

Full Length Research Paper

Studies on genetic variability and heterosis in vegetable pea (*Pisum sativum* L.) under high hills condition of Uttarakhand, India

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The estimates of genetic parameters of 39 (11 parents and 28 crosses) genotypes of garden pea (*Pisum sativum* L.) indicated a good amount of genetic variation in the experimental materials under investigation. Characters like plant height, days to first picking, 100 green pod weight, green pod yield and days to 50% flowering revealed higher values of heritability in broad sense and genetic gain indicating that the additive gene actions are important in determining these characters. Therefore, selection programme based on these characters would be more effective in improving yield parameters of garden pea. The cross VRP-5 x Pusa Pragati manifested maximum significant heterosis for days to 50% flowering, DVP-2 x VL-7 for days to first picking and PMR-32 x snow pea for number of green pods per plant and green pod yield per plant, respectively.

Key words: Vegetable pea, variability, heritability, genetic advance, heterosis.

INTRODUCTION

Garden pea (*Pisum sativum* L.) is an important vegetable crop due to its high nutritive value. It is a leading off-season vegetable grown in hilly regions of Uttarakhand. Its improvement is based mainly on exploiting the natural sources of germplasm by means of selection or hybridization followed by selection. An insight into the magnitude of variability present in a crop provides the basis for effective selection. Heritability is the portion of phenotypic variation which is transmitted from parent to progeny. The higher the heritable variation, the greater will be the possibility of fixing the characters by selection methods. The present investigation was therefore undertaken to predict the traits with high heritability and to create variation through hybridization so as to identify

superior plants in the segregating generation.

MATERIALS AND METHODS

Planting materials and raising of crop

Studies were conducted by using 39 (11 parents and 28 crosses) genotypes at GBPUA and T, Vegetable Research Block, Hill Campus, Ranichauri (TG). 11 parents viz., VRP-6 (P₅), VRP-5 (P₆), DVP-1 (P₇), PMR-32 (P₈), DVP-2 (P₉), DGP-207 (P₁₀), Azad Matar (P₁₁), VL-7 (P₁), Pusa Pragati (P₂), Arkel (P₃) and snow pea (P₄) and 28 crosses were evaluated in randomized block design with three replications during 2006 to 2007. Each plot consisted of two rows of 3 m length and was spaced at 40 cm apart. Plant to plant distance was maintained at 10 cm. A single non-experimental row was

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planted on either sides of each block so as to minimize environmental error due to border effect. All the recommended cultural practices were followed to raise the crop.

Recording of observation

The data were recorded on five randomly selected plants on the traits viz., days to 50% flowering (1), days taken to first picking (2), pod length in cm (3), number of green pods per plant (4), green pod yield per plant in g (5), number of primary branches per plant (6), 100 green pod weight in g (7), shelling percentage in percent (8) and plant height in cm (9). The data were analyzed as per Gomez and Gomez (1983). The parameters of variability were estimated by the formula given by Burton and Devane (1953). Heritability in broad sense was calculated as per formula given by Burton and Devane (1953) and Allard (1960). Heterosis was calculated as the increase or decrease over better parent and standard check by the following formulae as suggested by Hayes et al. (1955) (Table 3):

(1) Heterosis over better parent

$$\text{Heterobeltiosis (HB)} = \frac{\bar{F}_1 - \bar{BP}}{\bar{BP}} \times 100$$

(2) Heterosis over standard check

$$\text{Standard heterosis (SH)} = \frac{\bar{F}_1 - \bar{S}_p}{\bar{S}_p} \times 100$$

Where, \bar{F}_1 is the mean of particular individual (F_1); \bar{BP} is the mean of better parent in the cross and \bar{S}_p is the mean of standard/check parent.

RESULTS AND DISCUSSION

Perse performance

The mean sums of squares due to genotypes were found highly significant for all the characters under study indicating the presence of substantial amount of variation between the genotypes for the characters studied (Table 1). Average number of days taken to 50% flowering was found to be 34.46 ranging from 29.33 (VRP-5 x Arkel, VRP-6 x snow pea) to 46.33 days (DVP-2), while average number of days to first green pod picking was recorded to be 62.66 with a range of 56 days (VRP-6 x VL-7) to 87 days (DVP-2). The average pod length recorded was 8.83 cm (Table 1). The average number of green pods per plant was recorded as 8.78 with a range of mean values from 5.33 (VRP-6 and DVP-1) to 15 (PMR-32 x snow pea). The green pod yield per plant showed a range of 25.00 (DVP-1) to 129.66 g (PMR-32 x snow pea) with a average of 66.74 g. The maximum number of primary branches per plant was recorded in DVP-2 x Pusa Pragati (9.80) and minimum in VRP-6 x Arkel (5.03) with general mean of 7.05 (Table 1). The cross combination PMR-32 x Pusa Pragati exhibited highest average value for 100 green pod weight (941.00 g) followed by VRP-6 x Arkel (911.66 g), PMR-32 x snow pea (894.33 g) and VRP-6 x Pusa Pragati (880.0 g), while lowest 100 green pod weight was recorded in DVP-

1 x Arkel (516.66 g) with average of 713.09 g. The average value for shelling percentage was recorded as 41.02% with a range of 52.86% (PMR-32 x snow pea) to 21.83% (snow pea). The average for plant height was found to be 59.97 ranging from 38 cm (VRP-5) to 90.56 cm (PMR-32 x Pusa Pragati).

Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance

The results of coefficient of variation analysis (Table 2) showed that the PCV was higher than the GCV for all the characters under study. The genotypic coefficient of variances (GCA) varied from 8.14 (pod length) to 33.35 (green pod yield per plant). The estimates of GCA were found highest for green pod yield per plant (33.35), followed by plant height (26.82) and number of green pod per plant (21.02), respectively. The remaining characters revealed medium to lower estimates of GCA. Kumaran et al. (1995), Vikas and Singh (1999), Singh et al. (1996), Sureja and Sharma (2000) and Kalloo et al. (2005) also reported high estimates of genotypic variability for yield and its contributing traits. High estimates of broad sense heritability were recorded for plant height (97.84%), days to first green pod picking (95.80), 100 green pod weights (94.69%), green pod yield per plant (93.10), and days to 50% flowering (92.25%), whereas remaining characters revealed moderate heritability. Heritability estimate provides guide for the selection procedure to be followed by the breeder for improvement of these traits under a given environment. The high genetic advance as percent of mean along with high heritability was obtained for green pod yield per plant (66.28), plant height (54.67), number of green pod per plant (38.28), 100 green pod weight (32.07), while lowest for pod length indicating that these characters are least affected by environment. High heritability along with high genetic advance reveals that additive type of heritability is there. Therefore, these traits can be improved by selection and genotypic variability so realized can be maintained in subsequent generation. Similar findings were also reported by Kumar et al. (2000), Mahanta et al. (2001) and Chaudhary and Sharma (2003).

Heterosis

Morphological traits

Out of 28 crosses, 27 and 25 crosses revealed significant negative heterosis for days to 50% flowering over better parent and standard check, respectively. The cross combination VRP-5 x Pusa Pragati manifested maximum significant negative heterosis for days to 50% flowering (-36.69) and DVP-2 x VL-7 showed highest negative heterosis for days to first green pod picking. The

Table 1. Perse performance of parents and F1 crosses of garden pea.

Genotype	1	2	3	4	5	6	7	8	9
P ₅	40.00	61.66	8.30	5.33	31.00	6.80	608.33	37.83	39.00
P ₆	40.66	61.66	7.86	8.53	56.66	6.53	771.66	36.46	38.00
P ₇	42.66	64	9.65	5.33	25.00	6.46	560.00	35.00	50.70
P ₈	41.6	61.33	8.0	6.66	61.66	5.80	823.33	38.10	41.26
P ₉	46.33	87.00	9.04	10.00	82.00	8.40	783.33	36.73	77.60
P ₁₀	42.33	64.33	7.69	8.00	68.33	6.96	777.33	36.70	47.60
P ₁₁	42.66	64.00	7.84	8.00	71.33	5.26	776.66	38.26	40.90
P ₁	37.33	58.33	8.53	6.66	27.53	8.13	605.00	34.16	45.16
P ₂	37.33	61.33	9.23	9.66	58.33	5.40	548.66	38.50	43.46
P ₃	38.00	58.33	7.74	8.66	43.33	5.73	614.00	36.53	45.30
P ₄	44.66	77.66	9.39	7.00	70.66	6.40	855.00	21.83	76.96
P ₅ x P ₁	32.66	56.00	9.16	10.00	69.33	6.53	673.00	41.53	48.13
P ₅ x P ₂	33.00	56.66	8.95	11.00	96.66	6.73	880.00	35.26	52.13
P ₅ x P ₃	31.66	56.33	8.64	10.00	99.66	5.03	911.66	42.76	47.66
P ₅ x P ₄	29.33	57.33	8.69	11.00	64.66	7.56	633.33	45.26	77.40
P ₆ x P ₁	33.00	56.33	8.84	9.33	75.66	7.53	720.00	41.70	47.83
P ₆ x P ₂	31.66	56.33	10.32	9.33	111.33	7.26	730.33	46.60	61.26
P ₆ x P ₃	29.33	56.00	6.92	10.00	70.00	6.00	777.66	41.73	46.93
P ₆ x P ₄	30.33	77.60	9.13	14.33	82.00	8.33	680.33	36.66	65.73
P ₇ x P ₁	31.66	57.33	9.07	8.00	54.66	6.53	734.33	48.53	51.00
P ₇ x P ₂	32.00	57.33	9.84	6.66	64.00	5.86	516.66	46.36	57.00
P ₇ x P ₃	31.66	56.33	8.75	8.00	68.66	6.46	830.00	46.13	51.90
P ₇ x P ₄	32.66	57.33	8.67	8.33	102.33	6.40	696.66	44.23	59.03
P ₈ x P ₁	31.00	57.66	9.47	8.33	50.00	6.53	640.00	44.76	65.66
P ₈ x P ₂	31.33	56.66	9.54	8.66	88.33	6.70	941.00	38.13	90.56
P ₈ x P ₃	31.33	58.00	8.87	10.00	74.66	8.30	833.33	52.86	76.63
P ₈ x P ₄	29.66	78.00	7.43	15.00	129.66	8.80	894.30	52.80	82.06
P ₉ x P ₁	41.33	58.00	9.03	8.00	58.00	8.50	603.33	48.43	84.36
P ₉ x P ₂	42.00	77.66	9.41	13.00	116.33	9.80	608.33	46.83	88.06
P ₉ x P ₃	31.33	77.66	8.97	10.66	86.66	9.40	615.00	38.63	76.06
P ₉ x P ₄	32.00	78.33	10.15	9.66	87.33	8.80	669.33	41.73	85.33
P ₁₀ x P ₁	33.33	68.00	9.46	7.33	37.33	6.90	590.00	44.53	60.93
P ₁₀ x P ₂	31.33	59.66	8.36	9.66	70.66	5.80	729.66	40.70	60.93
P ₁₀ x P ₃	31.00	59.00	9.22	9.53	62.33	5.70	679.00	42.70	43.76
P ₁₀ x P ₄	29.33	59.00	9.57	9.33	72.33	9.00	746.66	45.86	82.73
P ₁₁ x P ₁	31.00	58.66	9.13	6.66	35.00	6.50	557.66	35.50	52.96
P ₁₁ x P ₂	29.66	58.00	9.57	8.00	48.66	6.00	632.66	41.70	59.06
P ₁₁ x P ₃	30.33	60.66	8.52	8.33	51.66	8.20	639.33	38.66	40.13
P ₁₁ x P ₄	30.33	58.33	7.69	9.00	69.33	7.40	926.66	39.06	77.36

magnitude of heterosis ranged from -35.63 (VRP-6 x VL-7) to -9.96% (DVP-2 x Arkel) over better parent and -3.99% (VRP-5 x Pusa Pragati) to 34.28 (DVP-2 x Arkel) over standard check, respectively. Early flowering and days to first picking may be attributed to quicker establishment, their faster growth and development of hybrids. These findings are in close agreement with those of Mishra (1998), Shah and Mohammed (2005) and Singh and Mir (2005). Out of 28 hybrids, only 3 showed positive significance heterosis over better parent and

4 significant negative heterosis over standard check. The cross combination VRP-5 x Arkel revealed significant highest heterosis for pod length over better parent and standard check, respectively. The cross combination PMR-32 x snow pea revealed significant positive heterosis for number of green pod (50.00% over better parent and 73.21% over standard parent) and green pod yield per plant (58.12% over better parent and 199.23% over standard parent). The heterosis for green pod yield per plant varied from -57.31 (Azad Matar x VI-7) to 58.12%

Table 2. Mean, range, genotypic and PCV, heritability and genetic advance in the population.

Character	Range	General mean SE(m) ±	Coefficient of variation (%)			Heritability (h ² %)	Genetic advance (GA)	Genetic advance as % of mean
			PCV	GCV	ECV			
Days to 50% flowering	29.33 - 46.33	34.64	15.09	14.50	4.20	92.25	9.94	28.69
Days to first green pod picking	56.00 - 87.00	62.66	13.51	13.23	2.76	95.80	16.71	26.66
Pod length	6.92 - 10.32	8.83	9.47	8.14	4.77	74.69	1.28	14.49
Number of green pod per plant	5.33 - 15.00	8.78	27.56	21.02	11.07	78.28	3.36	38.28
Green pod yield per plant	25.00 - 129.00	66.74	34.56	33.35	9.07	93.10	44.24	66.28
Number of primary branches/plant	5.03 - 9.80	7.05	18.91	16.50	9.23	76.15	2.09	29.64
100 green pod weight	516.66 - 941.00	713.09	16.44	16.00	3.78	94.69	228.74	32.07
Shelling percentage	21.83 - 52.86	41.02	15.19	13.45	7.06	78.38	10.06	24.52
Plant height	38.00 - 90.56	59.97	27.12	26.82	3.98	97.84	32.79	54.67

PCV, Phenotypic coefficient of variation; GCV, genotypic coefficient of variation.

Table 3. Estimates of heterosis for different traits of garden pea.

Genotype	1		2		3		4		5		6		7		8		9	
	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC
P ₅ x P ₁	-29.50*	-14.05*	-35.63*	-3.99	1.32	18.34*	0.00	15.47	-15.45*	60.00*	-22.26*	13.96	-14.08*	9.60*	13.06*	13.68*	-37.97*	6.24
P ₅ x P ₂	-30.21*	-14.92*	-34.87*	-2.06	-0.99	15.63*	10.00	27.02*	17.57*	123.07*	19.88*	17.45	12.34*	43.32*	-4.00	-3.47	-32.82*	-15.07*
P ₅ x P ₃	-30.93*	-15.78*	-35.25*	-3.42	-4.42	11.62*	0.00	15.47	21.53*	130.00*	-40.11*	-12.21	16.38*	48.47*	16.41*	17.05*	-38.58*	5.20
P ₅ x P ₄	-29.50*	-14.05*	-34.10*	1.71	-3.87	12.27*	10.00	27.02*	-21.14*	49.22*	-10.00	31.93*	-19.14*	3.14	23.22*	23.89*	-0.25	70.86*
P ₆ x P ₁	-28.77*	-13.15*	-35.25*	-3.42	-2.21	2.21	-6.70	7.73	-7.73	74.61*	-10.35	31.41*	-8.08*	17.26*	13.54*	14.07*	-38.36*	5.58
P ₆ x P ₂	-31.66*	-16.68*	-35.63*	-3.99	14.15*	14.15*	-6.70	7.73	35.76*	156.93*	-13.57*	26.70*	-6.76*	18.94*	26.87*	27.56*	-21.05*	35.23*
P ₆ x P ₃	-36.69*	-22.81*	10.73*	33.10*	-23.45*	-10.59*	0.00	15.47	-14.63*	61.55*	-28.57*	4.71	-6.72*	26.65*	13.61*	14.23*	-39.52*	3.59
P ₆ x P ₄	-34.53*	-20.18*	-35.25*	-1.70	0.99	17.95*	43.30*	65.47*	0.00	89.24*	-0.83*	45.37*	-13.14*	10.80*	-0.19	0.35	-15.29*	45.09*
P ₇ x P ₁	-31.64*	-16.68*	-35.25*	-1.70	0.33	17.18*	-20.00*	-7.62	-33.34*	26.14*	-22.26*	13.96	-6.25*	19.59*	32.20*	32.84*	-34.27*	12.58*
P ₇ x P ₂	-30.93*	-15.78*	-35.25*	-3.42	8.84*	27.13*	-33.40*	-23.09*	-21.95*	47.70*	-30.23*	2.26	-34.04*	-15.85*	26.21*	26.90*	-26.54*	25.82*
P ₇ x P ₃	-31.66*	-16.68*	-34.10*	-1.70	-3.20	13.04*	-20.00*	-7.62	-16.26*	58.45*	-23.09*	12.73	5.95*	35.17*	25.59*	26.27*	-33.11*	14.56*
P ₇ x P ₄	-29.50*	-14.05*	-33.72*	-1.40	-4.09	12.01*	-16.70*	-3.81	24.79*	136.61*	-23.80*	11.69	-11.06*	13.46*	20.41*	21.07*	-23.93*	30.30*
P ₈ x P ₁	-33.37*	-18.42*	-34.87*	-2.80	4.75	22.35*	-16.70*	-3.81	-24.79*	15.39	-22.26*	13.96	-18.29*	4.23	21.86*	22.52*	-15.38*	44.94*
P ₈ x P ₂	-34.53*	-20.18*	-34.44*	-0.56	5.53	23.25*	-13.40	0.00	7.71	103.85*	-23.80*	16.75	-20.12*	53.25*	3.81	4.37	16.70*	99.91*
P ₈ x P ₃	-32.37*	-17.55*	-10.34*	33.70	-2.32	14.08*	0.00	15.47	-8.95	72.30*	-1.19	44.85*	6.38*	35.72*	43.91*	44.70*	-1.25	69.16*
P ₈ x P ₄	-35.98*	-21.94*	-34.44*	-0.56	-1.97	-4.00	50.00*	73.21*	58.12*	199.23*	5.11	54.10*	14.17*	45.65*	43.75*	44.53*	5.74*	81.14*
P ₉ x P ₁	-10.79*	8.76*	-10.73*	33.10*	-0.11	16.66*	-20.00*	-7.62	-29.26*	33.85*	1.19	48.34*	-22.97*	-1.73	31.85*	32.57*	8.71*	86.22*
P ₉ x P ₂	-9.34*	10.52*	-10.73*	33.10*	4.09	21.57*	30.00*	50.11*	40.64*	166.17*	16.66*	71.02*	-22.34*	-0.92	27.49*	28.19*	13.47*	94.39*
P ₉ x P ₃	-32.37*	-17.55*	-9.96*	34.28*	-10.97*	15.89*	-13.40	0.00	-30.90	30.76*	12.61*	65.09*	-21.48*	0.16	5.17	5.74	-1.28	69.09*
P ₉ x P ₄	-30.93*	-15.78*	-21.83*	16.57*	12.72*	31.13*	-13.40	0.00	6.50	101.54*	4.76	53.57*	-15.09*	9.01*	13.59*	14.23*	1.41*	88.36*
P ₁₀ x P ₁	-28.05*	-12.28*	-31.42*	2.28	4.64	22.22*	26.70*	-15.35	-54.47*	-13.84	-17.05*	20.94	-24.68*	-3.90	21.35*	21.89*	-21.48*	34.50*
P ₁₀ x P ₂	-32.37*	-17.55*	-32.18*	1.14	-7.52*	8.01*	-3.40	11.54	-13.82*	63.07*	-30.95*	1.22	-7.23*	18.34*	10.79	11.41	-21.48*	34.50*
P ₁₀ x P ₃	33.37*	-18.42*	-32.18*	1.14	1.99	19.12*	-6.70	7.73	-23.98*	43.84*	-32.14*	-0.52	-13.31*	10.58*	16.25*	16.89*	-43.60*	-3.39

Table 3. Contd.

P ₁₀ x P ₄	-36.69*	-22.81*	-32.57*	0.56	5.86	23.64*	-6.70	7.73	-11.79*	66.92*	7.14	57.06*	-4.68	21.60*	24.85*	25.54	6.61*	82.62*
P ₁₁ x P ₁	-33.37*	-18.42*	-32.57*	0.56	0.99	17.95*	-33.41*	-23.10*	-57.31*	-19.22	-22.61*	13.43	-28.80*	-9.17*	-3.34	-2.81	-31.75*	16.90*
P ₁₁ x P ₂	-35.98*	-21.94*	-34.44*	-0.56	5.86	23.64*	-20.0*	-7.62	-40.65*	12.30	-28.57*	4.71	-19.23*	3.03	13.53*	14.15*	-23.89*	30.37*
P ₁₁ x P ₃	-34.53*	-20.18*	-31.03*	2.86	-5.53	10.33*	-16.7*	-3.81	-37.00*	19.22	-2.02	43.63*	-18.38*	4.12	5.25	5.83	-48.28*	-11.41*
P ₁₁ x P ₄	-34.53*	-20.18*	-32.95*	0.00	-14.93*	1.08	-10.0	3.92	-15.45*	60.00*	-11.54	24.66*	18.29*	50.92*	6.34	6.92	-0.39	70.77*

BP, Better parent; SC, standard/check parent; *significant at 5% level of significance.

(PMR-32 x snow pea) and 19.22 (Azad Matar x VL-7) to 199.23% (PMR-32 x snow pea) over better parent and standard check. Mishra (1998) and Shah and Mohammed (2005) also reported significant heterosis for number of pods per plant, and Shah and Mohammad (2005) and Singh and Mir (2005) for green pod yield per plant. The cross combination DVP-2 x Pusa Pragati revealed significant highest heterosis for number of primary branches and PMR-32 x Pusa Pragati for 100 green pods weight, respectively. Out of 28, only 7 and 16 crosses could reveal the positive significant heterosis over better parent and standard check for 100 green pods weight. The manifestation of heterosis for these traits had also been reported earlier by Sharma et al. (1998) and Kumar et al. (2000). Heterosis for shelling percentage was also reported by Sharma (1995). The significant negative heterosis for plant height to the extent of -48.28% (Azad Matar x Arkel) was observed over better parent and -15.07% (VRP-6 x Arkel) over standard check. These results confirm earlier findings of Sarawat et al. (1994). Therefore, the cross combinations VRP-5 x Pusa Pragati, DVP-2 x VL-7 and PMR-32 x snow pea can be exploited for the improvement of earliness and yield parameters of garden pea.

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