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HETEROSIS IN RICE HYBRIDS

J. RAMALINGAM,* N. NADARAJAN, C. VANNIARAJAN AND P. RANGASAMY

Department of Agricultural Botany, Agricultural College and Research Institute Madurai 625104

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ABSTRACT

All the five testers used in this study acted as complete restorer for WA source and maintainer for *O. perennis*. The hybrids IR 58025 A x IR 54742 and IR 58025 A x IR 29723 showed greater heterotic expression for all the economic traits studied. The mean outcrossing percentage was high in V 20 A and IR 58025 A among the cytosteriles. High outcrossing rate was observed in IR 58025 A when interplanted with IR 29723. The crosses IR 58025 A x IR 29723 and V 20 A x IR 24 can be used in hybrid rice programme since it displayed higher heterosis with high outcrossing rate.

Key words: Restoration, hybrid vigour, outcrossing potential, rice.

The success of hybrids in cross-pollinated crops provided encourages the plant breeder to exploit the phenomenon of hybrid vigour in self-pollinated crops like rice. Unlike cross-pollinated crops, floral biology of the self-pollinated crops normally does not allow high degree of cross-pollination to make hybrid seed production cost competitive, efficient and dependable. Hybrid rice is a potent tool which has already been commercially exploited in China during the 1970s [1]. In India, little success has been made so far. The practical utility of hybrid rice is mainly dependent on the availability of stable cytoplasmic male sterile lines, identification of suitable restorers, and heterotic expression to surpass the yield level of locally available cultivars besides resonable degree of outcrossing to produce F_1 seeds in bulk quantities with minimum cost. Hence, the present study has been carried out to determine the restoration ability of testers, heterotic vigour over the standard variety and nature of outcrossing of the CMS lines.

MATERIALS AND METHODS

Five cytoplasmic male sterile (CMS) genotypes, V 20 A, ZS 97 A, IR 58025 A, IR 62829 A (WA source), and IR 66707 (*Oryza perennis*) A, as lines and five testers, viz., IR 24, IR 54742-

*Present address: Tamil Nadu Rice Research Institute, Adhuthurai 612101.

22-19-3 (hereafter referred to as IR 54742), IR 29723-143-3-2-1 (IR 29723), IR 9761-19-1 (IR 9761) and ARC 11353 formed the materials of the present study. They were crossed in a line x tester design and the resultant 25 hybrids were evaluated for their fertility status on the basis of pollen fertility using 1% I-KI solution [2] and spikelet fertility [3] analysis during kharif 1992. About 20 completely fertile hybrids in pollen as well as spikelet fertility analyses were raised along with the standard check IR 50 in randomised block design replicated thrice during rabi 1993 at the spacing of 30 cm between rows and 20 cm between plants. Each genotype was accommodated in a single row of 6 m length. Ten competitive plants were selected randomly from each genotype and from each replication to measure the economic traits. Standard heterosis was calculated and the degree of significance determined was tested by t test [4].

To know the outcrossing potential, the parent lines of these 20 hybrids involving four CMS lines of WA source and five testers were raised in such a way that four rows of each A line was surrounded by two rows of the R line on both sides, thus, having a ratio of 4 : 2 of A : R lines. Three rows of purple puttu were raised as pollen barrier around the crossing block as well as between each cross combination [5]. Twenty plants with 20 x 10 cm spacing were accommodated in each row. All the plants in the CMS row were used for spikelet fertility analysis. The outcrossing percentage was computed as proportion of number of fully developed grains to the total number of spikelets.

RESULTS AND DISCUSSION

The fertility status based on pollen and spikelet fertility analysis of 25 hybrids is given in Table 1. The pollen fertility of the hybrids was in the range of 0.0–97.4% and spikelet fertility 0.0–92.5%. Based on pollen and spikelet

Table 1. Pollen and spikelet fertility in rice hybrids

Cross	Pollen fertility (%)	Spikelet fertility (%)	Category assigned
V 20 A x IR 24	97.38	91.20	R
V 20 A x IR 54742	95.30	90.20	R
V 20 A x IR 29723	94.44	89.21	R
V 20 A x IR 9761	91.89	84.22	R
V 20 A x ARC 11353	93.60	83.54	R
ZS 97 A x IR 24	87.65	90.40	R
ZS 97 A x IR 54742	88.91	92.48	R
ZS 97 A x IR 29723	83.65	84.25	R
ZS 97 A x IR 9761	85.61	87.38	R
ZS 97 A x ARC 11353	84.65	90.12	R
IR 58025 A x IR 24	90.80	92.15	R
IR 58025 x IR 54742	87.02	90.41	R
IR 58025 A x IR 29723	95.85	86.72	R
IR 58025 A x IR 9761	91.19	88.52	R
IR 58025 A x ARC 11353	89.52	90.24	R
IR 62829 A x IR 24	73.76	81.24	R
IR 62829 A x IR 54742	76.85	82.00	R
IR 62829 A x IR 29723	69.42	87.22	R
IR 62829 A xIR 9761	88.41	91.30	R
IR 62829 A x ARC 11353	61.20	80.78	R
IR 66707 A x IR 24	0.12	0.00	M
IR 66707 A x IR 54742	0.00	0.00	M
IR 66707 A x IR 29723	0.24	0.00	M
IR 66707 A x IR 9761	0.00	0.00	M
IR 66707 A x ARC 11353	0.00	0.00	M

Pollen fertility: 60% restorer (R); 0–0.99% maintainer (M).
Spikelet fertility: 80% restorer (R); 0–0.99% maintainer (M).

studies, the five testers were classified as restorers for all the CMS lines of the WA system (V 20 A, ZS 97 A, IR 58025 A and IR 62829 A) as the F_1s of these crosses had high fertility status. All the five testers acted as complete maintainers for the *Oryza perennis* (IR 66707 A) source of sterility. This indicates that the male sterile cytoplasm of *O. perennis* may be entirely different from the WA cytoplasm.

The standard heterosis and extent of outcrossing of the 20 crosses giving high F_1 fertility are presented in Table 2.

Table 2. Standard heterosis and outcrossing rate in rice hybrids

Cross	Standard heterosis for economic traits (%)					Outcrossing (%)	
	productive tillers	ear length	filled grains per ear	100-grain weight	grain yield	individual cross	mean of crosses with common CMS parent
V 20 A x IR 24	33.59*	0.73	6.62*	29.94*	28.46*	18.18	
V 20 A x IR 54742	23.94*	3.23*	- 7.92*	27.12*	2.57	13.13	
V 20 A x IR 29723	11.34*	- 8.63*	- 25.43*	45.76*	- 10.93*	18.19	
V 20 A x IR 9761	15.94*	- 5.37*	- 19.73*	44.07*	3.49	15.90	
V 20 A x ARC 11353	15.94*	- 6.01*	- 2.60*	35.03*	11.41*	15.74	16.37
ZS 97 A x IR 24	20.98*	- 1.33	+18.27*	41.81*	20.45*	12.21	
ZS 97 A x IR 54742	9.20*	- 9.62*	- 19.54*	35.59*	- 24.19*	16.09	
ZS 97 A x IR 29723	16.19*	- 11.21*	- 17.67*	42.94*	4.81	18.29	
ZS 97 A x IR 9761	12.98*	0.73	- 23.20*	32.20*	- 2.87	10.41	
ZS 97 A x ARC 11353	34.40*	- 4.84	- 5.32*	23.16*	24.22*	9.53	13.31
IR 58025 A x IR 24	2.08	5.61*	- 2.05*	31.07*	- 0.96	19.00	
IR 58025 A x IR 54742	29.36*	24.44*	24.98*	33.90*	52.79*	16.78	
IR 58025 A x IR 29723	46.63*	18.07*	10.46*	28.81*	61.03*	20.91	
IR 58025 A x IR 9761	21.42*	11.54*	- 7.21*	19.21*	2.72	9.98	
IR 58025 A x ARC 11353	- 8.00*	2.70*	0.68*	22.03*	- 8.84*	16.68	16.67
IR 62829 A x IR 24	- 8.00*	- 5.89*	- 35.57*	16.38*	- 45.67*	2.29	
IR 62829 A x IR 54742	28.10*	3.39*	- 7.62*	26.55*	28.31*	1.28	
IR 62829 A x IR 29723	2.90	4.28*	24.79*	23.73*	- 6.63*	11.94	
IR 62829 A x IR 9761	15.50*	- 5.89*	- 17.97*	20.90*	3.02	5.66	
IR 62829 A x ARC 11353	- 28.40*	- 12.51*	- 28.68*	- 2.26*	- 54.23*	12.01	6.64

*Significant at 5% level.

A hybrid with the potential of being released for commercial cultivation should surpass the yield level of the best locally adapted variety and its CMS component should have to ensure hybrid seed production in bulk quantities. Swaminathan et al. [6] also stressed the need to determine standard heterosis for commercialization of new hybrids.

In the present study, all the crosses except IR 58025 A x IR 24, IR 58025 A x ARC 11353, IR 62829 A x IR 24, IR 62829 A x IR 29723, and IR 62829 A x ARC 11353 for productive tillers, seven crosses for ear length; V 20 A x IR 24, IR 58025 A crossed with IR 54742, IR 29723 and ARC 11353 for filled grains per ear; all the crosses except IR 62829 A x ARC 11353 for 100-grain weight, and four crosses, viz., V 20 A x IR 24, IR 58025 A x IR 54742, IR 58025 A x IR 29723 and IR 62829 A x IR 54742, recorded significantly high heterosis (> 25%) over the standard variety for grain yield. The hybrids IR 58025 A x IR 54742 and IR 58025 A x IR 29723 are worth mentioning since they had heterotic expression for all the economic traits studied. They were followed by ZS 97 A x IR 24 for four traits, and V 20 A x IR 24 and V 20 A x ARC 11353 for three traits including grain yield. Similar high positive standard heterosis for grain yield was reported by other workers [7, 8].

The outcrossing rate was high in V 20 A and IR 58025 A among the cytosteriles when interplanted with different testers. Among the individual cross combination IR 58025 A x IR 29723 showed maximum outcrossing (20.91%), followed by IR 58025 A x IR 24 (19.00%), V 20 A x IR 29723 (18.90%), ZS 97 A x IR 29723 (18.29%), and V 20 A x IR 24 (18.18%). High outcrossing was reported by Bharaj et a. [9]. Hence these crosses could give rise to potential hybrids for exploitation of heterosis on commercial scale. When the heterotic expression is examined coupled with outcrossing, only two hybrids, viz., IR 58025 A x IR 29723 and V 20 A x IR 24, showed distinct superiority over others. Therefore, these two hybrids can be exploited successfully in hybrid rice breeding programme.

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