids in japonica / indica group showed negative heterosis over check variety for plant height while, none of the hybrid of indica / indica exhibited negative heterosis. Vaithiyalingan and Nadarajan (2010) observed similar results in sub specific crosses of rice. Betagomblin / Orumundakan Gedonzipetan / Mazila, Gedonzipetan / Betagomblin and Mazila / Betagomblin, the four japonica / japonica hybrids recorded significant negative heterosis for plant height. Negative heterotic hybrid combination is desirable for development of dwarf hybrids.

The hybrid Mazila / BPT-5204 registered highly significant positive relative heterosis, heterobeltiosis and standard heterosis for number of productive tillers per hill. Four hybrids of japonica / indica showed significant positive standard heterosis. None of the hybrids of japonica / japonica exhibited significant positive heterosis while only one hybrid in indica / indica (MLT-278 / Kavya) recorded positive significant standard heterosis. Significant positive relative heterosis was observed in four hybrids and heterobeltiosis in two hybrids of japonica / indica for productive tillers per hill.

None of the hybrids of all the three cross combinations exhibited positive significant standard heterosis for pollen fertility. Japonica / japonica and japonica / indica hybrids showed less pollen fertility

Table1. Estimates of heterosis for yield and component traits in intra and inter sub specific hybrids of rice

Cross	Days to 50% flowering			Plant height		
	RH	HB	SH	RH	HB	SH
Gedonzipetan x Mazila	-4.30**	-10.80 **	-14.50 **	-10.32 **	-13.60 **	-7.79 **
Gedonzipetan x Betagomblin	-0.33	-8.13 **	-9.76 **	-6.35 **	-11.74 **	-12.69 **
Gedonzipetan x Orumundakan	-5.18**	-17.29 **	-7.99 **	-3.90 *	-7.63 **	-0.94
Gedonzipetan x MLT-278	-7.25**	-12.14 **	-18.64 **	10.09 **	0.06	-1.03
Gedonzipetan x Kavya	4.45**	0.33	-9.76 **	-0.24	-6.77 **	6.10 **
Gedonzipetan x BPT-5204	-0.32	-8.88 **	-8.88 **	-5.74 **	-6.25 **	-6.25 **
Mazila x Betagomblin	-3.66**	2.41 **	0.59	-6.36 **	-14.78 **	-9.04 **
Mazila x Orumundakan	-3.43**	-10.11 **	0.00	1.49	1.25	8.59 **
Mazila x MLT-278	-4.87**	-6.48 **	-10.36 **	53.63 **	35.03 **	44.12 **
Mazila x Kavya	-0.32	-3.40 **	-7.40 **	-10.68 **	-13.46 **	-1.51
Mazila x BPT-5204	-3.32**	-5.33 **	-5.33 **	12.83 **	9.27 **	16.63 **
Betagomblin x Orumundakan	-19.49**	-24.20 **	-15.68 **	-13.78 **	-21.70 **	-16.03 **
Betagomblin x MLT-278	-6.36**	-9.04 **	-10.65 **	18.78 **	14.27 **	0.03
Betagomblin x Kavya	-0.94	-5.12 **	-6.80 **	6.90 **	-5.44 **	7.62 **
Betagomblin x BPT-5204	0.90	0.00	0.00	1.14	-5.16 *	-5.16 *
Orumundakan x MLT-278	-3.63**	-11.70 **	-1.78 *	14.25 **	0.21	7.47 **
Orumundakan x Kavya	-6.76**	-15.69 **	-6.21 **	1.21	-1.70	11.87 **
Orumundakan x BPT- 5204	-5.31**	-10.11 **	0.00	-2.37	-5.66 **	1.17
MLT-278 x Kavya	-10.53**	8.95 **	0.89	11.22 **	-4.86 **	8.27 **
MLT-278 x BPT-5204	-2.92**	-6.51 **	-6.51 **	12.05 **	1.34	1.34
Kavya x BPT-5204	1.25	-6.21 **	-6.21 **	0.77	-5.34 **	7.73 **

Table 1 Cont....

Cross	No. productive tillers per hill			Pollen fertility		
	RH	HB	SH	RH	HB	SH
Gedonzipetan x Mazila	-3.70	-9.30	-2.50	0.00	-12.50 *	-35.27 **
Gedonzipetan x Betagomblin	3.45	2.27	12.50	-0.27	-12.96 *	-35.62 **
Gedonzipetan x Orumundakan	-7.50	-13.95 *	-7.50	-17.92 **	-26.85 **	-45.89 **
Gedonzipetan x MLT-278	-14.61 **	-17.39 **	-5.00	-24.11 **	-30.65 **	-38.01 **
Gedonzipetan x Kavya	-3.23	-10.00	12.50	-37.94 **	-45.86 **	-46.23 **
Gedonzipetan x BPT-5204	20.48 **	16.28 **	25.00 **	-20.87 **	-31.16 **	-31.16 **
Mazila x Betagomblin	4.88	-2.27	7.50	8.98	8.64	-39.73 **
Mazila x Orumundakan	-1.33	-2.63	-7.50	-1.51	-3.55	-44.18 **
Mazila x MLT-278	16.67 **	6.52	22.50 **	-15.84 **	-31.80 **	-39.04 **
Mazila x Kavya	-9.09	-20.00 **	0.00	-28.76 **	-44.48 **	-44.86 **
Mazila x BPT-5204	41.03 **	37.50 **	37.50 **	-11.45 *	-31.16 **	-31.16 **
Betagomblin x Orumundakan	-8.64	-15.91 **	-7.50	19.39 **	16.57 *	-32.53 **
Betagomblin x MLT-278	-2.22	-4.35	10.00	11.85 *	-9.58 *	-19.18 **
Betagomblin x Kavya	-21.28 **	-26.00 **	-7.50	-10.86 *	-30.69 **	-31.16 **
Betagomblin x BPT-5204	16.67 **	11.36	22.50 **	-13.91 **	-33.22 **	-33.22 **
Orumundakan x MLT-278	-13.25	-21.74 **	-10.00	-2.33	-19.54 **	-28.08 **
Orumundakan x Kavya	-1.15	-14.00 **	7.50	-29.41 **	-44.14 **	-44.52 **
Orumundakan x BPT- 5204	-1.30	-5.00	-5.00	-4.12	-24.32 **	-24.32 **
MLT-278 x Kavya	6.25	2.00	27.50 **	3.81	-1.38	-2.05
MLT-278 x BPT-5204	2.33	-4.35	10.00	2.35	-3.08	-3.08
Kavya x BPT-5204	-4.44	-14.00 **	7.50	-0.34	-0.68	-0.68

RH - Relative heterosis, HB – Heterobeltiosis, SH - Standard heterosis
* Significant at 5 % level ** significant at 1% level

Table 1. Continued

Cross	Panicle length			No. of Filled seeds per panicle		
	RH	HB	SH	RH	HB	SH
Gedonzipetan x Mazila	10.34 **	9.90 **	-15.78 **	-17.67 **	-25.09 **	-21.04 **
Gedonzipetan x Betagomblin	15.85 **	12.50 **	-8.50 **	-19.08 **	-19.43 **	-15.08 **
Gedonzipetan x Orumundakan	19.16 **	12.08 **	-14.11 **	-12.47 **	-23.14 **	-18.99 **
Gedonzipetan x MLT-278	0.31	-17.25 **	-2.43	-34.32 **	-35.38 **	-29.61 **
Gedonzipetan x Kavya	7.14 **	-12.53 **	5.92 **	-0.56	-9.08 **	15.64 **
Gedonzipetan x BPT-5204	21.82 **	7.59 **	7.59 **	-0.09	-2.65	2.61
Mazila x Betagomblin	20.93 **	16.98 **	-4.86 **	1.46	-7.31 **	-3.17
Mazila x Orumundakan	68.92 **	59.48 **	21.24 **	39.91 **	34.48 **	16.20 **
Mazila x MLT-278	31.61 **	8.24 **	27.62 **	17.64 **	5.47 *	14.90 **
Mazila x Kavya	9.62 **	-10.78 **	8.04 **	-3.23	-18.74 **	3.35
Mazila x BPT-5204	23.62 **	8.80 **	8.80 **	35.06 **	25.88 **	25.88 **
Betagomblin x Orumundakan	20.90 **	10.63 **	-10.02 **	21.74 **	7.31 **	12.10 **
Betagomblin x MLT-278	11.81 **	-5.53 **	11.38 **	0.70	-1.37	7.45 **
Betagomblin x Kavya	3.60 *	-13.41 **	4.86 **	-10.29 **	-18.30 **	3.91
Betagomblin x BPT-5204	10.79 **	0.46	0.46	-14.57 **	-16.40 **	-12.66 **
Orumundakan x MLT-278	7.20 **	-15.70 **	-0.61	0.30	-13.16 **	-5.40
Orumundakan x Kavya	-12.79 **	-32.08 **	-17.75 **	-5.31 *	-22.99 **	-2.05
Orumundakan x BPT- 5204	23.37 **	3.34	3.34	16.27 **	4.47	4.47
MLT-278 x Kavya	3.62 **	2.26	23.82 **	3.47	-3.95	22.16 **
MLT-278 x BPT-5204	2.51	-5.28 **	11.68 **	14.26 **	9.57 **	19.37 **
Kavya x BPT-5204	22.03 **	11.40 **	34.90 **	9.02 **	-2.64	23.84 **

Table 1 Cont....

Cross	Spikelet sterility			Yield per plant		
	RH	HB	SH	RH	HB	SH
Gedonzipetan x Mazila	103.14 **	29.80 *	492.16 **	-35.50 **	-38.07 **	-53.38 **
Gedonzipetan x Betagomblin	113.41 **	46.36 **	399.35 **	-33.16 **	-35.07 **	-48.15 **
Gedonzipetan x Orumundakan	164.81 **	78.35 **	551.63 **	-25.58 **	-38.85 **	-53.96 **
Gedonzipetan x MLT-278	353.39 **	269.48 **	643.79 **	-52.09 **	-54.02 **	-62.36 **
Gedonzipetan x Kavya	346.74 **	235.05 **	324.84 **	-7.45 **	-23.32 **	-12.16 **
Gedonzipetan x BPT-5204	326.51 **	281.44 **	383.66 **	-11.16 **	-22.14 **	-22.14 **
Mazila x Betagomblin	19.67	4.58	377.12 **	-32.68 **	-37.13 **	-49.79 **
Mazila x Orumundakan	22.20	10.03	401.96 **	9.33 **	-7.12 **	-35.64 **
Mazila x MLT-278	12.92	-18.62	271.24 **	36.32 **	25.85 **	23.02**
Mazila x Kavya	39.62 *	-20.49	262.75 **	-24.50 **	-39.42 **	-30.59 **
Mazila x BPT-5204	-35.84	-60.89 **	78.43	45.40 **	23.08 **	23.08 **
Betagomblin x Orumundakan	-27.10	-29.52	157.52 **	-8.01 **	-26.10 **	-40.99 **
Betagomblin x MLT-278	59.28 **	26.63	332.03 **	8.16 **	6.84 **	-12.54 **
Betagomblin x Kavya	98.06 **	17.43	300.65 **	-36.94 **	-46.49 **	-38.70 **
Betagomblin x BPT-5204	50.52 *	-2.68	232.03 **	2.37	-7.94 **	-7.94 **
Orumundakan x MLT-278	75.78 **	36.31 *	398.04 **	-33.39 **	-46.99 **	-56.61 **
Orumundakan x Kavya	26.52	-25.76	171.24 **	-28.96 **	-49.46 **	-42.10 **
Orumundakan x BPT- 5204	60.11 **	1.97	272.55 **	-15.82 **	-37.52 **	-37.52 **
MLT-278 x Kavya	-49.63	-66.88 *	-33.33	11.09 **	-4.77 **	9.10 **
MLT-278 x BPT-5204	-34.92	-51.30	-1.96	2.16	-7.11 **	-7.11 **
Kavya x BPT-5204	4.00	-15.03	-15.03	-4.98 **	-11.02 **	11.94**

RH - Relative heterosis, HB – Heterobeltiosis, SH - Standard heterosis
* Significant at 5 % level ** significant at 1% level

than indica / indica hybrids. This indicates that the hybrid with distant parents produce low pollen fertility than closer ones. Similar results were found by Vaithiyalingan and Nadarajan (2010). Positive relative heterosis and heterobeltiosis was observed in Betagomblin / Orumundakan of japonica / japonica cross for pollen fertility but only one hybrid in japonica / indica cross (Betagomblin / MLT-278) showed significant positive relative heterosis. For panicle length, seven hybrids in japonica / indica recorded significant positive heterosis over standard variety. All the hybrids in japonica / japonica crosses registered positive relative heterosis and heterobeltiosis for panicle length indicating these cross combinations would evolve hybrids with long panicle. Four hybrids of japonica / indica viz., Gedonzipetan / BPT-5204, Mazila / MLT-278, Mazila / BPT-5204, Betagomblin / MLT-278 expressed significant positive heterosis for number of filled grains per panicle over check variety. All the three hybrids in indica / indica exhibited positive standard heterosis for filled grains per panicle while all the japonica / japonica hybrids recorded negative standard heterosis except Mazila / Orumundakan.

None of the hybrids of japonica / japonica group failed to express negative heterosis for spikelet sterility. But all the indica / indica hybrids exhibited negative heterosis for spikelet sterility. Spikelet sterility is more in case of japonica / indica and japonica / japonica crosses compared to indica / indica hybrids. Highly significant positive relative heterosis, heterobeltiosis and standard heterosis for yield per plant was recorded in japonica / indica hybrids, Mazila / BPT-5204 and Mazila / MLT-278. Vaithiyalingan and Nadarajan (2010) reported significant heterosis for yield per plant in japonica / indica crosses. In case of indica / indica hybrids, MLT-278 / Kavya and Kavya / BPT-5204 recorded significant positive heterosis over the standard variety for yield per plant.

There are many reports showing evidence of significant positive mid parent, better parent and standard heterosis for one or more of yield components in a number of crosses (Luat *et al*., 1985; Peng and Virmani *et al*., 1994). Maximum variation was observed in relative heterosis, heterobeltiosis and standard heterosis for yield per plant among hybrids followed by number of filled grains per panicle and panicle length. High heterotic effect for yield was observed in four crosses, Mazila / BPT-5204, Mazila / MLT-278 Kavya / BPT-5204 and MLT-278 / Kavya along with high hybrid vigour for number of productive tillers per hill, panicle length and number of filled grains per panicle. Thus it is obvious that hybrid vigour for yield is the result of interaction of simultaneous increase in the expression of yield components. The above hybrids exhibited superior heterotic values than the standard variety for most of the yield components including grain yield. Therefore these hybrids can be utilized for heterosis breeding.

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