Indian J. Agric. Res., **40** (3) : 178 - 183, 2006

HETEROSIS IN TWO LINE RICE HYBRIDS

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ABSTRACT

The two line system of heterosis breeding (S x R) in rice is a new approach for further increasing crop yields. An attempt was made to identify heterotic combinations among the 24 hybrids obtained by crossing four 'S' lines, *viz.*, TS6, TS16, TS18 and TS29 with six non-TGMS lines MDU5, IR20, CO43,CO45, ADT39 and Ponni. The three line hybrid CORH2 was taken as the standard check to estimate standard heterosis. The spikelet fertility is an important trait affecting the yield in hybrid rice breeding for which more than 50 percent of the hybrids showed significant standard heterosis. The hybrid TS29 x Ponni recorded the maximum standard heterosis (51.65 percent) followed by TS6 x Ponni (37.7 per cent) TS29 x CO45 (32.00 per cent) and TS16 x CO43 (23.06 per cent) for single plant yield. These hybrids recorded >10% heterosis over the three line hybrid CORH2 and hence they can be utilized in developing high yielding two line rice hybrids.

INTRODUCTION

Utilization of heterosis in agricultural crops is one of the most attractive achievements in Plant Breeding Science in the century. With per unit area yield rise by about 30% than the conventional rice varieties, hybrid rice has helped China to increase food production by over 300 million tonnes, since 1970s when the hybrid rice began to expand in the country. The major effective way to make use of crop heterosis is by developing hybrids utilizing male sterility. The three line system based on cytoplasmic genic male sterility has been found to be effective so far in the development of commercial hybrids. In this process the seed production is limited by the requirement of crossing at two stages *viz.*, AxB and AxR and heterosis is also limited by low frequency of maintainers and restorers in hybrid seed production. The development of new hybrid combination is time consuming one and the cost of seed production is also high. The excess dependence on a single source of CMS via wild Abortive (WA) cytoplasm and the cumbersome process of seed production and parental line development warrant the development of alternate approach to exploit the hybrid vigour in rice. Two line breeding is one such possibility which was first developed in China. It offers many advantages in simplifying the seed production, removal of restriction of restorer genes, exclusion of maintainers, freedom from choice of pollen parents and overcome the negative effects of male sterile cytoplasms. If avoids genetic vulnerability due to excess dependence on a single cytoplasmic source (WA cytoplasm). The TGMS line was identified by chinese and Japanese scientists which was completely sterile under high temperature (>32^{0}C) and under reduced or low temperature (<24^{0}C) it was fertile (Tan *et al.*, 1990 and Maruyama *et al.*, 1990) at panicle initiation stage have been taken into advantages for hybrid seed production and seed increase of TGMS lines. The two line system of heterosis breeding (SxR) utilizing temperature sensitive genic male sterile (TGMS) lines, the scope of developing two line hybrids has enlarged. However, the knowledge on the extent of hybrid vigour expressed in the cross combinations is a prerequisite for developing superior hybrids. The present study aims to analyse the extent of heterosis for yield and its component traits in 24 two-line rice hybrids.

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MATERIAL AND METHODS

The materials for the present study comprised of the crosses made utilizing four lines and six testers in a line x tester mating design. Resulting 24 hybrids and ten parents were evaluated in randomized block design with three replications. The three line hybrids CORH2 (IR 580 25A x C20R) was included as check. The seedlings of 25 days old were transplanted in the field at 20 x 15 cm spacing.

Recommended were recorded on five randomly chosen plants for the characters *viz.*, days to 50% flowering, plant height, number of productive tillers per plant, panicle length, number of filled grains per panicle, spikelet fertility percentage, 1000 grain weight, leaf area index, photosynthetic rate, dry matter production, harvest index and single plant yield.

Data were analysed using standard statistical procedures. The F_1 hybrid performance was evaluated on the basis of the estimates of heterosis over mid parent, better parent and standard check hybrid.

RESULTS AND DISCUSSION

The analysis of variance indicated significant differences among the genotypes for grain yield and other characters. The estimates of relative heterosis (di), heterobeltiosis (dii) and standard heterosis (diii) are presented in Table 1. Thirteen hybrids recorded significant negative standard heterosis of them seven hybrids *viz.*, C2, C9, C10, C12, C22, C23 and C24 showed earliness to flower. Negative heterosis for this trait was reported by Sharma and Mani (1990), Ganesan *et al.* (1997), Yolanda and Vijayandradas (1996), Chen *et al.* (1997) and Sampoornam and Thiyagarajan (1998). It was observed that, all the 24 hybrids recorded negative significant standard heterosis for plant height. This type of negative heterosis had been reported by Chen *et al.* (1997) and Sampoornam and Thiyagarajan (1998). None of the hybrids exhibited positive and significant standard heterosis for number of productive tillers per plant. Similar findings were reported by Yolanda and Vijayandradas (1996). Longer panicle length is desirable trait. Seven hybrids showed significant positive standard heterosis *viz.*, C10, C11, C12, C16, C17, C22 and C24 for panicle length.

Among the 24 hybrids, five hybrids *viz.*, C6, C12, C18, C22 and C24 had significant and positive standard heterosis for number of filled grains per panicle. Regarding the relative heterosis all the 24 hybrids exhibited heterosis in the positive direction. Twelve hybrids had significant heterosis in the positive direction over their better parent. Positive standard heterosis for this trait was reported by Patnaik *et al.* (1990), Singh *et al.* (1992), Wilfred Manuel and Prasad (1992), Feng *et al.* (1995), Chen *et al.* (1997), Zhu *et al.* (1997), Elsy and Rangaswamy (1998).and Sampoornam and Thiyagarajan (1998).

Spikelet fertility is an important trait affecting the yield in hybrid rice breeding. Twenty one hybrids recorded significant standard heterosis values, of them only one hybrid *viz.*, C24 showed positive significant value over the standard check hybrid CORH2.The critical sterility temperature for TS6, TS16, TS18 and TS29 were 32.6^0, 30.1^0, 31.1^0, and 31.1^0C respectively. Fertility was observed in TGMS lines at a higher temperature than the CST indicating that rainfall also plays a major role in the expression of fertility. For ideal hybrid seed production the TGMS lines should flower from April to July. Regarding 1000 grains weight, 12 hybrids exhibited significant and positive relative heterosis and two hybrids showed heterobeltiosis in positive manner. All the 24 hybrids recorded significant negative standard heterosis. Positive and significant heterobeltiosis was observed in eight cross combinations while five hybrids recorded positive and significant - standard heterosis for the trait Leaf Area Index. Regarding the relative heterosis a total of 13

Table 1. Estimates of percent heterosis over mid Parent (di) better parent (dii) and standard check (diii) for yield and component characters in two line rice hybrid

S.No	Hybrids	Days to 50% flowering			Plant height			No. of productive tillers per plant			Panicle length		
		di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii
1	TS6 x MDU5	5.84**	14.56**	-7.67**	5.25**	8.47**	-11.04**	21.28**	13.78**	-7.03	3.93	0.37	3.36
2	TS6 x IR20	-13.81**	-2.45**	-8.43**	-1.44	0.98	-13.82**	-0.11	-1.61	14.6**	-6.28	-6.86	-2.88
3	TS6 x CO43	-10.61**	0.40**	-5.75**	-2.41	3.77**	-9.69**	25.54**	9.30	-10.69**	-9.10	-11.28	-8.64*
4	TS6 x CO45	-9.61**	2.03**	-4.22**	-0.39	5.79**	-7.93**	-6.23	6.78	-23.83**	9.25	7.59	14.26
5	TS6 x ADT39	-10.70**	0.00	-6.13**	-3.79**	-3.76**	-16.25**	-19.92**	-23.42**	-31..43**	0.87	-3.77	9.12
6	TS6 x PONNI	-16.91**	-2.45**	-8.43**	-18.41**	7.70**	-6.27**	-12.98	-13.29*	-29.14**	0.95	-4.38	10.08
7	TS16 x MDU5	10.27**	24.07**	0.00	1.49	5.56**	-13.43**	-18.68**	22.03**	-44.17**	-0.74	-7.22	2.35
8	TS16 x IR20	-6.40**	1.089**	2.68**	4.89**	-4.49**	-16.10**	-20.14**	-26.96**	-42.11**	-0.36	-3.09	6.91
9	TS16 x CO43	-9.57**	-2.28**	-1.53**	2.36	7.83**	-4.47**	-10.94	-13.65	-43.26**	4.93	-0.91	9.31
10	TS16 x CO45	-9.30**	-1.53**	-0.77	-1.70	3.44*	-8.37**	-12.06*	-20.24**	-35.60**	8.96	6.92	17.95**
11	TS16 x ADT39	-6.49**	0.75	1.53**	0.61	0.25	-12.71**	-8.21	-20.42**	-28.74**	4.85	3.43	17.28**
12	TS16 x PONNI	-14.04**	-3.05**	-2.30**	-18.12**	6.90**	-5.30**	1.17	-8.45	-25.71**	6.39	4.17	19.92**
13	TS18 x MDU5	10.25**	-2.55**	2.30**	-3.27*	-2.05	-21.66**	-7.46	-20.75**	-43.26**	-10.01	-14.71*	-18.19
14	TS18 x IR20	-7.47**	-1.46**	3.45**	-3.18*	-1.59	-18.75**	-21.67**	-35.62**	-48.97**	-4.42	-12.95*	-9.12**
15	TS18 x CO43	-4.03**	1.47**	6.52**	-5.18**	5.53**	-15.60**	2.69	-6.20	-42.11**	-10.57	-16.11*	-17.76**
16	TS18 x CO45	-3.80**	2.19**	7.28**	-9.44**	0.67	-19.48**	33.22**	-45.51**	-38.46**	+22.37**	10.67	17.52**
17	TS18 x ADT39	-6.88**	-1.82**	3.07**	-0.44	3.97**	-16.84**	-45.28**	-57.05**	-61.54**	22.86**	7.96	22.42**
18	TS18 x PONNI	-10.31**	-1.09**	3.83**	-23.13**	7.03**	-14.40**	-42.67**	-53.31**	-62.11**	-3.32	-15.60**	-2.83
19	TS29 x MDU5	7.98**	17.90**	-4.98**	0.83	-0.54	-16.16**	1.17	-10.93*	-16.17**	2.40	-5.69	7.44
20	TS29 x IR20	-8.35**	2.81**	-1.92**	-5.31**	-3.32**	-18.49**	16.22**	7.04	0.74	-9.04	-12.90	-0.77
21	TS29 x CO43	-9.09**	1.20*	-3.45**	-4.88	2.88	-13.27**	3.63	-14.21**	-19.26**	‘-1.61	-8.47	4.27
22	TS29 x CO45	-9.89**	0.81	+3.83**	-11.63	-4.54**	-19.52**	19.41**	10.93*	4.40	8.79	5.10	19.73**
23	TS29 x ADT39	-11.35**	-1.60**	-6.13**	-0.10	1.54	-14.39**	-3.73	-6.07	-11.60	-0.78	-0.55	12.77
24	TS29 x PONNI	-16.11**	2.41	-6.90**	-22.67**	4.13*	-12.21**	10.40*	2.79	- 3.26	1.91	2.44	16.70*
	SE	0.35	0.41		1.15	1.32		0.76	0.88		1.15	1.33	

*,** Significant at Five percent and One per cent respectively.

Table 1. Continued

Table 1. Continued

S.No.	Hybrids	Number of filled grains per panicle			Spikelet fertility percentage			1000 grain weight			Leaf area index		
		di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii
1	TS6 x MDU5	13.86**	5.39**	-30.72**	8.51**	-9.22**	-11.91**	0.28	-7.05	-33.46**	20.94**	-17.53**	5.43**
2	TS6 x IR20	19.18**	6.23**	-24.06**	18.83**	-1.12**	-2.77**	5.53	-0.78	-31.11	36.17**	33.04**	18.06**
3	TS6 x CO43	22.39**	8.30**	-21 .28**	9.32**	-7.80**	-12.81**	-3.38	-7.89	-37.90**	20.65**	19.95**	1.55**
4	TS6 x CO45	22.01**	-1.51	-10.31**	18.43**	-1.88	-2.44	8.49*	-4.81	-22.92**	-14.68**	-15.37**	-28.35**
5	TS6 x ADT39	21.43**	0.24	-13.85**	10.75**	-7.44**	-9.97**	-0.36	-0.61	-38.95**	-2.34**	-4.99	-14.95**
6	TS6 x PONNI	29.73**	-1.76*	6.83**	13.49**	-5.08**	-7.83**	11.60*	7.76	-34.14**	-11.35**	-13.07**	-26.40**
7	TS16 x MDU5	21.75**	10.20**	-27.57**	6.23**	-11.61**	-14.23**	10.24*	6.59	-18.27**	-10.80**	-16.02**	-24.66**
8	TS16 x IR20	20.48**	5.11**	-24.85**	16.87**	-3.27*	-4.89**	13.50**	8.13	-17.08**	-8.67**	-13.57**	-23.30**
9	TS16 x CO43	25.95**	9.14**	-20.67**	4.94**	-11.97**	-16.28**	4.96	-1.37	-24.37**	12.75**	9.74**	-8.16**
10	TS16 x CO45	26.76**	0.45	-8.53**	15.42**	-4.88**	-5.44**	-12.36**	9.38*	-11.42**	-24.73**	-26.57**	-38.83**
11	TS16 x ADT39	21.36**	-1.72	-15.53**	8.29**	-9.98**	-12.44**	-17.62**	5.92	-18.78**	1.96**	- 3.90**	-13.10**
12	TS16 x PONNI	30.21**	-3.01**	5.47**	20.61**	0.33	-2.58**	21 .54**	5.88	-18.81**	-19.47**	-20.53**	-35.34**
13	TS18 x MDU5	25.28**	6.99**	-29.67**	16.72**	-5.20**	-8.01**	24.79**	-21.54**	-12.98**	18.55**	2.38**	-8.16**
14	TS18 x IR20	24.46**	2.74*	-26.55**	18.12**	-4.55**	-6.15**	14.86**	13.57	-21.15**	0.88**	-12.47**	-22.33**
15	TS18 x CO43	29.44**	6.16**	-22.84**	4.44**	-14.51**	-18.70**	6.14	5.79	-28.20**	47.33**	31.07**	-9.71**
16	TS18 x C045	29.60**	-2.08*	-10.83**	16.37**	-6.36**	-6.90**	-1.98	-9.92*	-27.05**	13.20**	0.93	-15.92**
17	TS18 x ADT39	28.26**	-1.15	-15.04**	21 .67**	-1.28	-3.97**	11.59*	6.29	-27.86**	5.65**	-8.68	-18.25**
18	TS18 x PONNI	41.14**	0.77	9.58**	18.04**	-4.16**	-6.94**	10.51*	1.60	- 31.05**	9.14**	-1 .67**	-20.00**
19	TS29 x MDU5	5.06**	-0.13	-34.35**	5.57**	-6.25**	-9.03**	13.14**	6.82	-23.53**	28.91**	27.54**	16.89**
20	TS29 x IR20	12.83**	3.16*	-26.25**	6.12**	-6.31**	-7.88**	5.66	1.22	-29.73**	15.18**	13.35**	3.88**
21	TS29 x CO43	14.98**	4.34**	-24.16**	4.60**	-6.29**	-10.88**	-1.27	-4.07	-35.32**	-46.18**	-48.52**	-52.81**
22	TS29 x CO45	40.18**	15.68**	5.34**	5.63**	-7.19**	-7.73**	-0.02	-10.76*	-27.73**	-26.97**	-30.30**	-36.11**
23	TS29 x ADT39	13.33**	-4.29**	17.74**	9.20**	-3.13**	-5.77**	-1.14	-2.83	-38.20**	-19.61**	-20.55**	-27.18**
24	TS29 x PONNI	28.45**	-0.79	7.88**	0.53**	-10.71**	-3.31*	9.42	3.68	-34.07**	-1.6 8**	-7.20**	-14.95**
	SE	1.19	1.38		1.12	1.30		0.85	0.99		0.02	0.02	

*,** Significant at Five percent and One per cent respectively.

Table 1. Continued

Table 1. Continued

S.No.	Hybrids	Photosynthetic rate			Dry matter production			Harvest index			Single plant yield		
		di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii
1	TS6 x MDU5	-0.62**	-2.50	2.77	15.55**	4.87	5.26**	13.68**	3.85**	10.20**	39.72**	39.41**	-4.16
2	TS6 x IR20	0.47**	-3.94	1.26	-7.72*	-9.11*	-8.77**	1.08**	-9.62**	-4.08**	12.80*	7.98	-12.19*
3	TS6 x CO43	-1.61	4.44*	6.89**	-16.18**	-16.47**	-15.58**	7.22**	0.00	6.12**	8.45**	-4.70	-6.43
4	TS6 x CO45	-5.92**	-10.61**	4.66**	-6.72*	-9.70*	-3.18	-17.65**	-19.23**	-14.29**	23.00**	2.23	14.80**
5	TS6 x ADT39	4.04*	-2.25	3.04	-14.10**	-16.29**	-15.98**	1.01	-3.85**	2.04**	32.99**	20.33**	10.54*
6	TS6 x PONNI	-4.35*	-10.76**	8.63**	-5.87	-17.00**	9.11**	5.50**	4.49**	10.20**	39.58**	12.32**	37.07**
7	TS16 x MDU5	-6.79**	-10.01**	-8.72**	-9.80*	-16.24**	-20.04**	-1.15	0.00	-12.24**	6.24	-0.69	-25.78**
8	TS16 x IR20	-1.94	-2.83	-6.56**	-6.53	-7.44	9.89*	12.94**	9.09**	-2.04**	-2.06	-11.90	-28.86**
9	TS16 x CO43	-8.30**	-15.45**	-5.42**	-8.35*	-10.89**	-9.94*	43.82**	42.22**	30.61**	50.86**	25.35**	23.06**
10	TS16 x CO45	-9.28**	-18.06**	-4.06	2.61	-3.02	3.98	10.64**	4.00**	6.12**	24.45**	-1.77	10.31*
11	TS16 x ADT39	-0.40	-1.33	-6.84**	-0.59	-0.70	-5.21	3.30**	0.00	-4.08**	-8.71**	-22.07**	-28.42**
12	TS16 x PONNI	-8.60**	-13.16**	-1.22	-5.83	-18.72**	6.84	9.47**	1.96**	6.12**	+29.00	-1.12	20.67**
13	TS18 x MDU5	-8.53**	-13.43**	-12.19**	-0.13	-0.95	-18.95**	5.49**	0.00	-2.04**	29.96**	-16.39*	-13.04**
14	TS18 x IR20	-7.03**	-9.74**	-13.20**	5.27	-3.84	-6.39	10.11**	2.08**	0.00	-16.46**	-27.87**	-41.34**
15	TS18 x CO43	-10.04**	-18.60**	-8.95**	-2.27	12.22**	-11.28	1.08**	-2.08**	-4.08**	34.76**	7.95	5.98
16	TS18 x C045	-13.26**	-23.08**	-9.94**	-2.33	-14.51**	-8.33*	-8.16**	-10.00	-8.16**	16.88**	-10.80*	0.17
17	TS18 x ADT39	-6.23**	-7.29**	-14.09**	-9.46	-16.47**	-20.44**	1.05	0.00	-2.04**	-23.58**	-37.20**	-42.31**
18	TS18 x PONNI	-8.36**	-20.09**	-2.72	-19.88**	-35.41**	-15.10**	-7.07**	-9.80**	-6.12**	29.52**	-3.87	17.31**
19	TS29 x MDU5	2.66	-1.75	-10.19**	-0.63	-11.62**	-7.14	-10.87**	-16.33**	-16.32**	23.18**	14.10*	0.00
20	TS29 x IR20	3.66	-2.70*	8.53**	-31.27**	-33.80**	-30.44**	-2.22**	-10.20**	-10.20**	29.90**	25.21**	0.74*
21	TS29 x CO43	1.71	0.71	14.48**	-2.36	-4.22	0.64	-8.51**	-12.24**	-12.24**	25.77**	19.03**	16.86**
22	TS29 x CO45	-3.68**	-3.53**	10.92**	-2.72	-3.69	3.26	1.01*	0.00	2.04**	32.04**	17.55**	32.00**
23	TS29 x ADT39	9.93**	-0.06	13.17**	0.37	-4.32	5.34	-2.08**	-4.08**	-4.08**	12.06**	9.49	0.57
24	TS29 x PONNI	-0.16	-3.64	17.30**	-11.81**	-20.65**	4.30	26.00**	23.53**	12.50**	44.65**	24.27**	51.65**
	SE	1.14	1.31		1.30	1.51		0.001	0.002		0.73	0.85	

*,** Significant at Five percent and One per cent respectively.

hybrids showed significant and positive relative heterosis.

Among 24 hybrids, eight hybrids recorded positive significant standard heterosis *viz.*, C3, C4, C6,C20,C21, C22, C23 and C24 for the trait photosynthetic rate. Three hybrids recorded significant positive relative heterosis and 14 hybrids recorded significant negative values over better parent.

Two cross combinations *viz.*, C1 and C6 showed positive, significant standard heterosis for the character dry matter production. Only one hybrid (C1) has recorded significant positive heterosis over their mid parent.

The estimates of standard heterosis for harvest index ranged from -16.32% (C19) to 30.61 % (C9). All the 24 hybrids recorded significant standard heterosis of them nine hybrids recorded positive significant standard positive heterosis over better parent and nine hybrids recorded significant negative heterobeltiosis.

The magnitude of heterosis, heterobeltiosis and standard heterosis for yield was observed in the range of -23.58 to 44.65 per cent, -37.20 to 39.41 per cent and -42.31 to –51.65 per cent respectively. Elsy and Rangaswamy (1998) and Sampoornam and Thiyagarajan (1998) reported standard heterosis for grain yield in two line rice hybrids. Eleven hybrids showed significant positive useful heterosis for single plant yield. The hybrid TS29 x CO45 and TS 29 x Ponni have shown maximum amount of heterosis heterobeltiosis and standard heterosis for single plant yield as well as other yield attributing components. These hybrids may be exploited for heterosis. According to Yuan (1990) the yield increase of two line hybrid was 5-10% over three line hybrids. From the present study, the aforesaid hybrids were observed with more than 10% standard heterosis over the three line hybrid CORH2.

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