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National Academy of Agricultural Science (NAAS) Rating : 3. 03

Studies of Combining Ability for Physical Quality Traits in Rice (*Oryza sativa* L.)

P. Jhansi Rani[1], P.V. Satyanarayana[2], N.Chamundeswari[3], M. Lal Ahamed[4], Y.Ashoka Rani[5] and V.Srinivasa Rao[6]

ABSTRACT: *Line x tester analysis was carried out from 10 selected entries with 7 lines and 3 testers which were selected based on their grain number and grain weight. General combining ability of parents and specific combining ability among 21 hybrids for physical quality traits viz., kernel length, kernel breadth, L/B Ratio, hulling percentage, milling percentage and head rice recovery were analysed. Mean squares due to males were larger in magnitude than female parents for all the characters except head rice recovery. The magnitude of SCA variance was higher than GCA variance for all the characters except L/B Ratio and for kernel length it was equal. The line MTU 1075 was found good general combiner for kernel length and the tester MTU 1010 found good general combiner for kernel length and L/B Ratio.*

Key words: *Combining ability, Quality traits, Rice.*

INTRODUCTION

Rice (*Oryza sativa* L.) has a special place in the feeding of Asian societies. However, rice physical quality has a direct impact on consumer preference and thus sales and consumption of this product. To maintain and transfer desirable traits of physical quality, rice breeders are looking for the most suitable parental combination. In this way, combining ability provides an important tool for selection of desirable parents and to get required information on gene action controlling desirable trait (Rastogi *et al.*, 2011). Different mating systems have been proposed to study and evaluate combining ability in genetic researches. Although the diallel crosses have been applied in breeding programs however, it requires a large workforce especially when the number of genotypes increases. Therefore, Kempthorne (1957) suggested line × tester technique as a faster method for estimating combining ability and screening suitable lines for hybridization. Since then, many researchers have practiced line × tester analysis over hybrid rice genotypes.

The performance of parent may not necessarily reveal it to be a good or poor combiner. Therefore, gathering information on nature of gene effects and their expression in terms of combining ability is necessary. At the same time, it also elucidates the nature of gene action involved in the inheritance of characters. General combining ability (GCA) is attributed to additive gene effects and additive x additive epistasis and is theoretically fixable. On the other hand, specific combining ability attributable to non-additive gene action may be due to dominance or epistasis or both and is non-fixable.

In this paper an attempt has been made to assess the combining ability and to determine the nature and magnitude of gene action for quality traits to explore the best cross combination for six physical quality traits in rice namely, kernel length, kernel breadth, L/B Ratio, hulling percentage, milling percentage and head rice recovery.

MATERIAL AND METHODS

Plant materials

The experimental materials comprised ten rice genotypes, seven genotypes (MTU 1071, MTU 1075, MTU 1081, MTU 1121, NRI 003, MTU-II-118-24-4-1 and MTU-PS-140-1) were used as females (designated as lines) and three genotypes (MTU 1010, MTU 3626 and TN 1) designated as testers were used as males.

[1,4] Department of Genetics and Plant Breeding, [5] Department of Plant Pysiology, [6] Department of Statistics and Mathematics, Agricultural College, Bapatla - 522101, Andhra Pradesh

[2,3] Department of Genetics and Plant Breeding , APRRI & RARS, Maruteru, West Godavari - 534122, Andhra Pradesh.

These parents were crossed to produce 21 F1 hybrids according to line x tester mating design (Kempthorne, 1957). This study was conducted in *kharif* 2012 and *rabi* 2012-13 at APRRI & RARS, Maruteru.

Single seedlings of each entry were transplanted at 20 x 20 cm spacing in a randomized complete block design with two replications. In this study six physical traits were evaluated. Kernel length (mm) and breadth (mm) were evaluated using micro dial meter.

$$\text{L/B ratio} = \frac{\textit{Mean length of grain in millimetres}}{\textit{Mean breadth of grain in millimetres}}$$

Hulling percentage =

$$\frac{\textit{Weight of dehusked grain or brown rice (g)}}{\textit{Weight of paddy (g)}} \; x\ 100$$

$$\text{Milling percentage} = \frac{\textit{Weight of milled rice (g)}}{\textit{Weight of paddy (g)}} \; x\ 100$$

$$\text{Head rice recovery} = \frac{\textit{Weight of whole rice (g)}}{\textit{Weight of paddy (g)}} \; x\ 100$$

Statistical Analysis

Data were recorded on ten randomly selected plants from parents and F1s. Combining ability analysis was done using line x tester method (Kempthorne, 1957). The variances for general combining ability and specific combining ability were tested against their respective error variances derived from ANOVA reduced to mean level. Significance test for GCA and SCA effects were performed using t-test.

RESULTS AND DISCUSSION

Although yield is the prime objective, grain quality is simultaneously treated as very important aspect, as the market value of milled rice depends on consumers and millers preference. Usually, long grains with slenderness are preferred over the bold grains. The analysis of variance revealed highly significant differences among the crosses for all the characters studied and lines x testers interaction was found significant for all the crosses except L/B ratio (Table 1). The magnitude of SCA variance was higher than GCA variance for all the characters except L/B Ratio and for kernel length it was equal. Contribution of lines was highest for kernel length and hulling percentage and testers for L/B ratio and contribution of interaction (line x tester) was highest for kernel breadth, milling percentage and head rice recovery (Table 2). Values showing *gca* effects of 10 parents (7 lines, 3 testers) and *sca* effects of 21 crosses were presented in Table 3 and Table 4 respectively.

Kernel length: Among lines, MTU 1121 (0.343), MTU 1071 (0.248) and MTU 1075 (0.139) while in testers MTU 1010 (0.158) and MTU 3626 (0.097) exhibited significant positive *gca* effects implying their good general combining ability which may be utilized in breeding programmes for improvement of this trait. The finer grain is preferred by consumers, so the parents with positive significant values are considered as the best general combiners to develop fine grain types. Component of variance due to *sca* (0.04^{**}) was equal to *gca* (0.04^{**}) and the ratio of *gca* variance to *sca* variance was unity (1.00) indicating the operation of both additive and non-additive gene action in equal magnitude. Similar results were established by Sreedhar (1999) and Ramesh Babu (1999).

Of 21 crosses evaluated 5 cross combinations showed significant *sca* effects in positive direction. They were, NRI 003/ TN 1 (0.313), MTU-II-118-24-4-1/ MTU 3626 (0.278), MTU-PS-140-1/ MTU 1010 (0.262), MTU 1075/ MTU 1010 (0.259) and MTU 1121/ TN 1 (0.183). Thus in the present study about the *sca* effects suggested that higher mean values of crosses were not always related to their *sca* effects.

The superior cross combinations identified based on their *sca* effects and *per se* performance are MTU 11-118-24-4-1/ MTU 3626 (low x high), MTU-PS-140-1/ MTU 1010 (medium x high), MTU 1075/ MTU 1010 (high x high) and MTU 1121/ TN 1 (high x low). The cross combinations involving high x high and Medium x high general combiners producing crosses with significant *sca* effect revealed the role of additive and additive x additive genetic component of variance which could be easily improved through simple selection procedures. NRI 003/ TN 1 (low x low) indicated the possibility of interaction between positive alleles from good combiners and negative alleles from poor combiners and suggested for the exploitation of heterosis in F_1 generation as their high yield potential would be unfixable in succeeding generations.

Kernel breadth: The grains with low breadth are preferable in the view of marketability and consumption by the people. The best general combiners identified based on their negative significant *gca* effects were MTU 1081 (-0.125) among lines and in testers MTU 1010 (-0127) implying their good general combining ability and may be utilized in breeding programmes for improvement of this trait. The ratio of *gca* variance to *sca* variance was low

(0.47) indicating the presence of non-additive gene action. Similar results were reported by Sanjeev Kumar *et al.* (2008) and Sanghera and Hussain (2012).

Two crosses NRI 003/ MTU 3626 (-0.220) and MTU 1075/ TN 1 (-0.157) had shown negative significant *sca* effects. From the results of *sca* effects and their *per se* performance these crosses were found to be superior with combination of Low x Low and High x Low combiners. The crosses with high x low and low x low *gca* effects were observed indicating the role of both additive and non-additive gene action in the inheritance of this trait. The importance of low x low crosses suggested that both the parents might be compatible to each other for most of the genes resulting in complementary interallelic inter actions. In these crosses non additive type variation can be exploited by multiple crosses followed by inter mating among desirable segregants.

L/B ratio: Among lines, MTU 1121 (0.191) and MTU 1081 (0.136) recorded significant positive *gca* effects. Whereas, only one tester MTU 1010 (0.238) exhibited significant positive *gca* effects. The results of *gca* effects revealed good general combining ability of parents and may be desirable for use in hybridization programmes. The ratio of general combining ability component of variance to specific combining ability component of variance was higher than unity (1.5) indicating the operation of additive gene action. Importance of additive variance for L/B ratio indicated that the variability available is fixable

Table 1
Analysis of variance for combining ability for physical quality traits in rice (*oryza sativa* L.)

Source of variation	*d.f*	*Kernel length (mm)*	*Kernel breadth (mm)*	*L/B Ratio (mm)*	*Hulling percentage*	*Milling percentage*	*Head rice recovery*
Replication	1	0.022	0.004	0.00015	2.58	0.291	0.453
Crosses	20	0.266**	0.05**	0.128**	7.06**	7.969**	8.993**
Line effect	6	0.442*	0.04	0.109	11.06	8.258	4.671
Tester effect	2	0.695*	0.18*	0.626**	11.96	11.326	1.744
Line X Tester effect	12	0.106**	0.04*	0.054	4.24*	7.264**	12.363**
Error	20	0.011	0.015	0.02	1.66	1.973	0.344
σ^2GCA		0.04**	0.007*	0.031**	0.726**	0.253	-0.915
σ^2SCA		0.04**	0.015**	0.018*	0.928	2.159*	5.75**
σ^2GCA/ σ^2SCA		1	0.47	1.72	0.78	0.12	-0.159

*, ** Significant at 5% and 1% level, respectively.

Table 2
Contribution of lines, testers and line x testers for physical quality traits in rice (*oryza sativa* L.)

Contribution of	*Kernel length (mm)*	*Kernel breadth (mm)*	*L/B Ratio (mm)*	*Hulling percentage*	*Milling percentage*	*Head rice recovery*
Line %	49.91	21.42	25.68	47.03	31.09	15.58
Tester %	26.15	33.82	49.00	16.93	14.21	1.94
Line X Tester %	23.94	44.76	25.31	36.04	54.69	82.48

Table 3
General combining ability effects for Physical quality traits

Parent	*Grain length (mm)*	*Grain breadth (mm)*	*L/B Ratio*	*Hulling percentage*	*Milling percentage*	*Head rice recovery*
			LINES			
MTU 1071	0.248**	0.104*	-0.012	0.748	-0.077	0.045
MTU 1075	0.139**	0.097*	-0.064	-0.202	-0.820	-0.869**
MTU 1081	-0.094*	-0.125**	0.136*	-1.880**	-1.032	-1.079**
MTU 1121	0.343**	-0.020	0.191**	2.121**	2.048*	0.171
NRI 003	-0.242**	-0.051	-0.052	-0.079	-0.194	0.105
MTU 11-118-24-4-1	-0.419**	0.009	-0.217**	-1.395*	-1.030	-0.020
MTU-PS-140-1	0.026	-0.013	0.016	0.688	1.105	1.646**
SE±	0.06	0.06	0.07	0.9	0.99	0.53
			TESTERS			
MTU 1010	0.158**	-0.127**	0.238**	-1.061*	-1.000*	-0.348
MTU 3626	0.097**	0.097**	-0.072	0.624	0.742	-0.010
TN 1	-0.255**	0.030	-0.166**	0.437	0.259	0.358
SE±	0.04	0.03	0.05	0.6	0.64	0.35

Table 4
Estimates of specific combining ability effects for physical quality traits

Cross	*Grain length (mm)*	*Grain breadth (mm)*	*L/B Ratio*	*Hulling percentage*	*Milling percentage*	*Head rice recovery*
1.MTU 1071 X MTU 1010	-0.090	-0.076	0.042	0.428	0.125	-0.394
2.MTU 1071 X MTU 3626	0.067	0.120	-0.103	-0.952	1.328	2.724**
3.MTU 1071 X TNI	0.023	-0.044	0.061	0.524	-1.454	-2.330**
4.MTU 1075 X MTU 1010	0.259**	0.065	0.024	0.223	1.599	3.019**
5.MTU 1075 X MTU 3626	0.035	0.092	-0.081	-0.457	-1.523	-0.903
6.MTU 1075 X TNI	-0.294**	-0.157*	0.058	0.234	-0.075	-2.116**
7.MTU 1081 X MTU 1010	-0.008	-0.048	0.079	0.151	-1.905	-1.936**
8.MTU 1081 X MTU 3626	-0.107	-0.117	0.099	-0.809	-0.077	0.062
9.MTU 1081 X TNI	0.115	0.165*	-0.177	0.658	1.981	1.874**
10.MTU 1121 X MTU 1010	-0.045	-0.058	0.074	-0.800	-0.380	-0.901
11.MTU 1121 X MTU 3626	-0.138	0.128	-0.241*	3.325**	1.908	-0.178
12.MTU 1121 X TNI	0.183*	-0.070	0.168	-2.524*	-1.529	1.079
13. NRI 003X MTU 1010	-0.235**	0.054	-0.178	0.175	2.972*	3.731**
14. NRI 003 X MTU 3626	-0.078	-0.220**	0.227*	-0.640	-2.185	-3.636**
15. NRI 003 X TNI	0.313**	0.166*	-0.049	0.466	-0.787	-0.095
16. MTU 11-118-24-4-1X MTU 1010	-0.143	-0.021	-0.058	0.741	-0.381	-1.184
17. MTU 11-118-24-4-1X MTU 3626	0.278**	-0.055	0.192	-0.029	-0.018	0.589
18. MTU 11-118-24-4-1 X TNI	-0.135	0.076	-0.134	-0.712	0.400	0.595
19. MTU-PS-140-1X MTU 1010	0.262**	0.085	0.019	-0.917	-2.031	-2.336**
20. MTU-PS-140-1X MTU 3626	-0.057	0.052	-0.091	-0.437	0.567	1.342
21. MTU-PS-140-1X TNI	-0.205**	-0.137	0.073	1.354	1.465	0.994
SE±	0.09	0.105	0.13	1.54	1.72	0.93

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

by simple selection procedures to recover segregants with slender grain types. Similar findings were earlier reported by Sharma *et al.* (2006) and Sanjeev Kumar *et al.* (2007).

Only one cross NRI 003/ MTU 3626 (0.227) exhibited significant positive *sca* effect. The crosses between two low combiners producing crosses with significant *sca* effects revealed the presence of non-additive interallelic interaction.

Hulling percentage: The line MTU 1121 (2.121) for hulling showed significant positive *gca* effects and thus revealing that it is good general combiner for bringing improvement of hulling trait. None of the tester is significant for this trait. The cross MTU 1121/ MTU 3626 (high x medium) only showed significant *sca* effects in positive direction. The cross combination involving high x medium general combiner revealed complementary gene action. After perusal of *sca* effects it can be inferred that high *per se* performance of crosses need not always necessarily correlate with their *sca* effect. The ratio of general combining ability component of variance to specific combining ability component of variance was low (0.78). This indicated predominance of non-additive gene action in the inheritance of this trait. This is in line with the findings of Raju *et al.* (2003).

Milling percentage: The line only MTU 1121 (2.048) had shown positive *gca* effect. None of the testers had shown significant *gca* effects. Only the cross NRI 003/ MTU 1010 (2.972) with low x low revealed the presence of non-additive interallelic interaction. However, most of the hybrids showed similar *per se* performance for this trait when compared with the parents. It can be noted that high *per se* performance of crosses need not always necessarily correlate with their *sca* effect due to unfavorable gene combinations. Hence, higher yielding hybrids found in present study with no reduction in milling % may be considered better. The ratio of general combining ability component of variance to specific combining ability component of variance was low (0.12) indicating the preponderance of non-additive gene action in the inheritance of this trait. Similar results were earlier reported by Sreedhar (1999).

Head rice recovery: The only line MTU-PS-140-1 had shown significant positive *gca* effect for this trait. Among 21 crosses, 4 crosses showed significant *sca* effects in positive direction and they were NRI 003/ MTU 1010 (3.731), MTU 1075/ MTU 1010 (3.019), MTU 1071/ MTU 3626 (2.724) and MTU 1081/ TN 1 (1.874). As per the *sca* estimates and *per se* performance of crosses the superior specific cross combinations identified were, NRI 003/ MTU 1010, MTU 1075/ MTU 1010, MTU 1071/ MTU 3626 and MTU 1081/ TN 1 (low x low). The crosses with low x low *gca* effects were observed indicating the role of non-additive gene action in the inheritance of this trait. The superiority of these crosses may be attributed to the genetic diversity of parents involved. The ratio of general combining ability component of variance to specific combining ability component of variance was low (0.159) indicating the importance of non-additive gene action in the inheritance of this trait. These results are in accordance with Sreedhar (1999) and Shyam Chandra *et al*. (2012).

CONCLUSIONS

Lines MTU 1081 can be used in further breeding programme for the enhancement of L/B ratio by reducing kernel breadth in order to develop fine grain rice varieties and MTU 1121 can be utilised for improvement of kernel length, L/B ratio, hulling and milling percentage. Among testers, MTU 1010 had sufficient scope for the exploitation of genetic potential under hybridization programme for development of kernel characters. Among 21 crosses, MTU 1075/ MTU 1010, NRI 003/ MTU 1010 and NRI 003/ MTU 3626 revealed wide scope for enhancing both grain dimensions and milling traits in order to develop promising rice varieties.

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