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Studies on Heterosis for Yield in CMS Based Pigeonpea [*Cajanus cajan* (L.) Millsp.] Hybrids.

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ABSTRACT

A study on hybrid pigeonpea [*Cajanus cajan* (L.) Millsp.] was carried out with 33 genotypes involving seven CMS lines (A), nine testers (R-lines), 16 hybrids and one check (Maruthi) which were evaluated in a randomized block design with two replications during *kharif,* 2017-2018 to elicit information on extent of heterosis in terms of yield and yield attributes. The results indicated that manifestation of relative heterosis for seed yield per plant was significantly superior for five hybrids ranging from -23.51 to 70.31%, two hybrids over betterparent ranging from -39.87 to 36.88% and four hybrids over standard check ranging from -51.03 to 28.99%. Besides seed yield, substantial heterosis was also observed in negative as well as positive direction for remaining traits. The best hybrids based on seed yield and yield components were ICPH 3481, ICPH 3496, ICPH 2438 and ICPH 2363. These hybrids were found to exhibit more than 25% standard heterosis for seed yield and its respective traits.

Keywords: *Pigeonpea, hybrid, mid-parent, betterparent, heterosis, relative heterosis, heterobeltiosis, standard heterosis, yield and yield components.*

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is a short-lived perennial member of family Fabaceae and it is invariably cultivated as annual crop for possessing high protein in food. Pigeonpea is an often cross pollinated (20-30%) crop with 2n=2x=22 diploid chromosome number with a genome size of 833.07 Mb (Varshney *et al.* 2012), which provides an opportunity to breed commercial hybrids. Globally, pigeonpea is cultivated approximately on 6.975 M ha area with an annual production and productivity of 5.052 M T and 724 Kg ha^{-1} respectively (FAOSTAT, 2016). In India, pigeonpea is being cultivated on 5.2 M ha with a production of 4.23 M T and productivity of 727 kg ha^{-1} (Directorate of Economics and Statistics, 2016-2017). In Andhra Pradesh, it is cultivated in an area of 3.71 M ha with a production of 1.65 M T and productivity of 445 kg ha^{-1} (Directorate of Economics and Statistics, 2016-2017).

Pigeonpea has been considered technically suitable for heterosis breeding due to predominance of non-additive gene action for the traits like seed yield and its attributes. Exploitation of heterosis is possible with the Genetic male sterility (GMS) based hybrids were found to give about 30% yield advantage (Reddy *et al*., 1978; Saxena *et al*., 1983). However, this technology could not be commercialized due to seed purity problems during hybrid seed production. So, far seven cytoplasmic male sterile systems have been bred in pigeonpea with varying degrees of success (Saxena and Nadarajan, 2010). Considering the importance of pigeonpea in fulfilling nutritional requirements, an attempt has been made to study the extent of heterosis for yield and yield attributes to identify the high yielding hybrids with desired morphological traits for increasing yield potential of pigeonpea.

MATERIAL AND METHODS

The present investigation was performed with seven CMS lines *viz*., ICPA 2039, ICPA 2078, ICPA 2048, ICPA 2043, ICPA 2047, ICPA 2199 and ICPA 2092 and nine restorer lines *viz*., ICPL 87119, ICPL 20108, ICPL 20137, ICPL 92047, ICPL 161, ICPL 90048, ICPL 81-3, ICPL 86022 and ICPL 88034 were synthesized manually. The resultant 16 hybrids along with their parents and standard check variety (Maruthi) were evaluated in a randomised block design with two replications during *kharif,* 2017-2018 at ICRISAT. Each entry was sown in four rows of four metres length with a spacing of 75 x 30 cm from row to row and plant to plant, respectively. Five competitive plants were selected at random from each genotype of each replication for the purpose of recording observations on days to 50% flowering, days to maturity, plant height (cm), number of primary branches $plant^{-1}$, number of pod clusters $plant^{-1}$, number of pods $plant^{-1}$, Pod length (cm), Pod width (cm), number of seeds pod^{-1}, 100 seed weight (g) and seed yield $plant^{-1}$ (g). The statistical analysis for mean values over two replications was done as per Panse and Sukhatme, 1985.

RESULTS AND DISCUSSION

Mean sum of squares for replication were non-significant for all the characters studied except for days to 50% flowering. Mean sum of squares for genotypes were highly significant for all the characters. It revealed the fact that, sufficient variability was present for all the characters studied among the genotypes evaluated in the present investigation (Table 1).

The values of percentage heterosis of hybrids for all the 11 characters over mid-parent, better parent and standard check are given in table 2. Early to flower is a desirable trait in hybrids to escape drought and for ensuring high yield. Therefore, negative heterosis for days to 50% flowering was considered desirable. Heterosis for this trait ranged from -15.05 to 9.33%, -21.08 to 8.97% and -34.82 to 7.59% over mid-parent, better parent and standard check, respectively. All hybrids exhibited significant heterosis over mid-parent and better parent in negative direction except ICPH 2447, ICPH 2429, ICPH 2438 and ICPH 2433 which showed significant heterosis in positive direction. Hybrids ICPH 2447, ICPH 2429, ICPH 2438, ICPH 2433, ICPH 3310 and ICPH 3933 showed significant heterosis over standard check in negative direction while rest of them in positive direction except ICPH 3467 and ICPH 3461 which showed non-significant heterosis over standard check. Similar findings were reported by Pawar *et al*. (2013), Pandey *et al*. (2013), and Mhasal *et al*. (2015) for this trait.

Heterosis for maturity ranged from -8.67 to 9.39%, -11.59 to 5.51% and -29.46 to 7.74% over mid-parent, better parent and standard check respectively. Significant heterosis over mid-parent, betterparent and standard check for this trait was observed in both negative and positive directions. These findings are in close agreement with the results of Reddy *et al*. (2015) and Singh and Singh (2016).

For plant height the range of heterosis over mid-parent, betterparent and standard check ranged from 22.60 to 55.11%, -2.92 to 24.41% and -19.08 to 28.26%, respectively. All hybrids showed significant heterosis over mid-parent in positive direction, while seven hybrids out of 16 showed significant positive heterobeltiosis and nine hybrids exhibited standard heterosis in both positive and negative directions. Similar results were documented by Mhasal *et al*. (2015).

Heterosis for number of primary branches ranged from 5.44 to 42.37%, -14.11 to 23.53% and -43.46 to 45.03% over mid-parent, betterparent and standard check respectively. Eleven hybrids showed significant heterosis over mid-parent in positive direction, four hybrids showed significant heterosis in both positive and negative direction and 15 hybrids showed significant heterosis over standard check in both positive and negative direction. For number of pods per plant, the estimates of heterosis ranged from -35.37 to 127.40%, -43.26 to 94.86% and -30.22 to 88.50% over mid-parent, better parent and standard check respectively. However, none of the hybrids showed significant difference over three estimates of heterosis. The present findings are in accordance with the results of Singh and Singh (2016) for number of primary branches plant^{-1} and number of pods plant^{-1}.

The magnitude of heterosis for number of pod clusters per plant ranged from -12.59 to 211.89%, -44.83 to 152.75% and -21.04 to 102.35 over mid-parent, better parent and standard check respectively. Among 16 hybrids, 14 hybrids showed significant heterosis over mid-parent in positive direction, nine hybrids showed significant heterosis over betterparent in both positive and negative direction and 11 hybrids showed significant heterosis over standard check in positive direction. ICPH 2429, ICPH 2363, ICPH 3461 and ICPH 2751 are some of the hybrids which exhibited high estimates for average heterosis, heterobeltiosis and standard heterosis. Similar findings were also reported in pigeonpea by Mhasal *et al*. (2015).

The estimates of heterosis for pod length ranged from -11.99 to 10.35%, -17.01 to 8.83% and -11.74 to 8.53% over mid-parent, better parent and standard check respectively. Among 16 hybrids, two hybrids showed significant heterosis in both positive and negative direction and one hybrid showed significant heterosis over better parent and standard check in negative direction. These results are in agreement with the results of Singh and Singh (2016). For pod width, none of the hybrids showed significant heterosis. However, ICPH 3310 (8.53%) followed by ICPH 2740 & ICPH 2447 (6.98%) and ICPH 3461 (6.20%) exhibited high standard heterosis.

For seeds per pod, the estimates of heterosis ranged from -16.47 to 8.68%, -20.88 to -1.41% and -18.92 to -3.24% over mid-parent, better parent and standard check respectively. Among 16 hybrids, three hybrids exhibited significant difference over all the three bases of heterosis in negative direction. These results are in accordance with the results of Patel and Tikka (2014) and Mhasal *et al*. (2015).

Heterosis for 100 seed weight (g) ranged from -1.64 to 18.97%, -10.09 to 9.24% and -31.52 to 17.75% over mid-parent, betterparent and standard check respectively. Among 16 hybrids, three hybrids, ICPH 2429, ICPH 4503 and ICPH 2751 showed significant heterosis over mid-parent in positive direction while two hybrids were significant in negative direction over better parent and seven hybrids showed significant standard heterosis in both positive and negative direction, ICPH 4503 is the only hybrid which showed both average and standard heterosis in positive direction. These results were congruent with the earlier findings of Gite *et al.* (2014).

For seed yield per plant, the degree of heterosis ranged from -23.51 to 70.31%, -39.87 to 36.88% and -51.03 to 20.35% over mid-parent,

Table 1. Analysis of variance for yield and yield components in pigeonpea hybrids.

S. No.	Characters	Mean sum of squares		
		Replication (df = 1)	Treatments (df = 48)	Error (df = 48)
1	Days to 50% flowering	44.18	1245.62**	3.74
2	Days to maturity	0.02	1526.91**	5.30
3	Plant height(cm)	514.45	4905.78**	232.62
4	Number of primary branches per plant	1.34	68.69**	1.58
5	Number of Pod clusters per plant	50.06	2250.98**	90.45
6	Number of pods per plant	112.30	10716.53**	351.85
7	Pod length (cm)	0.15	0.11**	0.05
8	Pod width (cm)	0.00	0.001**	0.00
9	Number of seeds per pod	0.07	0.09**	0.04
10	100-seed weight (g)	0.20	5.66**	0.12
11	Seed yield per plant (g)	13.45	1157.7**	48.65

** Significant at 1% level *Significant at 5% level

Table 2. Mid-parent heterosis(MP), Betterparent heterosis (BP) and standard heterosis (SH) in CMS-based pigeonpea hybrids

Hybrids	Days 50% to flowering			Days to maturity			Plant height (cm)		
	MP	BP	SH	MP	BP	SH	MP	BP	SH
ICPH 2671 F1	-1.08**	-5.78**	1.78**	-6.86**	-11.59*	-2.38**	30.41**	3.72	7.73
ICPH 3933 F1	-6.72**	-8.26**	-0.89**	-1.45**	-8.08**	1.48**	55.11**	7.67	11.84
ICPH 3467 F1	-2.80**	-8.13**	0.89	-1.44**	-5.26**	1.78**	23.18**	-8.73	16.18*
ICPH 2751 F1	-10.45**	-18.37**	7.14**	-1.23**	-2.42**	7.74**	42.02**	19.07**	23.67**
ICPH 3762 F1	-11.61**	-18.06**	5.36**	-1.27**	-2.77**	4.46**	31.20**	-2.66**	23.91**
ICPH 3481 F1	-8.01**	-13.30**	7.59**	0.00	-1.38**	5.95**	23.31**	-1.14**	25.85**
ICPH 3461 F1	-9.05**	-16.32**	7.59	-6.37**	-8.89**	0.59**	35.18**	7.67**	11.84**
ICPH 4503 F1	-15.05**	-16.84**	5.80**	-0.14**	-0.55**	7.44**	22.60**	-2.92**	20.53**
ICPH 3496 F1	-14.07**	-21.08**	3.57**	-2.35**	-2.22**	5.05**	29.83*	0.76**	28.26**
ICPH 2740 F1	-12.69**	-18.35**	1.33**	-4.43**	-7.01**	2.68**	33.96**	16.51*	21.01**
ICPH 3310 F1	0.00	-5.81**	-34.82**	3.39**	-3.94**	-27.38**	27.04*	8.13**	-19.08**
ICPH 2447 F1	9.33**	5.81**	-26.79**	9.39**	5.51**	-20.24**	43.19**	24.41*	-11.35
ICPH 2363 F1	-6.21**	-9.58**	-32.59**	-8.67**	-10.57**	-29.46**	33.42**	5.32	-4.35
ICPH 2429 F1	1.91*	0.63**	-28.57**	2.16**	1.96**	-22.62**	45.20**	22.08*	-5.85
ICPH 2438 F1	9.32**	8.97**	-24.11**	7.41*	5.51**	-20.24**	38.93**	10.99	-2.42
ICPH 2433 F1	6.25**	3.03*	-24.11**	6.56**	5.51**	-20.24**	32.85**	3.15	-1.93

Hybrids	Primary branches			Pod clusters per plant			Pods per plant		
	MP	BP	SH	MP	BP	SH	MP	BP	SH
ICPH 2671 F1	14.82*	-14.11**	11.52	43.38*	19.17	-14.1	23.66	1.76	30.22
ICPH 3933 F1	26.80**	-11.29*	15.18*	191.30**	118.95*	57.77*	16.74	-30.44	-10.98
ICPH 3467 F1	40.47**	3.46	40.84**	38.42**	-12.51	58.08*	51.28	34.74	42.52
ICPH 2751 F1	36.45**	11.69*	45.03**	158.08**	113.94*	54.16*	-35.4	-43.26	-3.94
ICPH 3762 F1	19.40**	-7.69	25.65**	73.93**	6.08	91.68*	18.04	-0.24	52.89
ICPH 3481 F1	23.04**	-0.38	35.60**	56.08**	-4.6	72.37*	38.83	13.7	88.5
ICPH 3461 F1	20.51**	-5.24	23.04**	200.56**	133.12*	67.97*	7.93	-0.98	51.76
ICPH 4503 F1	42.37**	23.53**	31.94**	56.26**	27.12	3.77	30.75	-1.44	25.01
ICPH 3496 F1	16.75**	-6.15	27.75**	-12.59	-	-0.31	-9.86	-26.77	23.98
ICPH 2740 F1	21.27**	0.00	29.84**	211.89**	142.92*	75.04*	-11	-21.14	30.74
ICPH 3310 F1	6.40	0.93	-43.46**	96.48**	49.26	-21	32.12	21.69	-30.22
ICPH 2447 F1	21.15	12.5	-34.03**	87.39**	52.71**	28.26	74.74	49.88	20.13
ICPH 2363 F1	10.00	-8.33	-30.89**	162.58**	120.85*	71.27*	127.4	94.86	56.55
ICPH 2429 F1	25.11*	8.4	-25.65**	204.37**	152.75*	102.35	65.21	39.73	15.86
ICPH 2438 F1	5.44	-11.89	-34.03**	96.08**	43.05**	64.84*	64.58	15.92	62.65
ICPH 2433 F1	11.28	-11.18	-25.13**	21.44	-13.73	8.48	16.29	-16.89	11.03

Hybrids	Pod length (cm)			Pod width (cm)			Seeds per pod		
	MP	BP	SH	MP	BP	SH	MP	BP	SH
ICPH 2671 F1	-2.75	-7.03	-1.14	-6.72	-9.42	-3.10	-7.04	-7.30	-10.81*
ICPH 3933 F1	-11.99**	-17.01*	-11.74*	0.00	-3.62	3.10	2.20	-1.41	-5.68
ICPH 3467 F1	1.60	-1.82	2.08	-2.33	-3.08	-2.33	-3.89	-4.95	-6.49
ICPH 2751 F1	0.00	-4.45	1.61	-7.58	-11.59	-5.43	-3.27	-3.81	-7.97
ICPH 3762 F1	1.12	-1.64	2.27	5.10	4.69	3.88	-3.29	-7.14	-8.65
ICPH 3481 F1	-4.07	-6.56	-2.84	4.76	3.12	2.33	-16.47**	-20.88**	-12.97*
ICPH 3461 F1	-0.97	-4.72	1.33	3.40	-0.72	6.20	1.31	-1.41	-5.68
ICPH 4503 F1	0.62	-0.10	-0.57	-0.78	-1.54	-0.78	7.55	5.64	-3.78
ICPH 3496 F1	0.14	-3.28	0.57	5.51	4.69	3.88	8.68	6.59	4.86
ICPH 2740 F1	3.51	-0.27	6.06	5.34	0.00	6.98	-8.28	-14.25**	-5.68
ICPH 3310 F1	2.16	1.49	-3.50	8.53	1.45	8.53	-4.61	-6.01	-7.03
ICPH 2447 F1	10.35*	8.83	5.02	8.66	2.99	6.98	-6.61	-7.73	-6.49
ICPH 2363 F1	5.83	1.29	8.53	3.10	-3.62	3.10	0.42	-2.19	-3.24
ICPH 2429 F1	2.32	0.30	-5.87	7.14	2.27	4.65	-4.02	-8.74	-9.73
ICPH 2438 F1	3.02	2.60	-2.94	5.98	1.53	3.10	-13.29**	-18.03**	-18.92**
ICPH 2433 F1	-1.47	-1.92	-7.95	5.22	1.55	1.55	-9.60*	-9.91	-10.27

Hybrids	100 Seed weight (g)			Seed yield per plant (g)		
	MP	BP	SH	MP	BP	SH
ICPH 2671 F1	2.02	-2.69	-1.72	17.75	14.91	-16.78
ICPH 3933 F1	1.95	-0.47	5.53	70.31**	4.75	-24.13**
ICPH 3467 F1	2.76	-3.90	1.09	11.90	-10.35	2.60
ICPH 2751 F1	9.96*	4.93	5.98	-23.51**	-39.87**	-23.88**
ICPH 3762 F1	-1.64	-9.40*	-4.80	-20.86**	-22.35**	-11.14
ICPH 3481 F1	3.17	-10.09*	-5.53	-3.51	-10.86	20.35**
ICPH 3461 F1	1.34	-4.93	-3.99	-11.28	-26.47**	-19.02*
ICPH 4503 F1	15.71**	5.26	17.75**	24.33**	4.08	6.79
ICPH 3496 F1	7.04	0.26	5.34	-3.48	-8.12	16.31**
ICPH 2740 F1	6.73	-5.38	-4.44	-0.46	-23.53**	3.24
ICPH 3310 F1	1.95	-1.87	-28.80**	-0.82	-34.04**	-51.03**
ICPH 2447 F1	4.02	-3.62	-18.03**	26.18*	11.19	-17.45*
ICPH 2363 F1	6.17	3.06	-20.56**	61.30**	35.01**	28.99**
ICPH 2429 F1	18.97**	9.24	-20.74**	-10.56	-26.49*	-45.43**
ICPH 2438 F1	8.04	4.87	-23.91**	43.35**	36.88**	1.63**
ICPH 2433 F1	0.27	-5.62	-31.52**	-20.53*	-22.82	-42.70**

** Significant at 1% level *Significant at 5% level
MP = Mid-parent (Averageheterosis); BP = Better parent (Heterobeltiosis);
SH = standard heterosis

betterparent and standard check respectively. Among 16 hybrids, eight hybrids were significantly different over mid-parent, better parent and standard check in both positive and negative direction. Hybrids ICPH 2363 (28.99%) followed by ICPH 3841 (20.35%) and ICPH 3496 (16.31%) recorded high standard heterosis among all hybrids tested. Similar observations have been reported earlier by Pagi *et al*. (2016) and Srivarsha *et al*. (2017).

CONCLUSION

The magnitude of heterosis over mid-parent, better parent and standard check differed in desirable direction. The estimates of heterosis showed four hybrids *viz*., ICPH 3481, ICPH 2363, ICPH 3496 and ICPH 2438 exhibited significant standard heterosis for seed yield per plant and for most of the traits like plant height, number of primary branches per plant and number of pod clusters per plant . Thus, all these hybrids can improve the yield potential of pigeonpea.

LITERATURE CITED

Directorate of Economics and Statistics , GOI. Annual report 2016-2017. Area and production of pigeonpea in India and Andhra Pradesh.

FAOSTAT 2016 Online Agriculture Statistics. http://faostat.fao.org

Gite U K, Madrap I A, Patil D K and Kamble K R 2014 Exploitation of heterosis in CMS based hybrids in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Journal of Agriculture Research and Technology*. 39(1): 138-140.

Mhasal G S, Marawar M W, Solanke A C and Tayade S D 2015 Heterosis and combining ability studies in medium duration F_1 hybrids. *Journal of Agricultural Research.* 53(1).

Pagi N K, Ravindrababu Y, Dharajiya D T, Patel J M and Patel M P 2016 Heterosis for seed yield and its component characters in pigeonpea [*Cajanus cajan* (L). Millsp.]. *International Journal of Agricultural Sciences.* 8(60): 3392-3395.

Pandey P, Kumar R, Pandey V R, Jaiswal K K and Tripathi M 2013 Studies on heterosis for yield and its component traits on CGMS based pigeonpea [*Cajanus cajan* (L). Millsp.] hybrids. *International Journal of Agricultural Research*. 8(4): 158-171.

Panse V G and Sukhatme P V 1985 Statistical Methods for Agricultural Workers. II ed. Indian Council of Agricultural Research, New Delhi. 268 p.

Patel P T and Tikka S B S 2014 Hybrid vigour in cytoplasmic geneic male sterility system based hybrids for seed yield and its associated traits in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Indian Journal of Genetics and Plant Breeding*. 74(2): 257-260.

Pawar R M, Tikka S B S, Sawant D M and Patil A H 2013 Heterosis in pigeonpea hybrids based on male sterile lines. BIOINFOLET- *A Quarterly Journal of Life Sciences*. 10(4b): 1303-1306.

Reddy B V S, Green J M and Bisen S S 1978 Genetic male sterility in pigeonpea. *Crop Sciences*., 8: 362-364.

Reddy V G, Jayalakshmi V and Sreenivas T 2015 Studies on fertility restoration and extent of heterosis in CMS based pigeonpea hybrids. *Journal of Food Legumes.* 28(1): 26-30.

Saxena K B and Nadarajan N 2010 Prospects of pigeonpea hybrids in Indian Agriculture. *Electronic Journal of Plant Breeding*. 1(4): 1107 – 1117.

Saxena K B, Wallis E S and Byth D E 1983 A new gene for male sterility in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *International Journal of Agricultural Sciences*. 5: 78-81.

Singh R S and Singh M N 2016 Heterosis and inbreeding depression for yield and yield traits in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Environment & Ecology*. 34(1A): 395-399.

Srivarsha J, Jahagirdar J E, Kumar C VS, Hingane, A J, Patil D K, Gite V K, Shruthi H B and Bhosle T M 2017 Study of cgms based short duration hybrids of pigeonpea [*Cajanus cajan* (L.) Millsp.] in terms of heterosis. *International Journal of Current Microbiology and Applied Sciences*. 6(11): 682-692.

Varshney R K, Chen W, Li Y, Bharti A K and Saxena R K 2012 Draft genome sequence of pigeonpea (*Cajanus cajan*), an orphan legume crop of resource-poor farmer. *Nature Biotechnology*. 30: 83-89.

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