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Heterosis for grain yield and grain quality traits in rice (*Oryza sativa* L.)

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ABSTRACT

A field experiments was conducted with 21 hybrids generated by crossing seven high yielding rice genotypes viz., ADT 41, ADT 46, CO 47, TKM 9, Jeeragasamba, ACM 98003 and AS 90033 which were selected based on grain type. The hybrids were synthesized in 7 x7 diallel fashion excluding reciprocals. Relative heterosis, heterobeltiosis and standard heterosis were estimated for yield and quality characters. High amount of heterosis existed for grain yield, hundred grain weight, hulling percentage, milling percentage, head rice recovery, linear elongation ratio, water uptake, volume expansion ratio and amylose content whereas it was low for the quality traits viz.,kernel length, kernel breadth, kernel L/B ratio, kernel length after cooking and alkali spreading value. The hybrids viz., ACM 98003 / AS 90033, ADT 41 / ADT 46, ADT 41 /ACM 98003, ADT 41 / AS 90033, CO 47/ TKM 9 and CO 47 / ACM 98003performed well for grain yield combined with several grain quality traits viz., hulling percentage, milling percentage, linear elongation ratio, water uptake, volume expansion ratio and amylose content, so these promising cross combinations can be further used in rice breeding programme.

Key words: Heterosis, heterobeltiosis, grain yield, grain quality, rice.

INTRODUCTION

Rice occupies the enviable prime place among the food crops cultivated around the world. India has the largest area among the rice growing countries and enjoys the second rank in rice production. India produces 89.09 million tons from an area of 41.92 million hectares with a productivity of over 2 tons per hectare (Department of agricultural cooperation, 2011). As increasing number of rice producing countries attained self-sufficiency, grain quality has become an important breeding objective in national programme. However, there is a continuous need to step up rice production to cope up with increasing population. Grain quality is of prime importance as a breeding objective next to grain yield. Rice breeders presently pay great attention to rice quality improvement. Therefore in recent years, emphasis in rice improvement programmes has been laid on selection of genotypes combining desirable traits, particularly grain quality characters. Among the quality characters, cooking quality with some physical parameters like hulling percentage, milling percentage, head rice recovery etc. are of particular interest, as a very large proportion of the world's rice is consumed as cooked rice [1]. Since milled rice is composed of about ninety per cent of starch, starch properties have great influence on its palatability and consumer acceptability [2]. Before undertaking a hybrid breeding programme, it is essential to determine the presence of significant heterosis for exploitation of hybrid vigour. Expression of heterosis, even to a small magnitude for individual component characters, is a desirable factor [3]. Extent of heterosis is measured as relative heterosis, heterobeltiosis and standard heterosis. Relative heterosis is of limited importance because it is only the deviation of F_1 from mid parental value. Heterobeltiosis is a measure of hybrid vigour over the better parent. Standard heterosis is the one which is very important from plant breeder's point of view. Hence, for the evaluation of hybrids, standard heterosis is to be emphasized. Keeping above points, a research work was undertaken to study the potentiality of hybrids for grain yield and grain quality traits.

MATERIALS AND METHODS

The materials consisted of seven divergent parents whose specific features are described below.

ADT 41: Selection from dwarf mutant of Basmati 370 with short duration and extra-long slender grains.

ADT 46: A cross derivative of ADT 38 / CO 45 with short duration and long slender grain.

CO 47: A cross derivative of IR 50 / CO 43 with medium duration and Medium slender grain.

TKM 9: A cross derivative of TKM 7 / IR 8 with short duration and Short bold red kernel.

Jeeragasamba: A local land race of Tamil Nadu with Short slender grain and desirable grain quality.

ACM 98003(pre-release): Derived from the cross, ADT 39 / IR 50with short duration and Medium bold grain.

AS 90033(pre-release): Derived from Jyothi / BR 51 cross with short duration and long bold red kernel.

All possible 21 crosses excluding reciprocals were made and the resultant F1's along with their parents were grown in a randomized block design with three replications at the Research farm of Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai, Tamil Nadu, India..Each parent and F1 was accommodated in three rows of 1.5 meter length. A spacing of 20 x 15 cm was adopted. Single seedling was planted in each hill. Recommended package of practices and plant protection measures were followed. Observations were recorded on randomly selected ten plants excluding the border plants in both the parents and hybrids for yield and quality characters *viz*., hundred grain weight, grain yield, hulling percentage, milling percentage, head rice recovery, kernel length, kernel breadth, kernel L/B ratio, kernel length after cooking, linear elongation ratio, water uptake, volume expansion ratio, alkali spreading value, amylose content and gel consistency for the heterosis analysis. The relative heterosis (d_i), heterobeltiosis (d_{ii}) and standard heterosis (d_{iii}) were estimated [4]. For computing standard heterosis, the best performing parent for each character was used as a standard check. In the present study ADT 41 was adjudged as standard check. Significance of above three types of heterosis was tested by 't' value and it was computed using the formula as suggested [5].

RESULTS AND DISCUSSION

The heterosis per cent observed for different traits over mid parent, better parent and standard check(ADT 41) given in Table 1. In case of kernel breadth, heterosis in negative direction is taken as a desirable onewhen the objective is evolving fine grain varieties. For Hundred grain weigh**,** the relative heterosis was significant in all 21 cross combinations of which 12 were positive and nine were negative. Significant positive heterobeltiosis was noticed in three crosses. Standard heterosis was significant in positive direction in seven hybrids. Only two hybrids *viz*., ADT 41 / ADT 46 and ADT 41 / TKM 9 had significant and positive relative heterosis, heterobeltiosis and standard heterosis. For Grain yield,out of 21 hybrids, 11 expressed significantly positive values for relative heterosis, heterobeltiosis and standard heterosis. With regard to standard heterosis, a total of 12 hybrids significantly excelled the standard check ADT 41. The highest value was recorded by ADT 41 / AS 90033 (96.47 per cent) followed by ADT 46/ AS 90033,ADT4 1/ACM 98003, ADT 46/ACM 98003,ACM 98003 / AS 90033, ADT 46 / CO 47, ADT 47 / TKM 9 and CO 47 / ACM 98003 which showed more than 30 per cent standard heterosis and positive and negative Standard heterosis was reported [6,7].

In case of hulling percentage, a total of 16 crosses exhibited significant values for all three types of heterosis. Highest per cent of standard heterosis (12.07) was observed in ADT 46 / TKM 9 while lowest (-1.09) was shown by ADT 41 / CO 47. For milling percentage, a total of 17 crosses were positively significant for standard heterosis. Highest value of 8.95 per cent was recorded by ADT 41 / ACM 98003 and the lowest value was found in ADT 41 / CO 47 with 0.12 per cent. Fourteen crosses were found to be positively significant for all three types of heterosis. Head rice recovery is an important character from the miller and consumer point of view. A total of seven crosses had significant and positive relative heterosis, heterobeltiosis and standard heterosis. The hybrids *viz.*,TKM 9 / AS 90033,CO 47/ ACM 98003, ADT4 1/ACM 98003,TKM 9 / Jeergasamba and TKM 9 / ACM 98003 showed more than 15 per cent standard heterosis.

Table 1. Heterosis of hybrids for different traits

Hybrid	Hundred grain weight			Grain yield			Hulling percentage			Milling percentage			Head rice recovery		
	di	**dii**	**diii**	**di**	**dii**	**diii**	**di**	**Dii**	**diii**	**di**	**dii**	**diii**	**di**	**dii**	**diii**
ADT 41 / ADT 46	7.94**	5.95**	9.69**	14.83**	10.13**	19.96**	3.94**	3.84**	4.03*	6.40**	6.16**	6.63**	-3.37**	-5.90**	-0.68
ADT 41 / CO 47	10.56**	1.62**	1.32	28.17**	21.40**	21.43**	-2.56**	-3.98**	-1.09	-0.89**	-1.88**	0.12	-4.66**	-9.44**	0.67
ADT 41 / TKM 9	13.65**	12.65**	12.33**	7.01**	0.86**	0.87	4.96**	4.88**	5.04**	5.24**	4.01**	6.50**	-6.60**	-9.53**	-3.48
ADT 41 / J. samba	6.32**	-24.56**	-24.67**	6.13**	-1.94**	-1.94*	-1.80**	-3.19**	-0.37	0.63	-2.22**	1.01	-4.09**	-8.28**	0.49
ADT 41 / ACM 98003	1.25**	-8.34**	12.78**	72.27**	59.65**	59.68**	5.51**	3.43**	7.68**	6.60**	4.36**	8.95**	23.32**	16.26**	16.26**
ADT 41 / AS 90033	1.50**	-5.57**	9.69**	88.79**	81.70**	96.47**	3.16**	1.79**	4.57**	2.22**	-0.35	4.92**	11.14**	10.57**	11.72**
ADT 46 / CO 47	1.57**	-8.22**	-4.85**	46.60**	33.49**	45.40**	6.41**	4.95**	8.11**	5.01**	4.20**	6.32**	-2.66**	-5.12**	5.45
ADT 46 / TKM 9	1.46**	-1.27**	2.20	33.56**	21.04**	31.87**	11.89**	11.88**	12.07**	5.36**	4.36**	6.85**	-6.11**	-6.62**	-0.38
ADT 46 / J. samba	10.80**	-22.24**	-19.38**	5.22**	-6.44**	1.90*	5.81**	4.41**	7.44**	-0.09	-1.47**	1.79	-9.73**	-11.39**	-2.91
ADT 46 / ACM 98003	-2.65**	-10.37**	10.57**	57.45**	40.41**	52.94**	3.71**	1.75**	5.93**	2.33**	0.40	4.82**	1.16	-6.98**	-1.82
ADT 46 / AS 90033	-8.29**	-2.83**	0.88	58.07**	57.50**	71.55**	3.97**	2.68**	5.49**	-0.79*	-3.07**	2.06	-5.04**	-7.06**	-1.92
CO 47 / TKM 9	-2.42**	-9.58**	-11.45**	35.38**	34.68**	20.48**	5.90**	4.44**	7.59**	1.57**	1.40**	3.82**	-7.04**	-8.91**	1.25
CO 47 / J. samba	7.60**	-19.30**	-32.60**	15.43**	12.44**	0.56	5.40**	5.34**	8.52**	4.77**	4.12**	7.56**	-6.66**	-7.32**	3.02
CO 47 / ACM 98003	-3.34**	-18.83**	0.00	50.42**	46.98**	31.47**	1.98**	1.44**	5.60**	2.91**	1.74**	6.21**	19.70**	7.53**	19.53**
CO 47 / AS 90033	-5.74**	-18.86**	-5.73**	2.50**	-6.36**	1.27	5.38**	5.24**	8.41**	3.00**	1.40**	6.77**	7.35**	2.47**	13.91**
TKM 9 / J. samba	3.04**	-26.50**	-27.75**	15.78**	13.34**	0.32	3.62**	2.23**	5.21**	3.93**	3.46**	6.89**	6.96**	5.55**	15.66**
TKM 9 / ACM 98003	-2.46**	-12.40**	7.93**	3.23**	1.39**	-10.24**	3.66**	1.69**	5.87**	2.46**	1.47**	5.94**	17.88**	7.87**	15.09**
TKM 9 / AS 90033	-8.50**	-15.57**	-2.20	-3.89**	-12.61**	-5.52**	5.15**	3.83**	6.67**	3.11**	1.69**	7.07**	17.77**	14.66**	22.33**
J. samba / ACM 98003	-3.02**	-35.04**	-19.82**	3.65**	3.32**	-11.83**	1.23**	0.65	4.78**	1.86**	1.33**	5.79**	-0.26	-9.83**	-1.20
J. samba / AS 90033	-2.70**	-33.80**	-23.35**	-3.32**	-13.75**	-6.75**	0.08**	0.00	2.90	-0.89**	-1.82**	3.38**	-4.25**	-7.98**	0.84
ACM 98003 / AS 90033	1.90**	-1.07**	22.03**	45.91**	30.54**	41.15**	0.96**	0.29	4.42**	2.07**	1.63**	7.01**	7.22**	0.59	1.63
SE	**0.02**	**0.03**	**0.03**	**0.18**	**0.21**	**0.21**	**0.99**	**1.14**	**1.14**	**0.61**	**0.71**	**0.71**	**1.44**	**1.68**	**1.68**

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Hybrid	Kernel length			Kernel breadth			Kernel L/B ratio			Kernel length after cooking			Linear elongation ratio		
	di	**dii**	**diii**	**di**	**dii**	**diii**	**di**	**dii**	**diii**	**di**	**dii**	**diii**	**di**	**dii**	**diii**
ADT 41 / ADT 46	-11.86**	-18.83**	-18.90**	6.37**	15.97**	16.15**	-18.07**	-29.94**	-29.81**	0.94**	-2.96**	-2.9**	13.76**	8.54**	20.0**
ADT 41 / CO 47	-3.35**	-18.25**	-18.30**	-1.79**	4.51**	4.69*	-2.98**	-21.70**	-21.63**	1.36**	-9.16**	-9.2**	3.63**	-3.00**	11.3**
ADT 41 / TKM 9	-12.67**	-27.08**	-27.10**	-11.02**	7.99**	7.81**	-8.17**	-32.51**	-32.45**	-2.38**	-13.44**	-13.4**	10.23**	2.99**	18.8**
ADT 41 / J. samba	-4.85**	-27.25**	-27.30**	17.54**	22.64**	13.02**	-18.09**	-35.47**	-35.34**	2.77**	-17.31**	-17.3**	5.76**	-1.20**	13.8**
ADT 41 / ACM 98003	-3.09**	-13.67**	-13.60**	-1.42**	14.58**	14.58**	-5.14**	-24.58**	-24.52**	-0.72**	-7.15**	-7.2**	1.63**	-3.51**	7.7**
ADT 41 / AS 90033	-9.96**	-20.50**	-20.50**	-8.79**	6.25**	6.25**	-4.93**	-25.06**	-25.00**	-1.26**	-6.35**	-6.4**	8.46**	0.59	17.9**
ADT 46 / CO 47	4.57**	-4.75**	-19.90**	1.05*	3.38**	16.67**	3.87**	-3.16**	-31.25**	-8.60**	-15.06**	-21.6**	-13.06**	-14.80**	-2.1
ADT 46 / TKM 9	-10.36**	-19.50**	-32.30**	-9.72**	-0.29	17.71**	-2.44**	-18.94**	-42.31**	-7.35**	-14.84**	-21.4**	2.85**	0.60	-16.1**
ADT 46 / J. samba	-15.87**	-31.49**	-42.40**	11.07**	-1.18	16.67**	23.16**	-30.44**	-50.48**	-2.55**	-19.10**	-25.4**	14.87**	12.35**	29.6**
ADT 46 / ACM 98003	1.33**	-2.28**	-17.80**	-6.31**	-0.59	17.19**	7.88**	-1.24**	-29.81**	-10.73**	-13.25**	-20.0**	-12.12**	-12.58**	-2.6
ADT 46 / AS 90033	4.82**	0.10	-15.80**	-3.73**	2.35**	20.83**	8.53**	-1.69**	-30.05**	3.63**	2.18**	-5.7**	-1.62**	-4.51**	12.0**
CO 47 / TKM 9	-1.35**	-2.89**	-32.90**	-5.43**	7.08**	20.83**	2.66**	-9.39**	-44.23**	5.83**	4.57**	-17.2**	7.39**	7.60**	23.6**
CO 47 / J. samba	7.30**	-5.30**	-34.50**	12.54**	25.28**	15.10**	-4.44**	-7.43**	-43.03**	0.12	-11.45**	-29.9**	-6.99**	-6.80**	7.2**
CO 47 / ACM 98003	-3.96**	-9.49**	-29.30**	-1.77**	6.77**	20.31**	-2.39**	-4.30**	-41.11**	-11.26**	-15.24**	-26.2**	-7.82**	-9.20**	4.4**
CO 47 / AS 90033	-3.37**	-8.05**	-29.60**	-1.69**	7.08**	20.83**	-2.08**	-5.08**	-41.59**	-16.52**	-21.38**	-29.5**	-13.66**	-14.51**	0.2
TKM 9 / J. samba	15.36**	3.23**	-30.90**	16.57**	48.68**	36.98**	-3.22**	-12.10**	-49.28**	4.82**	-6.31**	-27.6**	-9.16**	-9.16**	4.9**
TKM 9 / ACM 98003	-4.48**	-11.30**	-30.60**	0.19	4.06**	38.02**	-5.14**	-14.79**	-49.52**	-15.12**	-19.85**	-30.3**	-11.04**	-12.55**	0.7
TKM 9 / AS 90033	-1.57**	-7.73**	-29.40**	3.53**	7.31**	42.71**	-5.28**	-14.03**	-50.48**	-10.35**	-16.52**	-25.1**	-8.70**	-9.41**	6.1**
J. samba / ACM 98003	-4.77**	-20.15**	-37.60**	25.29**	52.83**	40.63**	-23.76**	-24.69**	-55.53**	-17.89**	-30.21**	-39.3**	-14.08**	-15.54**	-2.6*
J. samba / AS 90033	-6.82**	-21.22**	-39.60**	12.35**	37.36**	26.56**	-17.03**	-17.08**	-52.16**	-16.36**	-29.77**	-37.0**	-10.08**	-10.78**	4.5**
ACM 98003 / AS 90033	2.21**	1.17**	-20.90**	9.35**	9.57**	45.31**	-6.66**	-7.73**	-45.43**	-7.02**	-8.39**	-17.8**	-9.15**	-11.37**	4.0**
SE	**0.05**	**0.06**	**0.06**	**0.03**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.06**	**0.07**	**0.07**	**0.02**	**0.02**	**0.02**

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Hybrid	Water uptake			Volume expansion ratio			Alkali spreading value			Amylose content			Gel consistency		
	di	**dii**	**diii**	**di**	**dii**	**diii**	**di**	**dii**	**diii**	**di**	**dii**	**diii**	**di**	**dii**	**diii**
ADT 41 / ADT 46	0.33	-2.20*	2.90*	-2.34	-4.25**	-4.36	-0.88*	-0.88	-0.75	7.27**	5.15**	5.17**	-5.53**	-21.10**	-21.11**
ADT 41 / CO 47	-11.09**	-15.17**	-15.10**	0.31	-2.33	-2.39	-33.79**	-45.28**	-45.28**	7.92**	6.18**	9.71**	-35.63**	-48.33**	-48.32**
ADT 41 / TKM 9	1.25**	-2.51**	-2.61*	-7.25**	-9.90**	-9.94*	0.89*	0.00	0.00	5.91**	0.43	0.45	2.72**	-7.44**	-7.43**
ADT 41 / J. samba	14.57**	11.30**	11.30**	0.99	-5.12**	-5.18	4.78**	-7.55**	-7.55**	-0.17	4.01**	-4.01**	-30.57**	-40.77**	-40.77**
ADT 41 / ACM 98003	-9.07**	-12.30**	-5.51**	7.63**	2.59	2.50	-25.57**	-38.49**	-38.49**	4.12**	3.97**	3.92**	-26.02**	-41.01**	-41.01**
ADT 41 / AS 90033	-3.16**	-5.43**	-0.87	18.58**	13.02**	12.90**	-43.28**	-44.03**	-44.03**	0.56**	-3.49**	-3.48**	-36.86**	-43.41**	-43.41**
ADT 46 / CO 47	6.50**	-0.83*	4.35**	-5.99**	-6.64**	-10.34*	17.96**	-2.52**	-2.52	0.73**	-2.82**	0.40	-42.29**	-45.08**	-63.19**
ADT 46 / TKM 9	0.78*	-5.32**	-0.29	-4.36**	-5.26**	-9.03	0.00	-0.88	-0.88	13.19**	9.42**	5.08**	17.26**	7.62**	-13.67**
ADT 46 / J. samba	-3.48**	-8.53**	-3.77**	-4.44**	-8.51**	-12.15*	-5.35**	-16.48**	-16.48**	0.66**	-1.31**	-5.21**	14.29**	11.38**	-21.34**
ADT 46 / ACM 98003	-7.08**	-8.08**	-1.16	-3.77**	-6.50**	-10.18*	19.94**	-0.88	-0.88	-7.24**	-8.94**	-9.22**	-37.63**	-41.14**	-60.55**
ADT 46 / AS 90033	-6.16**	-6.33**	-1.45	-11.67**	-14.18**	-17.64**	1.34**	0.00	0.00	1.21**	-0.96**	-4.86**	-32.29**	-37.52**	-50.48**
CO 47 / TKM 9	13.38**	12.32**	4.06**	-0.81	-1.05**	-6.29	-20.15**	-33.55**	-34.72**	13.45**	5.94**	9.45**	33.90**	17.49**	-5.76**
CO 47 / J. samba	12.32**	10.25**	4.06**	12.40**	8.35**	2.59	-22.80**	-28.45**	-45.28**	2.55**	-2.93**	0.31	-14.25**	-20.37**	-43.77**
CO 47 / ACM 98003	18.21**	8.98**	17.39**	-4.73**	-6.80**	-11.75*	-16.18**	-16.18**	-45.28**	-14.49**	-15.99**	-13.19**	-32.87**	-33.47**	-59.72**
CO 47 / AS 90033	-0.39	-7.09**	-2.61*	-1.22	-3.37	-8.52	-25.91**	-38.11**	-39.75**	15.71**	9.33**	12.97**	-43.05**	-49.77**	-60.19**
TKM 9 / J. samba	5.27**	4.30**	-1.74	3.28*	-0.21	-5.98	14.47**	1.79**	0.00	10.26**	8.69**	0.31	-11.44**	-16.74**	-33.21**
TKM 9 / ACM 98003	7.43**	-0.09	7.54**	-0.90	-2.82	-8.41	-7.69**	15.61**	-24.53**	11.08**	5.48**	5.17**	1.63**	-11.51**	-29.02**
TKM 9 / AS 90033	0.78*	-5.16**	-0.58	27.20**	24.74**	17.55**	2.25**	2.71**	0.00	20.40**	18.90**	9.31**	4.96**	4.34**	-16.31**
J. samba / ACM 98003	1.34**	-4.94**	2.32	21.62**	19.79**	8.48	-13.22**	-19.57**	-38.49**	5.04**	1.13**	0.85	-6.35**	-13.75**	-39.10**
J. samba / AS 90033	14.45**	8.66**	13.91**	17.08**	15.32**	4.38	-37.05**	-43.80**	-45.28**	3.30**	3.11**	-4.86**	-7.84**	-12.86**	-30.94**
ACM 98003 / AS 90033	9.09**	7.72**	15.94**	41.94**	41.94**	28.53**	-21.27**	-34.24**	-35.97**	13.98**	9.54**	9.22**	30.16**	13.91**	-9.71
SE	**0.03**	**0.04**	**0.04**	**0.2**	**0.23**	**0.23**	**0.03**	**0.04**	**0.04**	**0.14**	**0.16**	**0.16**	**0.55**	**0.64**	**0.64**

** Significant at 5% level*
*** Significant at 1% level*

Among the kernel characters, kernel length has paramount importance as the slender grain having L/B ratio of 3.0 and above commend high premium price in the market. For kernel length, the relative heterosis was significant and positive in six out of 21 crosses but only two crosses *viz*., TKM 9 / Jeeragasamba and ACM 98003 / AS 90033 recorded significant and positive heterosis over better parent. None of the hybrids expressed significant and positive standard heterosis. This indicated that medium types would be obtained when a cross was effected between short and long grained variety which might be predominately due to partial dominance rather than over dominance genetic effects [8].Both positive and negative significant heterosis for kernel length was reported [9].In case of Kernel breadth, only ten hybrids showed significant and negative relative heterosis and none of the hybrids exhibited significant and negative heterobeltiosis and standard heterosis. For Kernel L/B ratio, five hybrids *viz*., ADT 46 / Jeeragasamba, ADT 46 / AS 90033, ADT 46 / ACM 98003, ADT 46 / CO 47 and CO 47 / TKM 9 recorded significant and positive relative heterosis and the highest level was observed in ADT 46 / Jeeragasamba (23.16 per cent).All the 21 hybrids had significant and negative values for heterobeltiosis and standard heterosis. The same trend for kernel L/B ratio was observed [10].

For Kernel length after cooking, the extreme values of relative heterosis were observed in Jeeragasamba /ACM 98003 (-17.89 per cent) and CO 47 / TKM 9 (5.83 per cent) and a total of six hybrids were positively significant. Only two hybrids *viz*., CO 47/ TKM 9 and ADT 46 / AS 90033 had positive and significant heterobeltiosis of 4.57 and 2.18 per cent respectively and reported [11].None of the hybrids exhibited significant and positive standard heterosis. Linear elongation without breadthwise expansion is considered a highly desirable trait in rice quality [12]. For linear elongation ratio, nine crosses had significant and positive relative heterosis and the range was between -14.08 (Jeeragasamba / ACM 98003) and 14.87 per cent (ADT 36 / Jeeragasamba). Four crosses *viz*., ADT 46 / Jeeragasamba, ADT 41 / ADT 46, CO 47/ TKM 9 and ADT 41 / TKM 9 recorded significant and positive heterobeltiosis. Fifteen out of 21 hybrids recorded significant and positive standard heterosis for this trait which ranged from -16.1 (ADT 46 / TKM 9) to 29.6 per cent (ADT 46 / Jeeragasamba). A total of four hybrids viz., ADT 41 / ADT 46, ADT 41 / TKM 9, ADT 46 / Jeeragasamba and CO 47/ TKM 9 possessed positive and significant values for all the three types of heterosis. Thirteen and seven hybrids showed significant positive relative heterosis and heterobeltiosis respectively with regard to water uptake. Nine hybrids excelled significantly over standard check ADT 41. The range was between -15.10 in ADT 41 / CO 47 and 17.39 per cent in CO 47/ ACM 98003. A total of six hybrids exhibited positive and significant relative heterosis, heterobeltiosis and standard heterosis. In case of volume expansion ratio, the value of standard heterosis varied from -17.64 (ADT 46 / AS 90033) to 28.53 per cent (ACM 98003 / AS 90033). A total of three hybrids *viz*., ACM 98003 / AS 90033, TKM 9 / AS 90033 and ADT 41 / AS 90033 recorded positive and significant relative heterosis, heterobeltiosis and standard heterosis.

For alkali spreading value, three crosses *viz*., TKM 9 / ACM 98003, TKM 9 / AS 90033 and TKM 9 / Jeeragasamba showed positive and significant heterobeltiosis. None of the hybrids showed significant and positive standard heterosis this trait. Amylose content is considered the single most important criterion for predicting the cooking, eating and processing characteristics of rice [13]. Among the hybrids CO 47 / AS 90033 exhibited highest standard heterosis of 12.97 per cent followed by ADT 41/ CO 47, CO 47/TKM 9, TKM 9/AS 90033 and ACM 98003/AS 90033.However, all the hybrids showed an intermediate amylose content of 19 per cent to 25 per cent in terms of mean value which is preferred by Indian consumers. Gel consistency is an important quality parameter deciding the softness of cooked rice. Seven out of 21 hybrids recorded significant and positive relative heterosis for gel consistency which ranged from -43.05 (CO 47/ AS 90033) to 33.90 per cent (CO 47 / TKM 9). The maximum heterobeltios is was recorded by CO 47 / TKM 9 (17.49 per cent) and the minimum of -49.77 per cent was found in CO 47/ AS 90033 and similar results was reported[14] . For standard heterosis all the 21 crosses were significantly negative which was ranged from -63.19 (ADT 46 / CO 47) to -5.76 per cent (CO 47 / TKM 9).

CONCLUSION

From the foregoing discussion, it could be concluded that high amount of heterosis existed for grain yield, hundred grain weight, hulling percentage, milling percentage, head rice recovery, linear elongation ratio, water uptake, volume expansion ratio and amylose content whereas it was low for the quality traits *viz.*, kernel length, kernel breadth, kernel L/B ratio, kernel length after cooking and alkali spreading value. The hybrids viz., ACM 98003 / AS 90033, ADT 41 / ADT 46, ADT 41 /ACM 98003, ADT 41 / AS 90033, CO 47/ TKM 9 and CO 47 / ACM 98003performed well for grain yield combined with several grain quality traits *viz*., hulling percentage, milling percentage, linear elongation ratio, water uptake, volume expansion ratio and amylose content, so these promising cross combinations can be further used in rice breeding programme.

REFERENCES

[1] Tomar, J.B. **1987.** *Oryza***, 24:** 112-118.

[2] JinsongBao, **2002**. *Cereal Res. Commn*., **30 (3-4):** 397-402.
[3] Hatchcock, R. and Mc Daniel. **1973.** *Crop Sci.,* **13:** 8 – 18.
[4] Fonseca, S. and F.L. Patterson. **1968.** *Crop Sci.,* **8:** 85 – 88.
[5] Wynne, J.C., D.A. Emery and P.W. Rice. **1970.** *Crop Sci*., **10:** 713 – 715.
[6] Kumar Babu, G., P.V. Satyanarayana, C. Panduranga Rao and V. SrinivasaRao.**2010.** *The Andhra Agric. J*., **57 (3):** 226-229.
[7] Sanjeev Kumar, H.B. Singh, J.K. Sharma and SalejSood.**2010.** *Oryza*, **47 (1):** 17-21.
[8] Krishna, L., Ch.D. Raju, Ch. SurenderRaju, S. Vanisree, P. Narsimha Reddy and B.B. Reddy. **2011**. *Madras Agric. J., 98 (4-6):* 109-112.
[9] Singh, N.B. and H.G. Singh. **1985.** *Indian J. Genet*., **45 (2):** 181-185.
[10] Vivekanandan, P. and S. Giridharan.**1995.** *Madras Agric. J*., **82(3):**214-215.
[11] Shivani, D., B.C. Viraktamath and N. Shobha Rani. **2009.** *Oryza*, **46 (3):** 250-253.
12] Pillaiyar, P. **1988.** *Madras Agric. J*., **75:**307-317.
[13] McKenzie, K.S. and J.N. Rutger. **1983.** *Crop Sci.,* **23:** 306-313.
[14] Mahalingam, L. and N. Nadarajan. **2010.** *Electron. J. Plant Breed*., **1 (4):** 973-976.