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IMPLICATIONS OF COMBINING ABILITY AND PER SE PERFORMANCE IN PIGEONPEA [*Cajanus cajan* (L.) Millspaugh]

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ABSTRACT

Pigeonpea is the major source of vegetable protein in Indian diet. The discovery of stable CMS system and breeding of commercial hybrids in pigeonpea has become a landmark in increasing the productivity of this crop. Keeping in view the combining ability estimates were worked out through a line x tester mating design to developed 32 F_1 hybrids using four CGMS lines ICPA-2043, ICPA-2047, ICPA-2092 with A_4 cytoplasm and BSMR-736A with A_2 cytoplasm and 8 testers ICPR-2671, ICPL-20181, BSMR-79, BSMR-175, BSMR-316, BSMR-528 and BSMR-253 and RVSA-0722 during *Kharif* 2012 at the Department of Agricultural Botany, Vasantrao Naik Marathwada Agricultural University, Parbhani. The 32 F_1s and 12 parents were planted with two replications during *kharif* 2013. The inter and intra row spacing was kept at 90 cm and 30 cm, respectively. Observations were recorded on days to 50% flowering, days to maturity, plant height (cm), number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of pods plant^{-1}, number of seeds pod $^{-1}$, test weight (g), grain yield plant^{-1} (g), harvest index (%). Statistical analysis was performed using SAS software available at ICRISAT, Patancheru. The mean performance of genotypes (parents and hybrids) for each of the characters studied was analyzed statistically, and the genotypic differences were found to be highly significant for all the characters. It indicated the presence of substantial genetic variation among the selected parental lines and their cross combinations. The variance components due to lines x testers and MSS due to hybrids were significant for all the characters. The MSS due to testers were significant for eight characters except days to maturity, number of secondary branches plant^{-1}, number of pods plant^{-1}, number of seeds pod $^{-1}$ and harvest index (%). Based on general combining ability effects three parents viz., ICPR-2671, ICPL-20181 and BSMR-175 were identified as good general combiners for grain yield plant^{-1}, which also possessed the good general combining ability effects for yield attributes like pods plant^{-1} and test weight. Based on specific combining ability effect two crosses ICPA-2047 x BSMR-175 and ICPA-2043 X ICPR-2671 were identified for their exploitation in heterosis breeding.

(Keywords: *Cajanus cajan*, general combining ability, specific combining ability)

INTRODUCTION

Pigeonpea is often cross pollinated crop and out crossing has been observed upto 70% which may be useful for the production of hybrid seed. In a hybrid breeding programme , the objective is to identify a new line that when crossed with other parents, may produce hybrids with superior performance. Combining ability analysis is frequently employed to identify the desirable parents and crosses. Therefore , it is urgently required to identify the best combiners and desirable crosses. Line x tester analysis is an extension of top cross method in which several testers are used (Kempthorne , 1957) which provides information about general and specific combining ability of parents and at the same time , it is useful in estimating various types of gene effects, besides identifying best heterotic crosses.

Cytoplasmic – genic male sterility has been used since long time to improve the yield level of pigeonpea. The discovery of stable CMS system (Saxena *et al*., 2005a) and breeding commercial hybrids in pigeonpea are a landmark achievement . This new hybrid pigeonpea breeding technology is capable of substantially increasing the productivity of pigeonpea. It is believed that the hybrid plants are naturally programmed to produce vigorous plants and greater yield. Pigeonpea hybrids showed hybrid vigour from the early seedling stage . In comparision to pure lines , the hybrids have been reported to have 18% longer radical and 15% greater seedling growth indices (Bharti and Saxena, 2012). Commercial hybrid of pigeonpea for large scale cultivation is now avaible (Saxena *et al.* 2011). Utilization of this hybrid technology in pigeonpea improvement will have

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impact in Indian pulse production (Tikle *et al*., 2015). The present investigation was conducted to study the combining ability of some cytoplasmic male sterile lines with possible restorers to exploit hybrid vigour for yield traits in pigeonpea.

MATERIALS AND METHODS

A line x tester mating design was used to develop 32 F_1 hybrids using four CGMS lines ICPA-2043, ICPA-2047, ICPA-2092 with A_4 cytoplasm, derived from *C.cajanifolius* (Saxena *et al*. 2005a) developed at ICRISAT and BSMR-736A with A_2 cytoplasm, derived from *C.scarabaeoides* (Tikka *et al*., 1997; Saxena and Kumar , 2003) from Agricultural Research Station, Badnapur ,V.N.M.A.U., Parbhani. The tester materials comprised of 2 genotypes (ICPR-2671, ICPL-20181) obtained from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru (Andhra Pradesh), 5 genotypes (BSMR-79, BSMR-175, BSMR-316, BSMR-528 and BSMR-253) from Agricultural Research Station, Badnapur, V.N.M.A.U., Parbhani. RVSA-0722 selected from local germplasm. All these 32 cross combinations were made during *kharif* 2012 in a line (4) x tester (8) mating design and sufficient number of hand pollinated seeds were produced during 2012 rainy season at the Department of Agricultural Botany, Vasantrao Naik Marathwada Agricultural University, Parbhani. The 32 F_1s and 12 parents were grown in Rndomized Block Design with two replications during *kharif* 2013 at the Department of Agricultural Botany, Vasantrao Naik Marathwada Agricultural University, Parbhani. The inter and intra row spacing was kept at 90 cm and 30 cm, respectively. Observations on five randomly selected competitive plants were recorded for days to 50% flowering, days to maturity, plant height (cm), number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of pods plant^{-1}, number of seeds pod $^{-1}$, test weight (g), grain yield plant^{-1} (g), harvest index (%). Statistical analysis was performed using SAS software available at ICRISAT, Patancheru. The general combining ability (gca) and specific combining ability (sca) variances their and effects were worked out as per the method given by Kempthorne (1957).

RESULTS AND DISCUSSION

In any breeding programme , it is necessary to identify superior genotypes, which are to be used as parents in hybridization. In this context the concept of combining ability is becoming important in plant breeding. The variance components due to lines x testers and MSS due to hybrids were significant for all the characters. The MSS due to testers were significant for eight characters, except days to maturity, number of secondary branches plant^{-1}, number of pods plant^{-1}, number of seeds pod $^{-1}$ and harvest index (%) (Table 1). The summary data of the general combining ability effects (Table 3) of the parents indicated that the the line ICPA – 2047 and the male parents ICPL –20181 (20.04), ICPR- 2671 (17.80) and BSMR – 175 (16.56) exhibited significant and positive GCA effects for plant height. The canopy development depends on the number of primary and secondary branches plant^{-1} in turn it determinate the yield. The line ICPA – 2043 (0.87) and the male parents ICPL-20181 (1.91), BSMR-175 (1.69) and ICPR-2671 (1.61) were good general combiners and possessed favourable genetic architecture for number of primary branches plant^{-1}. The data showed that BSMR-175 (7.77) had highest significant and positive GCA effect followed by ICPL-20181 (6.95) and ICPR-2671 (4.83) for number of secondary branches plant $^{-1}$. The estimates of GCA effects revealed that the line ICPA –2047 (11.10) and the male parent ICPR – 2671 (38.11) recorded the highest significant and positive GCA effects followed by BSMR – 79 (26.22) and ICPL – 20181 (21.40) for number of pods plant^{-1}. It was observed that the parents which showed high GCA effects were associated with medium to high *per se* performance. These parents appeared promising for use in breeding programme for high seed yield. The parents [ICPA-2043, ICPL-20181, BSMR-253 (0.08)] recorded the highest significant GCA effect for number of seeds pod^{-1}. Lines BSMR-736A (0.37) and ICPA – 2092 (0.07) and testers BSMR-316 (0.73) and BSMR-253 (0.64) exhibited significant and positive GCA effect for test weight (g). Singh and Shrivastava (2001) and Dalvi (2007) reported that good general combiners for 100-seed weight were the parents of the high heterotic hybrids. lines ICPA – 2092 and ICPA-2047 and the male parents ICPR- 2671, ICPL-20181 and BSMR – 175 exhibited significant and positive GCA effects for grain yield plant^{-1}. Lines ICPA – 2092 (1.28) and BSMR-736A (1.15) and the male parents ICPL – 20181 and BSMR – 175 (2.80) and 2.22 respectively recorded the highest GCA effect for harvest index. *Per se* performance of the ICPL-20181 and BSMR-175 were also high (Table 2). Reddy (1976), Narladkar and Khapre (1995), Pandey and Singh (2002) and Jahagirdar (2003) also reported similar results. They also recorded high per se performance for harvest index of pigeonpea.

Looking to the specific combining ability effects of the hybrids (Table 4) the highly significant and positive SCA effects in crosses were recorded by BSMR-736A X BSMR-79 (39.87), ICPA-2047 X RVSA-0722 (27.28) and ICPA-2043 X BSMR-253 (23.96) for plant height. It was observed that the high SCA effects in above cross combinations were from low x poor, high x high, poor x low GCA effects of parents respectively. Baskaran and Muthiah (2007) revealed that the high SCA effects of high x low combinations indicating the operation of additive x dominance gene effects and hence could be used in heterosis breeding in pigeonpea. The highest significant and positive SCA effects for number of primary branches plant $^{-1}$ regulated by crosses ICPA-2043 X ICPR-2671 (2.84), BSMR-736A X BSMR-79 (2.66) and ICPA-2047 X BSMR-175 (2.30) and highly significant and positive SCA effects were present in crosses ICPA-2047 X BSMR-175, ICPA-2043 X ICPR-2671 and ICPA-2092 X ICPL-20181 for number of secondary branches plant^{-1}. The high SCA effects among all the hybrids involved parents with high x low general combining ability .The high

Table 1. Analysis of variance for combining ability for selected characters in pigeonpea

		Mean sum of square									
Source of Variation	D.F.	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches $plant^{-1}$	Number of secondary branches $plant^{-1}$	Number of pods $plant^{-1}$	Number of seeds pod^{-1}	Test weight (g)	Grains yield $plant^{-1}$ (g)	Harvest index (%)
Replicates	1	26.09*	23.04**	155.80	0.68	4.32*	2732.55**	0.66**	0.65**	28.935	6.99*
Varieties	43	178.65**	220.05**	3025.77**	19.81**	353.72**	15309.45**	0.36**	4.10**	2282.048**	78.18**
Parents	11	11.45**	71.79**	1470.35**	1.20*	65.58**	907.54**	0.285**	2.30**	45.960**	45.21**
Parents (Line)	3	19.48*	22.55**	2561.52**	3.01**	53.24**	1364.83**	0.38**	6.11**	29.415*	78.14**
Parents (Testers)	7	9.33*	25.38**	1086.75**	0.47	76.46**	713..43**	0.22**	0.88**	7.22	34.14**
Parents (L vs T)	1	2.25	544.44**	882.09**	0.88	26.43**	894.40	0.44**	0.79**	366.72**	23.94**
Parents vs Crosses	1	15.96	32.24**	6514.90**	16.89**	222.37**	273984.50**	0.97**	13.10**	69803.27**	135.14**
Crosses	31	243.22**	278.71**	3465.14**	26.50**	460.20**	12075.50**	0.37**	4.45**	897.39**	88.04**
Line Effect	3	190.89	262.54	5108.79	35.18	400.98	5804.85	0.20	4.15	425.04	109.63
Tester Effect	7	692.64**	479.90	7223.65**	53.07*	738.53	21831.62	0.17	8.56*	2139.68**	96.51
Line * Tester Eff.	21	100.89**	213.96**	1977.50**	16.41**	375.88**	9719.27**	0.46**	3.12**	550.77**	82.13**
Error	43	4.26	2.95	96.24	0.55	0.90	239.84	0.09	0.05	8.55	1.67

*, &** =Significant at 5 % and 1 % level respectively

Table 2. *Per se* performance for yield and yield contributing characters of lines, testers, control cultivar and experimental hybrids

Sr. No.	Parents/crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches $plant^{-1}$	Number of secondary branches $plant^{-1}$	Number of pods $plant^{-1}$	Number of seeds pod^{-1}	Test weight (g)	Grains yield $plant^{-1}$ (g)	Harvest index (%)
Crosses											
1.	ICPA-2043XICPR-2671121.66	165.00	243.46	11.10	51.00	440.73	4.11	11.53	175.80	44.90	
2.	ICPA-2043XBSMR-79137.50	177.66	198.68	4.86	30.00	461.89	3.45	11.00	148.00	34.92	
3.	ICPA-2043XBSMR-175	126.66	176.50	233.13	6.75	26.66	365.37	4.21	13.20	164.11	39.31
4.	ICPA-2043XBSMR-316	134.00	174.00	214.06	6.13	25.50	355.64	4.18	12.21	145.50	34.83
5.	ICPA-2043XRVSA-0722	137.50	178.16	203.60	4.50	23.50	444.53	3.30	11.26	138.83	32.20
6.	ICPA-2043XICPL-20181	121.00	165.00	264.03	9.96	45.66	434.17	4.13	11.23	168.73	44.40
7.	ICPA-2043XBSMR-528	137.66	175.00	190.43	4.86	23.50	384.84	3.93	11.23	138.50	34.50
8.	ICPA-2043XBSMR-253	136.83	175.66	222.56	4.91	25.08	322.28	4.48	13.08	146.55	33.66
9.	ICPA-2047XICPR-2671124.33	172.00	265.05	7.03	28.80	464.01	3.75	11.26	166.20	35.58	
10.	ICPA-2047XBSMR-79136.33	176.66	227.28	5.06	25.21	424.56	3.66	11.25	145.83	34.66	
11.	ICPA-2047XBSMR-175	122.00	157.33	273.13	9.88	53.00	513.08	3.50	11.51	178.38	42.70
12.	ICPA-2047XBSMR-316	137.33	178.83	209.21	4.83	25.55	356.38	3.70	12.93	136.83	37.16
13	ICPA-2047XRVSA-0722	137.16	178.83	271.90	4.16	26.08	382.18	4.05	11.35	143.16	39.16
14	ICPA-2047XICPL-20181	124.66	173.00	256.23	6.73	28.75	426.43	4.01	11.50	164.13	38.25
15	ICPA-2047XBSMR-528	136.50	175.50	213.83	4.33	24.48	329.36	4.20	13.55	147.36	43.10
16	ICPA-2047XBSMR-253	135.00	178.16	208.70	5.00	26.28	378.83	3.91	12.46	150.66	40.88
17	ICPA-2092XICPR-2671124.83	173.00	253.66	7.10	28.93	447.77	3.65	11.88	163.55	40.10	
18	ICPA-2092XBSMR-79138.33	178.50	211.43	4.86	24.18	372.69	4.18	11.05	139.86	39.85	

Table 2. Continued....

Sr. No.	Parents/crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches $plant^{-1}$	Number of secondary branches $plant^{-1}$	Number of pods $plant^{-1}$	Number of seeds pod^{-1}	Test weight (g)	Grains yield $plant^{-1}$ (g)	Harvest index (%)
19	ICPA-2092XBSMR-175	120.83	155.00	236.98	9.23	45.00	402.42	3.95	13.01	170.70	41.55
20	ICPA-2092XBSMR-316	137.33	175.83	213.50	3.71	23.50	354.58	3.78	13.56	146.00	36.95
21	ICPA-2092XRVSA-0722	138.16	177.00	225.98	3.71	25.50	388.37	3.83	12.43	151.30	41.00
22	ICPA-2092XICPL-20181	120.83	155.66	237.15	9.75	47.00	459.31	3.93	11.36	173.90	44.25
23	ICPA-2092XBSMR-528	136.50	177.83	217.26	4.11	22.50	379.07	4.00	12.18	150.15	46.80
24	ICPA-2092XBSMR-253	137.33	179.00	190.56	5.06	24.53	390.63	3.88	12.21	151.96	33.61
25	BSMR-736AXICPR-2671	136.50	179.33	211.61	4.28	26.68	392.93	4.01	11.68	151.03	41.61
26	BSMR-736AXBSMR-79	137.33	172.33	254.56	6.91	28.78	438.72	4.00	11.28	166.10	37.66
27	BSMR-736AXBSMR-175	136.83	177.50	225.60	3.96	22.50	368.72	3.76	12.58	141.50	42.27
28	BSMR-736AXBSMR-316	134.66	176.00	215.66	3.91	23.50	337.56	3.93	12.76	134.00	41.38
29	BSMR-736AXRVSA-0722	133.00	177.33	216.88	4.46	25.50	372.16	3.75	13.30	150.56	41.36
30	BSMR-736AXICPL-20181	134.66	178.00	225.33	4.25	22.50	358.68	3.83	13.48	148.21	41.26
31	BSMR-736AXBSMR-528	137.00	179.00	198.95	4.40	23.50	411.68	3.71	11.65	147.55	36.84
32	BSMR-736AXBSMR-253	135.33	177.33	190.16	4.48	25.50	384.32	3.63	13.38	152.26	40.71
	Lines										
33	ICPA-2043	130.00	169.66	199.98	5.68	23.88	328.182	4.O3	12.46	122.66	38.50
34	ICPA-2047	130.83	169.50	222.83	5.41	30.50	321.35	4.50	11.01	119.58	38.33
35	ICPA-2092	132.66	170.50	230.10	4.98	25.03	299.77	4.10	12.83	117.30	39.00
36	BSMR-736A	134.00	173.66	185.25	4.06	25.00	334.42	3.91	10.83	119.33	31.41

Table 2. Continued....

		Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches $plant^{-1}$	Number of secondary branches $plant^{-1}$	Number of pods $plant^{-1}$	Number of seeds pod^{-1}	Test weight (g)	Grains yield $plant^{-1}$ (g)	Harvest index (%)
37	ICPR-2671	132.66	176.83	232.61	5.25	27.00	350.59	3.68	11.53	114.01	36.64
38	BSMR-79	133.00	174.00	220.58	5.00	34.50	334.61	4.01	11.31	115.48	37.22
39	BSMR-175	132.00	179.00	228.28	5.11	26.33	330.02	3.75	12.43	114.73	33.50
40	BSMR-316	129.83	176.33	209.18	5.20	23.00	314.71	4.23	11.18	114.93	38.83
41	RVSA-0722	134.16	179.00	215.68	5.75	26.50	321.56	4.13	11.36	115.75	37.41
42	ICPL-20181	132.66	178.66	230.83	5.21	25.00	324.99	3.98	11.41	115.21	40.13
43	BSMR-528	131.66	174.50	198.46	5.00	30.58	329.54	3.86	11.65	112.88	39,50
44	BSMR-253	132.00	175.00	200.08	5.65	26.20	321.21	4.10	11.61	116.45	41.05
	Checks										
45	BSMR-736	130.33	170.50	205.23	7.75	35.00	336.51	3.93	11.43	123.33	36.06
46	ICPH-2740	130.83	163.50	208.98	5.91	40.00	346.43	4.21	12.50	144.31	38.16
	Parental Mean	132.12	174.72	214.48	5.19	26.95	325.91	4.02	11.63	116.52	37.62
	Mean of crosses	132.67	173.93	225.64	5.75	29.01	398.51	3.88	12.13	153.03	39.23
	General Mean	132.52	174.14	222.6	5.60	28.45	378.52	3.92	11.99	143.07	38.79
	SE±	1.42	1.18	6.05	0.51	0.67	9.66	0.07	0.15	1.99	0.89
	CD at 5%	4.06	3.38	17.26	1.47	1.92	27.54	0.22	0.44	5.68	2.56
	CD at 1%	5.43	4.51	23.04	1.96	2.56	36.77	0.30	0.59	7.59	3.42
	CV %	1.52	0.96	3.9	13.03	3.31	3.67	2.93	1.86	1.98	3.28

Table 3. General combining ability effects (GCA) of parents for selected characters

Sr. No.	Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches $plant^{-1}$	Number of secondary branches $plant^{-1}$	Number of pods $plant^{-1}$	Number of seeds pod^{-1}	Test weight (g)	Grains yield $plant^{-1}$ (g)	Harvest index (%)
1.	ICPA-2043	-1.07**	-0.56*	-4.39**	0.87**	2.34**	2.93	0.08**	-0.29**	0.21	-1.89**
2.	ICPA-2047	-1.01**	-0.14	15.02**	0.11	0.74**	11.10**	-0.04	-0.16**	1.03**	-0.54**
3.	ICPA-2092	-0.90**	-2.45**	-2.32	0.18	1.12**	1.10	0.01	0.07*	2.88**	1.28**
4.	BSMR-736A	2.99**	3.16**	-8.29**	-1.17**	-4.21**	-15.15**	-0.05**	0.37**	-4.13**	1.15**
	Male parents										
5.	ICPR-2671	-5.84**	-1.60**	17.80**	1.61**	4.83**	38.11**	-0.007	-0.54**	11.10**	0.81**
6.	BSMR-79	4.69**	2.35**	-2.65	-0.33	-1.97**	26.22**	-0.06*	-0.99**	-3.09**	-2.45**
7.	BSMR-175	-6.09**	-7.35**	16.56**	1.69**	7.77**	14.15**	-0.03	0.44**	10.63**	2.22**
8.	BSMR-316	3.15**	2.22**	-12.53**	-1.11**	-4.50**	-47.20**	0.01	0.73**	-12.45**	-1.65**
9.	RVSA-0722	3.78**	3.89**	3.94*	-1.55**	-3.87**	-1.43	-0.15**	-0.05	-7.07**	-0.80**
10.	ICPL-20181	-7.38**	-6.02**	20.04**	1.91**	6.95**	21.40**	0.08**	-0.24**	10.70**	2.80**
11.	BSMR-528	4.24**	2.89**	-20.52**	-1.33**	-5.52**	-22.00**	0.07*	0.01	-7.14**	1.07**
12.	BSMR-253	3.44**	3.60**	-22.64**	-0.89**	-3.67**	-29.23**	0.08**	0.64**	-2.67**	-2.01**
	SE ± Gi (line)	0.43	0.36	1.80	0.17	0.17	2.17	0.02	0.04	0.38	0.28
	SE ± Gj (tester)	0.61	0.52	2.54	0.25	0.24	3.08	0.04	0.06	0.54	0.40

***,&**=Significant at 5% and 1% level respectively**

Table 4 . Specific combining ability effects (SCA) of crosses for selected characters

Sr. No.	Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches $plant^{-1}$	Number of secondary branches $plant^{-1}$	Number of pods $plant^{-1}$	Number of seeds pod^{-1}	Test weight (g)	Grains yield $plant^{-1}$ (g)	Harvest index (%)
2.	ICPA-2043XBSMR-79	1.19	1.93*	-19.91**	-1.43**	0.61	34.48	-0.46**	0.14	-2.16	0.03
3.	ICPA-2043XBSMR-175	1.15	10.47**	-4.68	-1.58**	-12.46**	-49.96**	0.27**	0.91**	0.22	-9.25
4.	ICPA-2043XBSMR-316	-0.76	-1.60*	5.35	0.60	-1.35**	1.66	0.19**	-0.36**	4.70**	-0.85
5.	ICPA-2043XRVSA-0722	2.11*	0.89	-21.59**	-0.58	-3.98**	44.78**	-0.52**	-0.52**	-7.34**	-4.34**
6.	ICPA-2043XICPL-20181	-3.21**	-2.35**	22.74**	1.41**	7.34**	11.58	0.06	-0.36**	4.77**	4.24**
7.	ICPA-2043XBSMR-528	1.82*	-1.27	-10.29**	-0.43	-2.33**	5.67	-0.11*	-0.62**	-7.60**	-3.92**
8.	ICPA-2043XBSMR-253	1.78*	-1.31	23.96**	-0.82*	-2.60**	-49.67	0.41**	0.58**	-4.02**	-1.66**
9.	ICPA-2047XICPR-2671	-1.49	-0.18	6.57	-0.46	-5.80**	16.53**	-0.09	-0.16	1.02	-5.92**
10.	ICPA-2047XBSMR-79	-0.03	0.52	-10.73**	-0.48	-2.57**	-11.01	-0.11*	0.26**	-5.14**	-1.56**
11.	ICPA-2047XBSMR-175	-3.57**	-9.10**	15.89**	2.30**	15.45**	89.57**	-0.31**	-0.90**	13.67**	1.78**
12.	ICPA-2047XBSMR-316	2.51**	2.81**	-18.91**	0.06	0.28	-5.76	-0.16**	0.22*	-4.78**	0.12
13	ICPA-2047XRVSA-0722	1.71	1.14	27.28**	-0.16	0.18	-25.73**	0.35**	-0.57**	-3.83**	1.27*
14	ICPA-2047XICPL-20181	0.38	5.22**	-4.47	-1.06**	-7.97**	-4.32	0.07	-0.23**	-0.64	-3.24**
15	ICPA-2047XBSMR-528	0.59	-1.18	-6.31	-0.21	0.23	-57.98	0.27**	1.55**	0.44	3.33**
16	ICPA-2047XBSMR-253	-0.11	0.77	-9.32*	0.01	0.18	-1.29	-0.02	-0.16	-0.72	4.20**
17	ICPA-2092XICPR-2671	-1.09	3.12**	12.54**	-0.46	-6.04**	10.30	-0.24**	0.21*	-3.48**	-1.23*
18	ICPA-2092XBSMR-79	1.86*	4.66**	-9.23*	-0.74*	-3.98**	-52.88**	0.34**	-0.17	-12.97**	1.79**
19	ICPA-2092XBSMR-175	-4.84**	-9.12**	-2.90	1.59**	7.08**	-11.08	0.08	0.36**	4.13**	-1.19*
20	ICPA-2092XBSMR-316	2.40**	2.12**	2.71	-1.11**	-2.13**	2.43	-0.12*	0.62**	2.52*	-1.91**
21	ICPA-2092XRVSA-0722	2.61**	1.62*	-1.28	-0.67	-0.76*	-9.55	0.08	0.27**	2.44*	1.28*
22	ICPA-2092XICPL-20181	-3.55**	-9.79**	-6.21	1.89**	9.89**	38.55**	-0.05	-0.60**	7.26**	0.92
23	ICPA-2092XBSMR-528	0.49	3.45**	14.47**	-0.49	-2.11	1.72	0.02	-0.04	1.36	5.21**
24	ICPA-2092XBSMR-253	2.11*	3.91**	-10.10**	0.01	-1.93**	20.50**	-0.10	-0.64**	-1.28	-4.88**
25	BSMR-736AXICPR-2671	6.67**	3.83**	-23.53**	-1.91**	-2.95**	-28.28**	0.19**	-0.28**	-8.97**	0.40
26	BSMR-736AXBSMR-79	-3.03**	-7.12**	39.87**	2.66**	5.95**	29.40**	0.23**	-0.24**	20.28**	-0.26
27	BSMR-736AXBSMR-175	7.26**	7.75**	-8.31*	-2.31**	-10.07**	-28.52**	-0.03	-0.37**	-18.03**	-0.34
28	BSMR-736AXBSMR-316	-4.15**	-3.33**	10.85**	0.44	3.20**	1.67	0.09	-0.48**	-2.44*	2.64**
29	BSMR-736AXRVSA-0722	-6.44**	-3.66**	-4.41	1.43**	4.56**	-9.49	0.07	0.83**	8.73**	1.77**
30	BSMR-736AXICPL-20181	6.38**	6.91**	-12.05**	-2.24**	-9.26**	-45.81	-0.08	1.21**	-11.39**	-1.93**
31	BSMR-736AXBSMR-528	-2.90**	-1.00	2.12	1.14**	4.21**	50.59**	-0.18**	-0.88**	5.79**	-4.62**
32	BSMR-736AXBSMR-253	-3.78**	-3.37**	-4.53	0.79*	4.36**	30.45**	-0.28	0.21*	6.04**	2.34**
	S. E. ± Crosses	1.22	1.04	5.09	0.50	0.48	6.16	0.08	0.12	1.09	0.80

x low combinations indicated the operation of additive x dominance gene effects and hence could be used in heterosis breeding. Crosses ICPA-2047 X BSMR-175 (89.57), BSMR-736A X BSMR-528 (50.59) and ICPA-2043 X RVSA-0722 (44.78) showed the highest significant and positive SCA effects for number of pods plant^{-1}. High x high, low x high, high x low general combiners were present in above cross combinations respectively. Also high SCA effects showing hybrids for number of pods plant $^{-1}$ had medium x high, high x low and high x average performing parents. Significant and positive SCA effects were present in crosses ICPA-2043 x BSMR-253 (0.41), ICPA-2047 X RVSA-0722 (0.35) and ICPA-2092 X BSMR-79 (0.34) for number of seeds pod^{-1}. The highest significant and positive SCA effects were registered by crosses ICPA-2043 X BSMR-528 (1.55), BSMR-736A X ICPL-20181 and ICPA-2043 X BSMR-175 (0.91 for test weight. Most of the hybrids showing significant and positive SCA effects combined with one good and one poor and such hybrids could produce desirable transgressive segregants if the additive genetic system present in the good combiners and the complementary epistatic effects in the F_1s act in the same direction to maximize the desirable plant attributes. Higher estimates of SCA effects were usually recorded in those hybrids which involved high and significant *per se* performance. In the present study the crosses BSMR-736A x BSMR-79 (20.28), ICPA-2047 x BSMR-175 (13.67) and ICPA-2043 X ICPR-2671 (11.44) showed the highest significant and positive specific combining ability (SCA) effects for grain yield plant^{-1} . Same crosses ICPA-2047 X BSMR-175 and ICPA-2043 X ICPR-2671 had superior *per se* performance. The high SCA effects in hybrids were due to low x high, high x low and low x high general combiners which gave significant SCA effects thereby indicating the involvement of non-allelic interactions. Vannirajan *et al*. (1999), reported that some of the cross combinations having parents with high x low and low x high general combining ability (GCA) effects also produced significant SCA effects. The data showed that highly significant and positive SCA effects were present in crosses ICPA – 2043 x ICPR – 2671, ICPA – 2092 x BSMR – 528 and ICPA – 2043 x ICPL – 20181 for harvest index (%).

From this study it is observed that the good combining parents viz., ICPR-2671, ICPL-20181 and BSMR-175 had the ability to produce higher yield and also higher pods^{-1} plant^{-1}, number of branches plant $^{-1}$ by imparting desirable genes in the progeny on crossing with diverse lines. Specific combining ability effects revealed that crosses ICPA-2047 x BSMR-175 (13.67) and ICPA-2043 X ICPR-2671 (11.44) were the two best cross combinations expressed significant SCA effects for grain yield plant^{-1} involving high x low and low x high parental interaction , respectively. These cross combinations also recorded significant SCA effects for branches plant^{-1} , number of pods plant^{-1} and test weight.

Therefore, these cross combinations may be utilized for their large-scale testing and general adaptability and for commercial exploitation.

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