Legume Research, 39 (2) 2016 : 163-169
Print ISSN:0250-5371 / Online ISSN:0976-0571

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com/www.legumeresearch.in

Study of genetic variability, character association, path analysis and selection parameters for heterotic recombinant inbred lines of garden peas (*Pisum sativum* var. *Hortense* L.) under mid-hill conditions of Himachal Pradesh, India

Viveka Katoch*, Prem Singh, Mayanglambam Bilashini Devi, Akhilesh Sharma, G.D. Sharma and J.K. Sharma

Department of Vegetable Science and Floriculture, College of Agriculture,
C.S.K. Himachal Pradesh Agricultural University, Palampur-176062, India.

Received: 29-10-2013 Accepted: 11-06-2014 DOI:10.18805/lr.v0iOF.6775

ABSTRACT

The present investigations involving forty five diverse pea recombinant inbreds and three standard checks were carried out for two successive years during 2011-2012 and 2012-13. The objective of the study was to ascertain genetic variability, heritability, genetic advance, correlation and path coefficient among yield and other horticultural and quality traits and identification of superior recombinants for their utilization in crop improvement programme. Wide range of variability was observed for most of the characters under study. The magnitude of phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variability (GCV) for all the traits. High phenotypic and genotypic coefficient of variations were recorded for protein content, ascorbic acid, plant height and pod yield per plant for both the years. Pod yield per plant and plant height exhibited high heritability associated with high genetic advance in the respective years indicating the additive gene action for their expression and are likely to respond better to selection. Pod yield showed a positive and significant correlation with number of pods per plant, pod length and number of seeds per pod both the years. Path analysis revealed that number of pods per plant and pod length have highest positive direct effect both the years and thus it may be treated as selection criteria for isolating higher yielding genotypes in garden peas. In heterosis study, some of the recombinant inbreds were found superior over standard checks which include L-14 and L-13 for pod yield/plant, number of pod/plant and earliness. These findings can be further utilized to develop and enhance the yield potential of garden pea.

Key words: Correlation, Heterosis, Path analysis, *Pisum sativum* var.*hortense* L., Variability.

INTRODUCTION

Garden pea (*Pisum sativum* var. *hortense* L.), a member of family Papilionaceae is an important vegetable crops of both temperate and subtropical areas of the world. The crop is grown for its green pods and dried seeds and is known for its superior quality protein like lysine content, the limiting amino acid in cereals (Monti, 1983). It is a leading vegetable crop in the North-Western Himalayan region of India comprising the states of Himachal Pradesh, Jammu & Kashmir and Uttarakhand. Owing to diverse agro-climatic conditions in Himachal Pradesh, the crop is grown round the year in one or the other region, yielding lucrative returns to the growers. Garden pea holds a very coveted position in the state by covering more than one-fourth of the total area under vegetable crops and ranks first in acerage of 22.8 thousand hectares and annual production of 254.2 thousand tones (Anonymous, 2011). The consumers have their special preference for hill grown peas because of their characteristic flavour, sweetness and freshness. The exploration of genetic variability in available germplasm is a pre-requisite for identification and development of new improved high yielding genotypes to further boost up the yield potential of the crop in the state. The possibility of improvement in any crop is measured by the variability available in the crop. Hence, it is essential to partition the variability into heritable and non-heritable components with the help of genetic parameters like genetic coefficient of variability, heritability and genetic advance.

Correlation studies provide an opportunity to study the magnitude and direction of association of one character with another, while path coefficient analysis gives the direct and indirect contribution of independent variables on dependent variable (Rathi and Dhaka, 2007). It is important for plant breeders to find out which of the characters are

*Corresponding author's e-mail: vivekarathour@gmail.com.

correlated with yield to bring about genetic improvement in the crop. An improvement in yield of self-pollinated crops like garden pea is effected mainly through selection of genotypes with desirable characters from the variation through recombination followed by selection. Heterosis amongst recombinant inbred lines is of great importance in vegetable crops as heterotic crosses may give transgressive segregants for economic traits in advanced generations.Thus, the present experiment was conducted to study the genetic variability, correlation and path coefficients and finding out heterotic recombinants for yield and yield attributing characters in garden pea.

MATERIALS AND METHODS

The experimental material constituted of 45 F_{10} pea recombinant inbred lines of the cross NDVP-250 × Palam Priya along with standard checks *viz.*, 'Azad P-1', 'Palam Priya' and 'Punjab-89'. The experiment was conducted during *Rabi*, 2011-12 and 2012-13 at the Experimental Farm of the Department of Vegetable Science and Floriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur situated at an elevation of 1290.8 m above mean sea level with 32^0 6^2 N latitude and 76^0 32 E longitude. The location is characterized by humid and temperate climate with an annual rainfall of 2,500 mm of which 80% is received during June to September and represents the mid-hill zone of Himachal Pradesh. The experiment was laid out in randomized complete block design (RBD) with three replications. Each genotype was grown in three rows of length 1.8 m at a row to row spacing of 45 cm and plant to plant spacing of 10 cm. All the recommended agronomic practices were followed to raise a healthy crop. The observations were recorded on randomly taken ten plants of each genotype in each replication for the quantitative traits *viz.*, days to 50% flowering, days to first picking, pod length (cm), number of seeds per pod, shelling per cent age, number of primary branches per plant, number of pods per plant, pod yield per plant (g), plant height (cm) and qualitative traits *viz.*, TSS (%), protein content (%) and ascorbic acid content (mg/100g). Analysis of variance was performed for individual season and error variance was tested for homogeneity (Gomez and Gomez, 1983).The combined analysis of variance of two season's data was done for each trait for forty five recombinant inbreds and three standard checks. The genotypic, phenotypic coefficients of variations and heritability were estimated as per the method of Burton and De Vane (1953). Genetic advance (GA) was calculated as per Burton and De Vane (1953) and Johnson *et al.* (1955). Coefficients of correlation were calculated as per the method suggested by Al-Jibouri *et al.* (1958) and path coefficients of different traits with seed yield per plant were carried out by Dewey and Lu (1959). Limits used for categorizing the magnitude of different parameters are as under:

Component	High (%)	Moderate (%)	Low(%)
GCV and PCV	More than 12	5-12	Less than 5
Heritability	More than 70	50-69	Less than 50
Genetic advance	More than 15	5-15	Less than 5

The estimates of heterosis were calculated as the deviation of segregants mean from the checks.

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant differences among the genotypes for all the traits studied during both the years as presented in Table 1. Significant difference of segregants *vs* check during both the year is observed for all the traits studied indicating superiority of segregants over the checks. The F-test of homogeneity over years showed significant differences for all the traits suggesting that interpretation of the results on the basis of pooled over years would not provide a clear picture. Hence, the results of individual years have been discussed.

The extent of variability for twelve polygenic traits in forty eight genotypes of garden pea in terms of general mean, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) along with heritability (h^2) and genetic advance (GA) are presented in Table 2. Result exhibited that the phenotypic coefficient of variability were always higher than their corresponding genotypic coefficient of variability indicating the influence of environmental component on the character expression (Ghosh *et al.*2010). In the present study, the differences between the genotypic and phenotypic variances were relatively low for all the traits studied. This indicated highly heritable and comparatively stable nature of the characters and thus, the selection based on phenotypic performance would be quite effective in the improvement of these traits. Maximum phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was observed for protein content for both the years. High phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were also observed for ascorbic acid, pod yield per plant and plant height during both the years, indicating sufficient scope to bring an improvement in these characters. Sharma and Bora (2013), Singh *et al.*(2013) and Yadav *et al.*(2012) have also reported high phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for plant height and pod yield/ plant.

Highest genetic advance under selection was exhibited by plant height followed by pod yield per plant with their high magnitude of genotypic coefficient of

Table 1: Analysis of variance for different characters in Garden pea during the years 2011-12 and 2012-13

Characters	Replication		Genotype (G)		Segregants		Checks		Segregants *vs* Checks		Error		F-test (Homogeneity test)
	Mean sum of squares												
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	
df	2	2	47	47	44	44	2	2	1	1	94	94	
Days to 50% flowering	61.03	13.59	109.25*	85.62*	83.46*	79.13*	420.33*	200.11*	4293.99*	3623.75*	12.85	9.71	1.32*
Days to 1st picking	122.06	14.77	47.31*	40.94*	41.40*	36.90*	169.33*	140.11*	1884.77*	1643.78*	9.00	15.94	1.77*
Pod length (cm)	0.08	0.07	0.74*	1.32*	0.56	1.07	2.04	3.90	30.59*	54.03*	0.10	0.11	1.10*
No of seeds/pod	0.02	0.07	1.18*	1.12*	0.88	0.82	3.20	3.65	49.27*	45.56*	0.06	0.10	1.67*
Shelling %	29.83	63.57	62.90*	75.73*	59.79*	71.89*	110.57*	47.14*	2735.33*	3464.97*	16.66	22.72	1.36*
No of primary branches/plant	0.29	0.06	0.11*	0.09*	0.09*	0.08*	0.33*	0.18*	4.35*	3.90*	0.02	0.02	1.00*
No of pods/ plant	160.93	5.10	11.08*	17.14*	11.71*	18.29*	2.14	0.32	516.47*	805.05*	2.22	2.49	1.12*
Plant height (cm)	898.54	187.30	425.22*	472.26*	449.98*	503.45*	85.03	15.24	19815.41*	22165.93*	28.17	19.44	1.45*
TSS	0.02	0.45	13.21*	4.99*	14.09*	5.27*	0.30	1.34	620.26*	231.70*	0.92	0.76	1.21*
Protein content	0.79	0.62	22.44*	22.55*	23.07*	22.99*	12.42*	11.61*	1029.84*	1036.64*	1.07	0.46	2.33*
Ascorbic acid (mg/100g)	4.61	1.94	32.68*	31.73*	33.16*	32.79*	6.49*	8.91*	1522.80*	1473.37*	2.37	1.56	1.52*
Pod yield/plant (g)	2580.28	72.25	380.68*	488.32*	351.61*	482.14*	630.41*	412.22*	16631.21*	22126.52*	37.65	40.92	1.09*

*Significance at 5% level

variability and heritability for both the years indicating the presence of additive effects for these characters. Therefore, a high genetic gain can be anticipated by selection procedure on these traits. Similar findings were also reported by Kumar *et al.* (2010).

Phenotypic correlation coefficient among different pairs of characters for both the years is given in Table 3. The results revealed highly significant positive correlation for pod yield per plant with number of pods per plant followed by pod length during both the years. Sharma *et al.* (2011); Kumari *et al.* (2008) and Kaur *et al.* (2004) also reported significant positive correlation of pod yield per plant with number of pods per plant and pod length. The strong association of these traits with pod yield indicated that genotypes with more number of pods per plant and pod length should be given emphasis for improving pod yield and desired improvement can be achieved through recurrent selection procedure. Pod length was positively and significantly correlated with number of seeds per pod during both the seasons. Sharma *et al.*(2003) also reported similar correlations of pod length with number of seeds per pod. A positive significant association between days to 50 per cent flowering and days to first picking during both the years was observed indicating that early flowering lines would be an appropriate selection criterion to fetch early yield. The results corroborates the findings of Sharma *et al.* (2007)**.** Correlation between most of the other traits though significant are of low magnitudes and hence of little consequence.

In view of the fact that correlation coefficients do not take into account extremely complex inter-relationships between various characters, path analysis was applied to partition the correlation coefficients into direct and indirect effects. The result of path analysis (Table 4) revealed highest positive direct effect of number of pods per plant on pod yield per plant followed by pod length during both the years. Ghobary (2010) and Sharma *et al. (*2009) also reported the similar results. All the indirect effects exhibited by the traits studied were of little significance as they are too low in magnitude and hence do not explain any phenomenon. The characters showing high direct effect on pod yield indicated that the direct selection of these traits might be effective. Therefore, it may be suggested that for effective improvement in pod yield per plant in garden pea, the selection should preferably be done for more number of pods per plant and increased pod length. These findings are in consonance with those of Rathi and Dhaka (2007) and Siddika *et al.* (2013).

Identification of heterotic recombinant inbreds for yield and component traits: A wide variation in magnitude and direction of heterosis during both the years was found among

TABLE 2: Parameters of genetic variability for pod yield and related traits of Garden pea

Characters	General mean		Coefficients of variation				Heritability (h^2)(%)		Genetic advance (% of mean)	
			Phenotypic (PCV)		Genotypic (GCV)					
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-2012	2012-13
Days to 50% flowering	104.05	97.74	6.45	6.05	5.45	5.15	71.40	72.30	9.87	8.81
Days to first picking	142.23	136.33	3.28	3.61	2.51	2.12	58.70	34.30	5.64	3.48
Pod length (cm)	8.20	7.39	6.80	9.70	5.63	8.57	68.40	78.00	0.79	1.15
No of seeds per pod	6.87	6.70	9.63	9.89	8.90	8.72	85.50	77.70	1.16	1.06
Shelling %	50.68	49.32	11.18	12.89	7.75	8.52	48.10	43.80	5.61	5.73
No of primary branches/ plant	1.42	1.44	15.78	14.53	11.77	10.71	55.60	54.30	0.26	0.23
No of pods/ plant	15.42	14.70	14.75	18.48	11.14	15.04	57.00	66.30	2.67	3.71
Plant height (cm)	70.28	72.91	18.03	17.90	16.37	16.85	82.40	88.60	21.52	23.82
TSS	17.28	16.82	12.96	8.76	11.71	7.06	81.70	64.80	3.77	1.97
Protein content (%)	13.19	13.43	21.71	20.82	20.24	20.20	86.90	94.10	5.12	5.42
Ascorbic acid (mg/100g)	18.26	17.77	19.34	19.19	17.41	17.85	81.00	86.50	5.89	6.08
Pod yield/ plant (g)	77.37	68.05	15.94	20.26	13.82	17.95	75.20	78.50	19.11	22.28

TABLE 3: Phenotypic correlation coefficients involving twelve variable characters in Garden pea

Trait		Days to first picking	Pod length	No of seeds per pod	Shelling %	No of primary branches/ plant	No of pods/ plant	Plant height	TSS	Protein content	Ascorbic acid	Pod yield/ plant
Days to 50% flowering	2011-12	0.410*	-0.254*	-0.357*	-0.001	0.265*	-0.129	-0.236*	-0.182*	-0.257*	-0.036	-0.326*
	2012-13	0.314*	-0.176*	-0.028	0.092	0.111	-0.011	-0.120	-0.215*	-0.294*	-0.008	-0.139
Days to 1st picking	2011-12		-0.157	-0.228*	0.021	0.067	0.047	-0.061	0.056	-0.153	0.059	-0.094
	2012-13		-0.201*	-0.162	0.042	0.082	-0.130	-0.135	-0.098	-0.221*	0.090	-0.295*
Pod length	2011-12			0.363*	0.022	0.038	0.100	-0.062	-0.008	0.034	0.034	0.461*
	2012-13			0.442*	0.067	-0.087	-0.021	-0.203*	-0.151	0.134	-0.061	0.318*
No of seeds per pod	2011-12				-0.002	-0.151	0.175*	0.069	0.071	0.191*	0.094	0.405*
	2012-13				0.127	-0.090	-0.050	0.048	-0.083	0.233*	0.015	0.213*
Shelling %	2011-12					0.233*	0.103	-0.016	0.049	0.185*	0.017	0.046
	2012-13					0.204*	0.055	0.042	-0.050	0.146	0.112	0.069
No of primary branches/ plant	2011-12						0.121	-0.152	0.001	-0.052	-0.133	0.046
	2012-13						0.062	-0.184*	-0.084	-0.037	0.023	-0.009
Number of pods / plant	2011-12							0.130	0.206*	-0.028	0.042	0.772*
	2012-13							-0.040	0.166*	-0.054	0.008	0.817*
Plant height	2011-12								0.108	-0.206*	0.130	0.034
	2012-13								0.052	-0.140	0.135	-0.118
TSS	2011-12									0.211*	-0.157	0.194*
	2012-13									0.259*	-0.025	0.142
Protein content	2011-12										-0.176*	0.075
	2012-13										-0.062	0.035
Ascorbic acid	2011-12											0.124
	2012-13											0.105

all the F_{10} recombinant inbreds for most of the traits studied. Appreciable economic heterosis was noticed for majority of the traits as shown in Table 5 and 6.During 2011-12, lines L-13 followed by L-14 and L-25over standard checks Azad P-1 and Punjab-89 for pod yield/plant; L-13 followed by L-25 over Azad P-1 and Palam Priya for number of pods/plant; L-14 over Palam Priya for shelling %; L-35 followed by L-32 and L-34 over Palam Priya for number of primary branches/ plant; L-9 over Azad P-1,Palam Priya and Punjan-89 for plant height; L-14 followed by L-17 over Punjab-89 for days to 50% flowering and L-32 followed by L-12 over Punjab-89and Palam Priya for protein content showed significant heterobeltiosis over the respective standard checks. Similarly, during the year 2012-13, lines L-14 followed by L-13 and L-29 over Azad P-1 for pod yield/plant; L-13 followed by L-44 and L-25 over all the three checks for number of pods/plant; L-4 followed by L-14 over Azad P-1 for shelling %; L-42 over Azad P-1 and Palam Priya for number of primary branches/plant; L-9 followed by L-18 over all the three checks for plant height; L-17 over Azad P-1 and Punjab-89 for days to 50% flowering and L-32 and L-12 over Palam Priya and Punjab-89, respectively, for protein content exhibited significant heterosis. These results corroborate the views of many workers as Ceyhan *et al.* (2008), Chaudhary *et al.* (2011) and Brar *et al.* (2012).

TABLE 4: Path coefficients analysis for different characters with pod yield for 2011-12 and 2012-13

Traits		Days to 50% flowering	Days to first picking	Pod length (cm)	No of seeds per pod	Shelling percentage	No of primary branches per plant	No of pods per plant	Plant height (cm)	TSS (%)	Protein content (%)	Ascorbic acid (mg/100g)
Days to 50%	2011-12	**-0.112**	-0.046	0.029	0.040	0.001	-0.030	0.015	0.027	0.020	0.029	0.004
flowering	2012-13	**0.058**	-0.018	0.010	0.002	-0.005	-0.006	0.001	0.007	0.012	0.017	0.001
Days to first	2011-12	-0.006	**-0.015**	0.002	0.003	-0.001	-0.001	-0.001	0.001	-0.001	0.002	-0.001
picking	2012-13	-0.042	**-0.135**	0.027	0.022	-0.006	-0.011	0.018	0.018	0.013	0.030	-0.012
Pod length (cm)	2011-12	-0.078	-0.049	**0.309**	0.112	0.007	0.012	0.031	-0.019	-0.002	0.010	0.010
	2012-13	-0.041	-0.047	**0.234**	0.103	0.016	-0.020	-0.005	-0.047	-0.035	0.031	-0.014
No of seeds/ pod	2011-12	-0.041	-0.026	0.042	**0.115**	-0.001	-0.017	0.020	0.008	0.008	0.022	0.011
	2012-13	-0.004	-0.023	0.063	**0.143**	0.018	-0.013	-0.007	0.007	-0.012	0.033	0.002
Shelling %	2011-12	0.000	-0.001	-0.001	0.001	**-0.046**	-0.011	-0.005	0.001	-0.002	-0.009	-0.001
	2012-13	0.001	0.001	0.001	0.001	**0.008**	0.002	0.001	0.001	-0.001	0.001	0.001
No of primary	2011-12	0.002	0.001	0.001	-0.001	0.002	**0.009**	0.001	-0.001	0.000	-0.001	-0.001
branches/ plant	2012-13	-0.003	-0.002	0.003	0.003	-0.006	**-0.029**	-0.002	0.005	0.002	0.001	-0.001
No of pods/ plant	2011-12	-0.092	0.034	0.071	0.124	0.073	0.086	**0.711**	0.093	0.146	-0.020	0.030
	2012-13	-0.009	-0.104	-0.017	-0.040	0.044	0.049	**0.795**	-0.031	0.132	-0.043	0.006
Plant height (cm)	2011-12	0.020	0.005	0.005	-0.006	0.001	0.013	-0.011	**-0.085**	-0.009	0.018	-0.011
	2012-13	0.013	0.014	0.021	-0.005	-0.004	0.019	0.004	**-0.105**	-0.006	0.015	-0.014
TSS (%)	2011-12	-0.008	0.002	-0.001	0.003	0.002	0.000	0.009	0.005	**0.042**	0.009	-0.007
	2012-13	-0.011	-0.005	-0.008	-0.004	-0.003	-0.005	0.009	0.003	**0.053**	0.014	-0.001
Protein content	2011-12	-0.008	0.002	-0.001	0.003	0.002	0.000	0.009	0.005	0.042	**0.009**	-0.007
(%)	2012-13	0.017	0.012	-0.008	-0.013	-0.008	0.002	0.003	0.008	-0.015	**-0.056**	0.004
Ascorbic acid	2011-12	-0.003	0.006	0.003	0.009	0.002	-0.013	0.004	0.012	-0.015	-0.017	**0.095**
(mg/100g)	2012-13	-0.001	0.012	-0.008	0.002	0.015	0.003	0.001	0.018	-0.003	-0.008	**0.134**
Correlation	2011-12	-0.326*	-0.094	0.461*	0.405*	0.046	0.046	0.772*	0.034	0.194*	0.075	0.124
coefficients	2012-13	-0.139	-0.295*	0.318*	0.213*	0.069	-0.009	0.817*	-0.118	0.142	0.035	0.105
Residual effect at phenotypic level					(2011-12) :	0.455						
					(2012-13) :	0.407						

TABLE 5: Magnitude of heterosis (over checks) in best top three F_{10} for yield and component traits in Garden pea

Character	Year	Best heterotic over	Heterosis (%)	Best heterotic over	Heterosis (%)	Best heterotic over	Heterosis (%)
		Azad P-1		PalamPriya		Punjab-89	
Days to 50% flowering	**2011-12**	L-14	-7.61*	NIL	-	L-14	-17.34*
		L-17	-6.92*	-	-	L-17	-16.72*
		L-41	-6.92*	-		L-41	-9.29*
	2012-13	L-17	-14.01*	NIL	-	L-17	-13.73*
		L-8	-13.36*	-	-	L-18	-13.40*
		L-14, L-28	-11.40*	-	-	L-8	-13.07*
Days to first picking	**2011-12**	L-14, L-15	-9.24*	NIL	-	L-14, L-15	-8.82*
		L-34	-7.62*	-	-	L-34	-7.19*
		L-43	-6.24*	-	-	L-17, L-43	-5.80*
	2012-13	L-14, L-17	-8.63*	NIL	-	L-14, L-17	-8.42*
		L-15, L-18, L-19	-6.00	-	-	L-15, L-18, L-19	-5.77*
		L-36, L-43	-5.76*	-	-	L-36, L-43	-7.67*
Pod length	**2011-12**	NIL	-	NIL	-	L-12	8.98*
		-	-	-	-	-	-
		-	-	-	-	-	-
	2012-13	L-39	16.23*	NIL	-	L-39	21.61*
		L-12	16.18*	-	-	L-12	21.51*
		L-27	12.48*	-	-	L-27	17.64*
Number of seeds/pod	**2011-12**	L-12	8.39*	NIL	-	L-12	12.88*
		-	-	-	-	L-14	7.35*
		-	-	-	-	-	-
	2012-13	NIL	-	NIL	-	L-12	16.89*
		-	-	-	-	L-13	14.41*
		-	-	-	-	L-27	12.43*
Shelling per cent	**2011-12**	NIL	-	L-14	21.41*	NIL	-
		-	-	L-35	19.01*	-	-
		-	-	L-4	17.83*	-	-
	2012-13	L-4	32.51*	NIL	-	NIL	-
		L-14	31.08*	-	-	-	-
		L-12	29.46*	-	-	-	-
No of primary branch/ plant	**2011-12**	NIL	-	L-35	52.78*	NIL	-
		-	-	L-32	47.22*	-	-
		-	-	L-34	41.67*	-	-
	2012-13	L-42	27.50*	L-42	30.77*	NIL	-
		L-8, L-36	25.00*	L-36, L-8	28.21*	-	-
		L-34, L-35	22.50	L-34, L-35	25.64*	-	-

* Significance at 5% level

TABLE 6: Magnitude of heterosis (over checks) in best top three F_{10} for yield and component traits in Garden pea

Character	Year	Best heterotic over	Heterosis (%)	Best heterotic over	Heterosis (%)	Best heterotic over	Heterosis (%)
		Azad P-1		PalamPriya		Punjab-89	
No of pods/plant	2011-12	L-13	39.46*	L-13	28.48*	L-13	25.90*
		L-25	36.07*	L-25	25.36*	-	-
		L-31	24.04*	-	-	-	-
	2012-13	L-13	92.22*	L-13	39.77*	L-13	36.84*
		L-44	80.52*	L-44	31.26*	L-44	28.52*
		L-25	76.32*	L-25	28.20*	L-25	25.52*
Pod yield/plant	2011-12	L-13	26.01*	NIL	-	L-13	37.68*
		L-14	19.36*	-	-	L-14	30.41*
		L-25	14.47*	-	-	L-25	25.07*
	2012-13	L-14	108.78*	NIL	-	L-29	27.03*
		L-13	106.25*	-	-	L-25	26.45*
		L-29	86.73*	-	-	L-44	24.06*
Plant height	2011-12	L-9	109.37*	L-9	93.05*	L-9	125.23*
		L-18	16.31*	-	-	L-18	25.12*
		-	-	-	-	L-14	19.43*
	2012-13	L-9	117.13*	L-9	102.12*	L-9	101.56*
		L-18	21.02*	L-18	12.65*	L-18	12.35*
		L-26	18.91*	L-19	10.87*	L-19	10.56*
TSS	2011-12	L-13	38.13*	L-13	41.13*	L-13	36.02*
		L-20	26.85*	L-20	29.60*	L-20	24.90*
		L-18	20.62*	L-18	23.24*	L-36	20.69*
	2012-13	L-20	33.33*	L-20	24.46*	L-20	15.41*
		L-7	28.89*	L-7	20.31*	L-13, L-41	1.67*
		L-13	26.67*	L-13, L-41	18.23*	-	-
Protein content	2011-12	L-12	21.54*	L-32	42.92*	L-32	88.51*
		L-17	15.38*	L-12	15.21*	L-12	51.96*
		L-41	12.31*	L-40	10.83*	L-40	46.19*
	2012-13	NIL	-	L-32	36.00*	L-12	47.84*
		-	-	L-12	29.11*	L-40	41.73*
		-	-	L-40	23.78*	L-13	35.62*
Ascorbic acid content	2011-12	L-44	11.69*	L-8	17.59*	L-8	29.83*
		-	-	L-44	16.23*	L-44	28.34*
		-	-	-	-	L-14	17.72
	2012-13	L-8	31.44*	L-8	18.66*	L-8	37.77*
		L-29	27.69*	L-29	15.28*	L-29	33.85*
		L-14, L-44	21.54*	-	-	L-14, L-44	27.40*

* Significance at 5% level

Thus, from the above results it can be concluded that the inbreds L-13 and L-14 were the best recombinants for for number of pod yield/plant showing maximum consistency across the years. L-13 and L-14 also exhibited consistent heterosis for number of pods/plant and earliness, respectively, and these recombinant inbreds can be further exploited for improvement in garden pea.

REFERENCES

Al-Jibouri, H.A., Millar, P.A. and Robinson, H.F. (1958). Genotypic and environmental variances and covariances in an upland cotton cross of interspecific origin. *Agron. J*. **50:**632-636.

Anonymous. (2011). Food and Agricultural Organization of United Nations: Economic and Social Department : The Statistical Devision.*http://faostat.fao.org*.

Brar, P.S., Dhall, R.K. and Dinesh. 2012. Heterosis and combining ability in garden pea (*Pisum sativum* L.) for yield and its contributing traits. *Vegetable Science* **39 (1):** 51-54.

Burton, G.W. and De Vane, E.H. (1953). Estimating heritability in tall fescue (*Festuca arundinaceae*) from replicated clonal material. *Agron. J*. **54:**478-481.

Ceyhan, E., Avci, M.A. and Karada, S. (2008). Line X tester analysis in pea (*Pisum sativum* L.): Identification of superior parents for seed yield and its components. *African Journal of Biotechnology* **7 (16):** 2810-2817.

Chaudhary, D.R., Singh, J. and Kumar, A. (2011). Identification of potential heterotic combinations and breeding for higher pod yield and earliness in garden pea (*Pisum sativum* L.). *Himachal Journal of Agricultural Research* **37 (1):** 27-34.

Dewey, D.R. and Lu, K.H. (1959). A correlation and path analysis of components of crested wheat-grass seed production. *Agron. J*. **51:** 515-518.

Ghobary, H.M.M. (2010). Study of relationship between yield and some yield components in garden pea (*Pisum sativum* L.) by using correlation and path analysis. *Journal of Agriculture Research Kafer El-Sheikh University***30:** 351-360.

Ghosh, K. P., Islam, A. K. M. A., Mian, M. A. K. and Hossain, M. M. (2010).Variability and Character Association in F2 Segregating Population of Different Commercial Hybrids of Tomato (*Solanum lycopersicum*L.). *J. Appl. Sci. Environ.* **4:** 91 – 95.

Gomez, A.A. and Gomez, K.A. (1983).Statistical Procedure for Agriculture Research, 2nd Ed. John Willey and Sons, Inc. New York, p 357-427.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955).Estimation of genetic and environmental variability in soybean. *Agron. J*. **47:**314-318.

Kaur, H., Singh M. and Brar P.S. (2004). Correlation and path analysis in garden pea (*Pisum sativum* L.).*Crop Improvement* **34(2):** 186-91.

Kumar, J., Ashraf, N. and Pal, K.(2010). Variability and character association in garden pea (*Pisum sativum* var. *hortense* L.).*Progresssive Agriculture* **10(1):** 124-131.

Kumari, A., Kumar, M. and Kohli, U.K. (2008). Genetic parameters and character association in garden pea (*Pisum sativum* L.). *Vegetable Science* **35(2):** 160-164.

Monti, L.M. (1983). Natural and induced variability in peas for protein production. In: Perspective for peas and lupins as protein crops (ed. Thompson and Carsey). *World crops* **8:** 23-29.

Rathi, R.S. and Dhaka, R.P.S. (2007).Genetic variability, correlation and path analysis in pea (*Pisum sativum* L.). *Journal of Plant Genetic Resources* **20(2)**: 126-129.

Sharma, A., Sood, M., Rana, A. and Singh, Y. (2007).Genetic variability and association studies for green pod yield and component horticultural traits in garden pea under high hill dry temperate conditions. *Indian Journal of Horticulture* **64(4):** 410-414.

Sharma, A.K., Singh, S.P. and Sharma, M.K. (2003).Genetic variability, heritability and character association in pea (*Pisum sativum* L.). *Crop Research* **26:** 135-39

Sharma, M.K., Chandel, A. and Kohli, U.K. (2009).Genetic evaluation, correlations and path analysis in garden pea (*Pisum sativum* var. *hortense* L.). *Annals of Horticulture* **2(1):** 33-38.

Sharma, M.K., Chandel, A. and Kohli, U.K. (2011).Genetic evaluation correlation coefficients and path analysis in garden pea (*Pisum sativum* var. *hortense* L.). *Progressive Agriculture***11(2):** 434-439.

Sharma, V.K. and Bora, L. (2013). Studies on genetic variability and heterosis in vegetable pea (*Pisum sativum* L.) under high hills condition of Uttarakhand, India. *African Journal of Agricultural Research* **8(18):** 1891-1895.

Siddika, A., Islam, A.K.M.A, Rasul, M.G., Mian, M.A.K. and Ahmed, J.U. (2013).Genetic variability in advanced generations of vegetable pea (*Pisum sativum* L.). *International Journal of Plant Breeding* **7(2):** 124-128.

Singh, S., Singh, L., Rahul, V.P. and Chandra, H. (2013). Study on genetic variability, heritability, genetic advance and genetic divergence in pea (*Pisumsativum* L.). *Journal of Progressive Agriculture* **4(1):** 28-30.

Yadav, B.K., Singh, S.K., Dubey, A.K. and Yadav, A.K. (2012). Studies on variability, heritability and genetic advance in table pea (*Pisum sativum* var. *hortense* L.). *Annals of Horticulture* **5(2):** 285-288.