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Combining ability Studies for Quality and Yield traits in some Restorer lines of Rice (*Oryza sativa* L)

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ABSTRACT

Twenty crosses derived from four lines and five testers were evaluated for yield and grain quality traits to assess gene action, combining ability of the parents and to identify best combinations. Productive tillers per plant, grain yield per plant, hulling recovery, milling recovery and head rice recovery were found to be under the control of non-additive gene action, while days to 50% flowering, plant height, panicle length, number of grains per panicle, test weight, kernel length, kernel width, kernel L/B ratio, kernel length after cooking (KLAC) and kernel breadth after cooking were under the control of additive gene action. Among the lines BR-827-35R was the best combiner for grain yield per plant, number of productive tillers per plant, test weight and head rice recovery and EPLT-109 for panicle length, number of grains per panicle, L/B ratio, kernel width and kernel breadth after cooking, while in testers 1005 was the best combiner for yield and many of the quality parameters. Cross EPLT-109 x IR 55838-B2-2 recorded significant SCA effects for plant height, earliness, kernel width in desirable direction, number of productive tillers, number of grains per panicle grain yield per plant, kernel length after cooking, L/B ratio and kernel elongation ratio. BR-827-35R x IR 63870-123 for earliness, plant height, productive tillers per plant, test weight, head rice recovery, kernel length after cooking and kernel breadth after cooking.

Key words : Combining ability, Gene action, Grain quality.

The combining ability studies provides useful information for the selection of high order parents for effective breeding besides elucidating the nature and magnitude of gene action involved in the inheritance of the character. For development of good quality hybrids identification of restorer lines with high yield and quality traits are important. In rice 65 hybrids have been released in India but many of them are not under spread due to non-acceptable grain quality. Hence, in the recent past emphasis is laid to include the parental lines having good physical and cooking quality traits in the breeding programme. The present study aims to identify gene action and combining ability of restorer lines for quality traits coupled with high yield for development of rice hybrids with acceptable quality.

MATERIAL AND METHODS

Four genetically diverse lines with good plant type and agronomic features were crossed to five testers in a line x tester design (Kempthorne 1957). The F_1s and parents were grown at Regional Agricultural Research Station, Warangal during *kharif,* 2010 in a Randomized Block Design with two replications. Each entry consists of two rows of 3 m length with a spacing of 20 cm between the rows and 15 cm between the plants in a row. All the recommended cultural practices were followed to obtain normal growth of the crop.

Observations were recorded on 10 plants selected randomly from each cross for all metric traits. Observations were taken on hulling and milling with the help of SATAKE company make laboratory huller and polisher. Data on head rice recovery was recorded. Kernel length and kernel breadth of 20 whole milled rice were measured by means of dial caliper and L/B ratio was computed as per Murthy and Govindaswamy (1967). Kernel elongation was determined by soaking 5g of whole milled rice in 12 ml distilled water for 10 minutes and later cooked for 15 min in water bath. Observations on length and breadth of cooked kernels and elongation ratio were recorded with the help of graph sheet to quantify cooking traits.

RESULTS AND DISCUSSIONS

The analysis of variance (Table-1) revealed highly significant differences among lines and

Table 1. Analysis of variance of combining ability for yield and quality traits in rice.

Source of Variation	DF	Days to 50% flowering	Plant height (cm)	No. of productive tillers / plant	Panicle length (cm)	No of grains per panicle	Test weight (g)	Grain yield plant^{-1} (g)	Hulling recovery (%)	Milling recovery (%)	Head rice recovery (%)	Kernel length (mm)	Kernel width (mm)	L/ B ratio	Kernel length after cooking (mm)	Kernel breadth after cooking (mm)	Kernel elongation ratio
Replications	1	0.62	25.55	193.72	0.21	655.60	0.017	39.39**	1.64	2.69	0.73	0.005	0.00008	0.0004	0.12**	0.02	0.002
Treatments	28	80.58**	506.70**	8077.80**	9.36**	7298.21**	27.92**	277.97**	2.28	9.39**	156.55**	0.32**	0.16**	0.22**	0.70**	0.31**	0.01**
Parents	8	67.12**	341.89**	3327.50**	9.58**	8037.88**	44.22**	78.28**	2.14	17.30**	219.06**	0.55**	0.24**	0.22**	0.61**	0.30**	0.01**
Parents vs Crosses	1	619.91**	2262.13**	26909.11**	46.68**	15912.48**	32.58**	3649.63**	0.01	14.94*	206.11**	0.04*	0.21**	0.21**	0.51**	1.34**	0.007
Crosses	19	57.87**	483.70**	9086.81**	7.31**	6533.39**	20.81**	184.60**	2.46	5.76*	127.62**	0.24**	0.12**	0.23**	0.74**	0.26**	0.01**
Line (Female)	3	253.66**	1236.84**	30327.82**	18.28*	3609.15	52.07**	133.22	3.59	3.35	192.21	0.52*	0.57**	1.16**	2.98**	0.79**	0.04*
Tester (Male)	4	30.52	913.14**	6558.83	9.27	20475.02**	38.18*	272.63	1.79	2.87	197.95	0.50*	0.03	0.04	0.60	0.28	0.01
Line x Tester	12	18.04**	152.27**	4619.22**	3.91	2617.24**	7.20**	168.10**	2.40	7.33*	88.03**	0.09**	0.04**	0.05**	0.23**	0.12**	0.009**
Error	28	1.65	8.74	526.97	1.92	302.24	0.09	3.70	1.40	2.80	5.19	0.006	0.001	0.003	0.008	0.01	0.002
Total	57	40.41	253.65	4230.30	5.55	3745.06	13.76	139.06	1.83	6.03	79.46	0.16	0.08	0.11	0.35	0.16	0.008

* and ** significant at 5% and 1% level respectively

Table 2. GCA and SCA variance for yield and quality traits in rice.

Source of Variation	Days to 50% flowering	Plant height (cm)	No. of productive tillers / plant	Panicle length (cm)	No of grains per panicle	Test weight (g)	Grain yield plant^{-1} (g)	Hulling recovery (%)	Milling recovery (%)	Head rice recovery (%)	Kernel length (mm)	Kernel width (mm)	L/ B ratio	Kernel length after cooking (mm)	Kernel breadth after cooking (mm)	Kernel elongation ratio
σ^2GCA (Lines)	25.20**	122.80**	12980.09**	1.64**	330.69	5.19**	12.95	0.22	0.06	18.70	0.05*	0.057**	0.116**	0.298**	0.077**	0.0044*
σ^2GCA (Testers)	3.61	113.05**	753.98	0.92	2521.59**	4.76*	33.62	0.05	0.01	24.09	0.06*	0.005	0.006	0.076	0.033	0.0012
σ^2GCA	15.60	118.47**	1990.70**	1.31**	1304.43**	5.00**	22.13	0.14	0.04*	21.09*	0.06**	0.034**	0.067**	0.199**	0.058**	0.0030**
σ^2SCA	8.19	71.76**	2046.12**	0.99	1157.49**	3.56**	82.19**	0.50	2.27**	41.41**	0.04**	0.02**	0.027**	0.114**	0.052**	0.0035**
σ^2GCA/ σ^2 SCA	1.90	1.65	0.97	1.32	1.13	1.40	0.27	0.29	0.02	0.51	1.28	1.752	2.436	1.736	1.107	0.852

* and ** significant at 5% and 1% level respectively

Table 3. Estimates of general combining ability effects for yield and quality traits in rice.

Source of Variation	Days to 50% flowering	Plant height (cm)	No. of productive tillers / plant	Panicle length (cm)	No of grains per panicle	Test weight (g)	Grain yield plant^{-1} (g)	Hulling recovery (%)	Milling recovery (%)	Head rice recovery (%)	Kernel length(mm)	Kernel width (mm)	L/ B ratio	Kernel length after cooking (mm)	Kernel breadth after cooking (mm)	Kernel elongation ratio
Lines																
BR-827-35R	6.700 **	0.72	76.87 **	-1.87**	-8.72	1.95**	4.29 **	0.47	0.54	4.90**	-0.05 *	0.23**	-0.29**	-0.54**	-0.12**	-0.09**
EPLT-109	0.60	13.79**	-31.52**	1.31 **	25.07**	-3.24**	1.77 **	-0.33	-0.76	1.70 *	-0.06 *	-0.27**	0.30**	-0.14**	-0.33**	-0.01
DR-714-1-R	-2.20 **	-13.37 **	1.475	0.48	-19.22 **	0.16	-3.09**	0.53	0.33	-1.19	0.32 **	-0.12**	0.28**	0.76**	0.19**	0.06**
SN-415R	-5.10 **	-1.15	-46.82**	0.06	2.87	1.11**	-2.96**	-0.67	-0.11	-5.41**	-0.20**	0.16**	-0.29**	-0.08 *	0.26**	0.04**
SE ±	0.40	0.93	7.25	0.43		0.09	0.60	0.37	0.52	0.72	0.02	0.01	0.01	0.02	0.04	0.01
Testers					5.49											
1005	1.77**	17.24**	-24.10 **	0.72	84.22**	-3.53**	8.84**	0.28	0.38	7.02**	-0.37**	-0.09**	-0.07**	-0.37**	-0.24**	0.04 **
IR60819-34	1.27 *	2.56*	-36.22**	1.40 *	6.97	0.47**	1.54 *	-0.43	-0.14	-6.14**	0.11**	-0.05**	0.10**	-0.08 *	-0.13 *	-0.06 **
IR62036-222	-0.10	-4.42**	17.65*	-0.09	-17.40*	1.64**	-2.57**	0.32	0.83	1.40	0.15**	0.06**	-0.01	0.19**	0.07	-0.005
IR63870-123	0.27	-4.98**	30.40**	-0.83	-42.77**	1.87**	-6.95**	0.41	-0.51	-3.06 **	0.23**	0.04 *	0.05 *	0.34**	0.21**	0.006
IR55838-B2-2	-3.22**	-10.40**	12.27	-1.19*	-31.02**	-0.45**	-0.85	-0.59	-0.55	0.77	-0.12**	0.04 *	-0.06**	-0.08 *	0.09	0.01
SE ±	0.45	1.04	8.11	0.49	6.14	0.10	0.68	0.41	0.59	0.80	0.02	0.01	0.02	0.03	0.04	0.01

* and ** significant at 5% and 1% level respectively

testers for all the characters except hulling recovery indicating presence of variability in the material under study. The lines showed significant differences for days to 50% flowering, plant height, productive tillers per plant, panicle length, number of grains per panicle, test weight, kernel length, kernel width, L/B ratio, kernel length after cooking, kernel breadth after cooking and kernel elongation ratio. While the testers exhibited significant differences for plant height, number of grains per panicle, test weight and kernel length. Partitioning of combining ability variances indicated importance of both additive and non-aditive gene action in expression of characters under study.

The variance due to SCA was higher than GCA (Table-2) for productive tillers per plant, grain yield per plant, hulling recovery, milling recovery and head rice recovery suggesting significant role of non additive gene action. The results are in agreement with the findings of Satyanarayana *et al.* (2000), Roy and Mandal (2001), Ramkumar Sharma and Mani (2005) and Salgotra *et al.* (2009), and. The variance due to GCA was higher than SCA for days to 50% flowering, plant height, panicle length, no. of grain per panicle, kernel width, L/B ratio, kernel length after cooking, kernel breadth after cooking suggesting major role of additive gene action in the expression of these characters. This was in agreement with findings of Gonya Nayak *et al.* (2011) and Roy and Senapati (2012).

The GCA values (Table-3) revealed that among the four lines BR-827-35R was the best combiner for grain yield per plant, number of productive tillers per plant, test weight and head rice recovery. Line EPLT-109 recorded significant positive value for panicle length, number of grains per panicle, L/B ratio and negative significant GCA value in desired direction for kernel width and kernel breadth after cooking. Among the testers 1005 and IR 60819-34 recorded significant positive GCA

Table 4. Estimates of specific combining ability effects for yield and quality traits in rice.

Source of Variation	Days to 50% flowering	Plant height (cm)	No. of productive tillers / plant	Panicle length (cm)	No of grains per panicle	Test weight (g)	Grain yield plant^{-1} (g)	Hulling recovery (%)	Milling recovery (%)	Head rice recovery (%)	Kernel length (mm)	Kernel width (mm)	L/ B ratio	Kernel length after cooking (mm)	Kernel breadth after cooking (mm)	Kernel elongation ratio
BR-827-35RX1005	-0.07	-7.60 **	-48.0 **	0.22	-18.02	-1.52**	4.75**	-0.08	0.11	-13.20**	0.14 *	-0.10**	0.17**	-0.06	-0.09	-0.07*
BR-827-35RX IR60819-34	1.42	13.37**	-52.37**	0.89	72.7**	-1.87**	2.75	0.62	2.04	4.76**	-0.32 **	-0.14**	-0.001	-0.49**	-0.30 **	-0.004
BR-827-35RX IR62036-222	-3.20**	0.96	-21.75	-0.45	1.60	-1.24**	3.92**	-1.61	-2.29	-5.75 **	-0.11	0.03	-0.06	0.22 **	0.12	0.07 *
BR-827-35RX IR-63870-123	-2.07 *	7.62**	66.00**	-2.31*	-21.52	1.68**	-0.09	-0.15	0.56	9.80**	-0.06	0.06	-0.08	0.22 **	0.44**	0.06
BR-827-35RX IR-55838-B2-2	3.92**	-14.35**	56.12**	1.64	-34.77 *	2.95**	-11.343**	1.23	-0.42	4.39 *	0.35**	0.15**	-0.02	-0.06	-0.16	-0.05
EPLT-109 X1005	4.02**	-5.37 *	-22.10	-0.51	-3.32	0.43	-5.92**	-0.43	-1.57	7.03**	0.04	-0.04	0.10 *	0.29**	-0.19	0.01
EPLT-109 XIR-60819-34	1.52	-3.29	6.52	-0.64	-28.07*	0.18	-2.47	0.39	0.09	0.32	0.10	0.13**	-0.10 *	-0.19 **	-0.05	-0.04
EPLT-109 X IR62036-222	-1.10	-0.16	18.65	-1.09	-11.70	0.55*	-1.76	0.77	3.25 *	2.91	0.04	0.03	-0.04	-0.37**	-0.01	-0.06 *
EPLT-109 X IR-63870-123	-0.47	-0.14	-43.60*	1.49	-8.82	0.48 *	-5.57**	-0.99	-2.37	-4.82 **	0.006	0.03	-0.04	-0.02	0.09	-0.005
EPLT-109 X IR-55838-B2-2	-3.97**	8.97**	40.52 *	0.75	51.92**	-1.645**	15.72**	0.25	0.60	-5.45 **	-0.19 **	-0.16**	0.08 *	0.30**	0.16	0.10 **
DR-714-1-RX1005	-0.17	10.79**	10.90	0.11	-0.02	0.97**	13.14**	0.30	0.22	5.73 **	-0.34**	0.19**	-0.39 **	-0.36**	0.02	-0.01
DR-714-1-RX XIR-60819-34	-2.17 *	-5.22*	23.02	-0.41	-17.77	1.12**	2.09	0.21	-0.18	-3.58 *	0.17 **	0.03	0.06	0.25 **	0.26 *	0.02
DR-714-1-RX IR62036-222	1.70	-0.34	18.65	0.93	2.10	1.54**	-4.19**	-0.217	-1.38	1.05	0.14 *	-0.002	0.05	0.07	-0.09	-0.01
DR-714-1-RX IR-63870-123	2.32 *	-9.67**	-10.60	-0.62	-5.02	-0.58*	-2.50	-0.39	0.002	-4.16 *	0.14 *	-0.02	0.09 *	-0.07	-0.18	-0.04
DR-714-1-RX IR-55838-B2-2	-1.67	4.44 *	-41.97 *	-0.01	20.72	-3.05**	-8.55**	0.08	1.34	0.96	-0.11	-0.19**	0.17**	0.10	-0.01	0.04
SN-415RX1005	-3.77**	2.17	59.20**	0.18	21.37	0.12	-11.98**	0.21	1.23	0.43	0.16 **	-0.04	0.11 *	0.13	0.25 *	0.07 *
SN-415RX IR-60819-34	-0.77	-4.84 *	22.82	0.15	-26.87 *	0.57 *	-2.38	-1.23	-1.95	-1.50	0.04	-0.028	0.04	0.44**	0.09	0.02
SN-415RX IR62036-222	2.60*	-0.46	-15.55	0.60	8.00	-0.85**	2.03	1.05	0.42	1.79	-0.07	-0.06 *	0.04	0.06	-0.01	0.01
SN-415RX IR-63870-123	0.22	2.20	-11.80	1.44	35.37**	-1.58**	8.16**	1.53	1.81	-0.82	-0.08	-0.07 *	0.03	-0.13	-0.35 **	-0.01
SN-415RX IR-55838-B2-2	1.72	2.17	-54.67**	-2.39*	-37.87**	1.74**	4.16**	-1.57	-1.52	0.10	-0.04	0.21**	-0.23**	-0.50**	0.01	-0.09 **
SE ±	**0.91**	**2.09**	**16.23**	**0.98**	**12.29**	**0.21**	**1.36**	**0.83**	**1.18**	**1.61**	**0.05**	**0.03**	**0.04**	**0.06**	**0.09**	**0.03**

* and ** significant at 5% and 1% level respectively

effects while IR 63870-123 and IR 62036-222 recorded significant negative GCA effects for grain yield per plant. Desirable GCA effects for number of grains per panicle, head rice recovery and kernel elongation ratio was exhibited by 1005 and also showed significant GCA in desirable direction for kernel width, kernel width after cooking. IR 55838-B2-2 recorded desirable significant GCA effects for earliness and dwarfness.

Out of 20 crosses (Table-4) only 6 crosses EPLT-109 x IR55838-B2-2, DR-714-IR x 1005, SN415R x IR63870-123, BR-827-35R x 1005, SN 415R x IR 55838-B2-2 and BR 827-35R x IR 62036-222 exhibited significantly positive SCA values for grain yield per plant. EPLT-109 x IR 55838-B2 exhibited favourable genes in desirable direction for earliness, number of grains per panicle, kernel width, L/B ratio, kernel length after cooking and kernel elongation ratio while BR-827-35R x IR 63870-123 recorded significant positive SCA effects for productive tillers per plant and head rice recovery and BR-827-35R x IR-55838-B2-2 for productive tillers per plant, test weight and kernel length and also plant height in desired direction. The cross SN415R x IR 63870-123 exhibited significant negative value for kernel breadth after cooking. BR-827-35R x IR 60819 showed high significant SCA effects for number of grains per panicle, head rice recovery and significant SCA effects for kernel breadth after cooking in desired direction.

The cross EPLT-109 x IR 55838-B2-2 seemed to be promising for development of both high yielding and superior grain quality genotypes due to its high and significantly positive SCA values for grain yield per plant and kernel elongation ratio (KER). Moreover the cross EPLT 109 x IR 55838-B2-2 involved high x low type of general combiners for grain yield per plant indicate additive x dominance type of gene action and low x low type of general combiners for KER indicating that poor x poor parental combination performed best. Similar results were earlier reported by Longham (1961), Roy and Senapathi (2012).

The perusal of results indicated that the parents BR-827-35R, EPLT-109, 1005 and IR 60819-34 appeared to have contributed favourable genes for yield, physical and cooking quality traits. Hence, these parents may be widely used in crossing programmes aimed to improve grain quality and yield in rice.

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