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Heterotic expression of two line hybrids in rice

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ABSTRACT

Extent of heterosis was explored in 4 thermo-sensitive genic male sterile (TGMS) lines and 22 non-TGMS testers by making 88 crosses. The magnitude of relative heterosis, heterobeltiosis and standard heterosis with checks (CORH 2 and ADTRH 1) were estimated. The hybrids, GD 98029 x IR 61608-213, GD 98049 x IR 61608-213 and GD 98014 x RR 166-645 could be exploited for earliness as they exhibited negative and significant standard heterosis for days to 50 percent flowering over the checks. Top yielding hybrids viz., GD 98049 x IR 63875-196-2-2-1-3, GD 98014 x TKM 11, GD 98049 x TKM 11, GD 99017 x TKM 12 exhibited significant standard heterosis over CORH 2 and ADTRH 1. Most of the high yielding hybrids manifested significant positive heterosis for yield contributing characters viz., more number of productive tillers plant^{-1}, long panicles, more number of filled grains panicle^{-1}, spikelet fertility and 1000 grain weight. Hence, these hybrids may be used for commercial cultivation in two line hybrid rice.

Key words : *rice hybrid, TGMS line, heterosis, grain yield,*

Hybrid rice has yield advantage of 20 percent over semi-dwarf varieties. Virmani and Edwards (1983) reviewed the status and prospects for breeding hybrid rice and concluded that exploitation of heterosis through hybrid breeding offered an important option to increase yield in this self-pollinated crop. A hybrid is commercially viable, when it is superior to the locally adopted best variety. Siddiq (1987) and Banumathy *et al.* (2003) emphasized the need for computing heterosis over the standard variety or hybrid. Even though China and other countries have achieved tremendous gains in heterosis breeding during the last two decades, it is felt that the maximum yield potential of hybrid rice has not been fully studied and exploited yet. The problem associated with the classical three-line system may be overcome by two-line system of hybrid rice breeding (Yuan *et al.,* 2000). The present investigation was initiated with the objective to analyze the extent of heterosis in two line hybrids and to identify the heterotic hybrids.

The investigation was carried out on two line rice hybrids obtained by crossing four thermo-sensitive genic male sterile (TGMS) lines (GD 98014, GD 99017, GD 98029 and GD 98049) as female parents with 22 Non-TGMS testers (ADT 39, ADT 43, ASD 19, CO 43, CO 47, IR 36, IR 66, IR 72, IR 65515-47-2-1-19, IR 68763-46-1-2-5-2, IR 62030-54-1-2-2, IR 65514-5-1-2-19, IR 59624-34-2-2, IR 63877-43-2-1-3-1, IR 61608-213, IR 10198-66-2, IR 63875-196-2-2-1-3, Padmini, RR 166-645, TKM 11, TKM 12, TRY 2) as male parents in line x tester mating design at Paddy Breeding Station, Tamil Nadu Agricultural University, Coimbatore to evolve 88 cross combinations. The hybrid combinations were evaluated in randomized block design with two replications along with their parents and two check hybrids *viz.,* CORH 2 and ADTRH 1. TGMS lines were maintained by multiplying stubbles. Standard agronomic practices were followed for raising the crop. Observations were recorded on days to 50% flowering, plant height, number of productive tillers plant^{-1}, panicle length, number of filled grains panicle^{-1}, spikelet fertility, 1000 grain weight, grain yield plant^{-1}, harvest index and biomass yield on five randomly selected plants at the time of maturity. Relative

Table 1. Hybrids with high per se performance, standard heterosis and specific character association (sca) effects

Hybrids	Mean	Standard heterosis		sca
		$d_{iii(1)}$	$d_{iii(2)}$	
Days to 50 % flowering				
GD 98029 x IR 61608-213	74.00	-11.90 **	-10.30 **	1.44
GD 98049 x IR 61608-213	75.00	-10.71 **	-9.09 **	-0.06
GD 99017 x IR 62030-54-1-2-2	76.00	-9.52 **	-7.88 **	-3.81 *
GD 99017 x IR 61608-213	76.00	-9.52 **	-7.88 **	4.19 *
GD 98014 x RR 166-645	76.50	-8.93 **	-7.27 **	-12.19 **
Plant height				
GD 98049 x IR 66	79.36	-16.32 **	-8.72 **	-7.90 **
GD 98014 x IR 72	80.34	-15.29 **	-7.61	-0.64
GD 98014 x IR 62030-54-1-2-2	81.84	-13.70 **	-5.87	2.13
GD 98014 x IR 66	82.08	-13.45 **	-5.60	6.27 *
GD 98049 x IR 65515-47-2-1-19	82.89	-12.60 **	-4.67	-8.91 **
Number of productive tillers				
GD 98014 x IR 66	16.32	33.22 **	31.08 **	2.50 **
GD 98014 x IR 59624-34-2-2	16.27	32.86 **	30.72 **	2.86 **
GD 98029 x TKM 12	15.50	26.53 **	24.50 **	1.76
GD 98029 x Padmini	15.30	24.90 **	22.89 **	1.10
GD 98014 x TKM 11	15.13	23.55 **	21.57 *	1.52
Panicle length				
GD 99017 x Padmini	31.49	30.09 **	24.44 **	3.28 **
GD 99017 x TKM 12	30.67	26.68 **	21.18 **	1.84 *
GD 98029 x Padmini	29.54	22.02 **	16.71 **	2.02 *
GD 98049 x TKM 11	28.83	19.06 **	13.89 **	2.73 **
GD 98014 x TKM 12	28.31	16.94 **	11.85 *	0.16
Number of filled grains/panicle				
GD 99017 x Padmini	248.60	76.96 **	125.55 **	50.18 **
GD 99017 x CO 43	215.35	53.30 **	95.38 **	27.79 **
GD 98049 x TRY 2	206.51	47.00 **	87.36 **	56.02 **
GD 98049 x TKM 11	200.63	42.82 **	82.03 **	29.70 **
GD 98049 x Padmini	191.61	36.40 **	73.84 **	-3.47
Spikelet fertility				
GD 99017 x TKM 11	96.90	34.34 **	52.77 **	7.70 **
GD 99017 x CO 47	96.58	33.90 **	52.26 **	8.49 **
GD 98049 x IR 66	96.05	33.16 **	51.43 **	7.27 **
GD 99017 x ADT 43	94.60	31.15 **	49.14 **	3.62
GD 98049 x IR 63877-43-2-1-3-1	92.91	28.81 **	46.48 **	7.02 **
1000 grain weight				
GD 99017 x TKM 12	31.62	49.50 **	53.50 **	4.79 **
GD 99017 x TRY 2	29.41	39.05 **	42.77 **	1.45 *
GD 98049 x TKM 11	29.05	37.35 **	41.02 **	2.44 **
GD 99017 x TKM 11	29.03	37.26 **	40.92 **	2.73 **
GD 98049 x IR 63875-196-2-2-1-3	29.00	37.12 **	40.78 **	3.12 **
Grain yield per plant				
GD 98049 x IR 63875-196-2-2-1-3	49.55	28.97 **	75.65 **	5.44 **
GD 98014 x TKM 11	48.69	26.73 **	72.60 **	11.54 **
GD 98049 x TKM 11	48.58	26.46 **	72.23 **	2.78
GD 99017 x TKM 12	47.69	24.13 **	69.05 **	6.26 **
GD 98049 x RR 166-645	47.66	24.05 **	68.95 **	12.12 **
Harvest index				
GD 98014 x TKM 11	0.66	7.32	20.00 **	0.21 **
GD 98029 x Padmini	0.64	4.07	16.36 **	0.24 **
GD 99017 x IR 63875-196-2-2-1-3	0.64	4.07	16.36 **	0.06 *
GD 99017 x TRY 2	0.63	1.63	13.64 *	0.10 **
GD 98029 x IR 10198-66-2	0.62	0.81	12.73	0.12 **
Biomass yield				
GD 99017 x Padmini	158.00	153.16 **	207.57 **	53.42 **
GD 98049 x TKM 11	115.50	85.07 **	124.84 **	17.03 **
GD 98049 x Padmini	113.52	81.89 **	120.99 **	4.64
GD 98049 x IR 65514-5-1-2-19	98.41	57.68 **	91.57 **	14.53 **
GD 98014 x IR 65515-47-2-1-19	97.17	55.70 **	89.16 **	15.45 **

Significant at 5% level; ** Significant at 1% level; $d_{iii\ (1)}$-Standard heterosis over ADTRH 1; $d_{iii\ (2)}$-Standard heterosis over CORH 2 heterosis, heterobeltiosis and standard heterosis were worked out utilizing the overall mean of each hybrid for each trait. Significance of heterosis was tested using the formula given by Snedecor and Cochran (1967).

Most of the hybrids flowered earlier as compared to check hybrids CORH 2 and ADTRH 1. The hybrids, GD 98029 x IR 61608-213, GD 98049 x IR 61608-213 and GD 98014 x RR 166-645 could be exploited for earliness as they exhibited negative and significant standard heterosis for days to 50% flowering over the checks ADTRH 1 and CORH 2. The earliness may be due to earliness of parental lines involved in these crosses. Heterosis for earliness had also been reported by Young and Virmani (1990), Latha (2001) and Patil *et al.* (2003).

Plant height may not have significant role to play in the expression of hybrid vigour by the hybrids (Dwivedi, 1985). The hybrid, GD 98049 x IR 66 had desirable *per se* performance and significant and negative heterosis over checks for plant height. Sampoornam (1998) and Patil *et al.* (2003) also reported negative heterosis for plant height. Number of productive tillers plant^{-1} is generally associated with higher productivity. The hybrids, GD 98014 x IR 66, GD 98014 x IR 59624, GD 98029 x TKM 12, GD 98029 x Padmini, GD 98014 x TKM 11 produced more productive tillers than checks. The male parents involved in these crosses had more number of productive tillers plant^{-1}. Present observations are supported by Sun *et al.* (2000) and Radhidevi *et al.* (2002). Heterosis for panicle length was relatively high in GD 99017 x Padmini, GD 99017 x TKM 12, GD 98029 x Padmini, GD 98049 x TKM 11, GD 98014 x TKM 12. These hybrids possessed long panicles compared to the checks. More length of panicles in these hybrids was due to the involvement of male parents with long panicles. Significant standard heterosis for panicle length was also indicated by Sundar (2000) and Banumathy *et al.* (2003).

Number of spikelets panicle^{-1} is one of the most important components of yield and probably this character would be helpful in breaking the yield ceiling (Singh and Maurya, 1999). Long panicle is generally associated with more number of spikelets. The hybrids, GD 99017 x Padmini, GD 99017 x CO 43, GD 98049 x TRY 2, GD 98049 x TKM 11 and GD 98049 x Padmini produced more filled grains compared to checks since the male parents involved in these crosses had favourable alleles for this character. The hybrids, GD 99017 x TKM 11, GD 99017 x CO 47, GD 98049 x IR 66, GD 99017 x ADT 43 exhibited high and significant heterosis for spikelet fertility over both the checks due to the involvement of male parents with high spikelet fertility. Radhidevi *et al.* (2002) and Patil *et al.* (2003) also reported similar results. Most of the hybrids had negative heterosis due to the problem of spikelet sterility, as reported by Virmani *et al.* (1982). The hybrid, GD 99017 x TKM 12 exhibited high and significant heterosis for 1000 grain weight. Standard heterosis for 1000 grain weight in F_1 hybrids depends upon the grain characters of parental lines (Reddy *et al.,* 1984). In the present study, the TGMS line GD 99017 had bold grain. Hence, most of the hybrids involving GD 99017 registered significant positive standard heterosis for this trait.

Yield contributing characters *viz.,* panicle length, number of filled grains panicle^{-1} and 1000 grain weight had contributed much for increased grain yield (Mue *et al.,* 1991; Mishra and Pandey, 1998). In the present study, estimates of heterosis for various yield components indicated that the significant yield increase was mainly due to increased number of productive tillers plant^{-1}, number of filled grains panicle^{-1} in GD 98014 x TKM 11, whereas more number of filled grains plant^{-1}, higher 1000 grain weight and more biomass in GD 98049 x TKM 11 (Table 1). In case of GD 99017 x TKM 12, long panicle and high 1000 grain weight were responsible for increased grain yield plant^{-1}.

The hybrid, GD 98014 x TKM 11 recorded 26.73 percent increased grain yield over ADTRH 1. Latha (2001) reported up to 26.11 percent increase in grain yield over the check CORH 2 in a two line hybrid. The hybrids, GD 98014 x TKM 11, GD 98049 x TKM 11, GD 99017 x TKM 12 and GD 98049 x RR 166-645 also recorded more than 30 percent yield advantage over ADTRH 1 and CORH 2. Hence, these hybrids may be used for commercial cultivation in two-line hybrid rice.

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