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Study on heterosis for seed yield and its components in pigeonpea [*Cajanus Cajan (L.) Millsp.*] under early sown condition in Chhattisgarh

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ABSTRACT

An experiment was conducted to evaluate heterosis for seed yield and its components in pigeon pea. Twelve parents and 35 F1' s produced from Line x Tester mating design in randomized block design were evaluated for for thirteen quantitative characters. All the crosses showed positive heterosis over mid parent and better parent for seed yield per plant showed by crosses positively significant for mid-parent heterosis observed for ICP7376 X ICPL 87119 followed ICP7376 X ICPL-87, ICP7382 X UPAS-120, ICP7406 X UPAS-120, ICP7382 X ICPL-87, ICP7004 X JKM-189, ICP7406 X JKM-189 and 12.26 ICP7406 X ICPL 87119. The significant positive heterobeltiosis were observed for seed yield per plant for crosses ICP7382 X UPAS-120 and ICP7004 X JKM-189. The hybrids showed heterosis for one or more yield related traits indicated that hybrid vigour in small magnitude for any one yield component may have additive effects on seed yield. The parents with good cross value could be further used in the future hybridization programmes.

Key words: Better Parent, Heterosis, Line x Tester Analysis, Mid Parent, Pigeonpea

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millsp.] belonging to the Family Leguminosae (Fabaceae) Genus *Cajanus*, Species *Cajan*, Tribe Phaseoleae, Sub-tribe Cajaninae, Order Fabales, is an often cross pollinated (20-70%) crop with diploid species (2n = 2x = 22) comprising a genome of 833.1 Mb arranged into 11 linkage groups. It is one of the major food legumes of the world which is widely grown in tropical and subtropical regions and occupies an important position in the economy of India (Varshney *et al*., 2012). In India during 2019-20 pigeonpea covered an area of 4.23 M ha producing around 3.89 M tones with the average productivity of 917 kg/ha (Anonymous, 2021). But yield plateau in the crop is evident as the productivity is stagnant at around 900 kg/ha despite of the yield potential of 1500-3000 kg/ha (Kumar *et al*., 2014).

This crop is being grown in Chhattisgarh since long back in Surguja, Rajnandgaon, Gariyaband, Raipur, Durg, Bastar, Bilaspur, Dantewada and Kabeerdham. In Chhattisgarh, acreage under pigeonpea is 65.9 thousand hectares with production and productivity of 39.9 thousand tons and 605 kg ha^{-1}, respectively (Anonymous, 2021). However, major constraints in growing pigeonpea in Chhattisgarh are water logging, frost and drought at reproductive stage. Thus there is an urgent need to evolve high yielding, early-medium duration varieties which can tolerate biotic and abiotic stresses. Heterosis is the most important tools for breeding programme that has provided major breakthrough in not only for yield but also for improving various other agronomically and economically important traits in case of several major crops. Performance of various hybrids of pigeonpea at past have registered whooping 75-100% higher yield in comparison to the most popular cultivars (Saxena and Sawargaonkar, 2014). Therefore utilization of heterosis for developing of high yielding hybrid varieties can be very impactful to increase the yield, reproductive ability, adaptability, disease and insect resistance, general vigour and quality, etc of pigeonpea. ICRISAT and ICAR have joint developed several hybrid varieties utilizing both GMS and CGMS. Currently new generation hybrids are being developed using A2 and A4 CGMS systems (Saxena *et al.,* 2006).

In current usage heterosis and hybrid vigor are used as synonyms and interchangeable. The amount of heterosis plays a key role in selecting of ideal parents for making superior crosses and also forms the basis for estimating genetic diversity (Swindell and Poehlman, 1976). The important genetic factors which effect magnitude of heterosis in crop plants include mode of pollination, genetic diversity of parents their genetic base and adaptability. Heterosis and hybrid vigor can bring about yield improvement in pigeonpea by exploiting additive and non additive component of gene action (Saxena and Sharma, 1990). Several researchers have already reported heterosis for grain yield in pigeonpea. Therefore, estimation of heterosis for yield and yield attributing traits will help in identifying superior crosses which will increase the probability of obtaining better transgressive segregants in later segregating generations.

MATERIAL AND METHODS

The field experiment was conducted during the *Kharif* 2012-13 and 2013-14 at Department of Genetics & Plant Breeding at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur-Chhattisgarh. The protein analysis work was done in the Quality Laboratory, Department of Genetics & Plant Breeding, College of Agriculture, IGKV Raipur-Chhattisgarh. In hybridization programme (Table-1) 5 varieties (ICPL 87119, BDN-2, UPAS-120, ICPL-87 and JKM-189) were used as male while 7 germplasm accessions were used as female (ICP7004, ICP7373, ICP7376, ICP7382, ICP7391, ICP7393 and ICP7406) to generate a set of hybrids in a Line x Tester fashion as proposed by Kempthorne (1957). A total of 35 hybrids were developed by hand emasculation and pollination. Sufficient numbers of hand pollinated F_1 seeds were produced during 2012-13 rainy season. The experimental material consisted 35 crosses. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications during *Kharif* 2013-14. The material was sown in single row of 4.0 m length and 60 cm apart with 20 cm plant to plant spacing. Sowing of 35 F_1s was done in first week of June. Recommended dose of fertilizer of 20:50:20 kg per ha of NPK was applied before sowing. All the recommended package of practices were followed to raise a healthy crop. Single plant per hill was maintained, border rows were planted to eliminate the border effect. Five plants were randomly selected and tagged in each genotype per replication for recording the observations for the 13 characters *viz:* days to flowering initiation, days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of pod clusters per plant, number of pods per cluster, number of pods per plant, pod length (cm), number of seeds per pod, 100 seed weight, seed yield per plant and protein content. The data were analyzed for heterosis as per statistical methods given by (Nadarajan and Gunasekaran, 2005).

RESULTS AND DISCUSSION

The Heterosis over mid parent (Relative heterosis) and over better parent (heterobeltiosis) was estimated for all the characters under study. The estimates of mid parent and better parent are given in Table 2, 3 and 4. Days to flowering initiation are significant relative heterosis for the trait ranged from -6.95 (ICP7382 X ICPL 87119) to 11.05 (ICP7393 X BDN-2). Among 35 hybrids, ICP7391 X UPAS-120 hybrids showed significant negative heterosis. Whereas, hybrid ICP7393 X BDN-2 showed significant positive heterosis in respectively for this trait. The significant heterobeltiosis ranged from -13.26 (ICP7004 X ICPL-87) to -9.47 (ICP7382 X ICPL-87). Heterosis for early flowering was also reported by Patel *et al.,* (1991), Gupta *et al.,* (1997), Patel and Tikka (2008) and Mallikarjuna *et al.,* (2012). The significant relative heterosis for days to 50% flowering varied from -11.54 (ICP7376 X ICPL-87) to 10.72 (ICP7393 X BDN-2). The significant heterobeltiosis for the trait ranged from -15.40 (ICP7376 X ICPL-87) to 10.17 (ICP7393 X BDN-2). The findings are in general supported by the result obtained by Chandirakala and Raveendran (2002), Lohithaswa and Dharmaraj (2003), Banu *et al.,* (2007), Dheva *et al.,* (2008), Shoba and Balan (2010) and Saroj *et al.,* (2014). The significant relative heterosis for days to maturity varied from -4.88 (ICP7382 X ICPL 87119) to 6.70 (ICP7393 X JKM-189). The significant heterobeltiosis for days to maturity ranged from-9.98 (ICP7004 X ICPL-87) to 5.15 (ICP7406 X JKM-189). The findings are in accordance to the findings of Gupta *et al.,* (1997), Aher *et al.,* (2006), Banu *et al.,* (2007), Dheva *et al.,* (2008), Bhavani and Bhalla (2009), Shoba and Balan (2010) and Saroj *et al.,* (2014). The significant relative heterosis for plant height ranged from -15.03 (ICP7004 X BDN-2) to 9.55 (ICP7376 X ICPL-87). The significant heterobeltiosis for plant height was -26.83 (ICP7004 X BDN-2) and all hybrids exhibited negative heterosis while there was no positive heterosis for the trait. These findings of heterosis are similar to observations of Banu *et al.,* (2007), Dheva *et al.,* (2008), Shoba and Balan (2010) and Gite *et al.,* (2014).

The number of primary branches per plant showed significant relative heterosis ranging from -26.82 (ICP7004 X BDN-2) to 25.42 (ICP7376 X ICPL 87119). The heterobeltiosis for the trait had a range of -42.89 (ICP7004 X BDN-2) to 11.19 (ICP7376 X ICPL-87). These findings are similar to the results of

Kumar and Srivastava (1998), Kumar *et al.*, (2009), Phad *et al.*, (2009), Sarode *et al.*, (2009), Pandey *et al.*, (2013) and Gite *et al.*, (2014). The relative heterosis for the number of pod clusters per plant varied from -27.96 (ICP7373 X UPAS-120) to 143.96 (ICP7382 X ICPL 87119). The significant heterobeltiosis for the trait ranged from -44.19 (ICP7382 X BDN-2) to 139.04 (ICP7382 X ICPL 87119).These results of heterosls are in accordance to the findings of Chandirakala and Raveendran (2002), Banu *et al.*, (2007), Kumar *et al.*, (2009) and Prasad *et al.*, (2013). The significant relative heterosis for the trait ranged from -23.08 (ICP7393 X BDN-2) to 36.83 (ICP7391 X ICPL 87119). The highest significant heterobeltiosis for number of pods per cluster was exhibited ranged from -28.29 (ICP7393 X BDN-2) to 36.83 (ICP7391 X ICPL 87119). Similar results were observed by Chandirakala and Raveendran (2002), Mallikarjuna *et al.*, (2012), Prasad *et al.*, (2013) and Saroj *et al.*, (2014). The significant relative heterosis for number of pods per plant varied from -40.66 (ICP7004 X ICPL 87119) to 29.51 (ICP7376 X ICPL-87). The negative heterosis significant heterobeltiosis for number of pods per plant from -58.64 (ICP7004 X ICPL 87119), only observed in results. Similar results for heterors were reported by Patel and Patel (1992), Patel and Tikka (2008), Kumar *et al.*, (2009), Phad *et al.*, (2009), Sarode *et al.*, (2009), Shoba and Balan (2010), Pandey *et al.*, (2013) and Gite *et al.*, (2014).

The significant relative heterosis for the pod length ranged from -11.30 (ICP7373 X BDN-2) to 9.79 (ICP7393 X ICPL 87119). The highest significant heterobeltiosis for the trait ranged from -13.15 (ICP7406 X ICPL 87119) to 7.46 (ICP7382 X ICPL-87). Similar reports were given by Banu et al., (2007), Mallikarjuna *et al.*, (2012), Prasad *et al.*, (2013) and Saroj *et al.*, (2014). The significant positive relative heterosis for the number of seeds per pod 18.03 (ICP7004 X UPAS-120) followed by 9.17 (ICP7406 X UPAS-120) and 8.26 (ICP7004 X JKM-189). All hybrids were showing positive heterosis. The significant positive heterobeltiosis for the trait 16.13 (ICP7004 X UPAS-120) followed by 9.17 (ICP7406 X UPAS-120). These findings of heterosis are similar to observations of Aher *et al.*, (2006), Banu *et al.*, (2007), Sarode *et al.*, (2009), Shoba and Balan (2010), Pandey *et al.*, (2013), Prasad *et al.*, (2013) and Saroj *et al.*, (2014). The range of relative heterosis for 100 seed weight was observed between -27.72 (ICP7393 X ICPL-87) to 15.31 (ICP7406 X ICPL 87119). The significant heterobeltiosis for the trait range from -30.80 (ICP7382 X ICPL-87) to 9.91 (ICP7382 X ICPL 87119). The findings are in accordance to the findings of Chandirakala and Raveendran (2002), Banu *et al.*, (2007), Kumar *et al.*, (2009), Prasad *et al.*, (2013) and Gite *et al.*, (2014). The significant mid-parent heterosis (relative heterosis) for the seed yield per plant varied from -45.22 (ICP7004 X BDN-2) to 27.16 (ICP7376 X ICPL 87119). The heterobeltiosis for the trait ranged from -63.08 (ICP7004 X BDN-2) to 18.41 (ICP7382 X UPAS-120). The significant positive mid-parent heterosis were observed for 27.16 (ICP7376 X ICPL 87119) followed 24.73 (ICP7376 X ICPL-87), 23.47 (ICP7382 X UPAS-120), 21.29 (ICP7406 X UPAS-120), 21.11 (ICP7382 X ICPL-87), 19.94 (ICP7004 X JKM-189), 19.02 (ICP7406 X JKM-189) and 12.26 (ICP7406 X ICPL 87119). The significant positive heterobeltiosis were observed for 18.41 (ICP7382 X UPAS-120) and 16.30 (ICP7004 X JKM-189). The hybrids showed heterosis for one or more yield related traits indicated that hybrid vigour in small magnitude for any one yield component may have additive effects on seed yield. More or less similar findings were also reported earlier by Patel *et al.*, (1991), Kumar and Srivastava (1998), Chandirakala and Raveendran (2002), Sekhar *et al.*, (2004), Aher *et al.*, (2006), Baskaran and Muthiah (2006), Banu *et al.*, (2007), Kumar and Krishna, (2008), Chandirakal *et al.*, (2010), Lay *et al.*, (2011), Prasad *et al.*, (2013) and Saroj *et al.*, (2014). The range of relative heterosis for protein content was observed from -17.52 (ICP7376 X ICPL 87119) to 20.05 (ICP7391 X JKM-189). The heterobeltiosis for the trait ranged from -19.92 (ICP7376 X ICPL 87119) to 19.74 (ICP7382 X BDN-2). More or less similar findings were also reported earlier by Lohithaswa and Dharmaraj (2003) and Shoba and Balan (2010).

CONCLUSION

Heterosis analysis for all the crosses showed positive over mid parent and better parent for plant height (cm) except ICP7373 X ICPL 87119, ICP7004 X JKM-189, ICP7376X ICPL-87, ICP7382 X UPAS-120 ICP7382 X ICPL-87 and ICP7406 X UPAS-120. All the cross combinations showed negative heterosis over better parent for plant height. Hence, here is sufficient scope of developing dwarf heterotic genotypes. All the crosses showed positive heterosis over mid parent and better parent for number of primary branches per plant, except ICP7004 X JKM-189, ICP7373 X ICPL 87119, ICP7376 X ICPL-87, ICP7382 X UPAS-120 and ICP7382 X ICPL-87. The one cross ICP7376 X ICPL-87 combination showed significant heterosis over better parent for number of primary branches per plant. All the crosses showed positive heterosis over mid parent and better parent

Table 1. List of the pigeonpea germplasm accession use in the research study

S. No.	Name of genotypes	Parents used as a line and tester	Pedigree source
1	ICP7004	Line	ICRISAT, Pantancheru (A.P.), India
2	ICP7373	Line	ICRISAT, Pantancheru (A.P.), India
3	ICP7376	Line	ICRISAT, Pantancheru (A.P.), India
4	ICP7382	Line	ICRISAT, Pantancheru (A.P.), India
5	ICP7391	Line	ICRISAT, Pantancheru (A.P.), India
6	ICP7393	Line	ICRISAT, Pantancheru (A.P.), India
7	ICP7406	Line	ICRISAT, Pantancheru (A.P.), India
8	ICPL 87119	Tester	ICRISAT, Pantancheru (A.P.), India
9	BDN-2	Tester	IGKV, Raipur (C.G.), India
10	UPAS-120	Tester	IGKV, Raipur (C.G.), India
11	ICPL-87	Tester	ICRISAT, Pantancheru (A.P.), India
12	JKM-189	Tester	IGKV, Raipur (C.G.), India

Table 2. Heterosis for seed yield and its components in Pigeonpea [*Cajanus cajan* (L.) Millsp.] under early sown condition in Chhattisgarh

S. No	Crosses (F_1's)	Characters									
		Days to flowering initiation		Days to 50% flowering		Days to maturity		Plant height (cm)		No. of primary branches per plant	
		MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
1	ICP7004 X ICPL 87119	0.53	-2.06	-3.37*	-4.44**	0.84	-0.17	-14.33**	-25.20**	-23.28**	-38.33**
2	ICP7004 X BDN-2	-1.20	-4.12*	5.36**	0.45	0.68	-2.16	-15.03**	-26.83**	-26.82**	-42.89**
3	ICP7004 X UPAS-120	2.63	0.52	3.73*	1.14	4.10**	1.33	-0.69	-11.32**	-6.40	-24.26**
4	ICP7004 X ICPL-87	-3.71*	-13.14**	-6.81**	-11.36**	-3.82*	-9.98**	-2.19	-13.68**	-4.42	-22.86**
5	ICP7004 X JKM-189	-5.87**	-6.82**	-7.94**	-9.09**	-1.29	-4.16*	5.57**	-7.79**	15.63**	-6.67
6	ICP7373 X ICPL 87119	2.84	2.43	-4.04**	-7.56**	-0.43	0.68	5.94**	-7.43**	14.90**	-7.11
7	ICP7373 X BDN-2	7.88**	7.01**	8.09**	5.76**	4.42**	2.73	-4.92**	-18.04	-9.78*	-29.20**
8	ICP7373 X UPAS-120	-4.17**	-4.30*	-2.99	-3.11	-2.86*	-4.27*	0.42	-10.24**	-2.24	-20.42**
9	ICP7373 X ICPL-87	-3.37*	-11.05**	-8.60**	-10.79**	-3.78*	-8.87**	-4.46**	-15.60	-12.35*	-28.83**
10	ICP7373 X JKM-189	1.17	-2.05	5.20**	3.73*	0.87	-0.85	-5.27**	-17.17**	-7.62	-25.00**
11	ICP7376 X ICPL 87119	3.65*	3.23	-5.99**	-7.56**	-1.01	-1.51	8.80**	-8.30**	25.42**	-8.64
12	ICP7376 X BDN-2	10.05**	9.16**	8.63**	4.14*	5.68**	3.19*	-11.69**	-26.54**	-19.11**	-42.50**
13	ICP7376 X UPAS-120	2.83	2.69	0.82	-1.15	-1.03	-3.19*	4.46**	-10.04**	11.26	-18.50**
14	ICP7376 X ICPL-87	-4.25**	-11.86**	-11.54**	-15.40**	-2.77	-8.57**	9.55**	-6.71**	21.50**	11.19*
15	ICP7376 X JKM-189	-3.26*	-6.31**	-4.40**	-5.06**	-4.05**	-6.39**	1.99	-14.00**	10.75	-19.05**
16	ICP7382 X ICPL 87119	-6.95**	-8.42**	-10.03**	-11.33**	-4.88**	-5.77**	-11.26**	-24.03**	-13.65**	-36.90**
17	ICP7382 X BDN-2	0.13	-1.84	0.96	-3.43*	1.83	0.87	-7.13**	-21.55**	-9.15	-35.22**
18	ICP7382 X UPAS-120	3.46*	2.37	3.86*	1.60	4.27**	3.46*	8.09**	-5.40**	18.72**	-12.75*
19	ICP7382 X ICPL-87	-0.58	-9.47**	-10.31**	-14.42**	-1.81	-6.40**	7.63**	-6.89**	20.94**	-11.31*
20	ICP7382 X JKM-189	2.32	0.25	2.08	1.14	4.72**	3.63*	-7.91**	-21.12**	-5.42	-30.64**
21	ICP7391 X ICPL 87119	0.82	0.54	-4.24**	-7.11**	0.00	0.00	-6.82**	-19.26**	-12.00*	-30.30**
22	ICP7391 X BDN-2	-3.42*	-3.55*	0.00	-2.84	-1.21	-3.06	-2.73*	-16.85**	-2.26	-24.78**
23	ICP7391 X UPAS-120	-3.25*	-4.03*	-6.54**	-7.09**	-3.63*	-5.26**	2.55	-9.12**	4.54	-16.66**
24	ICP7391 X ICPL-87	-3.54*	-10.66**	-11.22**	-13.95**	-1.89	-7.30**	-9.24**	-20.51**	-19.16**	-35.71**
25	ICP7391 X JKM-189	0.00	-3.79*	3.29*	2.56	4.59**	2.55	-0.13	-13.41**	4.19	-17.14**
26	ICP7393 X ICPL 87119	9.19**	6.52**	1.52	-3.78*	2.73	2.21	-0.74	-13.37**	4.06	-17.59**
27	ICP7393 X BDN-2	11.05**	8.77**	10.72**	10.17**	5.57**	4.12*	-11.55**	-23.86**	-19.21**	-37.83**
28	ICP7393 X UPAS-120	4.71**	1.61	0.61	-1.20	0.17	-1.03	3.48*	-7.61**	6.13	-15.39**
29	ICP7393 X ICPL-87	0.91	-4.57*	-8.00**	-8.68**	-2.44	-7.38**	-8.75**	-19.49**	-15.87**	-33.10**
30	ICP7393 X JKM-189	6.97**	0.76	7.69**	4.43*	6.70**	5.15**	0.67	-12.08**	6.59	-15.24**
31	ICP7406 X ICPL 87119	7.55**	6.68**	1.25	-0.67	3.50*	2.89	2.81*	-11.61**	7.67	-15.23**
32	ICP7406 X BDN-2	8.25**	6.95**	4.57**	0.46	4.26**	2.92	-11.40**	-24.85**	-20.45**	-39.13**
33	ICP7406 X UPAS-120	0.80	0.53	2.00	0.23	3.39*	2.23	6.25**	-6.60**	9.41	-13.30**
34	ICP7406 X ICPL-87	-0.87	-9.09**	-10.36**	-14.09**	-1.27	-6.19**	-8.44**	-20.45**	-15.66**	-33.33**
35	ICP7406 X JKM-189	-0.26	-3.03	0.46	0.00	3.48*	2.06	3.27*	-11.17**	9.04	-13.81**

Table 3. Heterosis for seed yield and its components in Pigeonpea [*Cajanus cajan* (L.) Millsp.] under early sown condition in Chhattisgarh

S. No	Crosses (F_1's)	Characters									
		No of pod clusters per plant		No. of pods per cluster		No. of pods per plant		Pod length (cm)		No. of seeds per pod	
		MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
1	ICP7004 X ICPL 87119	39.51**	11.00**	9.27*	7.69	-40.66**	-58.64**	-2.41	-3.03	3.23	3.23
2	ICP7004 X BDN-2	-4.06	-10.14**	15.08**	11.21*	-40.35**	-58.85**	-3.47	-8.39*	0.00	-1.61
3	ICP7004 X UPAS-120	22.65**	14.34**	7.46	-1.21	-7.62**	-30.33**	-4.62	-8.84**	18.03**	16.13**
4	ICP7004 X ICPL-87	19.20**	10.53**	-1.82	-6.90	-7.82**	-31.26**	1.18	1.06	-1.63	-2.42
5	ICP7004 X JKM-189	30.12**	25.92**	8.41**	5.45	10.84**	-22.03**	-1.01	-5.67	8.26*	5.65
6	ICP7373 X ICPL 87119	128.75**	103.93**	4.27	0.00	10.52**	-22.78**	7.32*	1.56	3.44	1.77
7	ICP7373 X BDN-2	61.74**	34.19**	-1.85	-2.51	-22.53**	-46.44**	-11.30**	-12.14**	5.83	5.83
8	ICP7373 X UPAS-120	-27.96**	-40.47**	-12.82**	-17.74**	-4.94**	-28.11**	-10.17**	-11.67**	3.75	3.75
9	ICP7373 X ICPL-87	1.81	-4.11	12.39**	9.48*	-11.83**	-34.07**	-1.99	-7.71*	2.89	2.05
10	ICP7373 X JKM-189	17.65**	0.37	21.18**	21.18**	-21.83**	-44.88**	2.43	1.04	-0.84	-1.67
11	ICP7376 X ICPL 87119	91.71**	71.08**	30.54**	29.90**	14.76**	-24.83**	2.04	-3.24	-3.17	-4.69
12	ICP7376 X BDN-2	70.35**	19.68**	4.92	0.45	-35.68**	-58.23**	-6.74**	-7.43*	-1.61	-4.69
13	ICP7376 X UPAS-120	72.52**	20.86**	0.44	-8.47*	3.74	-27.39**	-4.19	-5.60	0.00	-3.12
14	ICP7376 X ICPL-87	64.49**	26.91**	32.11**	24.14**	29.51**	-10.21**	5.32	-0.63	-5.60	-7.81
15	ICP7376 X JKM-189	103.33**	45.80**	10.85*	6.82	-11.46**	-41.56**	3.97	2.77	-2.85	-6.64
16	ICP7382 X ICPL 87119	143.96**	139.04**	6.22	-3.63	-30.36**	-53.60**	6.64*	6.30	-2.54	-4.11
17	ICP7382 X BDN-2	-27.42**	-44.19**	2.76	-2.42	-22.95**	-49.13**	8.28**	3.08	-1.08	-1.08
18	ICP7382 X UPAS-120	67.26**	28.17**	7.26*	7.26	27.83**	-8.66**	3.85	-0.43	0.00	0.00
19	ICP7382 X ICPL-87	38.01**	18.77**	5.00	1.61	25.20**	-11.43**	7.68*	7.46*	-1.98	-2.79
20	ICP7382 X JKM-189	45.50**	14.68**	2.99	-2.82	-21.41**	-47.21**	2.55	-1.98	0.84	0.00
21	ICP7391 X ICPL 87119	98.86**	74.09**	36.83**	36.83**	-21.67**	-47.33**	-0.39	-5.73	-0.81	-1.61
22	ICP7391 X BDN-2	33.12**	12.32**	23.86**	18.03**	-14.86**	-43.29**	0.32	-0.63	-6.61	-7.38
23	ICP7391 X UPAS-120	15.61**	-2.84	13.78**	3.23	7.40**	-22.42**	-7.31*	-8.85**	6.20	5.33
24	ICP7391 X ICPL-87	1.07	-2.89	21.01**	13.19**	-18.45**	-41.70**	-2.82	-8.49**	6.07	-6.07
25	ICP7391 X JKM-189	47.58**	28.15**	22.18**	17.18**	-5.72**	-36.08**	-0.74	-2.08	-1.67	-3.28
26	ICP7393 X ICPL 87119	94.95**	65.45**	-7.13	-17.21**	-7.01**	-36.96**	9.79**	6.59	4.10	2.42
27	ICP7393 X BDN-2	5.14	-8.51**	-23.08**	-28.29**	-29.03**	-52.34**	-3.73	-5.36	3.33	3.33
28	ICP7393 X UPAS-120	10.34**	-4.39	-5.14	-6.98	12.02**	-18.28**	2.99	1.99	-4.50	-4.50
29	ICP7393 X ICPL-87	64.17**	63.54**	-2.04	-6.98	-14.56**	-38.31**	5.23	1.65	-0.83	-1.64
30	ICP7393 X JKM-189	49.90**	34.40**	-3.60	-10.70**	-2.79	-33.53**	4.01	2.68	0.84	0.00
31	ICP7406 X ICPL 87119	35.85**	24.83**	-0.93	-6.58	-1.23	-33.84**	-9.69**	-13.15**	-4.82	-6.45
32	ICP7406 X BDN-2	70.71**	22.27**	8.65*	7.46	-28.32**	-52.44**	-9.09**	-9.77**	4.17	4.17
33	ICP7406 X UPAS-120	73.87**	24.16**	-12.44**	-15.97**	19.82**	-13.85**	-10.72**	-10.72**	9.17*	9.17*
34	ICP7406 X ICPL-87	118.76**	72.79**	4.35	3.45	-14.22**	-38.95**	-3.49	-7.65*	0.83	0.00
35	ICP7406 X JKM-189	76.08**	28.83**	-3.39	-5.09	5.62**	-28.68**	-4.62	-4.93	7.56	6.67

for number of pods per plant except ICP7004 X JKM-189, ICP7373 X ICPL-87119, ICP7376X ICPL-87119, ICP7376 X ICPL-87 and ICP7382 X ICPL-87. All the crosses showed negative heterosis over better parent for traits number of pods per plant. All the crosses showed positive heterosis for both types for seed yield per plant except ICP7004 X JKM-189, ICP7376X ICPL-87, ICP7382 X UPAS-120 and ICP7382 X ICPL-87, better parent for number of pod clusters per plant except ICP7004 X JKM-189 and ICP7382X UPAS-120. The positive heterosis of plant height was noted with primary branches per plant and number of pods per plant. Similarly, number of primary branches per plant showed positive heterosis with number of pods per plant. Hence, direct selection for the trait showing positive heterosis with seed yield per plant would lead to the development of high yielding, hybrid seed production with hybrid vigor genotypes. All the crosses showed positive heterosis over mid parent and better parent for seed yield per plant except ICP7004 X JKM-189, ICP7376X ICPL-87, ICP7382 X UPAS-120 and ICP7382 X ICPL-87 and better parent for number of pod clusters per plant except ICP7004 X JKM-189 and ICP7382X UPAS-120.

Table 4. Heterosis for seed yield and its components in Pigeonpea [*Cajanus cajan* (L.) Millsp.] under early sown condition in Chhattisgarh

	Crosses (F_1's)	Characters					
		100 seed weight (g)		Seed yield per plant (g)		Protein content (%)	
		MP	BP	MP	BP	MP	BP
1	ICP7004 X ICPL 87119	-8.95**	-17.82**	-40.14**	-58.28**	-9.72**	-12.42**
2	ICP7004 X BDN-2	-13.72**	-21.32**	-45.22**	-63.08**	-4.15	-7.54*
3	ICP7004 X UPAS-120	3.03	-1.40	-15.64**	-40.59**	-8.03**	-10.75**
4	ICP7004 X ICPL-87	-12.69**	-15.15**	-16.92**	-41.96**	-9.00**	-16.58**
5	ICP7004 X JKM-189	0.40	-5.27*	19.94**	16.30**	4.75	4.14
6	ICP7373 X ICPL 87119	-2.00	-6.45*	18.28**	-16.53**	-2.72	-9.76**
7	ICP7373 X BDN-2	4.34	0.70	-23.04**	-47.53**	-0.53	-1.57
8	ICP7373 X UPAS-120	-21.00**	-22.22**	-13.29**	-38.14**	-0.16	-7.34*
9	ICP7373 X ICPL-87	-15.22**	-22.18**	-19.12**	-42.79**	-8.35**	-19.42**
10	ICP7373 X JKM-189	-10.67**	-10.74**	-18.89**	-42.68**	5.53	1.33
11	ICP7376 X ICPL 87119	7.70**	3.56	27.16**	-18.03**	-17.52**	-19.92**
12	ICP7376 X BDN-2	-7.84**	-10.40**	-38.97**	-61.69**	-6.58*	-9.98**
13	ICP7376 X UPAS-120	-7.98**	-10.08**	-4.38	-37.85**	-8.74*	-11.35**
14	ICP7376 X ICPL-87	-9.15**	-17.18**	24.73**	-19.45**	-6.92*	-14.59**
15	ICP7376 X JKM-189	-7.05**	-7.83**	-2.48	-37.06**	5.69	4.97
16	ICP7382 X ICPL 87119	10.43**	9.91**	-33.09**	-56.17**	-7.64*	-14.37**
17	ICP7382 X BDN-2	6.82**	5.13	-22.79**	-50.82**	21.06**	19.74**
18	ICP7382 X UPAS-120	6.01*	-0.74	23.47**	18.41**	13.12**	4.92
19	ICP7382 X ICPL-87	-21.04**	-30.80**	21.11**	-20.51**	9.44**	-3.83
20	ICP7382 X JKM-189	-7.13**	-11.81**	-15.00**	-44.25**	16.41**	11.73**
21	ICP7391 X ICPL 87119	-0.52	-1.20	-17.81**	-44.52**	17.98**	10.32**
22	ICP7391 X BDN-2	0.79	0.34	-12.24**	-42.55**	17.81**	17.59**
23	ICP7391 X UPAS-120	9.16**	3.34	-0.13	-31.93**	-6.04*	-12.10**
24	ICP7391 X ICPL-87	0.63	-10.92**	-33.40**	-54.95**	-3.90	-14.88**
25	ICP7391 X JKM-189	-2.43	-6.32*	-1.44	-33.38**	20.05**	16.24**
26	ICP7393 X ICPL 87119	-4.48*	-14.35**	-2.74	-32.50**	-13.78**	-16.68**
27	ICP7393 X BDN-2	-12.63**	-20.86**	-29.54**	-52.69**	15.53**	11.85**
28	ICP7393 X UPAS-120	-7.68**	-12.28**	2.50	-28.12**	12.25**	8.53**
29	ICP7393 X ICPL-87	-27.72**	-29.24**	-23.51**	-46.79**	-6.95*	-14.99**
30	ICP7393 X JKM-189	-13.36**	-18.82**	0.86	-29.90**	-11.55**	-11.73**
31	ICP7406 X ICPL 87119	15.31**	8.75**	12.26**	-26.44**	-6.81*	-17.31**
32	ICP7406 X BDN-2	3.48	-1.36	-30.73**	-55.86**	12.65**	6.29
33	ICP7406 X UPAS-120	-9.73**	-9.99**	21.29**	-19.83**	11.86**	-0.71
35	ICP7406 X ICPL-87	-22.53**	-28.05**	-24.52**	-50.44**	10.06**	-7.17*
35	ICP7406 X JKM-189	-2.29	-3.45	19.02**	-21.92**	1.19	-7.21*

*Significant at 5% probability level, ** Significant at 1% probability level, MP- Mid Parent Heterosis, BP- Better Parent Heterosis

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