number of primary branches, the range of heterobeltiosis varied from -25.96 to 39.78. Plant height with number of primary branches per plant plays an important role in increasing the number of pods per plant as well as pod yield per plant. Number of pods per plant is one of the contributing character for increasing green pod yield. Eight and seven hybrids had significant positive relative heterois and heterobeltiosis respectively. HUVP-1 x EC-33866 exhibited highest significant relative heterosis (43.25) and heterobeltiosis (95.86). However, pod length and number of seeds per pod directly contribute to yield and hence their positive value increases the total yield. EC-33866 x Azad had highest relative heterosis (13.42) and heterobeltiosis (12.70) for length of pod, whereas PH-1 x UU-11 exhibited high relative heterosis (27.54) and heterobeltiosis (25.00) for number of seeds per pod. These resutls are in agreement with the results of Ram *et al* (1986).

In case of green pod yield per plant, HYVP-1 x UU-11 exhibited highest significant positive heterosis over mid parent and better parent. Heterobeltiosis ranged from -27.91 to 53.66. High heterosis for green pod yield per plant seems to have resulted due to the combined effect of heterosis observed in its yield on parent characters such as number of pods, per plant, pod length, plant height and number of primary branches. The genetic diverse of selected parents seems to be another cause for high heterosis observed in yield. Similar results were also reported by Parmar and Godwat (1990).

Considerable high heterosis in certain cross and low in other crosses revealed that the nature of gene varied in hybrids depending upon the genetic architecture of parents involved. Considering present study, the promising hybrids are HUVP-1 x UU- 11, HUVP-1 x PH-1, PH-1 x EC-33866 and HUVP-1 x EC-33866. These hybrids offer the best posibility of their future exploitation in the development of high yielding varieties.

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EXPLOITATION OF HETEROSIS USING MALE STERILITY AND DIVERSE PLANT TYPES IN PIGEONPEA

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ABSTRACT

The extent of heterosis for yield and yield and yield contributing components were studied in a set of 30 crosses involving a genetic male sterile line and 30 genetically diverse plant types of indeterminate and determinate types of Pigeonpea. Five cross combinations using male parents L.297, F21.M, OP.SP.L.Brown, S.Brown, L.298 and MS Prabhat. DT as female parent were identified as the best hybrids for grain yield on the *per se* performance with high heterotic expression. Development of hybrids using parental combination of determinate and indeterminate types would yield good hybrids vigour. High heterosis for traits like pods / plant, number of primary branches and grain/plant had influenced the grain yield.

KEY WORDS : Pigeonpea, Male Sterility, Plant Types, Heterosis

Pigeonpea, (*Cofanus Cafan* (L.Millsp.) is the important legume in India and early maturing types with good yield are preferred over late maturing traditional types. Development of improved types limited. With the discovery of genetic male sterility in Pigeonpea and the presence of natural out crossing it is now possible to breed hybrid Pigeonpea varieties. The importance of using stressed by plant breeders in order to obtain maximum hybrid vigour. This study was undertaken to study the extent of heterosis by involving a genetic male sterile line and diverse plant types *viz.*, determinate types (DT) and indeterminate types (IDT) in early pigeonpea for important yield and growth attributes.

METERIALS AND METHODS

A total of 30 hybrids was attempted using 30 genetically diverse lines representing diversity for plant type, maturity etc. and a genetic male sterile line MS.Prabhat DT during 1990 at the Indian Agricultural Research Institute, (IARI) New Delhi. Each of the hybrids and parents was raised in a plot with two rows of four m length in randomised block design replicated twice with a spacing of 30 x 30 cm. Two rows of border lines were sown around the entries to avoid any border effects. Observations were recorded on 5 random plants in each replication for different characters *viz.*, plant height, days to 50% flowering, days to 50% maturity, number of primary branches, number of secondary branches, number of pods per plant and seeds per pod, 100-seed weight, grains per plant and yield per plant. Combined Anova was carried out as per Panse and Sukatme (1989). The mean sum of squares due to block, treatments, parents, hybrids, contrast parents vs hybrids was tested against error mean squares by 'F' test of significance. Heterosis was measured over mid parent, better parent and over best available variety (BAV). Pusa 33, a high yielding and widely accepted check was included in the experiment to estimate the standard heterosis.

RESULTS AND DISCUSSION

Parental combinations and estimation of standard heterosis for all the characters are given in the Tables 1 and 2 respectively. Results indicated that the parents selected and hybrids showed larger variability (Table 3) for all the characters except number of secondary branches and seed/pod. Similar type of variability for different yield characters was reported by Balyon *et al.* (1986) and Bhongale *et al* (1987). The maximum heterosis over best available variety was observed for grains per plant in H-26 (136.59%), and it was followed

Table I. Details of parents and hybrid combinations

Hybrid code	Parents	Plant type
H-1	L.292	IDT
H-2	L.302	IDT
H-3	OP.SP.Brown	DT
H-4	L.297	IDT
H-5	(316X84034 P3 Brown)	DT
H-6	L.269	IDT
H-7	EPHYT.32	IDT
H-8	B6.RGDT Trial 2394	IDT
H-9	F21.M	DT
H-10	DT Trial ICPL-1.S2	IDT
H-11	ICPL.269.SP	IDT
H-12	20.71.48	DT
H-13	15-(DF1X78-1)	IDT
H-14	OP.SP.L.Brown	IDT
H-15	OP.SP	IDT
H-16	OP.Brown	IDT
H-17	Self 294 Brown	IDT
H-18	ICRISAT early dwarf	IDT
H-19	86.H.P Self	IDT
H-20	S.Brown	IDT
H-21	ACTH.Pant A77 SP4	IDT
H-22	OP.SP.Brown	IDT
H-23	278.White	IDT
H-24	1-138	IDT
H-25	P604, SP3	DT
H-26	383.S2	DT
H-27	L.298	IDT
H-28	274.No.Maiker	IDT
H-29	MS.Plc.SP.Brown S2	DT
H-30	Pusa 8330 brown S2	IDT
**	MS. Prabhat DT	DT
***	Pusa 33	IDT

** Female parent; *** Best available variety

plant in H-26 (117.86%), number of primary branches in H-12 (96.55), and secondary branches in H-25 (88.86%). Thus Pigeonpea has substantial amount of hybrid vigour for yield and it's components. The presence of hybrid vigour was reported as early as in 1957 by Solomon *et al* (1957). Increase by 40 per cent positive heterosis was observed for yield per plant in hybrids *viz.*, H-4 (51.52), H-9 (73.68), H-12 (50-84), H-14 (78.62), H-18 (40.67), H-20 (46.32), H-21 (48.88), H-26 (121.72), H-27 (47.95) and more than 20 per cent heterosis was exhibited for both the characters, pods per plant and number of primary branches per plant together in few of the above mentioned hybrids viz., H-4, H- 12, H-18, and H-26. It is very

Table 2. Estimation of standard heterosis for yield and yield components in pigeonpea

Hybrids	Plant height	Days to 50% flowering	Days to 50% maturity	No. of primary branches	No. of secondary branches	Pods/ plant	Seeds/ pod	100 seed weight	Grains plant	Grain yield per plant
H 1	19.42	16.17	12.93	44.82	-22.22	-3.76	12.50	- 11.86	18.45	5.31
*	165.00	117.5	145.5	23.00	6.00	158.50	3.75	7.71	371.00	28.76
**	227.50	118.5	161.5	21.00	7.00	153.00	4.05	6.69	375.50	25.17
H 2	-26.25	10.24	9.79	-6.89	-50.00	-33.54	6.94	- 15.28	-27.91	-40.50
*	167.50	11.5	153.5	16.00	5.50	121.00	4.15	8.16	322.50	26.35
**	140.50	112.5	157.0	13.50	4.50	106.00	3.85	6.43	228.50	14.22
H 3	-20.21	0.00	7.69	51.72	-61.11	-30.72	27.78	27.80	-19.87	3.22
*	150.00	1043.0	149.0	10.50	3.50	94.00	3.75	9.73	203.50	19.87
**	152.00	102.0	154.0	22.00	3.50	110.50	3.70	9.70	254.00	24.67
H 4	-5.57	14.20	14.33	62.06	33.33	24.45	8.33	-3.29	53.94	51.52
*	142.50	116.0	164.5	10.50	3.00	82.00	3.60	7.11	172.00	12.48
**	180.00	116.5	163.5	23.50	6.00	198.50	3.90	7.34	488.00	36.19
H 5	32.28	1.96	4.54	24.13	-50.00	22.26	6.94	-7.38	54.25	44.06
*	153.00	124.5	152.0	18.00	3.50	153.50	4.05	7.20	369.50	26.75
**	129.00	104.0	149.5	18.00	4.50	195.00	3.85	7.03	489.00	34.43
H 6	7.61	7.80	12.93	34.48	11.11	-61.12	13.89	3.82	-51.57	-51.34
*	195.00	108.0	137.5	23.00	5.50	115.50	3.65	7.41	265.50	19.69
**	205.00	110.0	161.5	19.50	8.00	62.00	4.10	7.61	153.50	11.63
H 7	4.99	4.40	6.44	37.93	5.55	-11.59	11.11	-0.66	19.24	10.00
*	192.50	103.0	134.5	20.00	6.00	153.50	4.25	8.07	370.00	25.67
**	200.00	106.5	152.5	20.00	9.50	141.00	4.00	7.54	348.50	26.29
H 8	-43.57	1.40	5.94	-44.82	-61.11	-30.40	12.50	3.16	-20.03	-16.65
*	191.50	100.5	145.0	13.50	5.50	112.50	4.05	9.39	314.50	24.87
**	107.50	103.0	151.5	8.00	3.50	111.00	4.05	7.83	253.50	19.92
H 9	4.20	3.40	9.44	27.58	-38.88	8.81	36.11	-5.53	80.12	73.68
*	193.50	111.5	150.5	15.00	6.50	151.00	3.85	7.98	330.50	26.35
**	198.50	105.5	156.5	18.50	5.50	173.00	4.90	7.17	571.00	41.51
H 10	-23.89	0.49	11.18	-23.89	3.74	4.17	-50.0	5.01	-26.02	-21.63
*	142.50	102.0	145.5	12.50	4.50	142.50	3.50	7.81	328.50	25.78
**	145.00	102.5	159.0	15.00	4.50	99.00	3.75	7.97	234.50	18.73
H 11	-4.20	12.20	8.39	-44.82	0.00	-4.38	31.94	-7.91	43.69	34 48
*	208.50	112.0	161.5	20.00	5.50	147.50	3.75	8.84	322.00	29 28
**	182.50	114.5	155.0	8.00	5.50	152.50	4.75	6.99	455.50	32.14
H 12	3.67	27.90	5.59	96.55	11.11	29.55	36.11	- 15.81	50.60	50.84
*	203.00	106.5	146.0	17.00	7.00	151.50	3.50	8.00	358.50	29 10
**	197.50	130.5	151.0	28.50	8.00	206.00	4.90	6.39	572.50	36.05
H 13	-27.82	1.96	2.45	-20.68	-44.44	-35.22	15.28	5.27	-17.19	11 67
*	187.50	101.0	144.0	19.00	9.00	133.00	3.75	7.89	208.00	16 45
**	137.50	104.0	146.5	11.50	5.00	103.00	4.15	7.99	262.50	21 11
H 14	-4.20	0.98	6.29	3.45	33.33	32.29	13.89	2.90	72.40	78 62
*	187.50	109.5	142.0	14.00	4.50	180.50	3.80	7.80	318.00	24.35
**	182.50	103.0	152.0	15.00	6.00	211.00	4.10	7.81	546.50	42.69
H 15	-33.07	17.15	6.64	-6.89	-27.70	21.94	15.28	-12.5	53.47	35.15
*	212.50	112.5	155.0	15.00	5.50	176.50	3.70	7.72	351.50	27 15
**	127.50	119.5	152.5	13.50	6.50	194.50	4.15	6.64	486.50	32 30
H 16	23.36	22.05	5.59	48.27	33.33	-19.43	33.33	-4.08	19.87	18.66
*	192.50	111.5	147.5	12.00	5.00	160.00	3.75	7.31	337.50	24 70
**	235.00	124.5	151.0	21.50	12.00	128.00	4.80	7.28	380.50	28 36
H 17	-18.64	5.30	11.88	-17.24	-27.77	-26.64	33.33	7.38	7.57	14.77
*	138.50	101.5	141.5	10.50	2.50	149.50	3.55	7.32	382.00	28 12
**	155.00	107.5	160.0	12.00	6.50	117.00	4.80	8.15	341.00	27 43
H 18	1.05	8.33	11.19	62.06	11.11	22.01	31.94	- 15.42	61.67	40 67
*	200.00	121.0	153.5	17.50	5.00	207.50	3.55	9.09	358.00	32 58
**	192.50	110.5	159.0	23.50	8.00	194.00	4.75	6.42	512.50	33.62

Table 2. (Contd.,)

Hybrids	Plant height	Days to 50% flowering	Days to 50% maturity	No. of primary branches	No. of secondary branches	Pods/ plant	Seeds/ pod	100 seed weight	Grains plant	Grain yield per plant
H 19	-14.70	18.62	11.19	41.37	11.11	-17.24	13.89	-2.50	9.93	9.33
*	172.50	116.0	157.5	11.50	5.50	139.00	4.35	7.26	284.50	20.64
**	162.50	121.0	159.0	20.50	8.00	132.00	4.10	7.40	348.50	26.13
H 20	-10.76	12.74	10.14	17.24	16.66	27.59	18.06	- 15.02	70.03	46.32
*	197.50	103.5	148.0	12.00	5.00	157.00	4.00	6.85	351.00	24.03
**	170.00	115.0	157.5	17.00	7.50	203.50	4.25	6.45	539.00	34.97
H 21	-6.30	11.76	2.09	41.37	-5.00	18.50	15.28	- 10.01	67.35	48.88
*	213.50	103.5	154.0	18.50	8.50	179.50	3.65	6.47	409.00	26.63
**	202.50	114.0	146.0	20.50	8.50	189.00	4.15	6.83	530.50	35.58
H 22	1.31	10.78	12.58	-24.13	33.33	-3.45	12.50	6.19	27.91	36.86
*	179.50	112.0	153.5	9.50	5.50	104.50	3.75	7.21	294.50	21.2
**	192.50	113.0	161.0	11.00	6.00	153.50	4.05	8.06	405.50	32.17
H 23	-6.82	0.98	7.69	-10.34	33.33	-26.33	18.06	-8.43	13.56	4.77
*	217.50	102.5	146.5	20.00	7.00	129.50	3.60	8.12	104.00	18.60
**	177.50	103.5	154.0	13.00	6.00	117.50	4.25	6.95	360.00	25.04
H 24	-22.57	9.80	10.84	-27.58	-33.33	-18.49	12.50	0.53	5.04	5.31
*	193.50	102.5	140.5	13.00	5.50	118.00	3.85	7.94	258.00	20.35
**	147.00	112.0	158.5	10.50	6.00	130.00	4.05	7.55	333.00	25.17
H 25	21.00	0.49	5.59	27.58	88.88	-16.30	36.11	-0.92	18.76	18.45
*	141.50	100.0	125.5	12.00	4.50	140.50	3.85	9.22	308.50	28.51
**	230.50	102.5	151.0	18.50	17.00	133.50	4.90	7.52	376.50	28.31
H 26	22.83	9.80	3.15	31.03	-66.66	117.86	1.39	-7.38	136.59	121.72
*	117.50	97.0	134.5	15.50	5.50	207.50	3.75	7.72	494.00	56.20
**	147.50	112.0	147.5	19.00	3.00	347.50	3.65	7.03	750.50	52.99
H 27	-1.57	6.8	9.09	6.89	-11.11	28.52	16.67	-5.93	57.25	47.95
*	180.00	111.0	152.0	18.00	8.00	173.50	3.65	6.17	391.00	24.33
**	177.50	109.5	156.0	15.50	8.00	205.00	4.20	7.14	498.50	35.56
H 28	-23.88	13.23	12.59	-20.68	-50.00	-0.63	15.28	- 12.11	19.71	5.56
*	203.00	115.5	151.0	18.00	6.50	101.00	3.85	8.24	234.50	19.34
**	145.00	115.5	161.0	11.50	4.50	158.00	4.15	6.61	379.50	25.53
H 29	-26.51	-0.49	10.49	-17.24	-50.00	22.88	13.89	-7.38	48.26	38.07
*	140.00	113.5	149.0	11.50	2.50	174.50	3.75	6.89	386.00	23.23
**	140.00	101.5	158.0	12.00	4.50	196.00	4.10	7.03	470.00	33.00
H 30	12.07	10.78	13.64	20.65	-22.22	-34.16	13.89	2.77	21.13	-17.57
*	160.00	102.0	147.0	16.00	5.50	152.50	3.70	7.93	348.00	28.06
**	213.50	113.0	162.5	17.50	7.00	105.00	4.10	7.80	250.00	19.70
MS. Prabhat.	146.00	109.5	153.0	8.50	5.50	129.00	4.05	6.50	318.00	20.35
BAV	190.50	102.0	143.0	14.50	9.00	159.50	3.60	7.59	317.00	23.90

* Parental mean; ** Hybrid mean

interesting to note that all the five pollinator parent involved in the cross had IDT plant type and the female line used had DT plant type and the hybrids were belonging to the early and medium maturity groups. The best hybrids which showed superior *per se* performances over best available variety were H-4, H-9, H-14, H-20, H-26 and H-27.

The range of pods per plant and yield per plant (Table 2) of the parents of the above mentioned superior hybrids was observed to be from 82(P-4) to 207.5(P-26). 12.48(P-4) to 24.35g(P-26) respectively. The range of these hybrids developed out of these parents was 173(H-9) to 347.5(H-26) for pods per plant and 35.56(H- 27) to

Table 3. Combined ANOVA (32 parents + 30 hybrids) for 10 yield contributing characters in early pigeonpea raised during 1990-91

Source	df	Plant height	Days to 50% flowering	Days to 50% maturity	No. of primary branches	No. of secondary branches	Pods per plant	Seeds per pod	100-seed weight	Grains per plant	Yield per plant
Replication	1	116.3	47.9**	35.2**	1.8	0.07	34.00	0.002	0.001	112	24.4
Parents	31	1143.9**	92.3**	127.4**	30.2**	5.3*	1807.40**	8.676**	1.396**	11354**	100.9**
Hybrids	29	2063.2**	113.8**	128.3**	48.9**	6.3*	3081.30**	0.253**	1.437**	27712**	171.1**
P vs. Hyb.	1	490.0*	219.8**	295.7**	66.1**	38.4**	5528.20**	5.446**	6.550**	241490**	538.7*
Error	61	69.6	3.3	2.9	2.8	1.4	84.6	0.048	0.007	456	12.2
Mean											
Parents :	-	177.3	108.0	147.6	15.17	5.5	145.0	3.79	7.77	318.0	25.12
Hybrids	-	173.3	110.8	150.7	16.66	6.6	158.5	4.21	7.31	406.5	29.29

* - Significant at 5% level; ** - Significant at both 5% and 1% level

development of superior hybrids would include parents in combination from two contrast plant types in Pigeonpea. Similar finding was reported by Prashad(1990). High heterosis for secondary branches and yield over parents was reported by Srivastava *et al.* (1976). From the results it is thus clear that higher heterosis present for pods per plant, number of primary branches, and grains per plant had influenced the higher grain yield as reported by Sinha *et al.* (1986). Higher heterosis for yield and yield traits were also observed by Reddy *et al.* (1979). Negative heterosis for plant height in Pigeon pea is desirable and (20%) was observed in hybrids H-3, H-5, H-8, H-10, H-13, H-16, H- 24, H-26, and H-29 over BAV.

Perusal of data clearly indicated that (Table 2) heterosis in grain yield was accompanied by heterosis in pod number and number of primary branches for most of the hybrids like H-4, H-5, H-9, H-12, H-14, H-20, H-21, and H-26. Conversely, negative heterosis over BAV was observed for pod number and yield per plant in the hybrids H- 30, H-10, H-8. Therefore it is suspected that heterosis with regard to pods per plant would decide the magnitude and direction of potential heterosis for grain yield. Considering the overall view of performance of hybrids attempted in study, it is evident that 25 crosses showed positive heterosis over BAV for grain yield (Table 2). So there is every possibility of exploiting heterosis at commercial level. Hybrids viz., H-4, H-9, H-14, H-20, H-27 should repeated in combination with genetic male sterile line for extensive evaluation at number of locations.

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