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Hybrid vigour and combining ability in long duration pigeonpea [*Cajanus cajan* (L.) Millsp.] hybrids involving male sterile lines

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Abstract

Hybrids, utilizing three genetic male sterile lines (DAMS-1, ICPMS 3783 and KPMS 1050) and 12 diverse genotypes of the long duration group of pigeonpea [*Cajanus cajan* (L.) Millsp] were evaluated for general and specific combining ability, variance components and standard heterosis. Among the lines DA 32, DA 34, DA 37, DA 46, DA 93-4, DA 93-2, DA 94-6 and Bahar mutant and testers DAMS-1 and ICPMS 3783 were found to be good general combiners for seed yield/plant^{-1} and other yield contributing traits such as secondary branches/plant^{-1}, clusters/plant^{-1} and number of pods/plant^{-1}. The tester DAMS-1 was also a good general combiner for primary branches/plant^{-1} and per cent pod setting. The estimates of σ^2gca and σ^2sca suggested partial dominance of additive genetic action for number of pods/plant^{-1}. While for days to flowering, days to maturity, plant height, number of primary branches/plant^{-1}, per cent pod setting, harvest index and seed yield/plant^{-1} over dominance with non additive genetic variance was observed. The contribution of testers to the performance of crosses were found significant for seed yield/plant^{-1} and yield attributing traits. Out of 36 cross combinations 10 showed higher magnitude of specific combining ability effects involving high x high (H x H) and low x high (L x H) combining ability effects of lines and testers, respectively for seed yield/plant^{-1}, number of secondary branches/plant^{-1} clusters/plant^{-1}, number of pods plant and per cent pod setting. The estimated standard heterosis ranged from 144.32 per cent (KPMS 1050 x DA 94-6) to 8.75 per cent (MS 3783 x DA 37). Out of 36 combinations, 12 registered highly significant positive heterosis for seed yield/plant^{-1} and number of primary and secondary branches/plant^{-1} clusters plant and number of pods/plant^{-1}.

Key words: Pigeonpea, genetic male sterility, hybrid vigour, combining ability

Introduction

In a hybrid breeding programme, success depends on the choice of parents and a clear knowledge of genetic system and the traits. Combining ability is one of the most effective tool for deciding the appropriate parents for hybridization. Almost all the breeding methods for pigeon pea improvement are designed to exploit additive genetic variance and to develop high yielding pure-line varieties. Pigeonpea [*Cajanus cajan* (L.) Millsp] is an often cross pollinated crop [1] and it has a substantial amount of non-additive genetic variance [2, 3 and 4], hybrid vigor for yield [5 and 6] which can be profitably exploited through heterosis breeding. The discovery of genetic male sterility [7] coupled with its often out crossing nature has opened the commercial utilization of heterosis in pigeonpea [8]. It also helps in choosing suitable cross combination for recombination breeding. The magnitude of heterosis provides a basis for genetic diversity and guides to choice of desirable parents for developing superior hybrids. The main objective of this investigation was to identify good general and specific combiners and heterotic cross combinations for yield and its component traits in long duration pigeonpea.

Materials and methods

Twelve, genetically diverse pigeonpea lines DA 32, DA 34, DA 37, DA 46, DA 92-4, DA 93-1, DA 93-2, DA 93-5, DA 94-6, Pusa 9, Sharad and Bahar mutant were crossed with three genetic male sterile testers i.e., DAMS 1, ICPMS 3783 and KPMS 1050 in a line x tester mating design during 1996-97 *kharif* season. Thirty six hybrids along with their 15 parents and one standard check variety 'Bahar' were sown in a completely randomized block design in three replications during 1997-1998 *kharif* crop season at T.C.A. Dholi, Muzaffarpur, Bihar. Each plot consisted 2 rows of 4m.length spaced at 60 x 25 cm. Five competitive plants were selected randomly from each plot for recording observations on plant height, number of primary and secondary branches/plant^{-1}, number of clusters and pods/plant^{-1}, per cent pod setting, harvest index and seed yield/plant^{-1}. Days to initial flowering and maturity were recorded on plot basis. The data were subjected to combining ability analysis and estimation of variance components [9] and heterosis [10].

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Results and Discussion

Analysis of variance for combining ability showed significant differences among the parents, hybrids, parents *vs.* hybrids, lines, testers and their interactions for all most all the traits with the exception of the variation of days to flowering of parents, variation for all other components was significant. Interaction of lines and testers showed no differences for plant height, primary and secondary branches/plant^{-1}, clusters/plant^{-1}, pods/plant^{-1} and seed yield plant. Harvest index was also non-significant for line and testers (Table 1). The estimates of σ^2GCA and σ^2SCA showed partial dominance of additive genetic action for number of pods/plant^{-1}. Similar results have also been reported in pigeonpea [11, 12]. Days to flowering, maturity, plant height, number of primary branches, per cent pod setting, harvest index and seed yield/plant^{-1} exhibited over dominance with non-additive gene action. The results are similar to those reported by [13, 4 and 14]. The results of this investigation such as over-dominance with non-additive genetic variance for seed yield and yield components like per cent pod set, number of primary branches and harvest index and partial dominance with additive genetic variance for number of pods/plant^{-1} revealed that selection and accumulation of desired alleles for the enhancement of yield and yield components is likely to be effective in the early generations in pigeon pea.

A greater contribution of lines to the performance of crosses was observed for days to flowering and maturity, plant height, per cent pod setting and harvest index. The contribution of testers to the performance of crosses were found significant for number of primary and secondary branches/plant^{-1}, number of clusters/plant^{-1}, number of pods/plant^{-1} and seed yield/plant^{-1}. The results also suggested significant contribution of maternal parents with more favourable alleles contributing to the number of primary and secondary branches/plant^{-1}, clusters/plant^{-1}, pods plant and seed yield/plant^{-1}. The contribution of lines and testers were also found equally important for the development of number of pods/plant^{-1}, per cent pod setting and seed yield plant This shows that the average general combiners may give high performance.

The general combining ability effects (Table 2) revealed that among the lines DA 32 was good general combiner for days to flowering. For primary and secondary branches/plant^{-1}, number of clusters/plant^{-1}, number of pods/plant^{-1} and per cent pod setting DA 32, DA 37, DA 46, DA 92-4. DA 93-1, DA 93-2, Pusa 9 and Bahar mutant and tester DAMS 1 were good general combiners while for seed yield out of 12 lines, eight were good general combiners. Among the tester MS 3783 and DAMS 1 were good general combiners for secondary branches/plant^{-1}, clusters/plant^{-1} number of pods/plant^{-1} and seed yield/plant^{-1}.

The specific combining ability effects (Table 3) showed that out of 36 hybrids only one cross (MS 3783 x Sharad) for days to maturity and another (DAMS 1 x Pusa 9) for plant height were good specific combiners. None of the hybrids was good specific combiner for days to flowering. The cross MS 3783 x DA 93-2 for days to flowering, DAMS 1 x Sharad for

Table 1. Analysis of variance for combining ability for ten characters in long duration pigeonpea

Source of variation	d.f.	Days to flowering	Day to maturity	Plant height (cm)	Primary brnaches/ plant^{-1}	Secondary branches/ plant^{-1}	Number of clusters/ plant^{-1}	Number of pods/plant^{-1}	Per cent pod setting	Harvest index	Seed yield/ plant^{-1}
Parents	14	160.47**	161. 8**	1196.97**	86.95**	294.59	40600.59**	87782.56**	7.97**	117.71*	9761.98**
Parents *vs.* hybrids	1	1.87	15.32	893.53**	551.42**	12985.06**	701707.66**	462237.45**	23.76**	224.54**	12044.14**
Hybrids	35	16.58	107.52*	191.89	12.82	425.89*	28398.76**	27409.86**	3.79*	71.99*	2052.92*
Lines	11	18.76	110.51*	270.76*	3.58	230.52*	19127.23**	25333.08*	4.53*	55.64	1491.24*
Testers	2	1.11	86.22	23.83	46.03**	3778.07**	288768.15**	173053.56**	20.36**	3.20	14138.59**
Line x testers	22	16.90	107.96*	167.73	14.43	218.83	9364.59	15207.92**	1.91	86.42*	1235.07
Error	100	12.06	77.31	189.27	22.80	266.90	11418.46	13198.13	2.78	64.24	1245.46
SE ± (line)		1.16	2.93	4.59	1.59	5.45	35.62	38.29	0.56	2.67	11.76
SE ± (tester)		0.58	1.47	2.29	0.79	2.73	17.81	19.15	0.28	1.34	5.88
σ^2GCA		-0.02	-0.03	1.52	-0.10	13.04	1198.74	768.45	0.12	-0.91	51.50
σ^2SCA		1.62	10.22	-7.18	-2.79	-16.02	-684.63	669.93	-0.29	7.39	-3.46

Per cent contribution of lines, testers, and line x testers to crosses

Source of variation	Days to flowering	Day to maturity	Plant height(cm)	Primary branches plant^{-1}	Secondary branches plant^{-1}	Number clusters plant^{-1}	Number of pods plant^{-1}	Per cent pod setting	Harvest index	Seed yield plant^{-1}
Lines	35.56	32.30	44.35	8.77	17.01	21.17	29.05	37.54	24.29	22.83
Testers	0.38	4.58	0.71	20.50	50.69	58.10	36.08	30.70	0.25	39.35
Lines x testers	64.06	63.12	54.94	70.73	32.30	20.73	34.87	31.76	75.46	37.82

*Significantat P=0.05, **Significantat P = 0.01.

Table 2. General combining ability effects of parents for yield and other traits in long duration pigeonpea

Parents	Days to initial flowering	Day to maturity	Plant height(cm)	Primary branches/ plant^{-1}	Secondary branches/ plant^{-1}	Number of clusters/ plant^{-1}	Number of pods/ palnt^{-1}	Per cent pod setting	Harvest index	Seed yield/ plant^{-1}
Lines										
DA 32	-2.75*	-3.78	-7.23	10.47**	16.80**	55.52**	73.45**	-0.32	1.15	13.80**
DA 34	-0.86	-1.78	2.77	20.64**	1.54	65.15**	111.21**	1.25*	3.58	16.86**
DA 37	-2.31	-3.22	2.21	8.42**	18.24**	66.40**	63.23**	2.15**	2.12	14.14**
DA 6	0.03	-0.89	6.88	10.69**	16.65**	41.04**	23.00**	1.24*	1.83	14.70**
DA 92-4	1.47	0.56	10.32*	11.31**	11.13*	25.19**	48.99**	1.39*	2.89	1.08
DA 93-1	1.03	0.11	1.00	10.47**	19.32**	45.59**	23.66**	1.34*	1.93	18.86**
DA 93-2	0.69	-0.22	-4.57	9.64**	20.91**	59.96**	42.79**	1.52*	3.07	19.08**
DA 93-5	-0.64	-1.56	-5.45	0.58	4.09	26.04**	2.66	1.40*	1.85	4.36
DA 94-6	0.47	-0.44	-1.34	0.47	2.20	27.04**	8.66	2.46*	3.02	21.86**
Pusa 9	0.92	0.00	-4-68	9.36**	24.57**	28.85**	33.34**	2.05*	1.35	0.58
Sharad	-0.09	10.11**	5.21	0.14	4.09	5.96	5.23	0.22	1.82	4.30
Bahar mutant	2.03	1.11	-3.12	10.19**	18.76**	37.03**	41.88**	2.14**	2.62	14.47**
SE±	1.16	2.93	4.59	1.59	5.45	15.62	18.29	0.56	2.67	4.76
Testers										
MS 3783	-0.14	-1.06	-0.15	0.64	7.12*	70.34**	76.00**	-0.11	-0.20	22.86**
DAMS 1	-0.06	1.78	0.88	2.67**	14.62**	130.48**	46.18*	0.69*	0.34	42.30**
KPMS 1050	0.19	-0.72	-0.73	-1.31	-11.74**	100.82**	59.82**	0.80*	-0.14	-10.56
SE ±	0.58	1.47	2.29	0.79	2.73	17.80	19.14	0.28	1.33	5.88

*Significant at P = 0.05, **Significant at P = 0.01.

Table 3. Specific combining ability effects in the crosses for seed yield and component traits in pigeonpea

Cross combinations	Days to initial flowering	Day to maturity	Plant height (cm)	Primary branches plant^{-1}	Secondary branches plant^{-1}	Number of clusters plant^{-1}	Number of pods plant^{-1}	Per cent pod setting	Harvest index	Seed yield plant^{-1}
MS 3783 x DA 32	-1.42	-0.39	4.70	-0.31	25.45**	88.68**	68-88**	5.57**	4.44	22.31**
MS 3783 x DA 34	0.03	0.94	-2.96	-2.08	23.21**	22.38*	74.79**	9.95**	-3.52	15.97*
MS 3783 x DA 37	-0.53	0.39	3.93	12.81**	-3.00	3.21	32.10**	-0.53	2.56	7.64
MS 3783 x DA 46	-1.86	-0.94	3.59	-1.75	24.44**	89.10	44.34**	6.29**	5.29	-0.75
MS 3783 x DA 92-4	2.36	3.28	7.48	11.58**	25.88**	5.32	26.68**	5.07**	2.60	24.14**
MS 3783 x DA 93-1	-1.52	-0.61	-9.19	-0.64	1.44	3.79	44.99**	7.12**	5.27	16.64*
MS 3783 x DA 93-2	5.14*	6.06	-1.30	12.92**	0.65	29.57*	28.55**	8.28**	2.81	36.47**
MS 3783 x DA 93-5	-2.19	-1.28	1.59	0.47	-5.34	48.77**	60.00**	10.13**	0.14	0.95
MS 3783 x DA 94-6	1-03	1.94	-5.85	-1.97	22.88**	3.44	36.66**	7.33**	4.35	26.64**
MS 3783 x Pusa 9	2.58	3.50	2.15	-1.08	24.99**	23.99*	53.00**	12.32**	4.93	41.47**
MS 3783 x Sharad	-2.42	-12.61**	-0.74	-0.64	25.99**	0.90*	65.10**	7.05**	3.63	5.08
MS 3783 x Bahar mutant	-1.19	-0.28	-3.41	10.69**	25.68**	18.57*	1.57*	7.45	9.81	2.38
DAMS 1 x DA 32	2.17	0.11	-1.66	4.00*	5.05	41.85**	7.71	6.59**	6.00	0.53
DAMS 1 x DA 34	0.28	-1.56	5.68	7..56**	24.29**	32.15**	134.04**	6.64**	2.94	16.14**
DAMS 1 x DA 37	-0.61	-2.44	-7.44	12.56**	-0.51	54.59**	4.40	7.79**	3.69	25.53**
DAMS 1 x DA 46	1.06	-0.78	2.90	-14.22**	-1.73	45.05**	34.84**	13.31**	0.72	4.75
DAMS 1 x DA 92-4	1.28	-0.56	-1.55	11.44**	22.05**	33.52**	3.49	8.52**	3.35	1.97
DAMS 1 x DA 93-1	1.06	-0.78	2.12	0.33	36.60**	71.07**	75.84**	0.00	0.65	10.86*
DAMS 1 x DA 93-2	-2.28	-4-11	8.01	0.89	36.82**	57.96**	77.29**	7.24**	7.90	17.70**
DAMS 1 x DA 93-5	-0.61	-2.44	-3.10	-1.22	0.49	29.70**	54.49**	9.54**	3.92	19.25*
DAMS 1 x DA 94-6	-0.72	-2.56	3.45	-0.67	1.29	84.04**	29.82**	7.75**	2.30	7.14
DAMS 1 x Pusa-9	-2.83	-4.67	-16.21	-1.44	4.18	30.48**	101.49**	11.21	0.09	20.30**
DAMS 1 x Sharad	-0.17	20.22**	7.57	-0.67	2.16	47.96*	94.40**	0.89	0.62	19.08*
DAMS 1 x Bahar mutant	1.39	-0.44	0.23	20.00**	28.82**	43.63**	44.29**	-0.200	2.70	36.56**
KPMS 1050 x DA 32	-0.75	0.28	-3.05	-0.69	10.41	46.82**	76.59**	0.02	-1.60	21.78**
KPMS 1050 x DA 34	-0.30	0.61	-2.71	0.53	1.07	24.49*	59.26**	-0.31	0.57	38.12**
KPMS 1050 x DA 37	1.14	2.06	3.51	-0.25	3.52	51.38**	27.70**	10.44**	6.25	2.11
KPMS 1050 x DA 6	0.80	1.72	-6.49	-2.47	2.70	44.07**	49.19**	-0.02	-6.01	4.00
KPMS 1050 x DA 92-4	-3.64	-2.72	-5.94	-0.14	7..93	28.84**	23.19**	18.58**	0.75	16.11**
KPMS 1050 x DA 93-1	0.47	1.39	7.07	0.31	8.04	67.29**	60.85**	13.81**	4.60	4.22
KPMS 1050 x DA 93-2	-2.86	-1.94	-6.72	-3.8	7.48	38.40**	58.74**	9.52**	10.71	25.78**
KPMS 1050 x DA 93-5	2.80	3.72	1.51	0.75	4.85	29.07**	5.52	14.42**	3.78	8.33
KPMS 1050 x DA 94-6	-0.30	0.61	2.40	2.64	8.41	80.60**	64.48**	7.42**	-2.08	13.78*
KPMS 1050 x Pusa 9	-0.25	1.17	14.07**	2.53	-0.82	42.94	48.48**	18.98**	4.85	18.56**
KPMS 1050 x Sharad	2.58	-7.61	-6.82	1.31	8.15	12.94*	29.30**	-0.74	-4.24	-4.00
KPMS 1050 x Bahar mutant	-0.19	0.72	3.18	-0.70	3.15	25.67**	51.74**	-0.61	5.08	42.56**
SE ±	2.00	5.08	7.94	2.76	9.43	9.69	10.33	0.96	4.63	8.88

*Significant at P = 0.05; **Significant at P = 0.01

Table 4. Standard heterosis for yield and other related characters in long duration pigeonpea

Cross combinations	Days to initial flowering	Day to maturity	Plant height (cm)	Primary branches plant $^{-1}$	Secondary branches plant^{-1}	Number of clusters plant^{-1}	Number of pods plant^{-1}	Per cent pod setting	Harvest index	Seed yield plant^{-1}
MS 3783 x DA-32	-15.46**	-2.66**	-14.47**	25.77**	8.69	1.99**	1.33	-8.31	50.63**	26.29
MS 3783 x DA 34	-3.16*	-1.54	-12.75**	10.59	56.52**	44.65**	45.75**	20.63	10.77	59.27*
MS 3783 x DA 37	0.82	-2.10	-9.96**	9.09	-50.74	16.79	-26.06	-19.20	22.90	8.75
MS 3783 x DA 46	-1.15	-0.56	-10.89**	10.59	66.65	64.30**	12.59	-9.46	77.62**	11.33
MS 3783 x DA 92-4	-0.28	-0.14	-10.23**	39.40**	97.09*	89.18**	58.25**	-8.17	36.56	55.14*
MS 3783 x DA 93-1	-2-30	-1.12	-10.76	25.77**	82.60*	102.36**	41.58*	-5.87	47.12*	46.90
MS 3783 x DA 93-2	2.87	1.40	-20.05**	-7.59	124.65**	28.98	15.51	15.47	23.22	28.34
MS 3783 x DA 93-5	0.58	0.28	-18.33	10.59	72.47	45.39*	15.60	0.00	-5.44	18.03
MS 3783 x DA 94-6	-1.44	-0.70	-15.00**	24.67**	21.74	35.82	4.79	-1.86	35.15	51.54*
MS 3783 x Pusa-9	-0.28	-0.14	-12.48**	22.73*	23.17	32.46	7.89	5.73	-4.96	4.11
MS 3783 x Sharad	4.03*	-1.96	-10.49**	21.23*	-2.91	24.75	10.19	-8.60	-13.02	20.09
MS 3783 x Bahar mutant	-2.00	-0.98	-7.70*	15.14	24.65	73.75**	35.73*	0.29	24.32	39.68
DAMS 1 x DA 32	-0-86	-0.42	-14.74**	22.73**	91.30*	30.35	17.82	14.61	44.08	42.77
DAMS 1 x DA 34	0.58	0.28	-7.17*	45.45**	50.74	80.47**	37.23*	33.52**	47.02*	54.63*
DAMS 1 x DA 37	-0.28	-0.28	-14.87	25.77*	66.65	44.40	20.75	3.44	-2.45	27.93
DAMS 1 x DA 46	2.30	1.12	-7.97*	36.36**	114.48**	71.52**	37.59*	0.29	37.19	64.94*
DAMS 1 x DA 92-4	2.00	0.99	-12.62**	19.68	65.22	18.40	31.12	41.70**	8.63	50.50*
DAMS 1 x DA 93-1	2.30	0.98	-13.42**	24.23**	88.39*	75.37**	41.84*	1.86	37.19	99.47**
DAMS 1 x DA 93-2	-1.44	-0.70	-16.20**	36.36**	39.00	35.32	-0.53	-9.02	83.47**	65.46*
DAMS 1 x DA 93-5	0.86	0.42	-15.14**	21.23*	108.70**	85.20**	48.85**	4.73	49.06*	86.59**
DAMS 1 x DA 94-6	2.30	0.98	-17.26**	40.90**	169.56**	96.27**	46.63**	-4.30	27.82	96.38**
DAMS 1 x Pusa-9	1.72	0.84	-14.97**	10.59	33.34	32.09	15.07	8.45	61.14*	62.36*
DAMS 1 x Sharad	1.72	-0.84	-13.02**	31.82**	205.78**	100.25**	69.50**	7.88	28.66	112-36**
DAMS 1 x Bahar mutant	4.31*	-2.10	-20.19**	4.86**	130.43**	69.90**	54.88**	12.75	58.79*	80.92**
KPMS 1050 x DA 32	2.59	1.26	-18.73**	15.14	65.22	56.34*	16.93	-7.30	28.87	57.72*
KPMS 1050 x DA 34	3.73	1.82	-17.40**	22.73**	165.22**	113.05**	103.64**	3.87	-9.42	109.79**
KPMS 1050 x DA 37	2.59	1.12	-13.15**	40.90**	110.13**	55.34*	49.56**	22.20*	51.78*	89.16**
KPMS 1050 x DA 46	2.30	1.12	-13.55**	13.64	159.43**	101.00**	26.15	-17.05	19.50	46.89
KPMS 1050 x DA 92-4	5.46**	2.66	-5.45	28.77**	76.82*	55.10*	44.42*	22.92*	15.06	90.70**
KPMS 1050 x DA 93-1	6.32**	2.94	-17.66**	13.64	86.96*	64.18**	30.32	2.14	46.44	86.07**
KPMS 1050 x DA 93-2	3.73	1.68	-9.83**	51.50**	78.26*	60.45**	45.57**	28.94*	47.07*	71.64*
KPMS 1050 x DA 93-5	0.28	0.00	-14.34**	30.31**	126.09**	89.43**	32.36	-8.88	33.00	66.49*
KPMS 1050 x DA 94-6	4.02*	1.96	-9.96**	10.59	91.30*	89.06**	50.18**	-0.57	90.01**	144.32**
KPMS 1050 x Pusa-9	4.31*	2.10	-18.86**	31.82**	137.70**	94.03**	45.13*	1.15	28.14	113.90**
KPMS 1050 x Sharad	5.46**	2.66	-10.89**	15.14	104.35**	59.20*	6.38	4.30	74.22**	55.14
KPMS 1050 x Bahar mutant	6.32**	3.07	-16.47**	22.73**	160.87**	88.68**	55.23**	5.87	41.16	121.12**

*Significant at P = 0.05; **Significant at P = 0.01.

days to maturity and KPMS 1050 x Pusa 9 for plant height exhibited positive and significant specific combining ability effects. The cross combinations of MS 3783 with DA 32, DA 34, DA 92-4, Pusa 9, and DAMS-1 with DA 34, DA 93-2 and Bahar mutant were good specific combiners for seed yield, number of primary and secondary branches/plant^{-1}, clusters/ plant^{-1}, number of pods/plant^{-1} and per cent pod setting. The SCA effects were significant in crosses MS 3783 x DA 93-2, MS 3783 x DA 94-6, DAMS-1 x DA 37, DAMS-1 x Pusa 9, KPMS 1050 x DA 32, KPMS 1050 x DA 34, KPMS 1050 x DA 93-2, and KPMS 1050 x Bahar mutant for yield/plant^{-1} only.

For improvement of days to flowering and maturity, plant height, primary branches, per cent pod setting, harvest index and yield/plant^{-1} where over-dominance of non additive gene action were recorded, hybrid breeding following repeated crossing in early segregating generation can prove useful in pooling desired genes. The cross combinations MS 3783 x DA 93-2 and DAMS 1 x Sharad and KPMS 1050 x Pusa 9 had significant SCA effects for days to flowering, maturity and plant height, respectively involved both low general combiner parents. For yield/plant^{-1}, number of primary and secondary branches/plant^{-1}, clusters/plant^{-1} and number of pods/plant^{-1}, the cross combinations involved both high general combiner parents showed significant SCA effect except the cross combinations involved low general combiner tester KPMS 1050. Similar results have been reported by Cheralu *et al.*, [15].

The estimates of heterosis over national control variety Bahar (Table 4) revealed that it ranged fro 4.11

(MS 3783 x Pusa 9) to 144.32 (KPMS 1050 x DA 94-6). Several crosses were promising with highly significant and positive heterosis for seed yield/plant^{-1} and yield contributing traits primary and secondary branches, clusters and pods/plant^{-1}. Eight crosses expressed highly significant and positive heterotic response for seed yield only. The expression of heterosis for days to flowering and maturity were also not so encouraging. Out of 36 crosses only 3 exhibited significantly negative standard heterosis. All the 36 combinations involved in the present investigation registered highly significant negative standard heterosis for plant height. Six crosses exhibited highly significant and positive standard heterosis for per cent pod setting. The range of standard hcterosis for harvest index was –13.02 (MS 3783 x Sharad) to 90.01 (K-PMS 1050 x DA 94-6). Highly significant and positive standard heterosis was exhibited for harvest index in 12 crosses. Lawn and Troedson [16] reported harvest index of pigeon pea ranging from around 10-52 per cent depending on: genotype, environment and agronomic management. Harvest index of pigeonpea is low particularly so for the long duration pigeonpea traditionally grown in India.

The estimates of heterosis for various yield components of heterotic hybrids indicated that significant yield increase was largely attributed due to increased primary and secondary branches/plant^{-1}, clusters plant^{-1}, and number of pods/plant^{-1} and harvest index. Similar results have been reported in the past by other workers [16, 17, 18 and 1]. Seven crosses exhibiting high SCA effects with high standard heterosis for seed yield and yield components involved both good general combiner parents. Five combinations exhibiting high SCA effects with high standard heterosis for seed yield and yield components involved either seed or pollen parent of low GCA effects. Cheralu *et al.*, [15] also reported that the combinations showed significant heterosis, indicating that at least one parent should be good general combiner in breeding for high seed yield.

References

1. **Singh B. D.** 1983. Mode of reproduction and pollination control. Plant breeding. Kalyani Publicastions, Ludhiana, pp 44-75.

2. **Sharma H. K., Singh L. and Sharma D.** 1973. Genetic analysis of flower initiation in pigeonpea. Indian J. Genet. **33**: 393-397.

3. **Reddy L. J., Green J. M. and Sharma D.** 1981. Genetics of *Cajanus cajan* (L.) Millsp x Atylosia spp. *In*: Proc. of the International Workshop of Pigeonpeas, Vol. 2.15-19, Dec. 1980. ICRISAT Center, India, Patancheru, A. P. India. pp. 39-50.

4. **Saxena K. B., Byth D. E. Wallis E. S. and De Lacy I. H.** 1981. Genetic analysis of a diallel crosses of early flowering pigeon pea lines of the International Workshop of Pigeonpeas, Vol. 2. 15-19, Dec. 1980. ICRISAT Center, India, Patancheru, A. P. India. pp. 81-92.

5. **Solomon S., Argikar G.P., Solanki M. S. and Morobad I. R.** 1957. A study of heterosis in *Cajanus cajan* (L.) Millsp. Indian J. Genet., **17**: 90-95.

6. **Shrivastava M. P., Singh L. and Singh R. P.** 1976. Heterosis in pigeonpea. Indian J. Genet., **36**: 197-200.

7. **Reddy B. V. S., Green J. M. and Bisen S. S.** 1978. Genetic male sterility in pigeonpea. Crop Science. **18**: 362-364.

8. **Singh Laxman, Gupta S. C. and Faris D.G.** 1990. Pigeon pea breeding. The pigeonpea. Nene Y.L., Susan D. Hall and Sheila V. K. (eds.). C.A.B. International, Wallingford. Oxon Ox 10 8 DE. UK. pp 375-400.

9. **Kempthorne O.** 1957. An Introduction to Genetic Statistics. New York, USA: John Wiley and Sons.

10. **Hays H. K. Immer E. R. and Simth D. C.** 1955. Methods of Plant Breeding. 2nd Edn. Pub. McGraw Hill Book Co., New York.

11. **Patil G. V., Zaveri P. P. and Pathak A. R.** 1992. Combining ability analysis of parents and hybrids using genetic male sterility in pigeonpea. Indian J. Genet., **52**: 292-296.

12. **Singh N. P., Singh B. B. and Singh P. K.** 1996. Genetic analysis of yield and its components in pigeonpea. International Chickpea and Pigeonpea News Letter. **3**: 60-62.

13. **Pandey N., Singh N. B. and Ojha C. B.** 1998. Combining ability analysis of parents and hybrids in long duration pigeonpea. International Chickpea and Pigeonpea News Letter. **5**: 36-38.

14. **Patel J. A., Pathak A. R., Zaveri P. P. and Singh R. M.** 1987. Combining ability analysis in pigeonpea (*Cajanus cajan* (L.) Millsp), Indian J. Genet., **47**: 183-188.

15. **Cheralu C., Muralidhar V., Satyanarayan A. and Venkateswariu S.** 1989.Heterosis in relation to combining ability in pigeonpea. (*Cajanus cajan*). Indian Journal of Agricultural Sciences. **59**: 68-70.

16. **Lawn R. J. and Troedson R. J.** 1990. Pigeonpea: Physiology of yield formation. The Pigeonpea. Nene Y.L., Susan D. Hall and Sheila V.K. (eds.). C.A.B. Intemational, Wallingford. Oxon Ox 10 8 DE. UK. pp 179-208.

17. **Omanga P. A.** 1985.The use of male sterile lints to measure the nature and magnitude of hybrid vigour in pigeonpea [*Cajanus cajan* (L.) Millsp.] East African Agricultural and Forest Journal. **48**: 51-55.

18. **Saxena K. B., Faris D. G., Reddy L. J., Sharma D., Reddy B. V. S., Gupta S. C. and Green J. M.** 1986. Prospects for hybrid pigeonpea. *In*: New Frontiers in Breeding Research Proc. 5th Intl. Congress SABRAO, Nov.25-29, 1985. Bangkok, Thialand. pp. 379-388.

19. **Singh G. P., Singh R. M. and Singh U. P.** 1989. Heterosis in pigeonpea hybrids. International Pigeonpea News Letter. **10**: 6-8.