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COMBINING ABILITY ANALYSIS TO IDENTIFY SUITABLE PARENTS FOR HETEROTIC RICE HYBRID BREEDING

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ABSTRACT

Combining ability study on grain yield and its components from Line x Tester analysis during the kharif season of 2012 in the research farm Department of Plant Breeding and Genetics, Indira Gandhi Agricultural University, Raipur, India for fourteen characters, involving three CMS lines, 20 testers and resulting 60 rice hybrids. The analysis revealed the predominance of non-additive gene action for all the characters under study. Among the CMS lines studied, IR58025Awas rated as good general combiner for fertile spikelet per panicle (14.38) followed by grain yield per plant (7.21), CMS CRMS32Awas also good general combiner for sterile spikelet per panicle (6.7) and days to flowering (4.04). Tester IR72164-352-2-5-5was found best general combiner for grain yield per plant (11.29).Three hybrid combinations could be selected also for shorter plant height and five cross combinations exhibited high SCA effects for grain yield per plant. IR58025A x Mancha (14.42) and IR58025A x IR72164-352-2-5-5 (14.07) crosses were found to involve both parents with high GCA effect indicating the involvement of non-additive gene action operating in these crosses.These combinations could be used for exploitation of heterosis in hybrid breeding program.

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INTRODUCTION

Success of any plant breeding programme depends on the choice of appropriate genotypes as parents in the hybridization programme. The combining ability studies of the parents provide information which helps in the selection of better parents for effective breeding. Combining ability analysis also provides information on additive and dominance variance. Its role is important to decide parents, crosses and appropriate breeding procedure to be followed to select desirable segregants (Salgotra *et al.,* 2009). Semi-dwarf high yielding modern varieties though has increased yield drastically in many rice-growing countries, yield plateaus have been achieved in most of the areas. In such a situation, hybrids can break through the yield ceilings of semi-dwarf rice began in early 60's. India is the second country to commercially exploit heterosis in rice after China. The discovery of CMS in rice (Athwal and Virmani, 1972) suggested that breeding could develop a commercially viable F_1 hybrid. The promising hybrids yielded 20-30% (Lin and Yuan, 1980) and 15-20% (Yuan, 1998) higher than the best hybrids and conventional rice varieties, respectively.

Line × tester technique (Kempthorne, 1957) is useful in deciding the relative ability of female and male lines to produce desirable hybrid combinations. It also provides information on genetic components and enables the breeders to choose appropriate breeding methods for hybrid variety or cultivar development programmes. Lot of research work is available on combing ability analysis in rice; however there is need to analyze combining ability in relation to mean performance, heterosis and other genetic parameters in rice where the improvement has been slow over the world due to various genetic barriers.Hybrid rice includes three line and two line hybrid rice that is developed via cytoplasmic male sterility and photo/thermo sensitive male sterility respectively given by Yuan and Peng (2005). The first approach is called three-line system involving CMS line, a maintainer line and restorer line. The second approach is called two-line system involving environmentally sensitive male sterility (Sheeba *et al.,* 2009). In 1974, Chinese scientist successfully transferred the male sterility gene from wild rice to create the CMS line and hybrid combination (FAO org., 2004).

The present research work was therefore carried out with the objective to assess combining ability based on mean performance, genetic components and heterosis controlling some economic traits in rice. The information obtained thus will be used in selection of suitable parents and choice of appropriate breeding methods to develop high yielding rice cultivar(s) or hybrid variety(s).Hence, the current investigation was undertaken to find out the best combination with respect to their combining ability effects among the parents and hybrids at IGKV Raipur.

MATERIALS AND METHODS

The present study entitled was conducted at the University Research cum Instructional Farm, Department of Genetics and Plant breeding, College of Agriculture, Indira Gandhi KirshiVishwavidyalaya, Raipur (Chhattisgarh) during wet season 2012. It is situated at 21º16' N Latitude and 81º36' E longitude at an altitude of 289.60 meters above mean sea level. It comes under sub-humid region receiving an average rainfall of 1400 mm annually, of which about 92 percent is received during rainy season between Junes to September and remaining 8 percent during winter season between October to March. The experimental material comprised of three CMS lines (IR58025A, CRMS31A, and CRMS32A) and 20 testers as varieties including accessions (RRH-1, RRH-2, R1557-1317-1-580-1, Nagina-22, Tarun Bhog, R1659-3629-1-462-1, Mancha, R-1240-927-3-1056-1, Jaldubi, Adhamchini, MTU-1001, TOX 981-11-2-3, Chinikapoor, R1949-1196-2-1, IR73007-44-1-2-3, IR72164-352-2-5-5, IR72910-177-1-1-3, R1213-3, Mahsuri and HR-NPT-6-3) from germplasm. The 3 CMS lines have cytoplasm derived from a WA and Kalinga cytoplasmic source. Lines (CMS) were crossed with 20 testers to generate 60 hybrid combinations in line x tester mating design. The twenty one days old seedlings of 60 F_1 hybrids along with their parents were transplanted in the main field during *kharif* 2012 at Research farm, IGKV, Raipur, Chhattisgarh. The experiment was conducted as randomized complete block design with two replications with inter-row and intra-row spacing of 20 cm having a plot size of 5x1 m^2. All recommended agronomical practices were followed to raise the ideal crop stand. Observations were recorded on ten agro-morphological characters such as days to 50 per cent flowering, plant height (cm), number of tillers per plant, number of productive tillers per plant, panicle length (cm), pollen fertility (%), spikelet fertility (%), biological yield per plant (g) and grain yield per plant (g) and 1000 grain weight (g). The mean data were recorded on five randomly selected plants from parents and F_1's from each replication. Heterosis was estimated from mean values according to the Fehr (1987). The significance of different types of heterosis was carried out by adopting't test' as suggested by Nadarajan and Gunasekaran (2005). However, combining ability analysis was done using line × tester method (Kempthorne, 1957) for general combining ability (GCA) and specific combining ability (SCA) were tested against their respective error variances derived from ANOVA reduced to mean level. Significance test for GCA and SCA effects were per-formed using t-test.

Genotype means were used for the analysis of variance (Singh & Chaudhary, 1985). Genotypes with significant and high mean performance than grand mean were adjudged as desirable ones. Combining ability analysis was also performed according to Singh & Chaudhary (1985). Significant and positive general combining ability (GCA) and specific combining ability (SCA) effects were considered as high (*h*), non-significant as average (*a*) and significant and negative as low (*l*). Heritability in broad sense $h^2_{(b.s)}$ was determined as outlined by Lush (1940). Standard error (S.E.) of broad sense heritability was calculated following Lothrop *et al.* (1985). Heterobeltiosis Ht (bel) was determined as outlined by Falconar and Mackey (1996).

RESULTS AND DISCUSSION

Analysis of variance, estimates of genetic components and contribution of lines, testers and line × tester interaction to the total variance have been shown in Table 1. Mean squares of parents and crosses were significantly different at a 1%

Table 1: Analysis of Variance for combining ability and components of variance for yield attributing traits in rice

Source of variance	df	Characters													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Replication	1	2.51**	154.99**	5.35**	2.64**	63.05**	91.76	520.10	175.23	20.72	4.290	467.18*	40.77*	8.25**	7.11
Parents	22	77.72**	1059.41**	4.71**	3.46**	11.82**	2467.78**	2080.02**	548.17**	109.77**	1531.51**	1420.99**	336.94**	41.01**	81.04**
Hybrids	59	115.93**	889.54**	10.62**	12.15**	16.44**	11165.43**	78570.53*	8350.34**	1527.07**	1383.79**	1371.32**	286.59**	55.74**	300.68**
Parent vs. hybrids	1	272.22**	7034.19**	3.99**	0.43	24.62**	36201.25**	7176.13**	75615.91**	11804**	3080.83**	1109.53**	570.23**	20.39**	1171.77**
Lines	2	1216.80**	6410.39**	2.55**	61.91**	200.19**	5644.15**	6372.33**	1345.99**	1109.39**	814.74**	2183.96**	1517.88**	111.08**	621.97**
Testers	19	155.06**	1430.07**	6.44**	7.15**	12.10**	14216.82**	30879.54**	14692.24**	2791.13**	2398.36**	1239.43**	405.45**	83.53**	470.43**
LinexTester	38	38.43**	328.70**	13.13**	12.03**	8.45**	9930.33**	13058.05**	5548.04**	917.02**	906.46**	1394.49**	162.36**	38.93**	198.90**
Error	82	0.20	9.05	0.12	0.19	2.12	375.06	176.69	218.79	16.92	20.749	94.791	11.96	1.05	16.54
s^2 GCA		28.15	156.15	0.38	0.98	4.27	0.01	242.08	107.44	44.92	30.44	13.79	34.75	2.54	15.10
s^2SCA		19.12	159.44	6.49	5.90	3.22	4751.05	6416.20	2664.53	452.16	443.68	638.70	74.53	18.77	91.44
s^2GCA /s^2SCA		1.47	0.98	0.06	0.17	1.32	0.00	0.04	0.04	0.10	0.07	0.02	0.47	0.14	0.17
s^2A		112.6	624.6	1.52	3.92	17.08	0.04	968.32	429.76	179.68	121.76	55.16	139	10.16	60.4
s^2D		76.48	637.76	25.96	23.6	12.88	19004.2	25664.8	10658.12	1808.64	1774.72	2554.8	298.12	75.08	365.76
s^2A/s^2D		1.47	0.98	0.06	0.17	1.33	0.00	0.04	0.04	0.10	0.07	0.02	0.47	0.14	0.17
Degree of Dominance		0.82	1.01	4.13	2.45	0.87	689.28	5.15	4.98	3.17	3.82	6.81	1.46	2.72	2.46

* = significant of p = 0.05 level., ** = significant of p = 0.01 level; 1; Days to 50% Flowering; 2 Plant height (cm);3.No. of Tillers; 4. Productive tillers; 5. Panicle Length(cm); 6. Spikelets/Panicle; 7. Fertile spikelets/Panicle; 8. Sterile spikelets/panicle ; 9. Spikelet Fertility (%); 10. Pollen Fertility (%); 11. Biological Yield (g); 12. Grain Yield (g); 13. 1000 grain weight (g); 14. Harvest index (%)

Table 2: General combining Ability (GCA) effect and mean performance of different parents for characters under study

Parents Lines	1	2	3	4	5	6	7	8	9	10	11	12	13	14
IR-58025A (WA)	-6.28**	13.51**	-0.26**	-1.36**	2.53**	11.02**	14.38**	-3.36*	5.1**	4.84**	8.53**	7.1**	1.60**	4.53**
	91.88	83.53	10.70	9.70	25.07	255.50	179.50	76.00	70.30	0.17	56.19	18.26	19.00	32.78
CRMS31A(Kalinga)	2.24**	-1.93**	0.25**	1.08**	-0.78**	-12.58**	-9.24**	-3.34*	0.33	-0.74	-4.48**	-3.92**	0.12	-2.68**
	94.10	86.99	10.45	9.30	22.77	247.38	181.98	65.40	73.50	0.16	54.83	19.44	19.69	35.92
CRMS32A(Kalinga)	4.04**	-11.58**	0.01	0.28**	-1.74**	1.56	-5.14**	6.7**	-5.42**	-4.1**	-4.05**	-3.18**	-1.72**	-1.85**
	101.90	77.94	10.50	9.80	22.71	227.50	169.00	58.50	76.21	0.13	64.73	19.65	19.33	30.32
SE (Lines)	0.05	0.34	0.04	0.05	0.16	2.27	1.65	1.62	0.39	0.48	1.19	0.4	0.13	0.44
Testers														
RRH-1	4.71**	-0.62	0.48**	-0.07	-1.37**	-27.18**	-28.99**	1.81	-9.14**	-11.62**	-5.27	-4.15**	-0.69*	-4.11
	107.58	129.63	11.05	9.76	20.74	197.53	156.26	41.26	79.35	62.00	102.25	32.83	16.45	32.08
RRH-2	5.13**	-2.51**	0.97**	0.32*	-2.02**	-34.98**	-2.15	-32.83**	11.61**	14.88**	10.94**	3.77**	-0.1	0.05**
	107.58	129.63	11.05	9.76	20.74	197.53	156.26	41.26	79.35	62.00	102.25	32.83	16.45	32.08
R1557-1317-1-580-1	6.8**	13.12**	0.12	-0.31	-2.24**	-76.09**	-118.52**	42.43**	-36.69**	-34.1**	24.72**	-13.18**	-3.14	-18.82**
	111.50	139.07	10.51	9.51	21.69	179.96	114.87	65.09	63.84	64.50	63.40	21.00	14.66	33.30
Nagina-22	2.46**	-0.81	0.02	-0.88	0.52	-4.98	-48.7**	43.72**	-15.6**	-13.81**	-1.8	-4.81	-2.32	-5.92**
	114.08	116.07	9.38	7.98	21.17	192.90	121.78	71.11	63.23	56.92	102.50	33.50	19.65	32.65
TarunBhog	2.63**	-11.3**	-0.65**	-1.66**	0.68	47.09**	73.25**	-26.16**	13.72**	11.08**	-1.58	3.29**	1.65**	3.67**
	114.08	134.90	11.65	9.78	25.75	171.93	123.63	48.30	71.93	57.50	137.50	45.50	25.53	33.07
R1659-3629-1-462-1	-11.87**	-7.27**	0.06	-0.48**	0.3	-24.5**	-6.84	-17.66**	6.24**	2.08	-8.48*	5.67**	3.34**	9.26**
	101.07	127.13	10.85	9.75	26.15	174.19	134.44	39.75	77.21	71.15	64.50	26.50	19.95	41.81
Mancha	-6.54**	-11.42**	2.23**	2.84**	0.25	-1.96	-29.25**	27.29**	-13.99**	-16.19**	3.35	2.04	0.75	-2.32
	97.75	133.17	8.06	6.90	28.28	253.75	182.17	71.58	71.92	70.50	82.50	34.00	24.63	41.18
R-1240-927-3-1056-1	1.13**	-1.65	-0.29*	0.16	-1.71**	-44.63**	-115.53**	70.9**	-38.26**	-38.95**	14.58**	-13.7**	-3.12**	-17.1**
	107.50	142.07	8.88	7.91	21.84	242.38	211.96	30.42	87.86	90.50	93.50	31.50	16.30	33.65
Jaldubi	3.3**	29.45**	-0.85**	-0.43**	1.71**	17.69*	-126.88**	144.57**	-46.65**	-36.71**	8.28*	-12.56**	-2.29**	-15.59**
	108.17	169.85	9.65	8.68	28.75	236.36	206.10	30.26	87.26	83.05	91.50	33.00	22.00	36.03
Adhamchini	3.55**	40.37**	0.63**	0.92**	2.35**	28.47**	8.33**	20.14**	-0.91	-0.84	-23.53**	-8.66**	-5.85**	-0.03
	107.75	165.67	9.68	8.75	25.34	166.01	146.28	19.73	88.11	72.50	61.50	27.50	9.85	44.69
MTU-1001	0.96**	-16.8**	-0.5**	0.02	-0.47	77.19**	92.28**	-15.09**	9.97**	11.87**	-12.81**	-3.26*	-1.7**	2.11
	99.17	125.24	6.43	5.58	27.35	153.05	198.10	54.95	78.32	64.50	59.00	24.40	19.83	41.32
TOX 981-11-2-3	2.63**	-0.44	-1.33**	-0.36*	-0.78	-4.06	33.47**	-37.53**	13.89**	19.78**	-2.45	2.22	0.12	4.59**
	109.43	136.70	9.78	8.95	26.78	250.11	193.33	56.78	77.31	87.00	116.50	50.00	25.22	42.93
Chinikapoor	-8.37**	-3.23**	0.48**	0.64**	-0.64	117.67**	135.65**	-17.98**	18.81**	17.84**	8.56*	5.57**	1.85**	2.43
	103.67	105.57	7.73	7.28	27.94	254.50	193.00	61.50	75.98	80.50	148.00	77.00	22.50	52.03
R1949-1196-2-1	-5.32**	-17.19**	-1.27**	-1.99**	-0.52	5.53	47.02**	-41.48**	18.65**	17.86**	-18.62**	-2.43	1.87**	4.14**
	97.67	107.65	8.86	8.15	26.60	254.12	218.00	36.12	85.83	82.00	106.00	45.00	11.00	42.56
IR73007-44-1-2-3	2.75**	-13.03**	0.07	-0.21	-0.86	4.34	-35.93**	40.26**	-16.33**	-9.31**	-2.52	0.95	1.79**	-0.34
	103.84	109.05	9.55	8.02	25.65	172.38	116.58	55.80	67.65	68.50	64.25	31.25	21.40	48.62
IR72164-352-2-5-5	2.01**	-7.91**	-0.23	0.01	2.54**	23.01**	54.32**	-31.31**	20.44**	26.64**	-6.51	11.29**	12.01**	14.19**
	106.58	105.74	9.60	8.78	25.58	193.43	153.88	39.55	79.45	92.95	63.29	30.95	24.38	48.96
IR72910-177-1-1-3	0.25	-5.11**	1.93**	0.74**	2.35**	-38.11**	7.17	-45.28**	17.33**	3.83*	-3.32	9.62**	1.42**	11.41**
	107.94	114.67	10.59	8.91	25.58	145.68	122.15	23.53	83.87	87.50	73.00	34.50	20.95	47.42
R1213-3	-2.79**	-9.74**	-0.62**	0.21	-1.07*	-94.18**	-56.56**	-37.62**	2.64*	-0.17	-13.89**	-2.56*	-1.1*	1.28
	98.33	123.71	8.88	8.26	22.81	216.53	163.75	52.78	75.61	70.00	87.00	40.50	27.08	46.93
Mahsuri	2.96**	24.37**	0.8**	1.72**	1.52**	6.39	53.85**	-47.46**	22.95**	15.78**	-6.48	3.72**	-4.94**	5.97**
	107.26	144.12	7.91	7.82	25.27	196.15	171.65	24.50	87.59	84.50	52.00	21.50	15.57	41.30
HR-NPT-6-3	-6.37**	1.72	-1.6**	-1.19**	-0.53	23.31**	64.03**	-40.73**	21.31**	20.04**	36.85**	17.15**	0.46	5.13**
	96.58	121.99	9.25	8.45	25.16	236.00	193.00	43.00	81.78	81.00	62.00	22.50	15.65	36.25
SE(Testers)	0.14	1.06	0.13	0.16	0.48	7.00	5.08	5.01	1.21	1.48	3.66	1.23	0.40	1.35

* = significant of p = 0.05 level., ** = significant of p = 0.01 level; 1.Days to 50% Flowering; 2.Plant height (cm);3.No. of Tillers ;4. Productive tillers ;5. Panicle Length(cm);6. Spikelets/ Panicle ;7. Fertile spikelets/Panicle;8. Sterile spikelets/panicle ;9. Spikelet Fertility (%) ;10. Pollen Fertility (%) ;11. Biological Yield (g) ;12. Grain Yield (g) ;13. 1000 grain weight (g) ;14. Harvest index (%)

level of probability in the all traits. The difference between parents indicated that they are suitable for genetic studies. Also, the significance of SCA and GCA for all studied traits revealed that both additive and non-additive gene effects contributed in trait control. The genotypes were found highly significant for all the traits which indicated that the treatments used in this study were significantly varied from each other. The mean sums of squares (MSS) of the treatments were further portitioned into parent, cross and parent vs hybrids. The results showed that all the parameters for parent, cross and parent vs hybrids were found highly significant except productive tillers for parent vs hybrids (Table 1).

Mean sum of squares for crosses was again portitioned into lines, testers and line x tester components. In case of lines, significant variances were observed in all fourteen characters. On the other hand, tester and line × tester was also found highly significant for all the characters. The results were in confirmation with the findings of Sarker *et al.* (2002), Roy *et al.* (2013) and Sharma *et al.* (2007). Acomparison of the magnitude of variance components due to GCA and SCA combined the nature of gene action incontrolling the expression of the traits was also reported by Bhadruet *al.* (2013) and Malik *et al.* (2013).The value of variance of general combining ability (*s*) was less than variance of specific combining ability (s^2 SCA) for all traits except days to 50% flowering and panicle length which revealed that the preponderance of non-additive gene action governing the traits concerned, conversely, additive gene action might be prevailed for fertile spikelets per panicle,

Table 3: Specific combining ability(SCA) effect and mean performance of different hybrids for characters under study

Hybrids	1	2	3	4	5	6	7	8	9	10	11	12	13	14
IR-58025A														
RRH-1	-4.30**	5.52**	4.49**	3.31**	-0.11	22.08*	50.59**	-28.51**	19.37**	25.96**	-15.05**	1.70	-2.60**	9.37**
	95.50	126.95	14.80	10.70	26.70	253.38	186.78	66.60	73.71	74.67	76.04	33.30	18.50	43.74
RRH-2	-0.97**	-2.75	-0.29	-1.79**	-0.58	13.70	7.62	6.08	-3.15	-6.36**	-0.98	9.58**	-6.19**	7.63**
	99.25	116.80	10.50	6.00	25.58	237.20	170.65	66.55	71.94	68.85	106.33	49.10	15.50	46.16
R1557-1317-1-580-1	1.87**	-3.70**	2.31**	1.59**	-0.90	55.83**	-35.31**	91.14**	-22.12**	-20.33**	28.32**	-7.57**	-2.80**	-9.58**
	103.75	131.47	12.25	8.75	25.04	238.23	11.35	226.88	4.67	5.90	149.40	15.00	15.85	10.08
Nagina-22	-1.80**	6.15**	0.16	-1.79**	2.37**	-35.70**	35.92**	-71.62**	22.07**	20.28**	-18.51**	1.82	1.33*	10.7**
	95.75	127.40	10.00	4.80	31.07	217.80	152.40	65.40	69.95	66.80	76.05	32.75	20.80	43.25
TarunBhog	2.28**	2.54	0.52**	0.65**	3.27**	-40.17**	-60.03**	19.86**	-9.10**	-7.65**	10.27**	-3.59*	3.67**	-8.38**
	100.00	113.30	9.70	6.45	32.13	265.40	178.40	87.00	67.25	63.76	105.05	35.45	27.11	33.77
R1659-3629-1-462-1	2.03**	-0.38	-1.74**	-3.33**	-0.56	-21.41*	-11.77	-9.64	-1.17	-1.51	-4.33	-3.72*	-5.65**	-2.38
	85.25	114.40	8.15	3.65	27.92	212.57	146.57	66.00	68.55	60.90	83.55	37.70	19.48	45.36
Mancha	2.95**	5.76**	-2.41**	-0.91**	4.07**	84.38**	88.57**	-4.19	16.43**	17.11**	19.89**	14.42**	-4.19**	7.5**
	91.50	116.40	9.65	9.40	32.50	340.90	224.50	116.40	65.93	61.25	119.61	52.20	18.35	43.66
R-1240-927-3-1056-1	-0.22	5.4**	-1.79**	-0.98**	1.37*	25.65*	-38.81**	64.45**	-20.68**	-17.94**	15.55**	-3.95*	4.83**	-6.99**
	96.00	125.80	7.75	6.65	27.84	239.50	10.85	228.65	4.54	3.44	126.50	18.10	23.50	14.39
Jaldubi	-1.88**	-17.10**	-0.43*	0.71**	1.93**	21.08*	27.25**	48.33**	-13.18**	-18.97**	-14.05**	-8.48**	-1.35*	-6.92**
	96.50	134.40	8.55	7.75	31.81	297.25	11.05	286.20	3.65	4.65	90.60	14.70	18.15	15.97
Adhamchini	6.37**	-16.62**	-1.91**	-0.89**	-1.50	-12.45	-5.61	-6.84	-1.63	-2.39	-8.08	-4.48*	-0.39	-3.20
	105.00	145.80	8.55	7.50	29.03	274.50	167.90	106.60	60.93	57.10	64.75	22.60	15.55	35.25
MTU-1001	-1.05**	12.24**	-1.58**	-0.14	0.75	-77.07**	-62.56**	-14.51*	1.91	-5.15*	11.16**	4.12*	3.52**	-1.94
	95.00	117.50	7.75	7.35	28.46	258.60	194.90	63.70	75.36	67.05	94.72	36.60	23.61	38.64
TOX 981-11-2-3	-2.47**	-5.21**	-1.99**	-0.86**	0.77	71.03**	106.15**	-35.12**	16.34**	14.64**	-26.81**	-5.37**	4.79**	5.63**
	95.25	116.40	6.50	6.25	28.17	325.45	304.80	20.65	93.71	94.75	67.11	32.60	26.70	48.69
Chinikapoor	-1.47**	0.57	-1.46**	-0.81**	-2.00	-115.80**	-134.08**	18.28*	-18.24**	-10.42**	-23.79**	-3.01	1.86**	6.4**
	85.25	119.40	8.85	7.30	25.54	260.35	166.75	93.60	64.05	67.75	81.14	38.31	25.50	47.30
R1949-1196-2-1	-5.02**	13.14**	-0.66**	-0.37	-0.41	38.17**	61.05**	-22.88**	8.28**	14.31**	-9.65	-2.07	5.10**	3.01
	84.75	118.00	7.45	5.10	27.25	302.19	273.25	28.94	90.42	92.50	68.10	31.25	28.76	45.63
IR73007-44-1-2-3	3.17**	-1.73	4.26**	3.59**	-1.18	-8.32	7.37	-15.69*	6.53**	12.53**	12.9*	10.4**	0.30	5.99**
	101.00	107.30	14.15	10.85	26.14	254.50	136.63	117.88	53.68	63.55	106.75	47.10	23.88	44.12
IR72164-352-2-5-5	-0.10	-0.20	4.16**	4.08**	-1.32	-14.79	35.35**	-50.14**	11.6**	10.63**	28.39**	14.07**	-2.45**	-0.98
	97.00	113.95	13.75	11.55	29.40	266.70	254.85	11.85	95.52	97.60	118.25	61.10	31.35	51.68
IR72910-177-1-1-3	-9.08**	-4.95**	0.39*	-1.86**	-0.44	4.18	-3.60	7.78	-5.47**	-6.71**	-14.25**	-9.77**	-1.73**	-4.70*
	86.25	112.00	12.15	6.35	30.09	224.55	168.75	55.80	75.34	57.45	78.80	35.60	21.48	45.18
R1213-3	0.7**	12.59**	0.49**	1.53**	0.64	27.45*	17.63*	9.82	-0.13	-8.21**	41.01**	7.92**	5.21**	-6.59**
	93.00	124.90	9.70	9.20	27.75	191.75	126.25	65.50	65.99	51.95	123.49	41.10	25.90	33.17
Mahsuri	1.7**	-11.88**	1.02**	1.66**	-3.04**	8.33	2.47	5.86	-5.07**	-15.46**	-8.38	-7.21**	-1.30*	-4.74*
	99.75	134.55	11.65	10.85	26.65	273.20	221.50	51.70	81.37	60.65	81.50	32.25	15.55	39.71
HR-NPT-6-3	7.28**	0.62	-3.53**	-3.42**	-3.14**	-46.14**	-33.71**	-12.42	-1.75	5.63**	-23.66**	-4.80**	-1.95**	0.19
	96.00	124.40	4.70	2.85	24.51	235.65	195.50	40.15	83.04	86.00	109.55	48.10	20.30	43.80
CRMS31A														
RRH-1	6.67**	13.37**	-2.37**	-1.48**	-1.09	35.2**	61.58**	-26.38**	21.82**	11.42**	12.52*	10.02**	2.33**	6.61**
	115.00	119.36	8.45	8.35	22.41	242.90	174.15	68.75	71.39	54.55	90.60	30.60	21.95	33.77
RRH-2	3.01**	4.69**	1.1**	2.07**	-0.73	26.85**	15.39*	11.46	-1.71	1.63	-18.30**	1.05	1.3*	8.16**
	111.75	108.80	12.40	12.30	22.12	226.75	154.80	71.95	68.61	71.25	75.99	29.55	21.50	39.48
R1557-1317-1-580-1	1.59**	-2.07	-1.60**	-0.84**	1.07	-17.34	61.56**	-78.90**	37.75**	36.98**	-24.32**	11.2**	-0.17	14.72**
	112.00	117.66	8.85	8.75	23.70	141.45	84.60	56.85	59.78	57.63	83.75	22.75	17.00	27.18
Nagina-22	-4.08**	-5.51**	-0.50**	0.67**	-0.02	15.70	-80.71**	96.41**	-38.39**	-37.19**	0.70	-11.36**	-0.79	-14.58**
	102.00	100.30	9.85	9.70	25.37	245.60	12.15	233.45	4.71	3.75	82.25	8.55	17.20	10.77
TarunBhog	-1.99**	7.2**	1.24**	1.98**	-1.14	-76.97**	-92.31**	15.34	-12.90**	-17.13**	-19.57**	-2.90	3.34**	5.69**
	104.25	102.52	10.93	10.23	24.40	205.00	122.50	82.50	59.53	48.70	62.20	25.12	25.30	40.63
R1659-3629-1-462-1	-0.74**	4.17**	0.01	0.63**	0.89	18.92	17.59*	1.34	1.77	-5.02*	4.68	4.7**	3.95**	3.79*
	91.00	103.52	10.40	10.05	26.06	229.30	152.30	77.00	66.73	51.80	79.55	35.10	27.60	44.33
Mancha	-4.83**	-14.92**	1.23**	0.51*	-2.62**	-48.92**	-100.01**	51.09**	-37.89**	-33.01**	-10.45*	-14.21**	1.10	-12.80
	92.25	80.28	13.80	13.25	22.50	184.00	12.30	171.70	6.83	5.55	76.25	12.55	22.15	16.15
R-1240-927-3-1056-1	-1.74**	-25.09**	2.13**	0.85**	-0.93	-21.40*	66.94**	-88.34**	34.37**	28.45**	-39.69**	3.52*	-0.59	12.07**
	103.00	79.88	12.18	10.91	22.23	168.85	92.98	75.88	54.82	44.25	58.25	14.55	16.60	26.25
Jaldubi	1.84**	11.06**	3.42**	2.47**	0.81	79.48**	2.38	77.11**	-6.90**	-10.39**	42.36**	3.59*	-0.42	-4.00**
	108.75	147.13	12.90	11.95	27.38	332.05	17.05	315.00	5.16	7.65	134.00	15.75	17.60	11.68
Adhamchini	-6.16**	17.85**	0.78**	-0.18	3.49**	31.25**	26.61**	4.64	2.27	-0.66	26.33**	2.39	1.90**	-9.83**
	101.00	164.84	11.75	10.65	30.71	294.60	176.50	118.10	60.06	53.25	86.15	18.45	16.35	21.42
MTU-1001	-0.58**	-20.98**	3.12**	1.92**	-1.49*	208.43**	216.66**	-8.23	17.99**	19.52**	-28.29**	-1.36	-1.36*	14.10**
	104.00	68.84	12.95	11.85	22.91	520.50	450.50	70.00	86.67	86.14	42.25	20.10	17.25	47.48
TOX 981-11-2-3	6.51**	-5.27**	2.65**	1.96**	-1.32	-53.32**	-60.77**	7.46	-8.35**	0.48	32.6**	1.80	1.82**	-10.52**
	112.75	100.90	11.65	11.50	22.77	177.50	114.25	63.25	64.25	75.00	113.50	28.75	22.25	25.35
Chinikapoor	-3.24**	5.41**	-2.32**	-2.99**	-0.39	8.50	48.39**	-39.89**	12.62**	16.91**	19.59**	5.8**	-1.65*	-1.13
	92.00	108.80	8.50	7.55	23.84	361.05	325.60	35.45	90.14	89.50	111.50	36.10	20.50	32.57
R1949-1196-2-1	-0.89**	16.03**	2.18**	2.54**	1.44*	-22.51*	-23.27**	0.76	-1.50	-0.11	-0.24	0.70	10.92**	0.64
	97.40	105.45	10.80	10.45	25.79	217.90	165.30	52.60	75.86	72.50	64.50	23.00	11.25	36.05
IR73007-44-1-2-3	-0.26	5.76**	-4.60**	-3.84**	1.22	-29.72**	-93.38**	63.66**	-37.08**	-36.44**	-9.74	-13.43**	3.20**	-13.40**
	106.10	99.35	5.80	5.85	25.23	209.50	12.25	197.25	5.30	9.00	71.10	12.25	25.30	17.53
IR72164-352-2-5-5	0.28	-4.51**	-2.55**	-2.61**	0.95	-43.19**	-0.62	-42.56**	11.74**	12.4**	-9.60	-1.76	4.18**	5.46**
	105.90	94.20	7.55	7.30	28.36	214.70	195.25	19.45	90.89	93.78	67.25	34.25	36.50	50.93

Table 3: Cont......

Hybrids	1	2	3	4	5	6	7	8	9	10	11	12	13	14
IR72910-177-1-1-3	5.24**	-5.71**	-2.02**	-0.54**	0.01	-50.57**	-36.37**	-14.19*	0.83	-2.57	-12.54*	-3.35	-3.48**	3.30*
	109.10	95.80	10.25	10.10	27.23	146.20	112.35	33.85	76.87	56.00	67.50	31.00	18.25	45.98
R1213-3	2.42**	-4.97**	-1.27**	-1.71**	0.04	-32.20**	-20.49**	-11.70	-1.94	0.53	-34.22**	-12.06**	-1.45*	-3.88**
	103.25	91.90	8.45	8.40	23.84	108.50	64.50	44.00	59.41	55.10	35.25	10.10	17.75	28.68
Mahsuri	2.17**	6.21**	-1.78**	-2.48**	-0.15	-28.67**	-9.06	19.61**	6.08**	15.88**	5.38	4.81**	-0.07	3.17
	108.75	137.20	9.35	9.15	26.23	212.60	186.35	26.25	87.74	86.40	82.25	33.25	15.30	40.41
HR-NPT-6-3	-5.24**	-2.74	1.12**	1.09**	-0.04	0.46	-0.09	0.56	-0.57	-1.69	62.8**	10.87**	-2.22**	-7.60**
	92.00	105.60	9.85	9.80	24.29	258.65	205.50	53.15	79.44	73.10	183.00	52.75	18.55	28.81
CRMS 32A														
RRH-1	-2.38*	-18.89**	-2.12**	-1.83**	1.19	-57.29**	-112.17**	54.89**	-41.19**	-37.38**	2.53	-11.72**	0.27	-15.98**
	107.75	77.45	8.45	7.21	23.73	164.55	4.50	160.05	2.63	2.40	81.05	9.60	18.05	12.01
RRH-2	-2.04**	-1.95	-0.81**	-0.28	1.31	-40.54**	-23.01**	-17.53*	4.86**	4.73*	19.28**	-10.64**	4.89**	-15.79**
	108.50	92.50	10.25	9.15	23.20	173.50	120.50	53.00	69.44	71.00	114.00	18.60	23.25	16.36
R1557-1317-1-580-1	-3.46**	5.77**	-0.71**	-0.75**	-0.17	-38.49**	-26.25**	-12.24	-15.63**	-16.65**	-4.00	-3.64*	2.97**	-5.14**
	108.75	115.85	9.50	8.05	21.50	134.45	0.90	133.55	0.64	0.65	104.50	8.65	18.30	8.14
Nagina-22	5.88**	-0.65	0.34	1.12**	-2.36**	20.01*	44.79**	-24.78**	16.33**	16.91**	17.81**	9.55**	-0.54	3.89*
	113.75	95.50	10.45	9.35	22.07	264.05	141.75	122.30	53.68	54.50	99.80	30.20	15.61	30.06
TarunBhog	-0.29	-9.74**	-1.77**	-2.63**	-2.13**	117.14**	152.34**	-35.20**	22.85**	24.78**	9.30	6.49**	-7.01**	2.68
	107.75	75.93	7.68	4.82	22.46	413.25	371.25	42.00	89.53	87.25	91.50	35.25	13.10	38.45
R1659-3629-1-462-1	-1.29**	-3.79**	1.73**	2.7**	-0.33	2.48	-5.82	8.30	-0.60	6.53**	-0.35	-0.99	1.70**	-1.41
	92.25	85.90	11.88	11.33	23.89	227.00	133.00	94.00	58.60	60.00	74.95	30.15	23.50	39.95
Mancha	1.88**	9.16**	1.18**	0.40	-1.46*	-35.46**	11.44	-46.90**	21.46**	15.9**	-9.44	-0.20	3.09**	5.30**
	100.75	94.70	13.50	12.35	22.70	211.60	127.85	83.75	60.43	51.10	77.70	27.30	22.30	35.08
R-1240-927-3-1056-1	1.96**	19.69**	-0.35	0.13	-0.44	-4.24	-28.14**	23.89**	-13.69**	-10.51**	24.13**	0.43	-4.24**	-5.08**
	108.50	115.00	9.45	9.40	21.76	200.15	2.00	198.15	1.00	1.93	122.50	12.20	11.10	9.92
Jaldubi	0.04	6.04**	-2.99**	-3.18**	-2.73**	-100.56**	24.87**	-125.43**	20.08**	29.36**	-28.32**	4.9**	1.77**	10.92**
	108.75	132.45	6.25	5.50	22.88	166.15	43.65	122.50	26.39	44.05	63.75	17.80	17.95	27.44
Adhamchini	-0.21	-1.23	1.13**	1.07**	-1.99**	-18.79	-21.00**	2.20	-0.63	3.05	-18.25**	2.10	-1.51**	13.02**
	108.75	136.10	11.85	11.10	24.27	258.70	133.00	125.70	51.42	53.60	42.00	18.90	11.10	45.09
MTU-1001	1.62**	8.74**	-1.54**	-1.78**	0.74	-131.36**	-154.10**	22.74**	-19.89**	-14.37**	17.13**	-2.75	-2.16**	-12.15**
	108.00	88.90	8.05	7.35	24.17	194.85	83.85	111.00	43.04	48.90	88.10	19.45	14.60	22.05
TOX 981-11-2-3	-4.04**	10.48**	-0.66**	-1.10**	0.55	-17.71	-45.38**	27.67**	-7.99**	-15.12**	-5.79	3.56*	-6.61**	4.89*
	104.00	107.00	8.10	7.65	23.68	227.25	133.75	93.50	58.86	56.05	75.55	31.25	11.98	41.57
Chinikapoor	4.71**	-5.68**	3.78**	3.8**	2.39**	107.31	85.69**	21.62**	5.62**	-6.49**	4.20	-2.79	-0.21	-5.27**
	101.75	87.75	14.35	13.55	25.67	474.00	367.00	107.00	77.38	62.75	96.55	28.25	20.10	29.26
R1949-1196-2-1	5.91**	-29.17**	-1.52**	-2.17**	-1.04	-15.66	-37.78**	22.12**	-6.78**	-14.20**	9.88	1.36	5.82**	-3.65
	106.00	50.60	6.85	4.95	22.35	238.90	154.90	84.00	64.83	55.05	75.05	24.40	26.15	32.58
IR73007-44-1-2-3	-2.91**	-4.03**	0.34	0.25	-0.04	38.04**	86.01**	-47.97**	30.55**	23.91**	-3.17	3.03	-3.50**	7.41**
	105.25	79.90	10.50	9.15	23.01	291.40	195.75	95.65	67.18	66.00	78.10	29.45	16.75	39.17
IR72164-352-2-5-5	-0.17	4.7**	-0.61**	-1.47**	0.37	57.97**	-34.73**	92.7**	-23.33**	-23.03**	-18.80**	-12.30**	-1.73**	-4.48**
	107.25	93.75	8.25	7.65	26.82	330.00	165.25	164.75	50.08	55.00	58.48	24.45	28.75	41.81
IR72910-177-1-1-3	3.84**	10.65**	1.63**	2.4**	0.43	46.39**	39.97**	6.42	4.64**	9.28**	26.78**	13.11**	5.21**	1.40
	109.50	102.50	13.65	12.25	26.69	257.30	192.80	64.50	74.93	64.50	107.25	48.20	25.10	44.91
R1213-3	-3.12**	-7.62**	0.78**	0.18	-0.69	4.75	2.86	1.59	2.07	7.68**	-6.80	4.15*	-3.76**	10.47**
	99.50	79.60	10.25	9.50	22.15	159.59	91.96	67.63	57.67	58.90	63.10	27.05	13.60	43.85
Mahsuri	-3.88**	5.67**	0.76**	0.82**	3.2**	20.34*	6.59	13.75	-1.01	-0.42	3.00	2.41	1.37*	1.57
	104.50	127.00	11.65	11.65	28.62	275.75	206.10	69.65	74.90	66.75	80.30	31.59	14.90	39.63
HR-NPT-6-3	-2.04**	2.12	2.41**	2.33**	3.19**	45.67**	33.80	11.87	2.32	-3.94	-39.14**	-6.07**	4.17**	7.41**
	97.00	100.80	10.90	10.25	26.56	318.00	243.50	74.50	76.59	67.50	81.50	36.55	23.10	44.64
SE (Hybrids)	0.20	1.50	0.18	0.23	0.68	9.90	7.19	7.08	1.71	2.09	5.08	1.75	0.56	1.91

* = significant of p = 0.05 level., ** = significant of p = 0.01 level; 1. Days to 50% Flowering; 2. Plant height (cm); 3. No. of Tillers; 4. Productive tillers; 5. Panicle Length(cm); 6. Spikelets/ Panicle; 7. Fertile spikelets/Panicle; 8. Sterile spikelets/panicle; 9. Spikelet Fertility (%); 10. Pollen Fertility (%); 11. Biological Yield (g); 12. Grain Yield (g); 13. 1000 grain weight (g); 14. Harvest index (%)

plant height and sterile spikelets per panicle (Table 1). But for plant height and fertile spikelets per panicle both additive and non-additive gene actions suppose to playing the role of controlling the trait. This was also reported by Annadurai and Nadaranjan (2001) and Soni *et al*. (2013). It was further supported by ratio (*s*) being less than one and degree of dominance being greater than one except days to 50% flowering and panicle length. Several workers have reported preponderance of non-additive gene action for number of tillers per plant, total number of grains per panicle and fertility percentage (Vaithiyalingan & Nadarajan, 2005), panicle length and 1000-grain weight (Punitha *et al*., 2004) and yield per plant (Sharma, 2006) The role of additive and non-additive gene effects for controlling these traits were also reported by Hong *et al*. (2002), Bisne*et al*. (2005), Mishra *et al*. (2015) and Rahimi *et al*. (2010).

Identification of parents based on mean performance and GCA effects

Mean performance of the parents and GCA effects have been given in Table 2. Significant and positive mean performance and GCA effects are preferable for all traits. It is evident that assessment of parents on the basis of mean performance and GCA effects separately, however, mean performance of the parents with nature of combining ability provides the criteria to select the parents for hybridization as suggested by Harer&Bapat (1982). On this basis, those parents who perform better for both mean performance and GCA effects have been treated as good general combiners in present study.

The Table showed that IR-58025A were produced highly

Table 4: High *sca* effects, per se performance and *gca* effects of parents for grain yield and corresponding characters

Crosses	Mean	*sca* effect	*gca* effect Line	tester	*gca* status	Characters performing high *sca* effects with grain yield
IR58025A x Mancha	52.20	14.42**	7.1**	2.04	H x H	Panicle length, spikelets per panicle, fertile spikelets per panicle.
IR58025A x IR72164-352-2-5-5	61.10	14.07**	7.1**	11.29**	H x H	No. of tillers, No. of productive tillers, sterile spikelets per panicle, biological yield.
CRMS 32A x IR72910-177-1-1-3	48.20	13.11**	-3.18**	9.62**	L x H	1000 grain weight
CRMS 31A x R1557-1317-1-580-1	22.75	11.2**	-3.92**	-13.18**	L x L	Harvest index, sterile spikelet per panicle, spikelet fertility, pollen fertility.
CRMS 31A x HR-NPT-6-3	52.75	10.87**	-3.92**	17.15**	L x H	Biological yield, days to 50% flowering.

* = significant of p = 0.05 level., ** = significant of p = 0.01 level; H = High gcaeffect; L = Low gcaeffect

significant GCA for plant height, fertile spikelet per panicle and number of spikelet per panicle, therefore this CMS line were considered as the best general combiner for the respective traits. Similarly, CRMS32A was identified as good general combiner for shorter plant height (-11.58) and sterile spikelet per panicle (6.70). Significant negative GCA effects for plant height are useful for the development of early dwarf variety. Hossain *et al.* (2009) and Salgotra*et al.*(2010) also mentioned similar report with the same parents. Results also showed that among the parental lines used in this study only IR-58025A (7.10) produced significant positive GCA for yield per plant which could be regarded as good general combiner for higher grain yield. On the other hand, for restorer, positive and significant GCA effects were found in Jaldubi for sterile spikelet per panicle (144.57), plant height (29.45), number of spikelet per panicle (17.60) and biological yield (8.28).Chinikapoor for fertile spikelet per plant (135.65) and number of spikelet per panicle (117.67)were found highly significant among all restorers. The results were in agreement with the findings of Hossain *et al.* (2009), Rashid *et al.* (2007), Singh and Kumar (2004), Malik *et al.* (2013) and Latha*et al.* (2013). Desirable GCA effects were also observed in Tarunbhog for plant height (-11.30), sterile spikelet per panicle (-26.165), fertile spikelet per panicle (73.25) and spikelet per panicle (47.09) Considering the exhibition of useful GCA effects by the restorers were identified as good general combiners for the traits concerned. However, none of parents was observed significant and positive GCA effect for grain yield, 1000 grain weight, harvest index, number of tillers, productive tellers and panicle length. These results were in accordance with the findings of Hossain *et al.* (2009). It could be mentioned that the parents with significant and positive GCA values might be contributed positive alleles in their hybrid due to its additive nature of gene action for the respective traits.

Desirable general combiners isolated in present studies for yield and its components are recommended to be used in multiple crossing programs to identify superior genotypes for development of high yielding cultivars. The GCA variance is primarily due to function of the additive genetic variance and represents a fixable portion of genetic variation. If epitasis is present, GCA also includes additive × additive type of non-allelic interaction (Singh & Narayanan, 2004). In perusal to Table 2, it was noted that high GCA effects were mostly dependant on the genetic makeup of line or tester instead of its mean performance as reported earlier in tomato (Saleem*et al.*, 2009a).

Identification of hybrids based on mean performance and SCA effects

Marilia *et al.* (2001) stated that specific combining ability (SCA) effects of hybrids alone had limited value for parental choice in breeding programme and must be used in combination with other parameters such as hybrid means and GCA of the respective parents. The hybrid combinations with high mean performance, desirable SCA estimates and involving at least one of the parent with high GCA would likely to enhance the concentration of favorable alleles (Kenga *et al.*, 2004) and this is what a breeder desires to improve a trait. Similar views have been expressed by various researchers (Thirumeni *et al.*, 2000; Manivannan and Ganesan, 2001; Gnanasekaran *et al.*, 2006) and Bhati *et al.* (2015) in rice. The identification of good specific combiners (hybrids) has been adjudged on the basis of mean performance, SCA effects estimates (Table 3) in present investigation.

The results of SCA effect of the present study are given in the Table 4. The results showed that out of 60 hybrid combinations three of them viz. CRMS32A x R1949-1196-2-1 (-29.17), CRMS31A x R-1240-927-3-1056-1 (-25.09) and CRMS31A x MTU1001 (-20.98) produced significant and negative SCA effect for shortening plant height with mean performance (50.60 to 164.84). Similarly, for growth duration seven combinations possessed significant and negative SCA with mean performance ranged from 84.75 to 115 days, which were desirable for early hybrid. In case of number of spikelets per panicle considerable magnitude of SCA effects were observed in five crosses having significant and positive SCA effect ranged from 79.48 to 208.43 where the hybrid combination CRMS31A x MTU-1001 produced the highest SCA effect. This combination could be selected for further evaluation for high yield heterosis. Six combinations possessed significant and positive SCA effect for grain yield per panicle with mean performance ranged from 8.55 to 61.10 g. per panicle. The combination IR-58025A x R-1240-927-3-1056-1 (14.42) produced the highest SCA effect followed by IR-58025A x IR72910-177-1-1-3 (14.07), CRMS32A x IR72910-177-1-1-3 (13.11), CRMS31A x R1557-1317-1-580-1 (11.20), CRMS31A x HR-NPT-6-3 (10.87) and CRMS31A x RRH-1 (10.02) for the trait. Significant and positive SCA effects were observed in nine hybrid combinations for spikelet fertility in which CRMS31AxMTU-1001 gave the highest (216.66) value.

On the other hand, five significant and positive values were found in five combinations for panicle length. Similar trends of positive and significant SCA effects were also observed in seven combinations for productive tillers. In case of pollen fertility only seven crosses range from 20.28 to 36.98 and for thousand grain weight only five crosses were found to have under significant and positive SCA effect which range from 4.79 to 10.92. The results were confirmed with the findings of Ganesen andRangaswamy (1997), Roy and Mondal (2001), Singh and Kumar (2004), Sao *et al.* (2006), Rashid *et al.* (2007) and Jhajhariа*et al.* (2013).

Specific combining ability refers chiefly to dominance variance and epistatic interaction (dominance × dominance, additive × dominance or additive × additive). It has relationship with heterosis therefore good specific combiners identified in present study for yield and its components are proposed for heterosis breeding.

Hybrids which had significant and positive SCA effects (presence of non-additive gene effects) and emerged from parents having significant and positive GCA effects can also be used for cultivar or valuable germplasm development provided that the selection of better genotypes should be postponed to later generations F_6 or F_8 to allow fixation of homozygosity for majority of the loci (Singh & Narayanan, 2004; Subbaraman&Rangaswamy, 1989; Saleem*et al.*, 2009b).

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