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Short Communication

Heterosis for physiological traits in hybrid rice (*Oryza sativa* L.)

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Hybrid rice (*Oryza sativa* L.) has unique advantage of better physiological efficiency. However the information on physiological traits in this crop are limited. Present study was therefore undertaken using five male sterile lines *viz.*, PMS 9A (L1), PMS 10A (L2), V 20 A (L3), IR 58025A (L4) and IR 62829A (L5) and seven pollinator varieties *viz.*, BR 736-20-3-1 (T1), IR 31406 (T2), IR 50400-64-1-2-2-22 (T3), IR 8866-20-3-1-4-2 (T4), MDU 3 (T5), MDU 4 (T6) and Pomi (T7). The 35 hybrids obtained in a line × tester mating fashion were evaluated in RBD for the nature and magnitude of heterosis for four physiological traits including leaf areas index (LAI), total chlorophyll content (TCC) at maximum tillering stage, total dry matter accumulation (TDMA) and harvest index (HI) after maturity along with grain yield per plant (GYP). The hybrids and parents were raised at Agricultural College and Research Institute, Madurai, Tamil Nadu during Rabi 1996-97 by adopting standard agronomical practices. Relative heterosis (RH), heterobeltiosis (HB) and standard heterosis (SH) were calculated and significance of heterosis was tested using 't' test. This information on the extent of heterosis would help in the choice of the best crosses for commercial exploitation.

Estimates of percent based on mid-parent, better parent and standard check (MDU 4) are presented in Table 1. All the hybrids except PMS 10A/MDU 4 showing significant RH effects were in positive direction for LAI. Similarly, 26 and 27 hybrids exhibited significantly positive HB and SH, respectively for this trait. The maximum heterosis recorded for this trait were 68.09 per cent (RH) and 66.21 per cent (HB). The range of SH was between -16.44 and 57.49 per cent. The highest level of heterosis exhibited by most of the hybrids expressed luxuriant vegetative growth of hybrids during maximum tillering stage. Seven hybrids showed significant RH in positive direction while four of the hybrids each recorded higher HB and SH for TCC. The hybrids IR 62829A/BR 736-20-3-1 expressed the maximum RH (72.64 per cent), HB (55.04 per cent) and SH (27.61 per cent) for TDMA. Peng and Virmani [1] reported 58 per cent of SH, 60 per cent of HB and 65 per cent of RH for this trait. Among the 11 hybrids showing significant positive heterosis for TDMA, only five hybrids exhibited significant SH for yield while others recorded insignificant or negative heeterosis. This variable heterosis for TDMA and yield may be due to crosses, fertilizers application and climatic conditions [2]. Singh and Maurya [3] reported standard heterosis in the range of –22.01 to 16.22 per cent for HI, which was very identical to the value of –39.17 to 12.97 per cent obsrved in the present study.

Among the three types of heterosis as far as breeders are concerned standard heterosis is more important since the hybrid to be released is expected to outperform the superior local variety or hybrid (standard check). At IRRI, the yield of promising F_1 rice hybrids bred using CMS lines showed high mid parental heterosis of 59 per cent and standard heterosis of 35 per cent [2,4]. In the present study, IR 58025A/Ponni showed highest heterosis for LAI (54.49 per cent) which also exhibited moderate level of SH for yield (23.62 per cent). However the hybrid IR 62829A / BR 736-20-3-1 which recorded the highest SH for yield recorded only 28.97 per cent SH for LAI. Another cross, IR 62829A / MDU 3 showing negative heterosis for LAI exhibited negative heterosis for yield (-29.19 per cent). These observations suggested that to get heterotic hybrids for grain yield, LAI during maximum tillering stage should be moderate as the two hybrids manifesting high and low SH for LAI recorded less heterosis for yield. The chlorophyll content did not show any relationship with yield. However the linear relationship between chlorophyll and yield in deep water rice has been reported earlier [5].

Variable response for yield was recorded for hybrids showing high heterosis for TDMA. These results showed that hybrids with higher TDMA would not

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Table 1. Heterosis per cent for physiological traits and yield in hybrid rice

Hybrid	Leaf area index			Total chlorophyll content			Total dry matter accumulation			Harvest index			Yield/plant		
	RH	RB	SH	RH	HB	SH	RH	HB	SH	RH	HB	SH	RH	HB	SH
$L_1 \times T_1$	24.8**	20.5**	19.3**	14.0**	6.1	3.6	12.2**	2.4	−18.6**	−7.1	−7.5*	−20.9**	−12.1*	−14.0*	−39.7**
$L_1 \times T_2$	46.8**	41.9**	40.2**	18.0**	−18.8	−20.7**	49.7**	31.8**	4.8	10.5	4.5	0.2	64.5**	56.2**	9.0*
$L_1 \times T_3$	59.1**	58.2**	47.4**	−2.1	−2.1	−4.4	39.6**	35.1**	7.4	−1.9	−4.4	−13.9**	55.2**	54.7**	9.0*
$L_1 \times T_4$	41.4**	37.9**	27.1**	−6.2	−11.2	−13.3**	17.5**	12.4*	−10.5**	−3.3	−9.0**	−11.8**	3.6	1.1	−25.6**
$L_1 \times T_5$	51.0**	50.9**	39.1**	−5.9	−13.3**	−15.3**	45.5**	44.4**	14.8**	−23.3**	−23.8**	−39.2**	−1.8	−9.0	−36.2
$L_1 \times T_6$	28.1**	23.1**	23.1**	−17.4**	−18.3**	−18.3**	12.0**	0.5	0.5	−18.3**	−24.3**	−24.3**	−4.2	−18.5*	−18.5**
$L_1 \times T_7$	19.9**	8.52	23.4**	25.6**	16.4**	13.6**	23.9**	20.0**	1.8	29.0**	26.2**	13.0**	54.8**	51.9**	10.6*
$L_2 \times T_1$	15.3*	12.9	11.8	−5.7	−12.4**	−14.2**	31.2**	15.8**	−0.1	−10.8**	−14.1**	−21.0**	12.9*	6.2	−19.3**
$L_2 \times T_2$	51.2**	48.2**	46.4**	6.0	5.1	3.0	13.7**	−2.9	−17.0**	−31.1**	32.5**	−35.3**	−15.6**	−22.8**	−41.3**
$L_2 \times T_3$	25.2**	24.1**	17.7**	−14.7**	−14.8**	−16.6**	13.7**	5.9	−9.4*	−22.6**	−23.3**	−29.5**	−7.0	−10.4	−31.9**
$L_2 \times T_4$	37.0**	31.8**	25.0**	16.6**	10.3**	8.0**	14.8**	6.1	9.2*	−8.1	−10.4**	−13.2**	6.3	4.7	−20.5**
$L_2 \times T_5$	52.3**	50.0**	42.4**	2.4	−5.7	−7.7	26.1**	21.5**	3.9	17.1**	−26.3**	−32.3**	−2.0	−12.4*	−33.5**
$L_2 \times T_6$	−31.7**	28.3**	28.3**	−36.0**	−36.7**	−36.7**	11.7**	3.6	3.6	2.6	−1.5	−1.7	23.9**	9.0	9.0*
$L_2 \times T_7$	16.5**	6.9	21.6**	-4.6	−11.8*	−13.6**	37.2**	36.6**	16.9**	20.9**	19.2*	9.6**	75.1	71.5**	30.3**
$L_3 \times T_1$	32.3**	30.6**	29.3**	−27.4**	−32.7**	−33.7**	3.5	−7.1	−23.5**	−15.9**	−19.9**	−24.7*	−17.3**	−23.5**	−39.8**
$L_3 \times T_2$	19.3**	17.9**	16.4*	−33.6**	−34.5**	−34.5**	40.7**	22.0**	0.5	−1.2	−2.1	−6.2	31.7**	18.5**	−6.7
$L_3 \times T_3$	52.0**	49.5**	44.1**	−11.3**	−11.7**	−13.0**	56.8**	49.2**	22.9**	11.5*	9.2	2.6	74.1**	65.0**	29.9**
$L_3 \times T_4$	2.4	−4.3	−7.7	7.0*	9.0	−0.6	15.5*	8.6	10.5*	−1.9	−3.4	−6.3	1.8	−1.5	−22.4**
$L_3 \times T_5$	22.7**	19.9**	16.6**	−35.6**	−38.1**	−39.0**	10.5*	7.8	−11.2**	5.8	−5.9	−11.5**	6.8	−6.0	−26.0**
$L_3 \times T_6$	5.6	3.7	3.7	−37.1**	−37.6**	−37.6**	−3.6	−12.1*	−12.1*	5.7	−8.6*	−8.6*	−8.8	−18.5**	−18.5**
$L_3 \times T_7$	-4.8	12.0	0.0	−5.5	−12.9**	−14.2**	24.8*	23.0**	4.3	−11.1**	−13.3**	−18.5**	15.8**	11.5	−12.2
$L_4 \times T_1$	27.2**	22.7**	30.7**	−14.7**	−21.2**	−21.9**	56.7**	34.9**	22.6**	17.5**	15.9**	0.5	62.1**	45.1**	22.8**
$L_4 \times T_2$	19.0**	14.7*	22.2**	−35.3**	−36.4**	−37.0**	35.2**	12.6*	2.3	13.0**	7.6*	3.1	46.7**	27.9**	8.3
$L_4 \times T_3$	9.8	−5.3	8.7	−35.3**	−35.8**	−36.4**	4.8	−2.2	17.9**	-8.7**	10.4**	−19.3**	−12.2**	−19.5**	−31.9**
$L_4 \times T_4$	−5.3	−13.7	−8.1	4.8	−1.5	−2.4	4.7	5.8	−14.4**	−17.3**	21.7**	24.1**	−5.0	−11.2*	−24.8**
$L_4 \times T_5$	37.5	48.1**	36.5**	−31.5**	−37.3**	−37.9**	25.8**	17.1**	6.4	17.5**	8.3*	−6.1	39.5**	−19.1**	0.8
$L_4 \times T_6$	32.7**	28.1**	36.5**	−30.8**	−31.1**	−31.1**	28.2**	22.4**	22.4**	−7.0*	−13.6**	−13.2**	10.9**	2.4	2.4
$L_4 \times T_7$	42.8**	38.3**	57.5**	−30.8**	−36.5**	−37.0**	34.6**	30.1**	18.2	17.3**	15.5**	3.2	57.0**	46.0**	23.6**
$L_5 \times T_1$	39.6**	30.2**	29.0**	11.0**	6.8	−3.0	72.6**	55.0**	27.6**	20.0**	15.8**	5.4	74.4**	84.2**	37.8**
$L_5 \times T_2$	37.8**	28.7**	27.1**	−4.0	−6.5	−10.3**	41.1**	22.4**	7.2	7.7	5.2	0.8	31.4**	21.0**	−9.4
$L_5 \times T_3$	27.9**	22.8**	14.5**	22.4**	18.2**	14.2**	−5.8	−14.4*	−22.2**	−12.8**	−13.4**	−20.8**	10.6**	7.4	−19.7**
$L_5 \times T_4$	68.1**	66.2**	45.7**	28.2**	25.7**	14.2**	32.6**	24.8**	2.7	−14.9**	−17.3**	−19.9**	6.1	5.3	−21.2**
$L_5 \times T_5$	6.0	−9.0	−16.4*	−10.4**	−14.7**	−22.5**	−3.4	−5.7	−22.4**	17.7**	6.0	−3.0	11.1**	0.0	−25.2**
$L_5 \times T_6$	47.2**	36.7**	36.7**	−7.0*	−11.2**	−11.2**	−31.3*	19.7**	19.7**	−16.2**	−19.8**	−19.8	1.8	−11.0**	−11.0**
$L_5 \times T_7$	29.2**	13.5*	29.1**	−10.9**	−14.7**	−22.5**	20.9**	19.1**	7.8	4.0	2.8	−6.0	31.2**	29.5**	−3.1
S.E.	0.3	0.3	0.1	0.1	0.1	0.1	1.8	2.1	2.1	1.2	1.4	1.4	0.9	1.1	1.1

L_1 = PMS 9A, L_2 = PMS 10A, L_3 V 20 A, L_4 = IR 58025A, L_5 = IR 62829A, T_1 = BR 736-20-3-1, T_2 = IR 31406, T_3 IR 500-64-1-2-2-22, T_4 = IR 8866-20-3-1-4-2, T_5 MDU 3, T_6 = MDU 4 and T_7 = Ponni *and ** highly significant at P = 0.05 and 0.01 levels, respectively; RH = relative heterosis; HB = heterobeltiosis and SH = standard heterosis

necessarily result in higher yield. This confirms the earlier reports of moderated and lack of correlation at higher level of dry matter production and spikelet fertility, which determined the yield [6]. All the hybrids showing positive SH for HI showed higher heterosis for yield. Among the components of TDMA and HI yield determining traits, the study revealed greater role of HI to contribute higher yield. It showed higher efficiency of partitioning the dry matter in high yielding hybrids. Accordingly, the hybrids IR 62829 A/BR 736-20-3-1, PMS 10A/Ponni, V20 A/IR 50400-64-1-2-2-22, IR 58025A/Ponni and IR 58025A/BR 736-20-3-1 were superior recording more than 20 per cent SH for yield with physiological traits in desired magnitude and direction. Hence, it suggested hybrid-breeding programme to aim at evolving F_1 hybrids in rice with broad leaves and higher harvest index to get maximum yield.

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