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STUDY OF HETEROSIS FOR YIELD AND YIELD CONTRIBUTING TRAITS ON CGMS BASED PIGEONPEA [*Cajanus cajan* (L.) Millspaugh] HYBRIDS

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ABSTRACT

Heterosis is the most important phenomenon for breaking the yield barrier level of crops. Hence, an experiment was undertaken to identify the best heterotic combinations for exploitation of heterosis or hybrid vigour. A line x tester mating design was used to develop 32 F_1 hybrids 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 , 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. Out of 32 crosses studied, 9 for days to 50 % flowering, 5 for days to maturity, 17 for plant height, 5 for number of primary branches plant^{-1}, 5 for number of secondary branches plant^{-1}, 29 for number of pods plant^{-1}, 7 for number of seeds pod^{-1}, 18 for test weight, 32 for grain yield plant^{-1} and 20 for harvest index recorded significant heterosis in desirable direction. From this study out of 32 crosses two promising crosses ICPA-2047 x BSMR-175 (44.64 %, 23.61 %), ICPA-2043 x ICPR-2671 (42.54 %, 21.82 %) were identified which were superior to standard checks BSMR-736 and ICPH-2740 respectively. Similarly, parent BSMR-316 for days to 50% flowering, ICPA-2047 days to maturity, ICPA-2043 for grain yield plant^{-1} were identified. Therefore, these crosses and parents could be exploited for heterosis breeding programme to boost up the seed yield and its component traits in pigeonpea.

(Key words : Pigeonpea, *Cajanus cajan*, hybrid vigour, standard heterosis, yield and yield attributes)

INTRODUCTION

Pigeonpa [*Cajanus cajan* (L.) Millspaugh] is also known as Redgram, Tur or Arhar. It is the second most important pulse crop after chickpea in India and rank fifth in the world. It belongs to the family Leguminaceae, subfamily papilionaceae and cultivated as food crop of the sub tribe Cajaninae. The quantum jump in yield potential observed in some crops in the past was primarily due to commercial exploitation of a single genetic phenomenon, commercially known as "hybrid vigour" or "heterosis" (Saxena and Sharma, 1990). It has become amply clear that most self pollinated crops also exhibit similar extent of heterosis as in case of cross pollinated crops. In pulses, for exploitation of heterosis or hybrid vigour either we have to use male sterility or in a normal bisexual flower, hybrids can be made. In pigeonpea genetic male sterility (GMS) was already exploited to produce hybrids. Several heterotic cross combinations were found in GMS – based hybrids. The range of commercial heterosis (standard heterosis) was 20 – 100%. This showed the potential of hybrid breeding technology in leguminous crop like pigeonpea. The development of CMS lines in pigeonpea made it easy to develop hybrids and exploit the hybrid vigour commercially. Heterosis over standard check is important than other types of heterosis, however, in some cases heterobeltiosis is also preferred. The primary data of experimental pigeonpea hybrids evaluated at ICRISAT and various ICAR centers showed that now the technology for exploiting heterosis at commercial level is

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available, which could be exploited effectively to breed heterotic hybrid (Saxena *et al*., 2006b).

Heterosis express the superiority of F_1 hybrid over its mid parental value in terms of yield and other characters. Heterobeltosis is the estimate of the superiority of F_1 hybrid over its better parent out of two parents involved in the particular crosses. Standard heterosis expresses the superiority of F_1 hybrid over its standard commercial check variety or hybrids. Exploitation of hybrid vigour is known to be one of the outstanding achievements of plant breeding. The study of magnitude and direction of heterosis are very important to know the potential of hybrids.

Pigeonpea has been considered technically suitable for heterosis breeding due to predominance of non-additive genetic variance for the traits like grain yield and other important yield components. Keeping in view the above aspects, present experiment was undertaken to identify the out yielding effects of hybrids for various agronomic traits and their possible exploitation for commercial use.

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 and 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 planted in 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 data were subjected to analysis for various characters for mean performance of parents and their hybrids and heterosis (Kempthrone, 1957).

RESULTS AND DISCUSSION

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 (Table 1).

Intermediate growth and early flowering are considered desirable trait in pigeonpea. Hybrids ICPA-2092 X BSMR-175 (-7.29), ICPA-2092 X ICPL-20181 (-7.29), ICPA-2043 X ICPL-20181(-7.16), ICPA-2043 X ICPR-2671(-6.65) over the check BSMR-736 with the range of -2.81 (ICPA-2043 X BSMR-175) to 6.14 (ICPA-2092 X BSMR-79) and crosses ICPA-2047 X ICPL-20181 (-4.71), ICPA-2092 X ICPR-2671 (-4.59) and ICPA-2043 X BSMR-175(-3.18) over the check ICPH-2740 with the range -3.18 (ICPA-2043 X BSMR-175) to 5.73 (ICPA-2092 X BSMR-79) showed significant and negative heterosis for days to 50% flowering. The significant and negative heterosis for days to flower was reported earlier by Chaudhari (1979), Singh *et al*. (1989) and Pandey and Singh (2002). The significant and negative heterosis in hybrids for days to 50% flower on all the three bases of estimation in pigeonpea were reported by Patel and Tikka (2008), Chandirakala *et al*. (2010) and Shoba and Balan (2010). The hybrids having negative significant heterosis had both parents with significant and negative heterosis for days to 50% flowering in the hybrids based on the genetic male-sterility system where as Khandalkar (2007) reported negative heterosis in CMS based hybrids showing preference for the early flowering hybrids. In general high heterotic estimates for days to maturity were observed in the crosses involving female parent ICPA-2092 followed by ICPA-2047 and ICPA-2043. Crosses ICPA-2092 X BSMR-175 (-9.09), ICPA-2092 X ICPL-20181 (-8.70) and ICPA-2047 X BSMR-175 (-7.72) showed significant and negative heterosis over the check BSMR-736 with the range of -3.43 (ICPA-2043 X ICPR-2671) to 5.18 (BSMR-736A X ICPR-2671) for days to maturity. Crosses ICPA-2092 X BSMR-175 (-5.20%), ICPA-2092 X ICPL-20181 (-4.79%) and ICPA-2047 X BSMR-175 (-3.77%) showed significant and negative heterosis over the check ICPH-2740 and its range was -3.77 (ICPA-2047 X BSMR-175) to 9.68 (BSMR-736A X ICPR-2671) for days to maturity. It was observed that, early maturing crosses included early maturing parents. The similar results for early maturing hybrids having at least one or both early maturing parents were reported by Kalaimagal and Ravikesavan (2003), Patel and Tikka (2008), Chndirakala *et al*., (2010) and Shoba and Balan (2010). They registered significant and negative heterosis in crosses on all the three bases of estimation in their studies. The maximum increase being noticed in cross ICPA-2047 X BSMR-175 followed by ICPA-2047 X RVSA-0722 and ICPA-2047 X ICPR -2671 over the checks BSMR-736 and ICPH-2740. Most of the crosses, particularly those with high standard heterosis also had the best F_1 *per se* performance (Table 2). Pandey and Singh (2002) reported negative standard heterosis for plant height in pigeonpea. As indeterminate growth habit is preferred over determinate, the plant height signifies its importance in yield. Significant and positive heterosis was reported by Wankhede *et al*. (2005) for plant height. Chandirakala *et al*. (2010) reported significant and negative heterosis for plant height on all the three bases of estimation. The number of branches favorably contributed to increasing the yield of the hybrid. Crosses ICPA-2043 X ICPR-2671 (43.23), ICPA-2043 X ICPL-20181(28.60), ICPA-2047 X BSMR-175 (27.53) exhibited the highest significant and positive heterosis over the check BSMR-736 with the range of -9.25 (ICPA-2047 X ICPR-2671) to 43.23 (ICPA-2043 X ICPR-2671) and hybrids ICPA-2043 X ICPR-2671 (87.61), ICPA-2043 X ICPL-20181 (68.45) and ICPA-2047 X BSMR-175 (67.04) exhibited the highest significant and positive heterosis over the check ICPH-2740 with the range of -14.37 (ICPA-2092 X BSMR-253) to 87.61 (ICPA-2043 X ICPR-2671) for number of primary branches plant $^{-1}$. Singh *et al*. (1989) reported that the hybrids which showed heterosis for primary branches also had heterosis for pods plant^{-1} and seed yield. Narladkar and Khapre (1996) and Pandey and Singh (2002) also reported significant and positive heterosis for number of primary branches plant^{-1}. Aher *et al*. (2006) reported the range of heterosis over mid parent and better parent for number of primary branches plant^{-1} from -1.10 to 3.15% and from -2.9% to 2.4% respectively. They revealed that the presence of significant heterosis over better parent in hybrid BDN-2 X BDN-2010 may be due to presence of dominance and additive x additive gene effects. Similar findings were also reported in pigeonpea by Patel and Tikka (2008) for number of branches plant^{-1}. Chandirakala *et al*. (2010) reported the range of heterosis from -23.69 to 29.33% over mid parent, from -42.83 to 28.87% over better parent and from -24.89-47.49% over standard check. The parents of heterotic hybrids had high *per se* performance as well as high general combining ability for number of primary branches. Crosses ICPA-2047 X BSMR-175 (51.43) , ICPA-2043 X ICPR-2671 (45.71) ICPA-2043 X ICPL-20181 (30.48) exhibited the highest significant and positive heterosis over the check BSMR-736 with the range of -14.29 (ICPA-2043 X BSMR-79) to 51.43 (ICPA-2047 X BSMR-175) and crosses ICPA-2047 X BSMR-175 (32.50) , ICPA-2043 X ICPR-2671 (27.50) and ICPA-2092 X ICPL-20181 (17.50) show significant and positive heterosis over the check ICPH-2740 with the range of -25.00 (ICPA-2043 X BSMR-79) to 32.50 (ICPA-2047 X BSMR-175) for number of secondary branches plant $^{-1}$. Pandey and Singh (2002) observed positive heterosis for number of secondary branches plant^{-1}. The number of pods plant^{-1} a principle components of yield exhibited higher magnitude of heterosis is generally positive for number of pods plant^{-1} in pigeonpea. Heterosis for number of pod plant^{-1} was estimated over the check which showed maximum number of pods to the respective location. Hybrids ICPA-2047 X BSMR-175(52.47), ICPA-2047 X ICPR-2671(37.89) and ICPA-2043 X BSMR-79 (37.26) showed significant and positive heterosis over the check BSMR-736 with the range of -2.12 (ICPA-2047 X BSMR-528) to 52 .47 (ICPA-2047 X BSMR-175). Crosses ICPA-2047 X BSMR-175 (48.10), ICPA-2047 X ICPR-2671 (33.94) and ICPA-2092 X ICPL-20181 (32.58) with the range of -2.56 (BSMR-736A X BSMR-316) to 48.10 (ICPA-2047 X BSMR-175) for number of pods plant^{-1}. Similar to this results Tutesa *et al*. (1992) reported the highest heterosis of 116.2% in hybrid H73-20 x EE-76 x UPAS- 120 for pods plant^{-1}. Narladkar and Khapre (1996) reported that heterosis for grain yield was due to total number of pods plant^{-1}. Wanjari *et al*. (2007) reported that positive heterosis could be useful for further exploitation. Patel and Tikka (2008) and Chandirakala *et al*. (2010) showed the heterosis for this trait ranged from 3.34 to 48.86%, -3.88 to 32.84% and 5.41 to 98.26% over mid, better and standard parent respectively. Hybrid MS CO 5 x ICPL 88009 showed the highest significant and positive heterosis of 42.06, 25.45 and 98.26% on all the three bases of estimation viz., mid parent, better parent and standard parent respectively. Cross ICPA-2043 X BSMR-253 (13.98 %, 6.32 %) showed significant and positive heterosis over the check BSMR-736 and ICPH-2740 respectively for number of seeds pod $^{-1}$. Sinha *et al*. (1994) and Patel *et al*. (1992) reported very less heterosis for seeds pod^{-1} in pigeonpea. Patel and Patel (1992) revealed that heterotic response for seeds pod^{-1} was marginal with negative effect. It was observed that crosses ICPA-2092 x BSMR-316 (18.66%, 8.53%), ICPA-2047 x BSMR-528 (18.51 %, 8.40 %), BSMR-736A x ICPL-2018 (7.87 %, 17.93 %) showed significant and positive heterosis over the check BSMR-736 and ICPH-2740 respectively for test weight (g). Similar hybrids had also high *per se* performance for 100 seed weight. Wankhede *et al*. (2005), Khandalkar (2007) and Dalvi (2007) recorded positive standard heterosis in pigeonpea for 100-seed weight. They reported highest heterosis of 10.11% over standard check. For yield, heterosis of 40% and above over the standard check is considered significant from practical point of view in most of the crop. In the present study, the heterosis over standard check BSMR 736 and ICPH 2740 was estimated. Fairly conspicuous vigour was noticeable in few hybrids which represents the best combinations of the two parents. The higher heterotic estimates were observed in the hybrids involving female parent ICPA 2092, followed by ICPA 2047 and ICPA 2043. Significant and highly positive heterosis was observed with hybrids ICPA-2047 x BSMR-175 (44.64, 23.61), ICPA-2043 x ICPR-2671 (42.54 %, 21.82 %), ICPA-2092 x ICPL-20181 (41.00 % , 20.50 %) with the range of 44.64% (ICPA-2047 X BSMR-175) to 8.65 % (BSMR-736A X BSMR-316) and -0.80 % (ICPA- 2047 X RVSA-0722) to 23.61 (ICPA-2047 X BSMR-175) over the check BSMR-736 and ICPH-2740 respectively for grain yield plant $^{-1}$. From the studies of heterosis, it was observed that the parents who had high *per se* performance produced higher heterotic values for grain yield in hybrids ICPA-2047 x BSMR-175, ICPA-2043 x ICPR-2671 and ICPA-2092 x ICPL-20181 (Table 2). The parents BSMR-175, ICPR-2671, ICPL-20181 were found to be most promising and need to be assessed for their utility in combination with existing male sterile lines. The parental lines involved in these heterotic cross combinations were from medium to high *per se* performance. The heterosis over standard checks were in consonance with the findings Pandey and Singh (2002) and Yadav and Singh (2004). Sekhar *et al*. (2004) reported heterosis of 40% over standard check in pigeonpea. Saxena *et al*. (2006 b) and Wanjari *et al*. (2007) reported the heterosis over standard check in positive direction. Khandalkar (2007) reported significant highest positive heterosis of 155.7% over standard check for grain yield in CMS based hybrids of pigeonpea. Dheva *et al*. (2008 a and b) observed the desirable range of heterosis 0.72 % to 57.35 % and 5.12 % to 28.20% over the standard check for grain yield plant^{-1}. CGMS based hybrids in extra short, short and medium maturity groups have recorded grain yield superiority of 61% over the best check cultivar in different locations across India (Saxena, 2008). Kumar *et al*. (2009a) observed the highest significant and positive heterosis of 51.38% for the hybrid LRG-30 x ICP-8863 over standard check for seed yield plant^{-1}. Chandirakala *et al*. (2010) and Shoba and Balan (2010) reported the significant and positive standard heterosis for yield plant $^{-1}$ in their studies. Saxena and Nadarajan (2010) reported 30% yield advantage of pigeonpea hybrid ICPH 2671 over local varieties in on-farm trials conducted in five states of India.

Crosses ICPA-2092 x BSMR-528 (22.63%), ICPA-2043 x ICPR-2671 (17.66%) and ICPA-2043 x ICPL-20181 (16.33%) showed significant and positive heterosis over the check ICPH-2740 and its range was -1.31 % (BSMR-736A X BSMR-79) to 22.63 % (ICPA-2092 X BSMR-528) for harvest index. Hybrids ICPA-2092 X BSMR-528 (29.77 %), ICPA-2043 X ICPR-2671 (24.51 %) and ICPA- 2043 X ICPL-20181 (23.11 %) showed significant and positive heterosis over BSMR-736 and its range was -3.17 % (ICPA-2043 X BSMR-79) to 29.77 % (ICPA-2092 X BSMR-528) for harvest index. These findings are in agreement with Marekar (1982) and Pandey and Singh (2002). They reported that most of the highly heterotic crosses had best F_1s *per se* performance.

The result of the present study indicated that high heterotic effects for economic yield and other associated characters, measures the feasibility of commercial cultivation of hybrids. Out of 32 crosses studied, 9 for days to 50 % flowering, 5 for days to maturity, 17 for plant height, 5 for number of primary branches plant^{-1}, 5 for number of secondary branches plant^{-1}, 29 for number of pods plant^{-1}, 7 for number of seeds pod^{-1}, 18 for test weight, 32 for grain yield plant^{-1} and 20 for harvest index recorded significant heterosis in desirable direction. As the result of the present study indicated that selection for developing high yielding varieties should be made by crossing BSMR-316 (123.83 days) for days to 50% flowering, ICPA-2047 (169.50 days) days to maturity, ICPA-2043 (122.66 gm) for grain yield plant $^{-1}$. In case of hybrid breeding programme high heterotic effects for economic yield and other associated characters, measures the feasibility of commercial cultivation of hybrids. From this study out of 32 hybrids two promising crosses ICPA-2047 x BSMR-175 (44.64, 23.61), ICPA-2043 x ICPR-2671 (42.54 %, 21.82 %) were identified which were superior to standard checks BSMR-736 and ICPH-2740 respectively. Therefore, these crosses and parents could be exploited for heterosis breeding programme to boost up the seed yield and its component traits in pigeonpea.

Table 1 . Analysis of variance for different characters in pigeonpea

		Mean sum of square									
Source of variation	DF	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 (%)
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 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)	Grain yield plant $^{-1}$ (g)	Harvest index (%)
	Crosses										
1.	ICPA-2043XICPR-2671	121.66	165.00	243.46	11.10	51.00	440.73	4.11	11.53	175.80	44.90
2.	ICPA-2043XBSMR-79	137.50	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-2671	124.33	172.00	265.05	7.03	28.80	464.01	3.75	11.26	166.20	35.58
10.	ICPA-2047XBSMR-79	136.33	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-2671	124.83	173.00	253.66	7.10	28.93	447.77	3.65	11.88	163.55	40.10
18	ICPA-2092XBSMR-79	138.33	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)	Grain 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..

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)	Grain yield plant $^{-1}$ (g)	Harvest index (%)
	Testers										
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
	S.E. ±	1.42	1.18	6.05	0.51	0.67	9.66	0.07	0.15	1.99	0.89
	C.D. at 5%	4.06	3.38	17.26	1.47	1.92	27.54	0.22	0.44	5.68	2.56
	C.D. at 1%	5.43	4.51	23.04	1.96	2.56	36.77	0.30	0.59	7.59	3.42
	C.V. %	1.52	0.96	3.9	13.03	3.31	3.67	2.93	1.86	1.98	3.28

Table 3 . Standard heterosis for yield and yield contributing characters in pigeonpea hybrids

Sr. No.	Crosses	Days to 50% flowering		Days to maturity		Plant height (cm)		Number of primary branches		Number of secondary branches	
		BSMR7	ICPH27	BSMR7	ICPH27	BSMR7	ICPH27	BSMR7	ICPH27	BSMR7	ICPH27
1	ICPA-2043XICPR-2671	-6.65**	-7.01**	-3.23**	0.92	18.63**	16.50**	43.23**	87.61**	45.71**	27.50**
2	ICPA-2043XBSMR-79	5.50**	5.10**	4.20**	8.66**	-3.19	-4.93*	-37.20**	-17.75*	-14.29**	-25.00**
3	ICPA-2043XBSMR-175	-2.81**	-3.18**	3.52**	7.95**	13.59**	11.56**	-12.90*	14.08	-23.81**	-33.33**
4	ICPA-2043XBSMR-316	2.81**	2.42*	2.05**	6.42**	4.30	2.43	-20.86**	3.66	-27.14**	-36.25**
5	ICPA-2043XRVSA-0722	5.50**	5.10**	4.50**	8.97**	-0.80	-2.58	-41.94**	-23.94**	-32.86**	-41.25**
6	ICPA-2043XICPL-20181	-7.16**	-7.52**	-3.23**	0.92	28.65**	26.34**	28.60**	68.45**	30.48**	14.17**
7	ICPA-2043XBSMR-528	5.63**	5.22**	2.64**	7.03**	-7.21**	-8.88**	-37.20**	-17.75*	-32.86**	-41.25**
8	ICPA-2043XBSMR-253	4.99**	4.59**	3.03**	7.44**	8.45**	6.50**	-36.56**	-16.90*	-28.33**	-37.29**
9	ICPA-2047XICPR-2671	-4.60**	-4.97**	0.88	5.20**	29.15**	26.83**	-9.25	18.87*	-17.71**	-28.00**
10	ICPA-2047XBSMR-79	4.60**	4.20**	3.62**	8.05**	10.74**	8.76**	-34.62**	-14.37	-27.95**	-36.96**
11	ICPA-2047XBSMR-175	-6.39**	-6.75**	-7.72**	-3.77**	33.08**	30.70**	27.53**	67.04**	51.43**	32.50**
12	ICPA-2047XBSMR-316	5.37**	4.97**	4.89**	9.38**	1.94	0.11	-37.63**	-18.31*	-27.00**	-36.13**
13	ICPA-2047XRVSA-0722	5.24**	4.84**	4.89**	9.38**	32.48**	30.11**	-46.24**	-29.58**	-25.48**	-34.79**
14	ICPA-2047XICPL-20181	-4.35**	-4.71**	1.47*	5.81**	24.85**	22.61**	-13.12*	13.80	-17.86**	-28.12**
15	ICPA-2047XBSMR-528	4.73**	4.33**	2.93**	7.34**	4.19	2.32	-44.09**	-26.76**	-30.05**	-38.79**
16	ICPA-2047XBSMR-253	3.58**	3.18**	4.50**	8.97**	1.69	-0.14	-35.48**	-15.49	-24.90**	-34.29**
17	ICPA-2092XICPR-2671	-4.22**	-4.59**	1.47*	5.81**	23.60**	21.38**	-8.39	20.00*	-17.33**	-27.67**
18	ICPA-2092XBSMR-79	6.14**	5.73**	4.69**	9.17**	3.02	1.17	-37.20**	-17.75*	-30.90**	-39.54**
19	ICPA-2092XBSMR-175	-7.29**	-7.64**	-9.09**	-5.20**	15.47**	13.40**	19.14**	56.06**	28.57**	12.50**
20	ICPA-2092XBSMR-316	5.37**	4.97**	3.13**	7.54**	4.03	2.16	-52.04**	-37.18**	-32.86**	-41.25**
21	ICPA-2092XRVSA-0722	6.01**	5.61**	3.81**	8.26**	10.11**	8.13**	-52.04**	-37.18**	-27.14**	-36.25**
22	ICPA-2092XICPL-20181	-7.29**	-7.64**	-8.70**	-4.79**	15.55**	13.48**	25.81**	64.79**	34.29**	17.50**
23	ICPA-2092XBSMR-528	4.73**	4.33**	4.30**	8.77**	5.86*	3.96	-46.88**	-30.42**	-35.71**	-43.75**
24	ICPA-2092XBSMR-253	5.37**	4.97**	4.99**	9.48**	-7.15**	-8.81**	-34.62**	-14.37	-29.90**	-38.67**
25	BSMR-736AXICPR-2671	4.73**	4.33**	5.18**	9.68**	3.11	1.26	-44.73**	-27.61**	-23.76**	-33.29**
26	BSMR-736AXBSMR-79	5.37**	4.97**	1.08	5.40**	24.04**	21.81**	-10.75	16.90*	-17.76**	-28.04**
27	BSMR-736AXBSMR-175	4.99**	4.59**	4.11**	8.56**	9.92**	7.95**	-48.82**	-32.96**	-35.71**	-43.75**
28	BSMR-736AXBSMR-316	3.32**	2.93**	3.23**	7.65**	5.08*	3.20	-49.46**	-33.80**	-32.86**	-41.25**
29	BSMR-736AXRVSA-0722	2.05*	1.66	4.01**	8.46**	5.68*	3.78	-42.37**	-24.51**	-27.14**	-36.25**
30	BSMR-736AXICPL-20181	3.32**	2.93**	4.40**	8.87**	9.79**	7.82**	-45.16**	-28.17**	-35.71**	-43.75**
31	BSMR-736AXBSMR-528	5.12**	4.71**	4.99**	9.48**	-3.06	-4.80**	-43.23**	-25.63**	-32.86**	-41.25**
32	BSMR-736AXBSMR-253	3.84**	3.44**	4.01**	8.46**	-7.34**	-8.31**	-42.15**	-24.23**	-27.14**	-36.25**

Table 3. Continued..

Sr. No.	Crosses	Number of pods $plant^{-1}$		Number of seeds pod^{-1}		Test weight (g)		Grain yield $plant^{-1}$ (g)		Harvest index (%)	
		BSMR736	ICPH2740	BSMR736	ICPH2740	BSMR736	ICPH2740	BSMR736	ICPH2740	BSMR736	ICPH27
1	ICPA-2043XICPR-2671	30.97**	27.22**	4.66*	-2.37	0.87	-7.73**	42.54**	21.82**	24.51**	17.66**
2	ICPA-2043XBSMR-79	37.26**	33.33**	-12.29**	-18.18**	-3.79**	-12.00**	20.00**	2.55*	-3.17	-8.50**
3	ICPA-2043XBSMR-175	8.58**	5.47*	7.20**	0.00	15.45**	5.60**	33.07**	13.72**	9.01**	3.01
4	ICPA-2043XBSMR-316	5.68*	2.66	6.36**	-0.79	6.85**	-2.27*	17.97**	0.82	-3.42	-8.73**
5	ICPA-2043XRVSA-0722	32.10**	28.32**	-16.10**	-21.74**	-1.46	-9.87**	12.57**	-3.80**	-10.72**	-15.63**
6	ICPA-2043XICPL-20181	29.02**	25.33**	5.08*	-1.98	-1.75	-10.13**	36.81**	16.92**	23.11**	16.33**
7	ICPA-2043XBSMR-528	14.36**	11.09**	0.00	-6.72**	-1.75	-10.13**	12.30**	-4.03**	-4.34	-9.61**
8	ICPA-2043XBSMR-253	-4.23	-6.97**	13.98**	6.32**	14.43**	4.67**	18.82**	1.55	-6.65**	-11.79**
9	ICPA-2047XICPR-2671	37.89**	33.94**	-4.66*	-11.07**	-1.46	-9.87**	34.76**	15.16**	-6.89**	-12.01**
10	ICPA-2047XBSMR-79	26.17**	22.55**	-6.78**	-13.04**	-1.60	-10.00**	18.24**	1.05	-3.88	-9.17**
11	ICPA-2047XBSMR-175	52.47**	48.10**	-11.02**	-17.00**	0.73	-7.87**	44.64**	23.61**	18.39**	11.88**
12	ICPA-2047XBSMR-316	5.91*	2.87	-5.93**	-12.25**	13.12**	3.47**	10.95**	-5.19**	3.05	-2.62
13	ICPA-2047XRVSA-0722	13.57**	10.32**	2.97	-3.95*	-0.73	-9.20**	16.08**	-0.80	8.60**	2.62
14	ICPA-2047XICPL-20181	26.72**	23.09**	2.12	-4.74*	0.58	-8.00**	33.08**	13.73**	6.08**	0.24
15	ICPA-2047XBSMR-528	-2.12	-4.93	6.78**	-0.40	18.51**	8.40**	19.49**	2.11	19.50**	12.93**
16	ICPA-2047XBSMR-253	12.58**	9.35**	-0.42	-7.11**	9.04**	-0.27	22.16**	4.40**	13.35**	7.12**
17	ICPA-2092XICPR-2671	33.06**	29.25**	-7.20**	-13.44**	3.94**	-4.93**	32.61**	13.33**	11.18**	5.07*
18	ICPA-2092XBSMR-79	10.75**	7.58**	6.36**	-0.79	-3.35**	-11.60**	13.41**	-3.08**	10.49**	4.41*
19	ICPA-2092XBSMR-175	19.59**	16.16**	0.42	-6.32**	13.85**	4.13**	38.41**	18.28**	15.20**	8.86**
20	ICPA-2092XBSMR-316	5.37*	2.35	-3.81	-10.28**	18.66**	8.53**	18.38**	1.17	2.45	-3.18
21	ICPA-2092XRVSA-0722	15.41**	12.10**	-2.54	-9.09**	8.75**	-0.53	22.68**	4.84**	13.68**	7.42**
22	ICPA-2092XICPL-20181	36.49**	32.58**	0.00	-6.72**	-0.58	-9.07**	41.00**	20.50**	22.69**	15.94**
23	ICPA-2092XBSMR-528	12.65**	9.42**	1.69	-5.14**	6.56**	-2.53*	21.74**	4.04**	29.77**	22.63**
24	ICPA-2092XBSMR-253	16.08**	12.76**	-1.27	-7.91**	6.85**	-2.27*	23.22**	5.30**	-6.80**	-11.93**
25	BSMR-736AXICPR-2671	16.77**	13.42**	2.12	-4.74*	2.19*	-6.53**	22.46**	4.65**	15.39**	9.04**
26	BSMR-736AXBSMR-79	30.37**	26.64**	1.69	-5.14**	-1.31	-9.73**	34.68**	15.09**	4.44	-1.31
27	BSMR-736AXBSMR-175	9.57**	6.43*	-4.24*	-10.67**	10.06**	0.67	14.73**	-1.95	17.22**	10.77**
28	BSMR-736AXBSMR-316	0.31	-2.56	0.00	-6.72**	11.66**	2.13*	8.65**	-7.15**	14.73**	8.42**
29	BSMR-736AXRVSA-0722	10.59**	7.43**	-4.66*	-11.07**	16.33**	6.40**	22.08**	4.33**	14.70**	8.38**
30	BSMR-736AXICPL-20181	6.59*	3.54	-2.54	-9.09**	17.93**	7.87**	20.18**	2.70*	14.42**	8.12**
31	BSMR-736AXBSMR-528	22.34**	18.83**	-5.51**	-11.86**	1.90	-6.80**	19.64**	2.24*	2.16	-3.46
32	BSMR-736AXBSMR-253	14.21**	10.94**	-7.63**	-13.83**	17.06**	7.07**	23.46**	5.51**	12.89**	6.68**

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