The Andhra Agric. J 60(2): 292-296, 2013

Heterosis for Yield and Yield Components in CMS based Hybrids in Rice (*Oryza sativa* L.)

P Venkata Subbaiah, M Reddi Sekhar, K H P Reddy and N P Eswara reddy
Department of Genetics and Plant Breeding, S V Agricultural College, Tirupati 517 502, A P

ABSTRACT

Forty eight hybrids developed from crossing four CMS lines and twelve testers were evaluated for the extent of heterosis over mid parent, better parent and standard parent for yield and yield components in rice during *rabi* 2010. Seven crosses out of 48 exhibited highly significant standard heterosis for grain yield plant^{-1}. Heterosis for grain yield was manifested due to the significant and positive heterosis for its components *viz*., total number of productive tillers per plant, number of grains per panicle, 200-kernel test weight and harvest index. The top four heterotic combinations identified for grain yield plant^{-1} were APMS 6A x MTU 1078, IR 58025A x MTU 5249, APMS 6A x MTU 7029 and IR 58025A x MTU 1078 which exhibited more than 20% standard heterosis.

Key words : : CMS lines, Heterosis, Rice, Yield components.

Rice is a staple food crop in India providing 43% of calories requirement for more than 70% of Indian population, which is grown in 44 million hectares with a production of about 90 million tonnes. To meet the demands of increasing population and to maintain self sufficiency the present production level needs to be increased upto 120 million tonnes by 2020 (Melissa *et al.,* 2009). Commercial exploitation of heterosis has been made possible by the use of cytoplasmic genetic male sterility and fertility restoration system. A number of cytosteriles, maintainers and restorer lines in rice have been developed to diversify the genetic and cytoplasmic base of commercial F_1 rice hybrids. Therefore, it is imperative to identify locally adapted maintainers and restorers among the lines developed using conventional breeding procedures, which could be converted into CMS lines for wide adaptability. Identification of locally adapted restorers which show consistently high degree of restoration of CMS lines would be of great value in commercial hybrid programme. Exotic CMS line IR 58025A has been widely used in three line breeding system. Hybrid rice is practically feasible and readily adoptable genetic option to increase the rice production. Hybrid rice giving a yield advantage of about 20-30 % over high yielding varieties is a better choice (Yuan, 2002). Hence, the present investigation was under taken to estimate the magnitude and direction of heterosis for yield and yield components in rice.

MATERIAL AND METHODS

Four cytoplasmic male sterile (CMS) lines *viz.*, APMS 6A, APMS 8A, PMS 16A and IR 58025A were crossed with twelve testers *viz*., MTU 1010, MTU 1075, MTU 1061, PLA 1100, MTU 7029, MTU 1001, MTU 1064, MTU 5249, MTU 4870, BPT 5204, MTU 1078 and MTU 2716 in a Line × Tester fashion (Kempthorne, 1957) to synthesize 48 hybrids. The hybrids along with parents were grown in a completely randomized block design with three replications at S.V Agricultural College, Tirupati during *rabi* 2010. Twenty four days old seedlings of each genotype were transplanted in three rows of 2.0 m length by adopting a spacing of 22.5 cm between rows and 10 cm between plants with in rows at the rate of 20 plants per row. The crop was grown with the application of fertilizer N, P and K at the rate of 120, 60 and 60 kg ha^{-1}, respectively. Standard agronomic practices were followed to raise a good crop. A composite sample of 10 plants from the middle row was used to record observations on these plants for days to 50 per cent flowering, days to maturity, plant height, total number of productive tillers per plant, panicle length, number of grains per panicle, 200-kernel test weight, harvest index and grain yield per plant. Estimation of heterosis over mid parent, better parent and standard parent for yield and yield components were computed as suggested by Rai (1979).

Table 1. Analysis of variance of Line x Tester for grain yield and its contributing characters in rice.

Source of variation	df	DF	DM	PH	TPTP	PL	NGPP	GY	200-KTW	HI
Replications	2	0.63	0.67	0.37	2.35	0.64	1387.17	26.71	0.15	7.11
Genotypes	63	221.50**	160.61**	157.50**	9.35**	6.00**	5723.80**	22.66**	0.72**	169.46**
(a)Parents	15	285.21**	218.62**	224.64**	10.64**	4.42**	3614.06**	13.92**	0.65**	104.66**
(b)Hybrids/Crosses	47	188.34**	144.77**	133.53**	9.14**	6.6**	6431.19**	17.96**	0.76**	84.49**
(i)Lines	3	106.32**	160.96**	69.23**	7.76**	19.06**	12886.20**	50.64**	0.74**	157.05**
(ii)Testers	11	373.09**	189.73**	213.61**	9.16**	7.92**	9703.19**	24.94**	1.05**	129.52**
(iii) Line × Tester	33	134.21**	128.31**	112.68**	9.26**	5.03**	4753.71	12.66**	0.66**	62.89**
(c)Parents vs. Crosses	1	824.17**	35.01**	277.36**	0.03**	1.01**	4122.87**	375.00**	0.12*	80.42**
Error	126	0.46	0.38	0.13	0.01	0.16	139.03	1.09	0.02	0.62

* Significant at P = 0.05 level; ** Significant at P=0.01 level

DF: Days to 50% Flowering; DM: Days to Maturity; PH: Plant Height; TPTP: Total number of Productive Tillers per Plant; PL: Panicle Length; NGPP: Number of Grains Per Panicle; GY: Grain Yield per plant; 200 KTW: 200-Kernel Test Weight; HI: Harvest Index

RESULTS AND DISCUSSION

The analysis of variance of Line x Tester revealed that the variance due to genotypes were highly significant for all the traits studied indicating considerable variation in the material taken for the study (Table 1). Similarly, the mean squares due to parents vs crosses was found significant which is indicative of presence of considerable heterosis among the crosses for all the traits. The estimates of standard heterosis of top ten hybrids selected for grain yield per plant and its components were presented in Table 2. The estimates of heterosis for grain yield plant^{-1} ranged from -11.84 to 73.44 % over the mid parent, -21.14 to 45.21 % over the better parent and -26.70 to 28.13 % over the standard parent BPT 5204 (Table 2). Out of 48 crosses nineteen crosses were found to be highly significant over better parent and seven crosses exhibited high manifestation of significant standard heterosis for grain yield plant^{-1}. Heterosis for grain yield was due to the significant and positive heterosis observed in the component traits *viz*., total number of productive tillers per plant, number of grains per panicle, 200-kernel test weight and harvest index. Similar results were reported by Dalvi *et al.,* (2005) and Pandya and Thripathi (2006).

The hybrids *viz*., APMS 8A X MTU 1010 and APMS 6A X MTU 1010 exhibited maximum significant negative standard heterosis in desirable direction for days to 50% flowering. These results were in conformity with the earlier findings of Raj *et al.,* (2007). Similarly, the hybrids *viz*., APMS 8A X MTU 1010 and APMS 6A X MTU 1010 recorded significant negative standard heterosis for days to maturity. The short plant stature is an important character of hybrid to impart lodging resistance in them. The hybrids *viz*., APMS 6A x MTU 1075 and APMS 8A x MTU 1010 displayed maximum negative standard heterosis for dwarfness in height. Similar kind of findings were reported by Jayamani *et al.,* (1997). The hybrids *viz*., IR 58025A x MTU 5249, IR 58025A x MTU 1010, IR 58025A x MTU 1001, APMS 8A x MTU 1010 and APMS 6A x MTU 7029 showed maximum significant positive standard heterosis for total number of productive tillers per plant. These findings were in agreement with reports of Faiz *et al.,* (2006).

For panicle length, the maximum standard heterosis was reported in the hybrid APMS 6A x MTU 1075. These results were in conformity with the earlier findings of Jayamani *et al.,* (1997). The hybrids *viz*., APMS 6A x

Table 2. Estimation of Standard heterosis in ten hybrids and range of heterosis for grain yield and its components in rice

HYBRIDS	DF	DM	PH	TPTP	PL	NGPP	GY	200-KTW	HI
APMS 6A x MTU 1078	-8.21**	-11.57**	14.62**	10.92**	6.42**	38.34**	28.13**	23.66**	-8.70**
IR 58025A x MTU 5249	-17.63**	-9.64**	6.51**	40.61**	-0.42	21.51**	26.74**	47.11**	-17.71**
APMS 6A x MTU 7029	-9.12**	-2.89**	0.23	21.40**	7.48**	7.88	26.20**	22.59**	5.29**
IR 58025A x MTU 1078	-1.82**	1.20**	13.48**	-11.35**	16.70**	2.57	25.74**	27.19**	-5.91**
IR 58025A x MTU 1010	-9.42**	-4.58**	4.12**	32.75**	14.94**	3.30	13.30*	35.22**	-39.53**
APMS 8A x MTU 1010	-23.10**	-13.73**	19.38**	30.57**	-7.21**	-23.81**	11.09*	18.74**	14.91**
APMS 6A x MTU 1075	-12.77**	-8.43**	30.21**	10.04**	22.81**	42.65**	11.03*	24.20**	-32.12**
IR 58025A x MTU 1001	-10.64**	-13.01**	2.81**	32.31**	5.60**	-2.07	9.68	30.30**	-13.90**
IR 58025A x MTU 2716	-10.03**	0.00	9.69**	-6.99**	8.86**	-12.78*	6.87	34.26**	4.79*
APMS 6A x MTU 1010	-23.10**	-15.90**	10.59**	-3.93	13.56**	22.66**	6.77	25.70**	1.11
Mid parent heterosis (Range)	-12.54 to 14.86	-12.38 to 10.03	-19.19 to 21.52	-40.21 to 70.09	-13.45 to 13.34	-42.18 to 67.44	-11.84 to 73.44	-26.53 to 50.63	-45.68 to 52.08
Heterobeltiosis (Range)	-20.06 to 10.37	-15.64 to 6.74	-29.17 to 19.78	-47.65 to 40.18	-15.05 to 9.67	-46.14 to 50.65	-21.14 to 45.21	-27.61 to 48.13	-51.22 to 28.59
Standard heterosis (Range)	-23.10 to 6.38	-15.90 to 4.58	-6.06 to 30.12	-42.36 to 40.61	-7.21 to 22.81	-46.34 to 53.13	-26.47 to 28.13	-9.10 to 60.06	-53.53 to 14.19

* Significant at P = 0.05 level; ** Significant at P=0.01 level

DF: Days to 50% flowering; DM: Days to maturity; PH: Plant height; TPTP: Total number of productive tillers per plant; PL: Panicle length; NGPP: Number of grains per panicle; GY/P: Grain yield per plant; 200 KTW: 200-Kernel test weight; HI: Harvest index.

Table 3. Top ten high yielding hybrids identified over standard check (BPT 5204) for grain yield and its components in rice

S.No	HYBRIDS	Mean grain yield per plant(g)	Standard Heterosis (%)	gca effects		sca effect	Useful and significant heterosis for component traits in desired direction
				Female	Male		
1	APMS 6A x MTU 1078	21.26	28.13	1.10**	3.14**	1.45*	DF, DM, PH, TPTP,PL, 200 KTW
2	IR 58025A x MTU 5249	21.03	26.74	0.90**	0.17	4.39**	DF, DM, PH, TPTP, PL, 200 KTW
3	APMS 6A x MTU 7029	20.94	26.20	1.10**	0.55*	3.72**	DF, DM, PH, TPTP, PL, 200 KTW, HI
4	IR 58025A x MTU 1078	20.86	25.74	0.90**	3.14**	1.25*	DF, PH, PL, 200 KTW
5	IR 58025A x MTU 1010	18.80	13.30	0.90**	2.27**	0.05	DF, DM, PH, TPTP, PL, 200 KTW
6	APMS 8A x MTU 1010	18.43	11.09	-1.29**	2.27**	1.88**	DF, DM, TPTP, 200 KTW, HI
7	APMS 6A x MTU 1075	18.42	11.03	1.10**	-0.35**	2.10**	DF, DM, PH, TPTP, PL, 200 KTW,HI
8	IR 58025A x MTU 1001	18.20	9.68	0.90**	-0.56**	2.29**	DF, DM, PH, 200 KTW, HI
9	IR 58025A x MTU 2716	17.73	6.87	0.90**	-0.04**	1.30*	DF, PH, 200 KTW, HI
10	APMS 6A x MTU 1010	17.71	6.77	1.10**	2.27**	-1.23*	DF, DM, PH, PL, NGPP, 200 KTW, HI
	Standard check	16.59	-	-	-	-	

* Significant at P = 0.05 level; ** Significant at P=0.01 level

DF: Days to 50% flowering; DM: Days to maturity; PH: Plant height; TPTP: Total number of productive tillers per plant; PL: Panicle length;

NGPP: Number of grains per panicle; 200 KTW: 200-Kernel test weight; HI: Harvest index.

MTU 1075, APMS 6A x MTU 1078, APMS 6A x MTU 1010 and IR 58025A x MTU 5249 exhibited maximum values for standard heterosis for number of grains per panicle. This was in agreement with the findings of Faiz *et al.,* (2006). The hybrids *viz.*,IR 58025A x MTU 5249, IR 58025A x MTU 1010 and IR 58025A x MTU 2716 exhibited maximum standard heterosis for 200-kernel test weight. Similar results were also reported by Patnaik *et al.*, (1990). For harvest index, the hybrids *viz.*, APMS 8A x MTU 1010 and APMS 6A x MTU 7029 registered maximum heterosis over standard parent.

In case of hybrid breeding programme, the overall heterosis for various characters may be low, but high heterotic effect for economic yield measures the feasibility of commercial cultivation of hybrids. Best four hybrids exhibiting more than 20 percent superiority over standard check BPT 5204 for grain yield per plant in the decreasing order were APMS 6A x MTU 1078 (28.13%), IR 58025A x MTU 5249 (26.74%), APMS 6A x MTU 7029 (26.20%) and IR 58025A x MTU 1078 (25.74%) and involved two male sterile lines (APMS 6A and IR 58025A) and three testers (MTU 1078, MTU 5249 and MTU 7029) (Table 3). The parents involved in these four combinations also had desirable significant *gca* effects for most of the traits under the study. Interestingly, nine hybrids out of ten promising hybrids also depicted significant and positive *sca* effect for grain yield per plant thereby indicating the importance of non-additive gene effects in the heterotic response of these hybrids.

All the high yielding hybrids also manifested significant and useful heterosis over standard check for four to seven component traits like total number of productive tillers per plant, number of grains per panicle, plant height, panicle length, 200 kernel test weight, days to 50 per cent flowering and days to maturity (Table 3). The present study also confirmed that high heterotic combinations were realized in the cross combinations involving either H x H (APMS 6A x MTU 1078, APMS 6A x MTU 7029 and IR 58025A x MTU 1078) or H x L (IR 58025A x MTU 5249) parental *gca* status for grain yield and its components indicating the importance of both additive and non-additive gene effects in realization of heterosis for grain yield. The heterotic potential realized in these four hybrids could be further evaluated across the locations and environments for testing their feasibility of commercialization in due course.

LITERATURE CITED

Dalvi V V, Patel D U and Naik M R 2005 Evaluation of rice hybrids for yield and morphological traits. *Crop improvement,* 32(2):109-113.

Faiz F A, Sabar M, Awan T H, Ijaz M and Manzoor Z 2006 Heterosis and combining ability analysis in basmati rice hybrids. *Journal of Animal and Plant Sciences*, 16: 1-2.

Jayamani P, Thiyagarajan K, Rangaswamy M and Sreerangaswamy S R 1997 Utilisation of anther derived lines in hybrid rice. *Oryza*, 34: 1-3.

Kempthorne O 1957 An introduction to Genetic Statistics. John Wiley and Sons. Inc., New York. 457-471.

Melissa A, Fitzgerald Susan R, Mc Couch and Robert d Hall. 2009 Not just a grain of rice: the quest for quality. *Trends in Plant Science*, 14(3): 1360-1385.

Pandya R and Thripathi R S 2006 Heterosis breeding in rice. *Oryza*, 43(2):87-93.

Patnaik R N, Pande K, Ratho S N and Jachuck P J 1990 Heterosis in rice hybrids. *Euphytica*, 49(3): 243-247.

Rai B 1979 Heterosis. *Agro-Biological Publications*, New Delhi. pp:155-183.

Raj D, Singh D N, Madhuri Arya and Praveen Singh 2007 Heteroisis in rainfed transplanted rice. *Oryza*, 44(3): 264-267.

Yuan C P 2002 Increasing yield potential in rice by exploitation of heterosis. Pp. 1-6 In: Hybrid rice, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore -3, India.

(Received on 28.10.2011 and revised on 27.12.2011)