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Studies on Gene Action and Combining Ability for Morpho- Physiological Traits in Rice (*Oryza Sativa* L.) Under Water Stress Condition

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ABSTRACT

Combining ability analysis was carried out involving 24 crosses for grain yield and, its components and some of the physiological characters in *line x tester* design under water stress condition. The magnitudes of specific combining ability variances were higher than the general combining ability variances for all the characters except for days to 50% flowering, grain yield per plant and chlorophyll stability index which indicated predominance of non additive gene action in the inheritance of these traits. Three crosses *viz.,* JGL 3855/Rajendra, MTU 1001/JGL 17004 and BPT 5204/Annada could be isolated as they possessed desirable SCA, heterosis and *per se* performance for yield and physiological traits.

Key words : GCA, Gene action, Rice, SCA.

Rice (*Oryza sativa L.*) is the major food crop for more than half of the global population and will continue to occupy the pivotal place in global food and livelihood security systems. But much of this important crop yield is divested by drought. Drought limits productivity more than any other factors, the global reduction in rice production due to drought averages 18 million tons annually (Zulqarnain Haider *et al.*, 2012). Out of 20.4 million ha of rainfed rice area in India, approximately 7.3 million ha of low land area is drought prone (Pandey and Bhandari 2008). The choice of suitable breeding method for the improvement of drought tolerant traits primarily depends on the relative importance of GCA and SCA variances. The performance of parent may not necessarily reveal it to be a good or poor combiner. Therefore, gathering information on nature of gene action and their expression in terms of combining ability is necessary and at the same time, it also elucidates the nature of gene action involved in the inheritance of characters. Hence, the present study was undertaken to study the combining of parents and crosses under water stress condition

MATERIALS AND METHODS

The experimental material comprised of six recipients and four donors crossed in LxT fashion to generate 24 F_1's. The parental material includes well adapted, commercially popular rice varieties *viz.,* Samba mahsuri (BPT 5204), Sona mahsuri (BPT 3291), Karimnagar samba (JGL 3855), Nellore mahsuri (NLR 34449), IR 64, Vijetha (MTU 1001) as lines and four donors *viz.,* Annada, Ramappa, Rajendra and JGL 17004 as testers. These parents were selected based on their attributes for grain quality, drought tolerance, influence of pests and diseases and high yield. The experiment was conducted at Andhra Pradesh Rice Research Institute & Regional Agricultural Research Station, Maruteru, West Godavari District, Andhra Pradesh during *Rabi* 2011-2012. All F_1's, and parents were planted in randomized block design with two replications in 4 rows of 5.0 meter length at a spacing of 20 x 15cm between and within row respectively. All the recommended agronomic and cultural measures were taken up in conducting the experiment. Observations were recorded on 10 random plants from each of the parents and F_1's for 19 characters *viz.,* days to 50% flowering, plant height, number of tillers per plant, number of panicles per plant, panicle length, filled grains per panicle, sterile grains per panicle, total spikelets per panicle, spikelet fertility percentage, test weight, grain yield, SPAD chlorophyll meter reading, relative water content, harvest index, chlorophyll stability index, leaf rolling, flag leaf area, specific leaf area and specific leaf weight. Water stress condition was imposed at reproductive stage by withholding irrigation for 15 days. Mean data was utilized for calculating following line x tester design (Kempthorne, 1957).

RESULTS AND DISCUSSION

The analysis of variance for combining ability for nineteen yield components and physiological traits under water stress condition revealed significant differences among lines and testers for all the traits indicating significant contribution towards combining ability of these characters. Predominance of additive gene action was indicated by more than unity ratio between s^2 GCA and s^2 SCA for days to 50% flowering, grain yield per plant and chlorophyll stability index. When additive effect forms the principal factor for genetic variance, use of pedigree method could be desirable. Similar results were reported earlier by Sharma and Mani (2008) for grain yield per plant. The estimate of s^2 GCA and s^2 SCA were equal to unity for test weight suggesting the equal importance of both additive and non additive type of gene action and complete dominance. Under such condition, use of reciprocal recurrent selection would be more effective as suggested by Comstock *et al.* (1949).The higher estimates of s^2 SCA than respective s^2 GCA for plant height, number of tillers per plant, number of panicles per plant, panicle length, filled grains per panicle, sterile grains per panicle, total spikelets per panicle, spikelet fertility percentage, SPAD chlorophyll meter reading, relative water content, harvest index, chlorophyll stability index, leaf rolling, flag leaf area, specific leaf area and specific leaf weight indicated that predominance of non additive gene action. The presence of non additive genetic variance is the primary justification for initiating the hybrid programme (Cockerham, 1961). Similar trend of results were also reported by Panwar (2005) and Karthikeyan *et al.* (2009) for panicle length. Hence, for exploiting the non additive gene action one would have to go for population improvement in addition to the heterosis breeding, while for exploiting additive gene action pedigree method of breeding is one of the important breeding procedures.

The information regarding general combining ability (GCA) effects of the parents is of prime importance, as it helps in successful prediction of genetic potentiality of crosses which yield desirable individuals in segregating population of self pollinated crops. Estimates of GCA effects showed that none of the line or tester was found to be good general combiner for all the traits studied (Table 1 and 2) . However, it was noted that the parental lines JGL 17004, JGL 3855, IR 64 and Annada proved to be best general combiners for days to 50% flowering and plant height in desirable direction. In addition, JGL 3855 also showed positively significant GCA effects for number of panicles per plant, total spikelets per panicle, relative water content, chlorophyll stability index and specific leaf area. BPT 5204 turned out to be a good combiner for plant height, number of panicles per plant, filled grains per panicle, sterile grains per panicle, spikelet fertility percentage, grain yield per plant and SPAD chlorophyll meter reading. The parental line, NLR 34449 showed significantly positive GCA effects for number of tillers per plant, panicle length, total spikelets per panicle, spikelet fertility percentage and harvest index. MTU 1001 emerged as good general combiner for number of tillers per plant, test weight, grain yield per plant, flag leaf area and chlorophyll stability index. Similarly, Annada and Ramappa possessed significant GCA effects for number of panicles per plant, panicle length, filled grains per panicle, total spikelets per panicle, spikelet fertility percentage, grain yield per plant , relative water content, harvest index, chlorophyll stability index and leaf rolling. High magnitude of GCA effects was exhibited by the lines BPT 5204, JGL 3855, NLR 34449 & MTU 1001 and by the testers Annada followed by Ramappa for most of the yield and drought related traits. Therefore, crosses involving Annada, Ramappa, NLR 34449 and JGL 3855 would result in identification of superior segregants with favourable genes for most of the drought tolerant and yield traits.

A specific combining ability effect is the index to determine the usefulness of a particular cross combination in the exploitation of heterosis. High magnitude of SCA effects for grain yield per plant resulted from the combination of high x low (MTU 1001/JGL 17004), high x medium (BPT 5204/ Rajendra), medium x high (JGL 3855/Ramappa) and low x high (IR 64/Ramappa) GCA effects of parents (Table 3 and 4). Peng and Virmani (1990) reported possibility of interaction between positive alleles from good combiners and negative alleles from poor

Table 1. Estimates of general combining ability effects for yield and yield contributing characters under water stress condition.

Parent	Days to 50% flowering	Plant height (cm)	Number of tillers per plant	Number of panicles per plant	Panicle length (cm)	Filled grains/ Panicle	Sterile grains/ Panicle	Total spikelets/ Panicle	Spikelet fertility %	Test weight (g)	Grain yield/ Plant (g)
Lines	1	2	3	4	5	6	7	8	9	10	11
BPT 5204	1.65**	-1.14*	0.19	1.52**	-0.02*	6.81**	-4.02**	2.81**	3.79**	-1.39**	1.15**
BPT 3291	4.77**	0.90	-0.31	0.15	-0.78*	0.06	2.88**	2.94*	-1.84**	1.09**	-2.74**
MTU 1001	4.27**	4.04**	1.69**	0.27	0.61	-2.81*	-0.75	-3.56**	0.18	2.21*	2.64*
NLR 34449	-1.60**	-0.54	1.19**	-1.98**	0.90*	4.94*	-1.63*	3.31*	1.58*	-0.90*	0.59
JGL 3855	-5.10**	-3.68**	-0.31	0.77*	-0.95*	1.19	3.63**	4.81**	-2.23**	-2.15*	-0.17
IR-64	-3.98**	-1.86*	-0.06	-0.73*	0.24	-10.19**	-0.13	-10.31**	-1.43*	1.14**	-1.46**
S.E	0.52	0.88	0.4	0.52	0.38	1.09	0.76	1.22	0.63	0.2	0.41
Testers											
Annada	-1.60**	-1.98*	-0.19	1.73**	0.85*	6.65**	-1.13*	5.52**	1.55**	1.49*	5.48*
JGL 17004	-8.69**	-0.39	-2.19**	-2.27*	-0.68*	-2.19*	0.29	-1.90	-0.52	-2.03**	-10.35**
Rajendra	6.81**	3.03**	-0.69*	-0.69	-1.19**	-10.77*	3.71**	-7.06*	-4.01**	0.80**	-0.38
Ramappa	3.48**	-0.67	3.06**	1.23*	1.02**	6.31**	-2.88*	3.44**	2.98**	-0.25	5.25**
S.E	0.43	0.71	0.32	0.43	0.31	0.89	0.62	0.99	0.51	0.16	0.33

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

Table 2. Estimates of general combining ability effects for physiological characters under water stress condition.

Parent	SPAD chlorophyll meter reading	Relative water content	Harvest index %	Flag leaf area (cm^2)	Leaf rolling	Chlorophyll stability index	Specific leaf area (cm^2 g^{-1})	Specific leaf weight (mg cm^{-2})
Lines	12	13	14	15	16	17	18	19
BPT 5204	1.69**	0.60	-2.19**	0.19	1.08**	-2.41*	-12.79**	-0.05
BPT 3291	0.27	-1.84**	-2.73*	3.75**	0.08**	-5.44**	33.72**	0.14
MTU 1001	0.13	0.65	1.13*	1.69**	0.08**	4.15**	-30.70**	0.10
NLR 34449	-1.27*	0.68	2.77*	0.47	-0.42**	1.29**	-4.98*	-0.25
JGL 3855	-2.40**	1.43*	-1.71**	-4.39**	-0.42**	1.88**	12.20**	-0.13
IR-64	1.58**	-1.51*	2.72**	-1.70**	-0.42**	0.53	2.55*	0.19
S.E	0.48	0.45	0.42	0.36	0.00	0.41	0.75	0.13
Testers								
Annada	1.72**	2.43**	3.05**	-2.19**	-1.58**	2.89**	7.33**	0.01
JGL 17004	-1.16**	-0.35	-1.78*	2.48**	0.75**	0.31	-6.80**	-0.23
Rajendra	-2.39**	4.01**	-2.27*	-3.59**	1.42**	-8.33*	-7.97*	-0.21
Ramappa	1.82*	1.94**	1.12*	3.31**	-0.58**	5.13**	7.45*	0.45
S.E	0.39	0.37	0.34	0.29	0.00	0.34	0.61	0.11

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

Table 3. Estimates of specific combining ability effects for yield and yield components under water stress condition.

Cross	Days to 50% flowering	Plant height (cm)	Number of tillers per plant	Number of panicles per plant	Panicle length (cm)	Filled grains/ Panicle	Sterile grains/ Panicle	Total spikelets/ Panicle	Spikelet fertility %	Test weight (g)	Grain yield/ Plant (g)
	1	2	3	4	5	6	7	8	9	10	11
BPT 5204/ Annada	1.60	-7.87**	3.62*	6.15**	1.09	15.85**	0.25	16.10**	0.92	-0.84	1.57
BPT 5204/ JGL 17004	-1.81	0.12	-1.94*	-0.35	-0.30	9.19**	6.33**	15.52**	-3.09*	-0.53	-3.10**
BPT 5204/ Rajendra	3.66**	-6.30**	-0.94	1.06	1.89*	-14.23**	-5.58**	-19.81**	2.59	1.24**	4.95**
BPT 5204/ Ramappa	7.02**	-1.69	-0.69	-6.85**	-2.68**	-10.81**	-1.00	-11.81**	-0.41	0.13	-3.41**
BPT 3291/ Annada	-2.52*	-5.07**	-3.94**	-1.48	-2.59**	-21.43**	0.38	-21.02**	-3.42*	-0.78	-4.09**
BPT 3291/ JGL 17004	-0.94	-4.38*	-0.94	-0.98	1.82*	10.44**	-1.54	8.90**	2.49	0.43	2.99**
BPT 3291/ Rajendra	3.06**	13.25**	3.06**	3.44**	-0.57	8.02**	5.04**	13.06**	-1.93	-0.76	-1.19
BPT 3291/ Ramappa	0.40	-3.80*	1.81*	-0.98	1.34	2.94	-3.88*	-0.94	2.86*	1.12*	2.28*
MTU 1001/ Annada	-0.02	-2.08	1.06	2.40*	-0.10	0.98	2.50	3.48	-1.33	0.46	0.97
MTU 1001/ JGL 17004	1.06	5.32**	4.52**	1.40	0.46	12.31**	-3.92*	8.40**	4.49**	1.57**	6.07**
MTU 1001/ Rajendra	3.56**	0.55	-2.94**	-3.19**	-0.74	-6.10*	4.17*	-1.94	-4.56**	-0.16	0.14
MTU 1001/ Ramappa	-4.60**	-3.79*	-2.69**	-0.60	0.38	-7.19**	-2.75	-9.94**	1.41	-1.87**	-7.18**
NLR 34449/ Annada	-2.65*	-3.03	-1.06	-1.85	0.73	-1.27	-2.13	-3.40	1.70	1.16**	1.65
NLR. 34449/ JGL 17004	4.94**	-6.01**	3.44**	1.65	-0.78	-8.44**	-1.04	-9.48**	0.15	-1.55**	-1.54
NLR 34449/ Rajendra	3.44**	1.75	-2.56**	-2.44*	-0.42	-9.35**	1.54	-7.81**	-2.43	0.44	-0.57
NLR 34449/ Ramappa	-5.73**	7.29**	0.19	2.65*	0.48	19.06**	1.63	20.69**	0.58	-0.06	0.46
JGL 3855/ Annada	6.35**	2.59	-1.44	-4.10**	0.00	-0.52	-4.38**	-4.90	3.07*	-1.59**	-2.29*
JGL 3855/ JGL 17004	-5.56**	-0.99	-1.94*	-0.10	-0.64	-13.19**	-0.29	-13.48**	-1.93	-0.31	-2.11*
JGL 3855/ Rajendra	-0.06	-7.44**	3.06**	3.31**	0.10	24.40**	-1.71	22.69**	4.71**	-0.95*	4.13**
JGL 3855/ Ramappa	-0.73	5.83**	-0.19	0.90	0.54	-10.69**	6.38**	-4.31	-5.85**	2.85**	0.28
IR-64/ Annada	-2.77*	-0.28	1.81*	-1.10	0.88	6.35**	3.38*	9.73**	-0.94	1.59**	2.18*
IR-64/ JGL 17004	2.31*	5.94**	-3.19**	-1.60	-0.55	-10.31**	0.46	-9.85**	-2.10	0.39	-2.31*
IR-64/ Rajendra	-3.19**	-1.82	-0.19	-2.19*	-0.27	-2.73	-3.46*	-6.19*	1.63	0.19	-3.62**
IR-64/ Ramappa	-6.81**	-3.84*	1.56	4.90**	-0.06	6.69**	-0.38	6.31*	1.41	-2.17**	3.72**
SE	0.74	1.24	0.56	0.73	0.53	1.54	1.08	1.72	0.89	0.28	0.58

Table 4. Estimates of specific combining ability effects for physiological traits under water stress condition.

Cross	SPAD chlorophyll meter reading	Relative water content	Harvest index %	Flag leaf area (cm^2)	Leaf rolling	Chlorophyll stability index	Specific leaf area (cm^2 g^{-1})	Specific leaf weight (mg cm^{-2})
	12	13	14	15	16	17	18	19
BPT 5204/ Annada	1.61	3.73**	2.49**	-0.42	-1.42**	1.53	-3.71*	-0.05
BPT 5204/ JGL 17004	-0.06	-6.02**	-1.95*	2.08**	0.25**	-2.60**	-4.61**	-0.50
BPT 5204/ Rajendra	-1.19	3.62**	-4.33**	3.42**	1.58*	-0.23	8.45**	0.24
BPT 5204/ Ramappa	-0.37	-0.15	3.78**	-0.91	-0.42**	1.30	-0.13	0.31
BPT 3291/ Annada	-1.56	-1.05	1.41	0.24	1.58*	-5.70**	-17.84**	0.91**
BPT 3291/ JGL 17004	3.39**	-1.32	1.32	-0.27	1.25*	0.59	10.17**	-0.68*
BPT 3291/ Rajendra	-3.76**	-0.86	-0.61	-0.53	-0.42**	-2.65**	20.33**	-0.43
BPT 3291/ Ramappa	1.93	3.23**	-2.12*	0.57	-.0.42**	-0.95	-12.67**	0.14
MTU 1001/ Annada	-2.35*	1.86	-3.76**	-1.60*	-0.42*	1.22	13.23**	-0.24
MTU 1001/ JGL 17004	4.07**	3.06**	0.30	4.09**	-0.75*	0.45	5.17**	1.08**
MTU 1001/ Rajendra	0.43	-0.96	2.32*	-2.49**	0.58**	-0.01	-22.09**	0.35
MTU 1001/ Ramappa	-2.15*	-3.96**	1.15	-0.01	0.58*	-1.67	3.69*	-1.18**
NLR 34449/ Annada	-5.47**	0.46	0.41	1.16	0.08*	4.31**	6.09**	0.97**
NLR 34449/ JGL 17004	-0.11	1.91*	1.75*	3.88**	-0.25*	-1.39	-20.98**	-1.36**
NLR 34449/ Rajendra	-1.53	-0.53	-0.95	-4.37**	1.08**	-1.72	-4.82**	-0.26
NLR 34449/ Ramappa	7.11**	-1.84	-1.21	-0.66	-0.92*	-1.19	19.71**	0.71*
JGL 3855/ Annada	-1.71	-1.80	0.01	3.27**	0.08**	-1.27	1.72	-0.92*
JGL 3855/ JGL 17004	-5.24**	2.55*	-2.93**	4.49**	-0.25**	3.55**	-8.65**	0.45
JGL 3855/ Rajendra	4.44**	-0.64	5.63**	4.87*	-2.92**	6.07**	17.07**	-0.43
JGL 3855/ Ramappa	2.51*	-1.25	-2.71**	3.64**	3.08*	0.37	-10.15**	0.90*
IR-64/ Annada	-3.11**	-1.99*	-0.56	3.86**	0.08*	-0.08	0.50	-0.67*
IR-64/ JGL 17004	-2.05*	-1.36	1.50	-0.76	-0.25*	-0.59	18.90**	1.01**
IR-64/ Rajendra	1.62	-0.63	-2.06*	-0.47	1.08*	-1.46	-18.94**	0.54
IR-64/ Ramappa	3.54**	3.98**	1.11	-2.63**	-0.92*	2.14*	-0.45	-0.88**
SE	0.68	0.64	0.59	0.52	—	0.59	1.06	0.18

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

combiners in high x low combiner crosses and suggested for the exploitation of heterosis in F_1 generation as their high yield potential would be unfixable in succeeding generations. The crosses with average or poor general combiners as their parents with high SCA effect was noticed in JGL 3855/Rajendra for number of tillers per plant, filled grains per panicle, spikelet fertility percentage, SPAD chlorophyll meter reading, harvest index, flag leaf area and leaf rolling, JGL 3855/JGL 17004 for days to 50% flowering, BPT 5204/Annada for plant height and number of tillers per plant, BPT 5204/ Rajendra and BPT 3291/JGL 17004 for panicle length, JGL 3855/Ramappa for test weight, MTU 1001/JGL 17004 for SPAD chlorophyll meter reading and specific leaf weight indicating that SCA effects of these crosses does not depend upon GCA effects of their parental lines. It might be due to differential expression of component traits in specific genetic background or may be due to complementary type of gene action, which can result in strong transgressive segregants for the desired traits due to segregation of genes with strong potentials and their specific buffers (Lingham, 1961). In such crosses where non additive gene effects played a predominant role in association with additive components the recurrent selection or reciprocal recurrent selection suggested for further improvement. High SCA effects may not be appropriate choice for heterosis exploitation because hybrid with low mean values may also posses high SCA effects. Furthermore, heterosis value alone may also mislead the identity of superior hybrids. Exploitation of hybrids for heterosis breeding is best judged by *per se*, SCA effects and magnitude of heterosis, based on these three criteria the hybrid JGL 3855/Rajendra was suitable for heterosis breeding under stress condition, since it exhibited desirable mean, SCA effects and heterosis for twelve traits including seven yield contributing traits *viz.*, plant height, number of tillers per plant, number of panicles per plant, filled grains per panicle, total spikelets per panicle, spikelet fertility percentage, grain yield per plant and five drought tolerant traits namely SPAD chlorophyll meter reading, harvest index, leaf rolling, chlorophyll stability index and flag leaf area followed by MTU 1001/JGL 17004 for nine traits *viz.,* number of tillers per plant, filled grains per panicle, sterile grains per panicle, spikelet fertility percentage, grain yield per plant, test weight, SPAD chlorophyll meter reading, flag leaf area and specific leaf weight, BPT 5204/ Annada for eight traits *viz.,* plant height, number of tillers per plant, number of panicles per plant, filled grains per panicle, total spikelets per panicle, relative water content, harvest index and leaf rolling, NLR 34449/Ramappa for six traits namely days to 50% flowering, filled grains per panicle, total spikelet per panicle, SPAD chlorophyll meter reading, specific leaf area and leaf rolling. Based on the results from the present study it was concluded that three crosses *viz.,* JGL 3855/Rajendra, MTU 1001/ JGL 17004 and BPT 5204/Annada could be isolated as they possessed desirable SCA, hetetosis and *per se* performance for yield and physiological traits.

LIERATURE CITED

Cockerham C C 1961 Implication of genetic variances in a hybrid breeding programme. *Crop Sciences*, 8: 720-722.

Comstock R E, Robinson H F and Harvey P H 1949 A breeding procedure designed to make use of both general and specific combining ability. *Agronomy Journal*. 41: 360-367.

Kempthrone O 1957 *An introduction of Genetic Statistics*. John Wiley and sons inc., New York. 458-471.

Lingham D C 1961 The high – low method of improvement. *Crop Science,*: 376-378.

Pandey S and Bhandari H 2008 Drought : Economics costs and research implications. In Serraj, R., Bennett, J and Hardy, B. (eds) *Drought frontiers in rice: Crop improvement for increased rainfed production*. World Scientific publishing and International Rice Research Institute, Singapore. 3-17.

Panwar L L 2005 Line x Tester analysis of combining ability in rice (*Oryza sativa* L.). *Indian Journal of Genetics,* 65 (1): 51-52.

Peng Y J and Virmani S S 1990 Combining ability for yield and four related traits in relation to breeding in rice. *Oryza,* 27: 1-10.

Sharma R K and Mani S C 2008 Analysis of gene action and combining ability for yield and its component characters in rice. *Oryza.* 45 (2): 94-97.

Zulqarnain Haider, Khan A S and Zia S 2012 Correlation and path coefficient analysis of yield components in rice (*Oryza sativa* L.) under simulated drought stress condition. *American-Eurasian Journal of Agriculture and Environmental Science,* 12 (1): 100-104.

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