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Combining ability analysis of grain quality traits in rice (*Oryza sativa* L.)

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ABSTRACT

Seven high yielding rice genotypes viz., ADT 41, ADT 46, CO 47, TKM 9, Jeeragasamba, ACM 98003 and AS 90033 and their 21 crosses which effected in a half diallel fashion (excluding reciprocals) were subjected to combining ability studies for grain yield and grain quality analysis. Predominance of additive genetic variance was observed for hundred grain weight, kernel length, kernel L/B ratio and kernel length after cooking whereas non-additive genetic variance was greater for grain yield, hulling percentage, milling percentage, head rice recovery, kernel breadth, linear elongation ratio, water uptake, volume expansion ratio, alkali spreading value, amylose content and gel consistency suggesting the postponement of selection to later generation from the segregating population in pedigree breeding programme.ADT 41 and AS 90033 were good general combiners for grain yield and grain quality traits. The hybrid combinations viz., CO 47/ Jeeragasamba, ADT 41 / ACM 98003, TKM 9 / Jeeragasamba, ACM 98003 / AS 90033 and CO 47 / TKM 9 were identified as good specific combiners for grain yield and grain quality traits.

Key words: Combining ability, diallel, grain yield, grain quality, rice.

INTRODUCTION

Rice is the main cereal crop consumed by more than half of the world's population. As increasing number of rice producing countries attained self-sufficiency, grain quality has become an important breeding objective in national programme. A survey made in 1990 verified that grain quality is one of the major objectives [1]. Plant breeders continuously refine and improve genetic traits of new varieties required to produce the most desirable products. Selection for improved milling, cooking, eating and processing qualities is an essential component of breeding programme designed to meet industry and consumer standards. Recent interest in producing premium quality rice for export markets resulted in selection for specific taste and cooking characteristics. In order to develop varieties with better grain quality, information regarding the choice of parents to be crossed is essential. Combining ability analysis provides information on nature and magnitude of gene action for the traits of economic importance and also helps in the identification of potential parents and cross combinations. Diallel cross analysis is the one which is commonly usedand it also enables to understand the nature of gene action involved in the expression of various characters. Hence, the present study was undertaken to assess the combining ability of promising rice genotypes using half diallel analysis.

MATERIALS AND METHODS

The materials for the present study comprised of 21 crosses of rice which were generated by crossing the seven genotypes of rice *viz*., ADT 41, ADT 46, CO 47, TKM 9, Jeeragasamba, ACM 98003 and AS 90033 in a half diallel fashion (excluding reciprocals). The 21 hybrids along with seven parents were raised in a randomized block design with three replications during June, 2003 at Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai. Each genotype 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 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. The general and specific combining ability variances were estimated by Method 2 and Model 1 [2]. The experimental material for this method comprises of $\frac{p\ (p\ -1)}{2}$ F_1's and p inbred lines.

RESULTS AND DISCUSSION

Analysis of variance for combining ability

The analysis of variance showed significant differences among 28 genotypes for all the traits studied.The analysis of variance for combining ability indicated that mean squares due to general and specific combining ability were significant for all characters (Table 1). The additive genetic variance was relatively higher than non-additive genetic variance for hundred grain weight, kernel length, kernel L/B ratio and kernel length after cooking. Predominance of additive gene action for these traits was reported [3], [4], [5], [6], [7]. Non-additive genetic variance was greater for grain yield, hulling percentage, milling percentage, head rice recovery, kernel breadth, linear elongation ratio, water uptake, volume expansion ratio, alkali spreading value, amylose content and gel consistency. This was in accordance with the findings reported [8], [9], [10].

General combining ability

The selection of suitable parents for hybridization is one of the most important steps in a breeding programme to get best combination in F_1 hybrids or in segregating generations. The *gca* is controlled by additive genes which is fixable [11]. It provides information on the choice of parents in terms of expected performance of their progenies. Of the seven parents evaluated, the parent ADT 41 possessed significantly high *gca* effects for hundred grain weight, grain yield, kernel length, kernel breadth, kernel L/B ratio, kernel length after cooking, volume expansion ratio, alkali spreading value, amylose content and gel consistency. AS 90033 was a good combiner for improvement of hundred grain weight, grain yield, milling percentage, kernel length, kernel length after cooking, water uptake, volume expansion ratio and gel consistency. ADT 46 was quite promising with significant *gca* effects for hundred grain weight, grain yield, kernel length, kernel breadth, kernel L/B ratio, kernel length after cooking and alkali spreading value (Table 2).

Specific combining ability

The specific combining ability is the deviation from the performance predicted on the basis of general combining ability [12]. It is an important criterion for the evaluation of hybrids. Eleven hybrids *viz*., ADT 41/AS 90033, ADT 41 / ACM 98003, ADT 46 /AS 90033, ADT 46 / ACM 98003, CO 47 / TKM 9, ADT 46/ CO 47, CO 47 / ACM 98003, TKM 9 / Jeeragasamba, ADT 46 / TKM 9, ACM 98003 / AS 90033 and CO 47 / Jeeragasamba exhibited positive and significant *sca* effect for grain yield. The hybrid CO47 / Jeeragasamba recorded significant *sca* effect in desirable direction for nine traits *viz*., hundred grain weight, grain yield, hulling percentage, milling percentage, kernel length, kernel L/B ratio, kernel length after cooking , water uptake and volume expansion ratio. The hybridADT 41 / ACM 98003 showed positive and significant *sca* effect for grain yield, hulling percentage, milling percentage, head rice recovery, kernel lengthandamylose content. Interestingly, the hybrid TKM 9 / Jeeragasamba between the bold grain parent, TKM 9 and short slender type Jeeragasamba possessed desirable *sca*effects for six quality traits *viz.*, milling percentage, head rice recovery, kernel length, kernel L/B ratio, kernel length after cooking and alkali spreading value besides grain yield. The hybrids ACM 98003 / AS 90033 and CO 47 / TKM 9 registered significant *sca* effects for six quality traits.

High magnitude of *sca* effects in these hybrids resulted from the combination high x high (ADT 41with ACM 98003) and medium x low (TKM 9, CO47 with Jeeragasamba) *gca* of parents. An interaction between positive and positive alleles in crosses involving high x high combiners which can be fixed in subsequent generations if no repulsion phase linkages are involved was reported [13] , [14]. In crosses with medium x low *gca*effects, the high positive *sca*effects may be due to the dominant x recessive interaction, expected to produce desirable segregants in subsequent generations [15].

Table 1. Analysis of variance for combining ability

Source of variation	df	Mean squares													
		HGW	GY	HP	MP	HRR	KL	KB	KLBR	KLAC	LER	WU	VER	ASV	AC	GC
GCA	6	0.742*	81.668*	4.079*	2.536*	14.171*	2.310*	0.209*	0.961*	5.680*	0.011*	0.073*	0.246*	0.706*	1.862*	501.451*
SCA	21	0.011*	44.722*	5.113*	2.864*	19.232*	0.155*	0.028*	0.051*	0.424*	0.016*	0.064*	0.261*	0.124*	2.442*	202.794*
Error	54	0.001	0.023	0.648	0.251	1.388	0.002	0.001	0.001	0.002	0.001	0.001	0.026	0.001	0.012	0.203
σ^2 GCA		0.081	4.105	0.115	0.036	0.562	0.239	0.020	0.101	0.584	0.001	0.001	0.001	0.065	0.060	33.184
σ^2 SCA		0.011	44.699	4.465	2.613	17.844	0.153	0.027	0.050	0.422	0.016	0.063	0.235	0.123	2.430	202.591
σ^2 GCA / σ^2 SCA		7.364	0.092	0.026	0.014	0.031	1.562	0.741	2.020	1.384	0.063	0.016	0.004	0.528	0.025	0.164

HGW = Hundred grain weight, HP = Hulling percentage, MP = Milling percentage, HRR = Head rice recovery, KL = Kernel length, KB = Kernel breadth, KLBR = Kernel length/breadth ratio, KLAC = Kernel length after cooking, LER = Linear elongation ratio, WU = Water uptake, VER = Volume expansion ratio, ASV = Alkali spreading value, AC = Amylose content, GC = Gel consistency, J. samba = Jeeragasamba
****** Significant at 5% level.*

Table 2. General combining ability effects of parents

PARENT	HGW	GY	HP	MP	HRR	KL	KB	KLBR	KLAC	LER	WU	VER	ASV	AC	GC
ADT 41	0.14**	2.09**	-1.40**	-0.62**	-0.84*	0.76**	-0.23**	0.64**	1.28**	0.02	-0.09**	0.11*	0.07**	0.29**	6.32**
ADT 46	0.10**	3.35**	0.45	-0.53**	-1.79**	0.30**	-0.06**	0.16**	0.55**	0.02	0.00	-0.25**	0.41**	-0.42**	-3.39**
CO 47	-0.13**	-0.63**	0.43	-0.13	1.56**	-0.13**	-0.09**	0.03**	-0.25**	-0.01	-0.07**	-0.12*	-0.36**	0.65**	-9.93**
TKM 9	0.03**	-3.00**	0.40	0.38*	1.43**	-0.33**	0.17**	-0.32**	-0.32**	0.03**	-0.08**	-0.04	0.29**	0.22**	12.19**
J. samba	-0.58**	-4.76**	-0.27	-0.27	-0.26	-0.84**	-0.08**	-0.30**	-1.28**	0.01	0.01	-0.03	-0.12**	-0.70**	-0.46**
ACM 98003	0.28**	0.34**	0.38	0.80**	-0.75	0.16**	0.15**	-0.10**	-0.14**	-0.07**	0.15**	0.09	-0.27**	-0.10**	-5.85**
AS 90033	0.17**	2.60**	0.02	0.38*	0.65	0.08**	0.13**	-0.11**	0.17**	0.00	0.08**	0.25**	-0.03**	0.05	1.12**
SE	**0.01**	**0.05**	**0.25**	**0.15**	**0.36**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.05**	**0.01**	**0.03**	**0.14**

HGW = Hundred grain weight, HP = Hulling percentage, MP = Milling percentage, HRR = Head rice recovery, KL = Kernel length, KB = Kernel breadth, KLBR = Kernel length/breadth ratio, KLAC = Kernel length after cooking, LER = Linear elongation ratio, WU = Water uptake, VER = Volume expansion ratio, ASV = Alkali spreading value, AC = Amylose content, GC = Gel consistency, J. samba = Jeeragasamba
****** Significant at 5% level, ****** Significant at 1% level*

Table 3. Specific combining ability effects of hybrids

HYBRID	HGW	GY	HP	MP	HRR	KL	KB	KLBR	KLAC	LER	WU	VER	ASV	AC	GC
ADT 41 / ADT 46	0.08**	-4.25**	0.47	2.52**	-0.32	-0.45**	0.19**	-0.45**	0.08	0.10**	0.14**	0.09	0.03	1.28**	8.03**
ADT 41 / CO 47	0.12**	0.09	-3.13**	-2.19**	-2.96**	0.02	0.00	0.03	0.17**	0.01	-0.42**	0.05	-0.38**	1.23**	-10.66**
ADT 41 / TKM 9	0.21**	-2.71**	1.24	1.51**	-5.01**	-0.48**	-0.20**	-0.08**	-0.26**	0.08**	0.02	-0.40*	0.17**	-0.42**	5.11**
ADT 41 / J. samba	-0.02	-1.66**	-1.92*	-1.46**	-1.23	0.01	0.15**	-0.22**	0.25**	0.03**	0.41**	-0.17	0.38**	-0.49**	-13.12**
ADT 41 / ACM 98003	-0.03	8.77**	3.12**	2.71**	7.56**	0.10*	-0.05*	0.04	0.29**	0.02	-0.31**	0.09	-0.29**	0.69**	-7.96**
ADT 41 / AS 90033	0.01	15.79**	1.28	0.47	3.77**	-0.37**	-0.18**	0.02	0.07	0.10**	-0.08**	0.46**	-0.68**	-1.13**	-17.15**
ADT 46 / CO 47	0.02	4.88**	1.52*	1.81**	0.51	0.36**	0.07**	0.11**	-0.56**	-0.19**	0.18**	0.02	0.41**	-0.15	-14.73**
ADT 46 / TKM 9	0.02	3.83**	4.36**	1.65**	-2.43*	-0.43**	-0.18**	-0.01	-0.46**	0.03**	0.02	0.01	-0.19**	1.33**	9.04**
ADT 46 / J. samba	0.14**	-1.95**	1.74*	-1.05**	-2.08	-0.72**	0.05*	-0.37**	0.04	0.25**	-0.19**	-0.16	-0.20**	-0.05	14.58**
ADT 46 / ACM 98003	-0.05*	5.82**	0.04	-0.11	-1.02	0.24**	-0.17**	0.29**	-0.47**	-0.13**	-0.24**	-0.19	0.37**	-1.56**	-16.37**
ADT 46 / AS 90033	-0.16**	8.25**	0.08	-1.51**	-2.47*	0.48**	-0.07**	0.29**	0.87**	0.01	-0.18**	-0.71**	0.15**	-0.73**	-14.00**
CO 47 / TKM 9	-0.06**	4.94**	1.20	-0.76	-4.93**	-0.05	-0.08**	0.04	0.84**	0.17**	0.24**	0.01	-0.32**	1.24**	22.91**
CO 47 / J. samba	0.07**	1.69**	2.53**	2.37**	-2.31*	0.33**	0.06**	0.07*	0.32**	-0.05**	0.15**	0.45**	-0.19**	0.11	0.35
CO 47 / ACM 98003	-0.06**	4.38**	-0.17	0.41	6.87**	-0.26**	-0.07**	-0.05	-0.39**	0.00	0.47**	-0.40	-0.04	-3.52**	-9.05**
CO 47 / AS 90033	-0.07**	-5.49**	2.17**	1.20*	2.51*	-0.20**	-0.04	-0.06	-1.09**	-0.13**	-0.15**	-0.39	-0.14**	2.20**	-16.46**
TKM 9 / J. samba	0.02	4.00**	0.22	1.41**	4.47**	0.82**	0.21**	0.15**	0.66**	-0.12**	-0.04	-0.06	0.36**	0.54**	-12.00**
TKM 9 / ACM 98003	-0.04	-3.76**	0.05	-0.28	4.67**	-0.17**	0.00	-0.06	-0.79**	-0.09**	0.14**	-0.31	-0.13**	1.03**	-2.73**
TKM 9 / AS 90033	-0.15**	-4.82**	0.97	0.89	7.08**	0.02	0.12**	-0.08*	-0.51**	-0.09**	-0.08**	0.84**	0.27**	1.81**	2.09**
J. samba / ACM 98003	-0.06**	-2.40**	-0.06	0.26	-2.22*	-0.21**	0.30**	-0.32**	-0.88**	-0.12**	-0.13**	0.53**	-0.10**	0.99**	0.59
J. samba / AS 90033	-0.02	-3.37**	-1.02	-0.91	-2.55*	-0.30**	0.05*	-0.17**	-0.93**	-0.09**	0.34**	0.17	-0.52**	-0.44**	1.18**
ACM 98003 / AS 90033	0.14**	3.60**	-0.61	0.43	-1.63	0.20**	0.18**	-0.09**	0.16**	-0.01	0.26**	1.26**	-0.12**	2.11**	26.23**
SE	**0.02**	**0.14**	**0.72**	**0.45**	**1.06**	**0.04**	**0.02**	**0.03**	**0.04**	**0.01**	**0.02**	**0.15**	**0.03**	**0.10**	**0.40**

HGW = Hundred grain weight, HP = Hulling percentage, MP = Milling percentage, HRR = Head rice recovery, KL = Kernel length, KB = Kernel breadth, KLBR = Kernel length/breadth ratio, KLAC = Kernel length after cooking, LER = Linear elongation ratio, WU = Water uptake, VER = Volume expansion ratio, ASV = Alkali spreading value, AC = Amylose content, GC = Gel consistency, J. samba = Jeeragasamba

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

CONCLUSION

From the above discussion it was concluded that to explore both additive and non-additive type of gene action of grain yield and grain quality traits, it was suggested to postpone the selection to later generation in pedigree breeding programme. Among the parents, ADT 41 was adjudged as the best since it had significantly desirable *gca* effects for ten out of 15 characters studied. AS 90033and ADT 46 which possessed favourable*gca* effects for eight traitswere considered as the next best general combiners. Based on *sca* effects the following five hybrids *viz*., CO 47/ Jeeragasamba, ADT 41 / ACM 98003 and TKM 9 / Jeeragasambawere identified as the best specific combiners which combined minimum of six grain quality traits with grain yield.

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