G.J.B.B., VOL.7 (4) 2018: 614-620 ISSN 2278 – 9103

GLOBAL JOURNAL OF BIO-SCIENCE AND BIOTECHNOLOGY

www.scienceandnature.org

ASSESSMENT OF HYBRID VIGOUR IN SHORT DURATION PIGEONPEA HYBRIDS [*Cajanus cajan* (L.) Millsp.]

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ABSTRACT
Heterosis was assessed in the twenty seven hybrids of pigeonpea [*Cajanus cajan* (L.) Millsp.,] developed from twelve parents. The whole experimental material was evaluated in a randomized block design with three replications during *kharif* 2016-17. Nine crosses had significant positive heterobeltiosis for the grain yield and its components. The estimates of heterosis showed that the crosses ICPA 2039 x ICPL161 and ICPA 2039 x ICPL 90048 had significant standard heterosis for grain yield per plant and some of its components. These hybrids can be further progressed for assessing the stability across locations

KEY WORDS: Hybrid vigour, pigeonpea, heterobeltiosis.

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millsp.] a diploid legume crop species (2n=2x=22) belonging to the tribe *Phaseoleae*, is predominantly cultivated by the farmers of semi-arid regions. India is considered as the center of origin of pigeonpea (Van der Maesen, 1980) because of its natural genetic variability available in the local germplasm and the presence of its wild relatives in the country. Natural out-crossing in pigeonpea was first reported by Howard *et al*. (1919). The estimates of natural out-crossing vary greatly between 2 to 70% in different environmental conditions (Saxena *et al*., 1990). Globally, pigeonpea enjoys the position of sixth most important legume food crop. With the production of 4.23 million tonnes from an area of 5.21 million hectares, it stands in the second position among the pulse crops after chickpea in India (DES, 2017). The Indian sub-continent alone contributes nearly 92 % of the total pigeonpea production in the world. Although India leads the world both in area and production of pigeonpea, its productivity is lower (673 kg/ha) than the world average (762.4 kg/ha) (FAOSTAT 2015). To break the yield plateau, the hybrid technology has been attempted in pigeonpea. For a successful heterosis breeding programme two things, first adequate level of hybridity for yield and quality at prevailing input levels and second efficient and economical way of production of adequate quantity of F1 seeds are very important, so that heterosis exploitation becomes economical (R.S. Singh and M.N. Singh, 2015). Keeping in view, the present study was carried out to exploit maximum hybrid vigour through CMS lines for broadening genetic base and enhancement of seed yield in pigeonpea.

MATERIALS & METHODS

The experiment was conducted at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India during *kharif* 2015-16. In *kharif* 2015, material was generated by crossing three CMS lines *viz*., ICPA 2039, ICPA 2089, ICPA 2156 with nine different fertility restorer *i.e*., ICPL 88034, ICPL 88039, ICPL 149, ICPL 161, ICPL 81-3, ICPL 89, ICPL 90048, ICPL 86022, ICPL 92047. The experimental material consisting forty one genotypes including twelve parents (three females as lines and nine males as testers) and resultant twenty seven crosses along with two checks (VL Arhar1 and ICPL 161) were raised in Randomized Block Design with three replications. The genotypes were sown in single plot row of 4m length with 75cm × 30cm. All the recommended agronomic practices and plant protection measures were implemented for the maintenance of healthy crop. The observations *viz*., plant height (cm), days to 50% flowering, pollen fertility, days to maturity, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per pod, 100 seed weight (g), grain yield per plant (g), harvest index (%) were recorded for five randomly selected plants in each genotype and in each replication. The data were statistically analysed and heterosis over better parent (BH) and standard heterosis (SH) were calculated as per standard procedure.

RESULTS & DISCUSSION

Heterosis or hybrid vigour is manifested as an improved performance for F1 hybrid generated by crossing two parents. Both positive and negative heterosis is useful in the crop improvement depending on the breeding objectives. In general positive heterosis is desirable for yield and negative heterosis for earliness *etc*. Twenty seven crosses developed from twelve parents were evaluated in the experiment for the standard heterosis and heterobeltiosis. The results are presented in the table 1, table 2 and table 3.

The range of standard heterosis is -5.44 to 32.72 and -9.53 to 26.98 % for VL Arhar1 and ICPL 161 respectively. Ten crosses exhibited significant positive heterosis over the check VL Arhar1, of which the cross ICPA 2039 x ICPL 149 (32.72%) recorded maximum significant positive heterosis. Five crosses exhibited significant positive heterosis over ICPL 161, of which ICPA 2039 x ICPL 149 (26.98%) recorded maximum significant positive heterosis. For plant height, the heterobeltiosis ranged from -8.33 to 33.50 %. Eleven crosses exhibited significant positive heterobeltiosis. Out of 27 crosses maximum significant heterobeltiosis is manifested by ICPA 2039 x ICPL 149 (33.50%) followed by ICPA 2039 x ICPL 86022 (21.71%). The results were in agreement with those of Wankhade *et al.* (2005), Baskaran and Muthiah (2006), Patel and Tikka, (2008), Sarode *et al.* (2009), Chandrikala *et al.* (2010), Vaghela *et al.* (2011), Pandey *et al.* (2013), Sudhir *et al.* (2015). In context of breeding for short duration hybrids, early flowering and early maturity is generally preferred. So negative heterosis is desirable for flowering and maturity. For days to 50% flowering, the standard heterosis range is 10 to 33.16 and -17.39 to 0 percent for VL Arhar1 and ICPL 161 respectively. No significant negative heterosis is exhibited over the check VL Arhar1. Out of 27 crosses, 23 crosses manifested significant negative heterosis over the check ICPL 161. Maximum significant negative heterosis is recorded by ICPA 2089 x ICPL 88039 (-17.39%) and ICPA 2156 x ICPL 86022 (-17.39%) over the check ICPL 161. The heterobeltiosis ranges from -12.50 to 14.93%. Ten crosses exhibited significant negative heterobeltiosis. Maximum significant negative heterobeltiosis is recorded by ICPA 2089 x ICPL 88034 (-12.50%). Heterosis in both negative and positive directions for days to 50% flowering have also been reported by Wankhade *et al.* (2005), Baskaran and Muthiah (2006), Wanjari *et al.* (2007), Patel and Tikka (2008), Sarode *et al.* (2009), Chandrikala *et al.* (2010), Vaghela *et al.* (2011), Pandey *et al.* (2013). For days to maturity, the range of standard heterosis ranged from 12.70 to 28.57 and -11.47 to 1% for VL Arhar1 and ICPL 161 respectively. None of the crosses exhibited significant negative heterosis over VL Arhar1 for this trait. Out of the twenty seven crosses, the maximum significant negative heterosis was manifested by ICPA 2089 x ICPL 86022 (-11.47%) followed by ICPA 2039 x ICPL 88039 (-9.73%) over the check ICPL 161. The range of negative heterobeltiosis is -8.10 to 18.71%. Two crosses recorded significant negative heterobeltiosis *viz.,* ICPA 2039 x ICPL 88034 (-8.10%) and ICPA 2089 x ICPL 88034 (-7.85%). These results are in agreement with earlier results reported by Solanki *et al.* (2008) and Pandey *et al.* (2013).

For the full exploitation of heterosis, hybrids with good amount of fertile pollen are needed. Among the hybrids maximum pollen fertility was exhibited by ICPA 2156 x ICPL89 (99.32%) followed by ICPA 2039 x ICPL 92047 (99.30%). The range of standard heterosis is -12.70 to 0.90 and-13.46 to 0.02 for VL Arhar1 and ICPL 161 respectively. None of the crosses showed significant positive heterosis over all the checks. The range of heterobeltiosis for the trait pollen fertility is -13.43 to 0.92 percent. None of the crosses exhibited positive significant heterobeltiosis. Results were in agreement with those reported by Wanjari *et al.* (2007) and Sudhir *et al.* (2015).

Number of primary branches per plant is one such character which influences productivity. Therefore, the hybrids with more primary branches per plant have to be identified. The range of standard heterosis is -7.96 to 12.89 and -0.78 to 21.69 percent for VL Arhar1 and ICPL 161 respectively. None of the crosses registered significant negative heterosis over VL Arhar1 for this trait. Over ICPL 161, the cross ICPA 2039 x ICPL 81-3 (21.69%) showed significant positive heterosis. The range of heterobeltiosis for the trait number of primary branches per plant is -18.26 to 22.50%. Two crosses exhibited significant positive heterobeltiosis for this trait *viz.,* ICPA 2039 x ICPL 90048 (22.50%) and ICPA 2039 x ICPL 81-3 (19.67%). Similar results were earlier reported by Shoba and Balan (2010), Pandey *et al.* (2013) and Sudhir *et al.* (2015).For the trait number of secondary branches per plant, the range of standard heterosis is -14.31 to 13.64 and -12.63 to 16.55% for VL Arhar1 and ICPL 161 respectively. The cross ICPA 2156 x ICPL 88034 (13.64%) recorded significant positive heterosis over the check VL Arhar1. Three crosses exhibited significant positive heterosis over the check ICPL 161. Maximum significant positive heterosis was shown by ICPA 2156 x ICPL 88034 (16.55%) followed by ICPA 2039 x ICPL 90048 (14.59%) over the check ICPL 161. Heterobeltiosis ranged from -13.22 to 20.04%. Maximum significant positive heterobeltiosis is exhibited by ICPA 2156 x ICPL 88034 (20.04%) followed by ICPA 2039 x ICPL 90048 (13.81%). Results were in conformity with those obtained by Wankhade *et al.* (2005), Baskaran and Muthiah (2006), Patel and Tikka (2008), Sarode *et al.* (2009), Chandrikala *et al.* (2010), Vaghela *et al.* (2011), Pandey *et al.* (2013) and Sudhir *et al.* (2015).

More number of pods per plant is believed to be closely related to achieve high yield. The range of standard heterosis was -38.49 to 126.33 and -62.83 to 36.76 % for VL Arhar1 and ICPL 161 respectively. Maximum significant positive heterosis was recorded by ICPA 2039 x ICPL 161 over both the checks VL Arhar1 and ICPL 161. The range of heterobeltiosis for the trait number of pods per plant is -51.09 to 64.68 percent. Out of twenty seven crosses, nine crosses manifested significant positive heterobeltiosis. Maximum significant positive hetero beltiosis is exhibited by ICPA 2039 x ICPL 90048 (64.68%) followed by ICPA 2039 xICPL 88034 (45.37%). These results are in agreement with the finding of Baskaran and Muthiah (2006), Patel and Tikka (2008), Sarode *et al.* (2009), Chandrikala *et al.* (2010), Vaghela *et al.* (2011), Pandey *et al.* (2013) and Sudhir *et al.* (2015).Positive heterosis for number of seeds per pod is found to be desirable to increase the yield. The range of standard heterosis was -12.50 to 5 and -4.55 to 14.55 percent over the check VL Arhar1 and ICPL 161 respectively. None of the crosses recorded significant positive heterosis over the check VL Arhar1.

TABLE 1: Estimation of standard heterosis (over check VL Arhar1) for yield and yield contributing characters

Sr. No	Crosses	Plant height (cm)	Days to 50 per cent flowering	Pollen fertility (%)	Days to maturity	No. of primary branches per plant	No. of secondary branches per plant	No. of pods per plant	No. of seeds per pod	100 seed wt. (g)	Grain yield Per Plant (g)	Harvest Index (%)
1.	ICPA 2039 x ICPL 88034	10.84**	21.58**	-1.19	15.24**	-5.03	0.50	56.84**	-5.00	-17.06**	27.29**	-3.20
2.	ICPA 2039 x ICPL 88039	5.49	14.74**	0.78	13.02**	-5.35	10.98	1.50	-5.00	-18.09**	-9.62	21.30
3.	ICPA 2039 x ICPL 149	32.72**	32.63**	0.14	28.57**	-4.40	-1.16	75.42**	-6.67	-14.68**	45.27**	25.36*
4.	ICPA 2039 x ICPL 161	24.70**	31.05**	-4.30*	25.71**	-2.52	7.32	126.33**	-5.83	-16.38**	89.28**	22.97*
5.	ICPA 2039 x ICPL 81-3	23.48**	33.16**	0.58	26.98**	12.89	4.33	25.42**	-7.50	-13.65**	4.58	8.83
6.	ICPA 2039 x ICPL 89	9.38*	26.32**	-12.70**	23.49**	-2.83	7.82	-5.66	-6.67	-20.48**	-29.49**	-9.11
7.	ICPA 2039 x ICPL 90048	6.37	31.05**	-2.27	27.30**	6.32	11.73	77.67**	-6.67	-7.51	65.62**	12.59
8.	ICPA 2039 x ICPL 86022	3.55	19.47**	-1.05	20.63**	-7.08	0.83	-7.38	-5.00	-19.80**	-32.10**	44.49**
9.	ICPA 2039 x ICPL 92047	21.54**	26.32**	0.88	20.63**	-5.35	-1.00	46.81**	-5.83	-24.57**	9.78	-4.96
10.	ICPA 2089 x ICPL 88034	1.60	14.21**	-2.88	15.56**	-6.70	4.49	11.06*	-12.50**	-15.02**	-9.62	13.63
11.	ICPA 2089 x ICPL 88039	-4.33	10.00**	-3.79*	14.92**	-7.89	-0.25	-9.14	3.33	-17.06**	-14.83*	44.51**
12.	ICPA 2089 x ICPL 149	19.11**	18.95**	-4.40*	14.92**	-5.50	1.16	22.26**	0.00	-24.23**	-10.57	20.72
13.	ICPA 2089 x ICPL 161	1.60	20.53**	-12.43**	21.90**	-5.57	8.99	2.72	-5.83	-25.60**	-19.08**	32.55**
14.	ICPA 2089 x ICPL 81-3	6.71	16.32**	-12.02**	17.46**	-5.63	6.57	21.53**	-5.00	-16.72**	5.05	25.16*
15.	ICPA 2089 x ICPL 89	-5.44	15.79**	-10.23**	16.19**	0.94	4.08	-17.13**	-5.83	-14.68**	-23.34**	55.48**
16.	ICPA 2089 x ICPL 90048	2.33	13.68**	-4.03*	20.95**	-7.04	3.19	-30.33**	-4.17	-8.19*	-29.26**	-19.92
17.	ICPA 2089 x ICPL 86022	-0.83	13.68**	-0.10	12.70**	-5.47	-9.48	-38.49**	-7.50	-16.04**	-47.00**	23.35*
18.	ICPA 2089 x ICPL 92047	-3.26	14.74**	-11.68**	20.63**	-6.89	-3.49	-1.83	-5.83	-12.97**	-27.60**	34.86**
19.	ICPA 2156 x ICPL 88034	10.60*	18.95**	-5.15**	19.37**	-4.81	13.64*	-20.10**	-5.83	-15.36**	-34.23**	-0.89
20.	ICPA 2156 x ICPL 88039	-2.77	21.58**	-12.56**	22.86**	-7.39	-8.99	-17.31**	0.00	-7.85*	-19.08**	34.90**
21.	ICPA 2156 x ICPL 149	4.28	20.53**	0.00	21.59**	-7.96	-14.31*	6.41	-6.67	-17.75**	-19.08**	49.51**
22.	ICPA 2156 x ICPL 161	6.47	19.47**	0.44	18.73**	-0.25	1.66	-15.25**	-6.67	-21.50**	-36.59**	43.35**
23.	ICPA 2156 x ICPL 81-3	10.60*	20.00**	-1.86	18.10**	-4.72	-1.66	-19.60**	-5.00	-8.87*	-25.28**	40.41**
24.	ICPA 2156 x ICPL 89	-1.80	11.58**	0.90	17.46**	0.63	-3.16	-25.08**	-4.17	-7.17	-33.28**	-15.1
25.	ICPA 2156 x ICPL 90048	0.63	11.58**	-3.49*	17.14**	2.58	-14.81*	-19.45**	5.00	-7.85*	-24.29**	61.08**
26.	ICPA 2156 x ICPL 86022	4.52	10.00**	0.00	19.37**	-6.64	-13.64*	1.63	-10.00*	-16.72**	-16.24*	19.55
27.	ICPA 2156 x ICPL 92047	9.04*	13.68**	-4.10*	17.46**	-7.48	-3.00	2.33	-10.83**	-19.45**	-16.86*	51.45**
	SE (d) ±	5.48	1.91	1.67	3.61	0.75	1.21	9.57	0.16	0.37	4.52	3.14
	CD at 5 %	11.01	3.84	3.35	7.25	1.51	2.41	19.21	0.32	0.73	9.08	6.31
	CD at 1 %	14.68	5.12	4.45	9.65	2.02	3.22	25.60	0.43	0.98	12.1	8.41

* - Significant at 5 % level of significance ** - Significant at 1 % level of significance

TABLE 2 : Estimation of standard heterosis (over check ICPL 161) for yield and yield contributing characters

Sr. No	Crosses	Plant height (cm)	Days to 50 per cent flowering	Pollen fertility (%)	Days to maturity	No. of primary branches per plant	No. of secondary branches per plant	No. of pods per plant	No. of seeds per pod	100 seed wt. (g)	Grain yield Per Plant (g)	Harvest Index (%)
1.	ICPA 2039 x ICPL 88034	6.05	-8.70**	-2.05	-9.48**	2.37	3.07	-5.23	3.64	2.10	-6.43	-33.61**
2.	ICPA 2039 x ICPL 88039	0.93	-13.83**	-0.10	-11.22**	2.03	13.82*	-38.67**	3.64	0.84	-33.57**	-16.81*
3.	ICPA 2039 x ICPL 149	26.98**	-0.40	-0.74	1.00	3.05	1.37	5.99*	1.82	5.04	6.78	-14.02
4.	ICPA 2039 x ICPL 161	19.30**	-1.58	-5.14**	-1.25	5.08	10.07	36.76**	2.73	2.94	39.13**	-15.67*
5.	ICPA 2039 x ICPL 81-3	18.14**	0.00	-0.30	-0.25	21.69**	7.00	-24.22**	0.91	6.30	-23.13**	-25.36**
6.	ICPA 2039 x ICPL 89	4.65	-5.14*	-13.46**	-2.99	4.75	10.58	-43.00**	1.82	-2.10	-48.17**	-37.66**
7.	ICPA 2039 x ICPL 90048	1.77	-1.58	-3.12	0.00	14.61	14.59*	7.36*	1.82	13.87**	21.74**	-22.79**
8.	ICPA 2039 x ICPL 86022	-0.93	-10.28**	-1.91	-5.24	0.17	3.41	-44.03**	3.64	-1.26	-50.09**	-0.91
9.	ICPA 2039 x ICPL 92047	16.28**	-5.14*	0.00	-5.24	2.03	1.54	-11.29**	2.73	-7.14	-19.30**	-34.82**
10.	ICPA 2089 x ICPL 88034	-2.79	-14.23**	-3.73*	-9.23**	0.58	7.17	-32.89**	-4.55	4.62	-33.57**	-22.07**
11.	ICPA 2089 x ICPL 88039	-8.47*	-17.39**	-4.63**	-9.73**	-0.71	2.30	-45.10**	12.73**	2.10	-37.39**	-0.89
12.	ICPA 2089 x ICPL 149	13.95**	-10.67**	-5.24**	-9.73**	1.86	3.75	-26.13**	9.09*	-6.72	-34.26**	-17.21*
13.	ICPA 2089 x ICPL 161	-2.79	-9.49**	-13.19**	-4.24	1.80	11.77	-37.94**	2.73	-8.40	-40.52**	-9.10
14.	ICPA 2089 x ICPL 81-3	2.09	-12.65**	-12.79**	-7.73**	1.73	9.30	-26.57**	3.64	2.52	-22.78**	-14.16
15.	ICPA 2089 x ICPL 89	-9.53*	-13.04**	-11.01**	-8.73**	8.81	6.74	-49.92**	2.73	5.04	-43.65**	6.63
16.	ICPA 2089 x ICPL 90048	-2.09	-14.62**	-4.87**	-4.99	0.20	5.84	-57.90**	4.55	13.03**	-48.00**	-45.08**
17.	ICPA 2089 x ICPL 86022	-5.12	-14.62**	-0.97	-11.47**	1.90	-7.17	-62.83**	0.91	3.36	-61.04**	-15.41*
18.	ICPA 2089 x ICPL 92047	-7.44	-13.83**	-12.45**	-5.24	0.37	-1.02	-40.68**	2.73	7.14	-46.78**	-7.51
19.	ICPA 2156 x ICPL 88034	5.81	-10.67**	-5.98**	-6.23*	2.61	16.55**	-51.72**	2.73	4.20	-51.65**	-32.03**
20.	ICPA 2156 x ICPL 88039	-6.98	-8.70**	-13.33**	-3.49	-0.17	-6.66	-50.04**	9.09*	13.45**	-40.52**	-7.49
21.	ICPA 2156 x ICPL 149	-0.23	-9.49**	-0.87	-4.49	-0.78	-12.12	-35.70**	1.82	1.26	-40.52**	2.53
22.	ICPA 2156 x ICPL 161	1.86	-10.28**	-0.44	-6.73*	7.53	4.27	-48.79**	1.82	-3.36	-53.39**	-1.69
23.	ICPA 2156 x ICPL 81-3	5.81	-9.88**	-2.72	-7.23**	2.71	0.85	-51.42**	3.64	12.18*	-45.08**	-3.70
24.	ICPA 2156 x ICPL 89	-6.05	-16.21**	0.02	-7.73**	8.47	-0.68	-54.73**	4.55	14.29**	-50.96**	-41.77**
25.	ICPA 2156 x ICPL 90048	-3.72	-16.21**	-4.33*	-7.98**	10.58	-12.63*	-51.33**	14.55**	13.45**	-44.35**	10.47
26.	ICPA 2156 x ICPL 86022	0.00	-17.39**	-0.87	-6.23*	0.64	-11.43	-38.59**	-1.82	2.52	-38.43**	-18.01*
27.	ICPA 2156 x ICPL 92047	4.33	-14.62**	-4.93**	-7.73**	-0.27	-0.51	-38.17**	-2.73	-0.84	-38.89**	3.87
	SE (d) ±	5.48	1.91	1.67	3.61	0.75	1.21	9.57	0.16	0.37	4.52	3.14
	CD at 5 %	11.01	3.84	3.35	7.25	1.51	2.41	19.21	0.32	0.73	9.08	6.31
	CD at 1 %	14.68	5.12	4.45	9.65	2.02	3.22	25.60	0.43	0.98	12.1	8.41

* - Significant at 5 % level of significance ** - Significant at 1 % level of significance

Sr. No	Crosses	Plant height (cm)	Days to 50 per cent flowering	Pollen fertility (%)	Days to maturity	No. of primary branches per plant	No. of secondary branches per plant	No. of pods per plant	No. of seeds per pod	100 seed wt. (g)	Grain yield Per Plant (g)	Harvest Index (%)
1	ICPA 2039 x ICPL 88034	12.87**	-6.85**	-2.34	-8.10**	-16.80**	6.15	45.37**	1.79	0.41	40.84**	-20.16*
2	ICPA 2039 x ICPL 88039	9.87*	-5.63*	0.92	-5.07	-2.59	11.91	-5.93	1.79	-18.64**	-9.48	0.05
3	ICPA 2039 x ICPL 149	33.50**	5.44*	0.10	8.00**	10.14	5.88	12.02**	0.00	4.60	21.10**	3.40
4	ICPA 2039 x ICPL 161	12.50**	2.47	-5.07**	4.21	5.44	11.59	30.61**	0.89	2.51	32.76**	-15.86*
5	ICPA 2039 x ICPL 81-3	14.93**	7.20**	-0.47	6.38*	19.67*	8.48	-12.70**	-1.77	5.86	-9.46	-22.93**
6	ICPA 2039 x ICPL 89	18.86**	3.90	-13.43**	3.73	6.55	11.15	-12.56**	0.00	-2.51	-21.99**	-36.33**
7	ICPA 2039 x ICPL 90048	12.49**	7.79**	-3.54*	6.93*	22.50**	13.81*	64.68**	-6.67	4.63	83.25**	-7.14
8	ICPA 2039 x ICPL 86022	21.71**	-1.73	-2.21	1.33	6.68	4.63	-14.15**	0.88	-2.89	-24.87**	16.86
9	ICPA 2039 x ICPL 92047	18.20**	3.00	-0.53	0.00	-3.53	-7.75	36.07**	0.89	-10.89*	21.47**	-27.93**
10	ICPA 2089 x ICPL 88034	3.47	-12.50**	-4.02*	-7.85**	-18.26**	10.37	21.50**	-19.23**	2.89	17.18*	-4.42
11	ICPA 2089 x ICPL 88039	-0.35	2.45	-3.66*	6.47*	-8.18	0.59	-8.07	-4.62	-17.63**	-14.69*	36.99**
12	ICPA 2089 x ICPL 149	19.80**	-5.44*	-4.43*	-3.47	-5.80	8.38	-21.93**	-7.69*	-1.77	-25.44**	9.35
13	ICPA 2089 x ICPL 161	-8.33*	-5.76*	-13.13**	1.05	-5.86	13.32*	-40.73**	-13.08**	-8.40	-43.25**	-9.30
14	ICPA 2089 x ICPL 81-3	-0.68	-6.36*	-12.94**	-1.60	-5.92	10.81	-15.40**	-12.31**	4.27	-9.05	-11.37
15	ICPA 2089 x ICPL 89	-1.27	2.33	-10.98**	3.98	0.63	7.29	21.48**	-13.08**	6.84	39.66**	8.92
16	ICPA 2089 x ICPL 90048	6.85	-0.46	-5.28**	4.10	-7.34	5.12	0.62	-11.54**	3.86	-5.97	-4.40
17	ICPA 2089 x ICPL 86022	3.55	5.88*	-1.27	4.41	-5.77	-6.08	-23.96**	-14.62**	1.65	-6.67	-0.24
18	ICPA 2089 x ICPL 92047	-5.91	-6.44*	-12.92**	0.00	-7.18	-10.08	-7.40	-13.08**	2.82	-12.57	2.27
19	ICPA 2156 x ICPL 88034	12.62**	-8.87*	-6.26**	-4.81	-16.61**	20.04**	-12.59*	0.89	2.48	-14.72	-24.10**
20	ICPA 2156 x ICPL 88039	-0.25	14.93**	-12.44**	18.71**	-4.69	-8.22	-16.34**	7.14	-8.47*	-18.96**	3.31
21	ICPA 2156 x ICPL 149	4.89	-4.18	-0.03	2.13	-3.08	-9.01	-32.05**	0.00	5.70	-32.54**	14.50
22	ICPA 2156 x ICPL 161	-3.95	-6.58**	-0.37	-1.58	5.03	5.71	-51.09**	0.00	-3.36	-55.53**	-1.91
23	ICPA 2156 x ICPL 81-3	2.94	-3.39	-2.88	-1.06	0.33	2.25	-44.03**	0.88	-14.10**	-35.31**	-0.57
24	ICPA 2156 x ICPL 89	0.75	-1.40	0.05	5.11	5.96	-0.17	9.81	2.68	-16.24**	21.55**	-40.52**
25	ICPA 2156 x ICPL 90048	3.24	-2.30	-4.75**	0.82	8.01	-13.22*	16.34**	5.00	4.25	0.63	23.36**
26	ICPA 2156 x ICPL 86022	7.23	3.98	-1.17	13.25**	-1.69	-10.39	25.63**	-4.42	0.83	47.50**	-8.44
27	ICPA 2156 x ICPL 92047	6.05	-7.30**	-5.44**	-2.63	-5.71	-9.61	-3.48	-4.46	-4.84	0.40	14.85
	SE (d) ±	5.49	1.92	1.67	3.61	0.76	1.21	9.58	0.16	0.37	4.53	3.15
	CD at 5 %	11.01	3.84	3.35	7.25	1.51	2.42	19.22	0.32	0.74	9.08	6.31
	CD at 1 %	14.67	5.12	4.46	9.66	2.02	3.22	25.6	0.43	0.98	12.1	8.41

* - Significant at 5 % level of significance   ** - Significant at 1 % level of significance

Over ICPL 161 maximum significant positive heterosis was registered by ICPA 2156 x ICPL 90048 (14.55%) followed by ICPA 2089 x ICPL 88039 (12.73%). For the trait number of seeds per pod, heterobeltiosis ranged from -19.23 to 7.14%. None of the crosses exhibited significant positive heterobeltiosis. These findings were in agreement with the findings of Patel and Tikka (2008), Sarode *et al.* (2009), Kumar *et al.* (2012), Pandey *et al.* (2013) and Sudhir *et al.* (2015).The range of heterobeltiosis for the trait 100 seed weight is -18.64 to 16.24 percent. The range of standard heterosis for the trait 100 seed weight was -25.60 to -7.17 and -8.40 to 14.29 percent over the check VL Arhar1 and ICPL 161 respectively. None of the crosses showed significant positive heterosis over the check VL Arhar1. Six crosses recorded significant positive heterosis over the check ICPL161. Maximum significant positive heterosis is manifested by ICPA 2156 x ICPL 89 (14.29%) followed by ICPA 2039 x ICPL 90048 (13.87%) over the check ICPL 161. Maximum significant positive heterobeltiosis is exhibited by ICPA 2156 x ICPL 89 (-16.24%) followed by ICPA 2156 x ICPL 81-3 (-14.10%). Heterosis with respect to 100 seed weight in positive and negative direction have also been reported by Wankhade *et al.* (2005), Baskaran and Muthiah (2006), Patel and Tikka (2008), Sarode *et al.* (2009), Kumar *et al.* (2012), Pandey *et al.* (2013) and Sudhir *et al.* (2015). For the trait harvest index, the range of standard heterosis was -19.92 to 61.08 and -45.08 to 10.47 percent over the checks VL Arhar1 and ICPL 161 respectively. Out of 27 crosses, 15 crosses exhibited significant positive heterosis over the check VL Arhar1. Maximum significant positive heterosis manifested by ICPA 2156 x ICPL 90048 (61.08%) followed by ICPA 2089 x ICPL 89 (55.48%) over the check VL Arhar1. None of the crosses showed significant positive heterosis over the check ICPL 161.The range of heterobeltiosis ranged from -40.52 to 36.99 percent for the trait harvest index. Maximum significant positive heterobeltiosis is recorded by ICPA 2089 x ICPL 88039 (36.99%) followed by ICPA 2156 x ICPL 90048 (23.36%). The significant positive and negative heterosis for harvest index was also reported by Singh and Singh (2009), Dheva *et al.* (2009), Bharate *et al.* (2010), Gupta *et al.* (2011) and Pandey *et al.* (2013).

The development of a high yielding hybrid is the eventual goal of any breeding programme. The high degree of heterosis for yield need not be due to the high heterosis in all yield contributing characters but may be of heterosis in one or two yield contributing characters even. The range of standard heterosis was -47.00 to 89.28 and -61.04 to 39.13 percent over the checks VL Arhar1 and ICPL 161 respectively. The cross ICPA 2039 x ICPL 161 (89.28%) exhibited significant positive heterosis over the check VL Arhar1 followed by ICPA 2039 x ICPL 90048 (65.62%). Maximum significant positive heterosis is recorded by ICPA 2039 x ICPL 161 (39.13%) over the check ICPL 161 followed by ICPA 2039 x ICPL 90048 (21.74%). A wide range of variation in the estimates of heterobeltiosis and standard heterosis in positive and negative direction was observed for grain yield per plant. For the trait, heterobeltiosis ranged from -55.53 to 83.25%. Nine crosses manifested significant positive heterobeltiosis for this trait. Maximum significant positive heterobeltiosis is manifested by ICPA 2039 x ICPL 90048 (83.25%) followed by ICPA 2156 x ICPL 86022 (47.50%). These findings were in close agreement with the results of earlier workers Pandey and Singh (2002), Wankhade *et al.* (2005), Baskaran and Muthiah, (2006), Wanjari *et al.* (2007), Solanki *et al.* (2008), Patel and Tikka, (2008), Sarode *et al.* (2009), Singh and Singh, (2009),Dheva *et al.* (2009), Bharate *et al.* (2010), Chandrikala *et al.* (2010), Vaghela *et al.* (2011), Gupta *et al.* (2011), Kumar *et al.* (2012), Pandey *et al.* (2013) and Sudhir *et al.* (2015).

CONCLUSION

The heterosis breeding has been used extensively in improving yield potential through development of hybrid cultivars in most of the crops including pigeonpea. The exploitation of heterosis for developing high yielding commercial hybrids in pigeonpea has been found highly fruitful inspite of its often- cross pollinated nature because significant heterosis is encountered F_1 hybrids for successful and economical technology for commercial hybrid seed production is available. The crosses ICPA 2039 x ICPL 90048, ICPA 2156 x ICPL86022, ICPA 2039 x ICPL88034, ICPA 2089 x ICPL 89, ICPA 2039 x ICPL 161, ICPA 2156 x ICPL 89, ICPA 2039 x ICPL 92047, ICPA 2039 x ICPL 149 and ICPA 2089 x ICPL 88034 had significant positive heterobeltiosis for the grain yield and its components. The estimates of heterosis showed that the crosses ICPA 2039 x ICPL161 and ICPA 2039 x ICPL 90048 had significant standard heterosis for grain yield per plant and some of its components.

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