Table 3. **Estimates of gene effects with their standard errors for the yield and yield contributing characters of the cross 'High branch x ICPL-4'**

Characters	m	d	h	i	j	l	Epistasis
Plant height (cm)	176.70+ 0.8991**	32.50 +2.8364**	-50.40 +7.4879**	-75.00 +6.7160**	-4.50 +3.5000	166.40 +13.6189**	D
Days to 50% flowering	128.45 +0.4622**	87.50 +0.7937**	146.90 +2.5417**	133.20 +2.4367**	24.50 +0.8381**	-113.60 +3.9481**	D
Days to 50% maturity	173.10 +0.4150**	109.20 +0.7176**	182.20 +2.3045**	169.20 +2.1944**	34.90 +0.7810**	-130.00 +3.6022**	D
No. of primary branches	18.95 +0.3976**	14.20 +1.1269**	22.60 +2.7584**	22.60 +2.7584**	1.95 +1.1969	-28.90 +4.9496**	D
No of secondary branches	7.55 +0.1893**	9.00 +0.3873**	0.95 +1.1290**	11.00 +1.0832**	4.45 +0.4430**	-16.10 +1.8380**	D
pods/plant	349.50 +1.7921**	122.90** +3.2023	-234.90 +10.2976**	-281.80 +9.6128**	50.30 +3.9248**	432.20 +16.4317**	D
Seeds/pod	3.70 +0.3756**	-0.41 +0.0663**	0.32 +0.2045	0.09 +0.2004	-0.29 +0.0713**	-0.56 +0.3155**	D
100-Seed weight (g)	6.42 +0.0247**	-0.42 +0.0479**	1.30 +0.6595**	2.24 +0.1375**	0.43 +0.0541**	-2.32 +1.3079	D
Grains/plant	501.90 +4.3595**	159.30 +5.2853**	-517.65 +21.3740**	-512.60 +20.3919**	-35.75 +6.4031**	777.70 +30.2511**	D
Grain yield / plant (g)	32.09 +0.2374**	9.92 +0.6514**	-24.76 +1.8945**	-24.89 +1.6123**	-2.55 +1.1480*	47.02 +3.4133**	D

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

recurrent selection procedure seems to be best suited method of breeding for improvement in this crop. Effort should be made to pool up the genotypes having predominance of additive genetic variation and complementary epistasis, for further improvement at yield level.

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HETEROSIS IN EIGHT PARENT DIALLEL CROSS IN GARDEN PEA

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ABSTRACT

Diallel analysis was carried out by using eight parents of garden pea (*Pisum sativum* L.) along with 28 hybrids. These were evaluated for heterosis. Analysis of variance revealed significant difference for all the characters except length of pod indicating the presence of genetic diversity in the studied material. The amount of heterosis was high for number of pods per plant and green pod yield per plant, moderate for days to 50 per cent flowering, plant height, number of primary branches per plant and number of seeds per pod, while remaining characters exhibited low heterosis. The most heterotic hybrids for green pod yield per plant were HUVP-1 x UU-11, HUVP-1 x PH-1 and PH-1 x UU-11.

KEY WORDS : Garden Pea, Diallel Cross, Heterosis

Garden pea (*pisum sativum* L.) is a very common vegetable and is characterised by high protein and sugar contents. It is grown as winter vegetable in the plains of North India and as summer vegetable in the hilly areas. Inspite of its vast nutritional values, this crop has received very little attention of research workers so far. Exploitation of hybrid vigour in garden pea has been recognised as an important tool by the breeder for increasing the yield. The aim of the present study, was to spot out the best combination of parents giving high degree of useful heterosis.

MATERIALS AND METHODS

Eight diverse genotype (HUVP-1, HUVP-2, PH-1, EC-33866, Bonneville, VL-6, Azad and UU-11) were selected for the present study. These varieties were crossed in all possible combinations excluding reciprocals during winter 1992-93. A set of 36 genotypes comprising of 8 parent and 28 hybrids was planted during winter 1993-94 in a randomised block design with three replications. The recommended package of practices was followed to raise a good crop. Observations were recorded on randomly selected 10 plants per plot for all the 8 characters (Table 1) except days to 50 per cent flowering and days to maturity of green pods which were recorded on the line basis. Relative heterosis and heterobeltiosis expressed by the hybrids, was calculated as the deviation of hybrids from its mid parent and better parent respectively.

RESULTS AND DISCUSSION

Analysis of variance revealed significant differences among parents for all the characters except length of pod indicating the presence of considerable variability in the studied materials (Table 1. The diversity among the parents ultimately resulted into hybrids significant difference from each other. The parents vs hybrids comparision indicated that mean of hybrids was significantly different from that of parents as a group for all the characters except plant height and length of pod.

Several crosses exhibited conspicuous heterotic response over mid parental value for different characters. The measurement of heterosis over mid parent value has limited commercial value. Therefore, from practical point of view, the heterosis may better be measured in terms of superiority of F_1 over better parents (heterobeltiosis). The degree of heterosis varied from cross to cross for all the traits (Table 2). For days to 50 per cent flowering, 19 and 20 two hybrids had significant negative relative heterosis and heterobeltiosis respectively. PH-1 x EC-33866 exhibited lowest significant relative heterosis (-22.43) and heterobeltiosis (-19.23). Similar results were also reported by Moitra and Singh (1986). With regards to maturity of green pods, PH-1 x EC-33866 showed lowest negative heterosis over mid and better parent. The early maturity will be helpful in receiving high return of the produces. Therefore, the hybrids exhibited negative heterosis, were considered as favourable for this character. In case of plant, Bonneville x UU-11 and PH-1 x UU-11 hybrids manifested positive significant relative heterosis and heterobeltiosis respectively. Moderate heterosis was observed for this character. With regard to

Table 1. Analysis of variance (mean square) for different characters

Source of variation	df	Days to 50% flowering	Days to maturity of green pods	Plant height (cm)	No. of primary branches per plant	No. of pods per plant	No. of seeds per pod	Length of pod (cm)	Green pod yield per plant (g)
Replication	2	5.84	3.39	10.79	0.26	20.58	0.57	0.33	14.18
Parent	7	47.88**	31.04**	91.78**	0.21**	43.45**	0.01*	0.25	334.578**
Hybrid	27	81.33**	60.37**	285.09**	0.42**	65.39**	1.37**	0.96	289.688**
Parent Vs Hybrid	1	104.76**	49.65**	0.61	0.28**	117.72**	4.55**	0.01	1037.557**
Error	70	3.90	3.99	9.49	0.04**	3.36	0.44	0.66	11.757

*, ** = Significant at 5% and 1% level of significance, respectively

e 2. Heterosis in percentage over mid parent (MP) and better parent (BP) for various characters

Crosses	Days to 50% flowering		Days to maturity of green pods		Plant height (cm)		No. of primary branches per plant		No. of pods per plant		No. of seeds per pod		Length of pod (cm)		Green pod yield per plant (g)	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
P-1xHUVP-2	-1.30	-3.55**	1.35**	2.30**	-17.19**	-23.07**	-9.06**	-13.98**	-13.81**	-30.45**	7.56**	6.08*	-2.12	-2.37	-12.34**	-3.31*
P-1x PH-1	-3.96**	-7.61**	-2.53**	-4.21**	11.27**	6.19**	-1.66	-4.30*	15.08**	-6.49**	17.61**	17.61**	-4.01	-8.50**	52.74**	52.54**
P-1xEC-33866	-3.05**	-3.05**	0.58	0.00	17.46**	17.93**	34.02**	39.78**	43.25**	95.85**	16.39**	12.11**	7.65**	-7.03**	32.98**	13.42
P-1xBonneville	-7.28**	-8.12**	-2.33**	-3.45**	3.17**	5.76**	4.55**	11.29**	7.99**	-5.59**	16.09**	17.44**	-5.71**	-6.53**	41.93**	39.12**
P-1x VL-6	-0.51	-1.02	0.58	0.00	-3.60**	-7.02**	-0.51	5.38**	35.37**	10.50**	18.28**	25.00**	-4.39	-5.14*	21.76**	30.81**
P-1x Azad	-1.05	-4.06**	-0.39	-1.15*	-4.98**	-6.65**	-0.54	0.00	-1.77	-19.90**	13.57**	1.80	-0.45	-1.72	24.75**	5.75**
/P-1 x UV-11	4.78**	-0.90	2.57**	-1.41**	-4.93**	-6.28**	0.55	-2.15	20.60**	-3.14	21.74**	24.26**	-5.42*	-6.69**	55.50**	53.66**
'P-2x PH-1	-6.49**	-7.98**	-2.76**	-3.52**	-4.53**	-7.20**	-11.05**	-8.93**	-38.05**	-38.60**	-3.64	-2.27	4.61	9.71**	-15.89**	-23.15**
'P-2xEC-33866	-10.13**	-7.98**	-5.45**	-5.08**	-11.38**	-17.97**	8.64**	19.64**	-9.44**	-6.50**	3.50	1.05	-0.15	0.78	2.36**	5.25**
/P-2xBonneville	-7.61**	-6.38**	-3.33**	-3.52**	-3.85**	-12.64**	-1.59	10.71**	-5.39**	4.97*	14.45**	17.44**	3.62	2.46	3.91**	12.13**
'P-2x VL-6	-8.62**	-6.91**	-5.06**	-4.69**	3.28**	-7.20**	1.06	13.10**	-5.37**	-3.94*	9.28**	5.10*	-2.49	-2.99	18.43**	15.61**
P-2x Azad	-10.46**	-11.17**	-6.43**	-6.25**	6.19**	0.31	-4.55**	-8.70**	-17.62**	-18.73**	9.18**	-0.90	12.71**	10.98**	-2.39*	-10.26**
VP-2x UU-11	9.05**	0.90	5.38**	0.35	7.15**	0.81	4.65**	2.27	-16.71**	-16.18**	20.57**	24.85**	4.39	3.25	16.09**	29.75**
1xEC-33866	-22.43**	-19.23**	-16.08**	-15.08**	-16.87**	-12.33**	-17.46**	-22.77*	-76.60**	-75.62**	2.73	1.05	-8.95**	-3.57	-5.92**	-19.83**
1xBonneville	-7.73**	4.66**	0.59	0.00	4.68**	-2.36*	-10.88**	-18.10*	13.50**	24.69**	18.39**	17.05**	-2.47	-7.80**	28.78*	26.08**
1x VL-6	3.98**	0.51	0.39	-0.78	5.76**	-2.47**	-8.33**	-15.38*	5.02**	5.64**	10.75**	5.10*	0.62	4.95*	17.27	9.56**
1 x Azad	4.63**	3.78**	-1.77**	-0.79	2.19*	5.35**	2.22	0.00	4.76**	5.24**	8.04**	-3.15	5.18*	-0.97	17.84**	-0.21
1 x UU-11	-0.25	-9.05**	-1.68**	-7.07	21.53**	47.06**	-5.68**	-5.00	10.86**	-12.20**	27.54**	25.00**	2.18	35.95**	39.59**	41.11**
33866xBonneville	-6.15**	-5.18**	-0.19	0.39	-10.68**	-12.47**	-23.30**	-21.78**	-20.81**	-9.01**	-28.18**	-31.58**	-21.46**	-21.63**	7.30**	26.64**
33866x VL-6	-4.59**	-4.10**	-2.33**	-2.33**	-7.83**	-10.77**	-21.95**	-23.08**	-21.65**	-17.85**	-5.18*	-3.68	2.18	0.72	3.54**	-6.25**
33866x Azad	-6.28**	-3.24**	-2.52**	-2.33**	[illegible]	-19.89**	-2.59	2.17	-25.13**	-21.60**	-3.40	-10.36**	13.42**	12.70**	-5.25**	-4.54**
33866 x UU-11	-6.22**	-11.31**	-3.51**	-7.77**	[illegible]	15.41**	-8.99**	[illegible]	28.88**	-27.04**	13.65**	7.37**	-2.72	-4.64*	0.94	-14.75**
nneville x VL-6	-5.67**	-5.18**	0.19	0.78	[illegible]	-9.21**	26.32**	-25.96**	-8.68**	-15.75**	1.09	8.14**	2.39	0.72	-4.26**	0.68
nneville x Azad	-3.17**	-5.18**	-1.17*	-0.78	-0.30	-4.35**	-8.63**	-2.17	-14.06**	-6.06**	2.54	-9.01**	0.93	1.36	-2.38*	16.21**
nneville x UU-11	-4.83**	-10.86**	-0.74	-5.65**	29.59**	24.75**	13.99**	25.00**	1.04	10.56**	17.30**	16.28**	1.32	3.64	22.88**	19.05**
-6 x Azad	-5.79**	-8.21**	-4.47**	-4.65**	-17.08**	-21.38**	-1.02	5.43**	-27.65**	-27.65**	-8.13**	-13.51**	9.12**	6.90**	-19.85**	-27.91**
-6 x UU-11	-11.54**	-16.74**	-6.10**	-10.25**	8.51**	3.22**	-11.46**	-3.41	-17.79**	-16.01**	26.03**	17.35**	-1.81	-2.37	28.22**	39.54**
ad x UU-11	3.94**	-4.52**	3.70**	-1.06*	-10.85**	-11.16**	2.22	0.00	-32.78**	-34.09**	14.07**	-24.32**	3.13	0.46	-12.37**	-26.14**
±	1.32	1.37	1.33	1.39	2.02	2.06	0.16	0.18	1.25	1.43	0.44	0.46	0.54	0.54	2.33	2.54

*, ** = Significant at 5% and 1% level of significance, respectively

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 th..ugh hybridis...ion and recombi...ation has bee... 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