Pak.J.Bot., 30(2): 209-219, 1998.

COMPARISON BETWEEN F_1'S AND THEIR PARENTAL GENOTYPES FOR THE PATTERNS OF CHARACTER CORRELATION AND PATH COEFFICIENTS IN CHICKPEA (*CICER ARIETINUM*)

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Abstract

A study was undertaken to estimate the level and pattern of correlation between various plant characters including grain yield, separately in 28 F1s and 18 homozygous parental genotypes of chickpea grown under similar conditions. The correlation coefficients were partitioned into direct and indirect effects through path analysis. Highly significant genetic differences were recorded for all the characters studied both in F_1 and parental lines. A comparison between F_1 populations and parental lines revealed that the ranges of genotypic variations in F_1 were greater than their corresponding ranges in parental lines. Study of correlation coefficients revealed that genetic correlation's in F_1's as well as in parental lines were higher than phenotypic correlations. Positive and highly significant genetic correlation of grain yield in parental genotypes was observed with number of primary and secondary branches per plant, pods per plant, 100-seed weight and biological yield per plant, whereas in F_1 highly significant and positive correlation of grain yield was noted only with number of secondary branches, pods per plant and biological yield per plant. However, F_1 and parental genotypes appeared to be similar with respect to the pattern of correlation of grain yield with other plant characters except 100 seed weight. The correlation of 100-seed weight with grain yield in F_1 was negative and highly significant, whereas it was positive and highly significant in the case of parents. The study of correlation coefficients between yield components showed that the pattern of correlations between plant height and secondary branches, primary branches and 100-seed weight, biological yield and 100-seed weight and between harvest index and 100-seed weight were dissimilar in F_1 and parental genotypes. The results of path analysis showed harvest index and biological yield to have maximum direct effect on grain yield respectively in parental lines and F_1 genotypes. These results showed that the pattern and level of association between various plant characters in F_1 and parental genotypes were not similar for all the cases. However, the level and pattern of correlation of grain yield with number of secondary branches, number of pods and biological yield per plant were similar in both the sets of genotypes.

Introduction

Chickpea is an important component of rain fed cropping system in Pakistan where it is cultivated on about one million hectares with a total production of 550 thousand tons. Seed is economically the most important component of this crop which is valued for good quality protein and starch contents. It is normally consumed in combination with cereals which make it a perfect diet. The productivity and production of chickpea has remained stagnant except for few exceptional years. Lack of high yielding varieties

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is the most important factor among the major causes responsible for low yields in chickpea. Although, breeders have been putting lot of efforts to evolve high yielding disease resistant varieties of chickpea, they have not been able to achieve a break through in its productivity. Therefore, further efforts are required to devise more efficient breeding techniques to exploit artificially created genetic variability.

The presence of genetic variability is an important pre-requisite for a breeding programme aimed at genetic improvement of any crop. Grain yield which is the most important component of majority crop plants is a complex character and is final product of several contributory factors and their interaction. The knowledge of association between yield and these factors provides the basis for planning a breeding programme for maximum genetic gain. The path coefficient study provides an opportunity to examine the magnitude and direction of association of yield with its direct and indirect components.

Character correlation has been a popular subject of study among the breeders. However, most of these studies were made on land races or homogeneous lines of various crops (Ali, 1985, Asawa *et al.*, 1981, Bakhsh, 1991, Banerjee *et al.*, 1986, Chaudhry, 1991, Chihan & Sinha, 1982, Ghafoor *et al.*, 1990; Gupta *et al.*, 1972). Therefore, previously made recommendations about the selection criteria for yield improvement are normally based on such studies whereas selection is usually made from segregating populations or from heterogeneous land races. Dahiya *et al.*, (1986) made a comparison between various selection criteria from F_3 and F_4 populations and concluded that number of fruiting branches were effective for yield increase. When F_2 and F_3 populations were studied for yield comparison in chickpea, it was found that number of fruiting branches, pods/plant and seeds/plant were good indication of yield (Ram *et al.*, 1980). Tomer *et al.*, (1982) reported similar results from his studies on F_1 and F_2 generations.

Present investigation was undertaken to make a comparison between F_1 progenies and their parental genotypes for the pattern and level of character correlation and for direct and indirect effect of these characters on yield. The main objective was to establish a selection criteria based on characters which remain stable for the pattern of their association with yield across various generations.

Materials and Methods

The experimental material of this study consisted of 18 pure lines and 28 F_1 populations. The hybrid populations were developed by crossing these pure lines in various combinations. The crosses were made at NARC and all possible precautionary measures were taken to avoid selfing. The F_1 and parental lines were then evaluated during 1994-95 in two separate experiments, planted side by side, in randomized complete block design with three replications. Each plot consisted 4m long 2 rows with spacing of 30cm between rows and 10cm between plants within a row. These experiments were conducted in the experimental field of pulses programme, National Agricultural Research Center, Islamabad, during 1994-95. Ten plants of each genotype were randomly selected from each replication both for parental and F_1 populations at the time of maturity. Data for plant height, number of primary branches, number of secondary branches,

Table 1. Analysis of variance and means for yield and yield related plant characters in 18 pure lines (parental lines) of chickpea.

Genotype	X1	X2	X3	X4	X5	X6	X7	X8
Pk51814	46.53	4.44	28.33	68.22	22.71	34.84	48.50	17.45
Pk51830	48.53	6.00	30.11	55.22	22.02	34.53	42.89	15.29
ILC482	49.00	5.66	24.77	68.00	26.35	48.23	49.06	18.90
F87-508C	50.97	5.11	22.25	60.00	25.29	31.10	45.30	14.53
HG202-6-1	50.27	4.66	21.22	60.22	27.46	33.90	39.85	12.65
PK51860	47.63	5.33	21.10	49.09	25.22	26.27	44.81	13.02
PK1792	52.20	4.88	25.89	69.33	19.44	31.80	33.07	11.59
F84-78C	43.83	4.55	17.00	35.11	17.69	13.83	40.90	5.25
F83-47C	42.83	4.45	24.33	58.66	12.04	23.97	40.81	10.03
ICC13301	37.43	3.00	14.66	37.22	12.19	11.68	45.32	4.46
CAI18608	44.10	3.66	13.08	35.44	23.94	17.23	44.18	6.94
CM72	44.35	5.55	13.50	40.22	23.30	23.87	36.99	8.73
ICC13416	46.83	4.77	18.89	38.33	24.70	24.45	44.79	10.81
F85-114C	45.87	7.00	18.88	49.22	27.92	24.59	39.57	11.96
HI-11287	47.87	7.55	15.54	52.00	29.03	30.55	40.52	13.04
ICC13728	43.20	4.00	12.33	51.78	23.72	24.27	46.35	12.74
ICC11514	45.53	4.88	18.89	84.09	22.46	29.56	46.30	12.94
ILC5902	43.10	3.88	18.78	63.44	10.90	25.49	44.61	8.32
MS(V)	37.87**	3.78**	82.81**	564.54**	90.82**	214.92**	49.78**	44.67**
MS(R)	80.28**	0.63	3.17	33.82	10.34	03.95	2.73	07.59
MS(E)	10.11	0.66	9.35	35.54	07.72	22.78	10.55	03.34

X1 = Plant height, X2 = No. of primary branches, X3 = No. of secondary branches, X4 = No. of pods/plant, X5 = 100 seeds weight (gm) X6 = biological yield/plant, X7 = Harvex Index (%), X8 = Grain yield/plant (gm).

pods per plant, 100-seed weight biological yield, harvest index and grain yield were recorded on individual plants in all F_1 and parental genotypes. These data were averaged to calculate means of each character for individual genotype. The statistical analysis was performed to determine the significance of differences between mean values (Steel & Torrie, 1960). Genotypic (rg) and phenotypic (rp) correlation coefficients between two characters were determined by the following formulae proposed by Dewy & Lu (1959):

$$rg = \frac{Cov.Gij}{(6gi)\ (6gj)}$$

where rg = genotypic correlation coefficient, Cov.Gij and 6gi and 6gj are estimates of variety components of covariance and variance, respectively, for trait I and j.

$$Rp = \frac{Mij}{(Mii)\ (Mij)}$$

where Mij is the mean product of varieties, Mii and Mij are variety mean squares for trait I and j.

The genetic correlation coefficients were used for path coefficient analysis demonstrated by Dewey & Lu (1959) by solving of simultaneous equations, where grain yield was kept as resultant variable and the yield contributing characters like (a), (b), (g) as causal variables.

Results

The results of analysis of variance and means for yield and other characters studied in parents and F_1 genotypes are presented in Table 1 and 2, respectively. The genotypic differences for all the parameters studied in both the populations were highly significant. Plant height in parents and F_1's ranged from 37.5 to 52.2cm and 20.03 to 58.73 cm, respectively. Number of pods per plant in parental genotypes ranged from 35.11 to 84.04 against 57.17 to 211.16 in F_1's, 100-seed weight ranged from 10.90 to 29.03gm in parental genotypes whereas in F_1 it ranged from 12.36 to 35.30 gm. Harvest index varied from 33-49% in parents 34.5 -52.5% in F_1 genotypes. A range of 4.46 to 18.90 and 9.97 to 43.60 respectively in parents and F_1 genotypes was noted for grain yield per plant (gm).

Genetic and phenotypic correlations of yield with other plant characters and between various plant characters in parents and F_1's are given in Table 3. Generally, the genetic correlation coefficients in both the cases were greater than those of phenotypic correlations. The genetic correlation of yield with plant characters like plant height (0.747), number of primary branches (0.509), number of pods per plant (0.678), number of secondary branches and biological yield per plant (0.96) was positive and highly significant. The genetic correlation of yield in F_1 populations was positive and highly significant with number of fruit bearing branches (0.592), number of pods per plant (0.728) and biological yield per plant. 100-seed weight in this population was negatively correlated with yield (-0.406). Genetic correlation of plant height in parental genotypes was positive and highly significant with all the characters except harvest index (Table 3). On the contrary, this correlations in F_1 populations was non significant. Similarly, the pattern of correlations of primary branches with other yield components in parents was different from that of F_1 populations. Secondary branches both in parents and F_1's were positively and highly significantly correlated with number of pods and biological yield per plant and negatively correlated with 100-seed weight. The correlation patterns of pods per plant with rest of the characters in F_1 and parental genotypes were similar except for 100-seed weight where it was highly significant and negative in F_1's (-0.553) compared to non significant positive in parental genotypes (0.026). The study of Table 3 for rest of the correlation coefficients indicated that correlations of 100-seed weight with biological yield, harvest index and grain yield/plant were different in two populations, whereas, correlation pattern of biological

Table 2. Analysis of variance and means for yield and yield related plant characters in 28 F_1 progenies of chickpea.

GENOTYPES	X1	X2	X3	X4	X5	X6	X7	X8
C11514xILC482	20.03	5.76	31.89	96.55	19.87	45.58	47.28	21.93
PK51814xHI11287	21.21	4.66	53.00	100.6	23.53	56.47	51.57	22.68
PK51814xHG202-6-1	23.87	5.11	51.22	104.55	20.87	48.48	46.72	28.18
HG202-6-1x(ICC11514xLC482)	22.77	5.00	49.66	111.86	16.60	58.67	46.70	27.50
HG202-6-1xHI1087	55.33	6.50	47.83	123.66	14.12	57.19	50.33	27.10
HI1087xHG202-6-1	52.16	6.72	52.33	125.16	15.08	54.75	49.16	27.19
C141x(ICC11514xILC3279)	57.16	4.72	62.49	190.33	15.36	68.46	52.42	43.61
(CM72xNEC138-2)xCM72	55.50	6.83	42.50	90.66	23.73	61.99	41.20	25.66
F87-508CxF85-114C	54.30	5.54	37.78	104.55	22.37	57.57	40.50	22.42
HI11287xPK51814	51.50	5.33	33.78	77.89	23.53	62.07	41.99	26.80
50180xF83-47C	56.14	5.22	43.33	79.50	28.91	58.34	41.30	17.74
ICC11514xILC482	55.18	6.11	45.76	89.45	25.63	45.83	42.79	17.13
PK51792xILC5902	59.50	4.72	39.83	108.33	35.36	61.49	51.93	29.73
AARI92146xICC13416	62.30	6.11	6.11	46.22	125.55	22.40	63.30	43.71
ICC13728xCAI18608	58.73	6.89	40.44	109.89	23.05	69.16	40.89	28.25
CM72x(ICC11514xILC482)	57.98	5.33	65.49	211.16	13.43	80.23	44.35	34.49
C727xCM72	48.16	5.11	71.99	159.50	12.38	107.38	46.74	49.95
HG202-6-1xPK51830	48.07	2.83	46.33	88.83	17.93	50.90	48.50	21.10
PK52291xP3-7-1	51	5.67	32.83	116.50	29.08	61.18	47.25	27.32
(ICC11514xILC482)xPK51833	44.50	4.83	44.33	108.33	25.32	58.07	52.03	29.93
50264xPK51832	54.50	4.50	22.83	79.17	26.52	33.82	46.97	9.97
PK51835xICC13416	48.53	5.33	36.17	113.67	20.52	52.83	47.20	24.60

(Cont'd.)

Table 2 (Cont'd.)

GENOTYPES	X1	X2	X3	X4	X5	X6	X7	X8
(ICC11514xILC482)xCM72	51.83	5.67	33.00	106.17	24.90	62.63	43.07	36.93
E101xCM72	59.10	5.33	26.97	103.00	28.68	62.17	52.08	29.80
(CM72xICC11514)xILC482	49.83	5.33	37.50	81.30	23.62	49.57	50.72	16.30
NEC138-2xILC4421	46.33	2.83	38.50	95.50	24.47	26.32	39.70	12.85
(ICC11514xILC482)xCM72	46.50	4.50	29.67	105.83	24.35	55.63	48.87	29.70
CM72x(ICC11514xILC482)	49.50	4.00	30.57	54.17	20.47	50.45	34.57	21.87
MS(V)	431.0**	2.96**	402.8**	3142.4*	85.79**	610.5*	63.1*	212.5**
MS(R)	12.75	0.52	58.36	11.92	2.32	0.92	33.82	5.51
MS(E)	4.41	0.49	17.29	44.15	2.61	7.93	11.99	10.21

X1 = Plant height, X2 = No. of primary branches, X3 = No. of secondary branches, X4 = No. of pods/ plant, X5 = 100 seeds weight (gm) X6 = biological yield/plant, X7 = Harvex Index (%), X8 = Grain yield/plant (gm).

yield with harvest index and grain yield and that of harvest index with total grain yield resembled in two sets of populations. The results of path coefficient analysis showed that harvest index in F_1 genotypes and number of pods per plant in parental genotypes had maximum direct effect on yield (Table 4). A comparison between two sets of genotypes for corresponding path coefficient values showed that qualitatively and quantitatively these values were different in most cases.

Discussion

Genetic improvement of chickpea for high grain yield has been the focal point of chickpea breeders in Pakistan. Grain yield is a complex character which is final product of many contributory factors. Therefore, a detailed knowledge of these factors, their direct and indirect contribution to yield and knowledge of relationship between these traits when combined into a single genotype would provide basis for effective breeding programme. Present investigation was made to study the behavior of important yield traits in F_1 and their parental genotypes, with the objective of finding a suitable combination/set of characters which enhance yield and does not change their behavior when put in different genetic background. Selection of parental lines for hybridization and then single plants from segregating populations based on such information are expected to give better results than ever before. This is because the previous reports on character association show that selection criteria previously used were based on information derived from homogeneous lines.

The results of present study revealed that there was considerable variation both in parents and F_1 populations for the characters studied. The wider range of variability in F_1 may be an attribute of different levels of heterosis in various F_1 hybrids. Highly significant genetic differences for the traits as evaluated in this investigation were reported by Singh (1988), Malik *et al.*, (1988), although in pure lines. Maximum genetic variability in this study was observed for pods per plant in all the populations which is similar to the observation made by Filippetti & Margano (1983). The prevalence of genetic variability observed in the present study provides scope for the identification of better genotypes.

The estimates of correlation coefficients revealed that genetic correlations were higher than phenotypic correlations for almost all the characters in F_1, F_2 and parental populations. These results are similar to the reports of Rani & Rao (1981), Singh *et al.*, (1985) and Malik *et al.*, (1988) from their studies on different crops.

In parental genotypes all the characters were positively correlated with yield. Positive correlation of yield with number of pods per plant, number of primary branches, number of seeds per plant, 100 seed weight and harvest index have already been reported (Bhall *et al.*, 1976, Singh *et al.*, 1985, Jain *et al.*, 1981, Chaudhry & Khan, 1974). The pattern and level of correlation of yield with its components was different in some cases between F_1 and parents. All the plant characters in parental genotypes were positively and highly significantly associated with yield. Contrary to that, plant height, number of primary branches and harvest index in F_1 were non significantly correlated with yield. The interrelation of yield components were similar in some cases while they were different in others between F_1 and parental genotypes. For example, the relation-

Table 3. Genetic (rg) and phenotypic (rp) correlation coefficients between yield and yield components in purelines (A) and F_1 (B) populations of chickpea.

Variables			X1	X2	X3	X4	X5	X6	X7	X8
X1	A:	rg	1	0.62**	0.678**	0.467**	0.736**	0.872**	-0.326	0.747**
		rp	1	0.413	0.439	0.436	0.469*	0.574*	-0.148	0.593**
	B:	rg	1	0.216	-0.091	0.177	.200	0.227	-0.193	0.105
		rp	1	0.225	-0.051	0.173	0.184	0.225	-0.154	0.115
X2	A:	rg		1	0.166	0.088	0.712**	0.488*	-0.339	0.509*
		rp		1	0.233	0.167	0.549*	0.408	-0.235	0.440*
	B:	rg		1	0.031	0.199	-0.072	0.046	-0.017	0.221
		rp		1	0.148	0.129	-0.090	0.278	-0.059	0.196
X3	A:	rg			1	0.598**	-0.034	0.618**	0.088	0.675**
		rp			1	0.500	0.009	0.609**	-0.006	0.587**
	B:	rg			1	0.755**	-0.663**	0.631**	0.238	0.592**
		rp			1	0.695**	-0.625**	0.574**	0.156	0.551**
X4	A:	rg				1	0.026	0.726**	0.178	0.648**
		rp				1	0.031	0.652**	0.127	0.638**
	B:	rg				1	-0.553**	0.628**	0.355	0.728**
		rp				1	-0.509**	0.595**	0.264	0.665**
X5	A:	rg					1	0.508	0.042	0.529*
		rp					1	0.392	0.013	0.474*
	B:	rg					1	-0.362	-0.039	-0.406*
		rp					1	-0.350	-0.026	-0.391*
X6	A:	rg						1	0.262	0.960**
		rp						1	0.079	0.854**
	B:	rg						1	0.123	0.885**
		rp						1	0.074	0.803**
X7	A:	rg							1	0.426*
		rp							1	0.229
	B:	rg							1	0.289
		rp							1	0.222

X1 = Plant height, X2 = No. of primary branches, X3 = No. of secondary branches, X4 = No. of pods/plant, X5 = 100 seeds weight (gm) X6 = biological yield/plant, X7 = Harvex Index (%), X8 = Grain yield/plant (gm).

Table 4. Direct and indirect effects via various paths of 7 yield characters on the grain yield in Pure lines (A) and F1 (B) progenies of chickpea.

Chara-cters	Direct effect	Indirect effect via	X1	X2	X3	X4	X5	X6	X7	Total corre-lation
X1	(A)	0.115	-	0.170	0.258	0.129	0.259	-0.031	-0.153	0.748
	(B)	-0.153	-	0.029	0.034	0.078	-0.013	0.203	-0.015	0.105
X2	(A)	0.276	0.071	-	0.063	0.024	0.251	-0.017	-0.159	0.509
	(B)	-0.135	-0.033	-	-0.012	0.088	0.005	0.310	-0.0013	0.221
X3	(A)	0.381	0.078	0.046	-	0.1644	-0.0119	-0.0242	0.0412	0.6746
	(B)	-0.3739	0.014	-0.0042	-	0.3321	0.0422	0.5637	0.0187	0.5925
X4	(A)	0.2748	0.0539	0.0244	0.2281	-	0.0092	-0.0258	0.0837	0.6482
	(B)	0.4397	-0.0271	-0.0269	-0.2825	-	0.0351	0.5617	0.0278	0.7278
X5	(A)	0.3517	0.0849	0.1964	-0.0129	0.0072	-	-0.0181	0.0195	0.6289
	(B)	-0.0636	-0.0307	0.0098	0.248	-0.2431	-	-0.3236	-0.0031	-0.4062
X6	(A)	-0.0356	0.1006	0.1347	0.2598	0.1996	0.1786	-	0.1226	0.9603
	(B)	0.8941	-0.0348	-0.0468	-0.2358	0.2762	0 023	-	0.0096	0.8856
X7	(A)	0.4687	0.0376	-0.0935	0.0335	0.0491	0.0147	-0.0093	-	0.4253
	(B)	0.0784	0.0296	0.0023	-0.089	0.156	0.0025	0.1098	-	0.2895

X1 = Plant height, X2 = No. of primary branches, X3 = No. of secondary branches, X4 = No. of pods/plant, X5 = 100 seeds weight (gm) X6 = biological yield/plant, X7 = Harvex Index (%), X8 = Grain yield/plant (gm).

ship of primary branches with 100 seed weight was significant and positive whereas same association in F_1 was negative although non significant. The present investigation revealed that the pattern of association between plant characters may be different in F_1 hybrid populations as compared to that of the parents where from these F_1's are derived. This indicates that each of the plant characters positively associated with yield in pure lines may not contribute positively to yield increase on combining these characters through hybridization. It is therefore proposed that the criteria for single plant selection from segregating generations should be decided on the basis of correlation information on segregating generations and pure lines together and only those characters be given consideration for the decision of selection criteria which are stable in their relation with yield in different genotypes.

Genetic correlation of secondary branches, number of pods and biological yield per plant with grain yield was positive in parents and F_1 hybrid populations. Positive correlation of yield with fruiting branches (Dhaiya *et al.*, 1986, Naidu *et al.*,, 1986), with pods per plant and seeds per plant (Tomer *et al.*, 1982, Ram *et al.*, 1980, Slimath & Bahl, 1983, Agrawal, 1976) have already been reported in hybrid populations. This indicated that the association of these plant characters in chickpea remained stable across the pure line and hybrid genotypes. Hence it may be recommended that high biological yield, and greater number of pods and fruit bearing/secondary branches available in various pure lines should be combined through hybridization in a single genotype to enhance yield potential of chickpea. It is also proposed that these parameters be given more importance while making selection from segregating populations.

References

Ali, N. 1985. Genetic variability and correlation studies in *Brassica juncea*. *Pak. J. Bot.*, 17: 297-303.

Asawa, B. M., R.K. Chandra and R.L Panday. 1981. Character correlation and divergent in pigeonpea. *Ind. J. Agric. Sci.*, 51:12-17.

Agrawal, I. 1986. Genetic variability in populations of chickpea crosses. *Indian J. Agric. Sci.*, 56: 142-144.

Bahl, P. N., R.B. Mehra and D.B. Raju. 1976. Path analysis and its implications for chickpea breeding. *Z. Pflzenzuchtg*, 77: 67-71

Bakhsh, A., M. Zubair and A. Ghafoor. 1991. Character correlation and Path analysis in Lentil. *Pak. J. Agric. Res.*, 12: 246-251.

Banerjee, H. T., B. Bhattercharjee and M. Das. 1968. A note on the relationship between growth and yield of the yellow sarson strain. *Ind. J. Agric.*, 13:203-204.

Chaudhry, A. R., N. Rehman, M. Akram and M. Hussain. 1991. Analysis of yield components in cowpea. *Pak. J. Agric. Res.*, 12: 252-254.

Chihan, V.S. and P.K. Sinha. 1982. Correlation and Path analysis in lentil. *LENS*, 9:19-22.

Chowdry, M. A. and M.A. Khan. 1974. Correlation studies in gram (*Cicer arietinum* L.). *Pakistan J. Agri. Sci.*, 11: 184-186.

Dahiya, B. S, R.S. Waldia, L.S. Kaushik and I.S. Solanki. 1984. Early generation yield testing versus visual selection in chickpea (*Cicer arietinum* L.). *Theor., Appl. Genet.*, 68: 525-529.

Dahiya, B.S., M.R. Naidu, R. Bakhshi and M. Bali. 1986. Selection procedures in chickpea breeding. p. 63-75. In *Genetic and crop improvement*. (Ed.) R.K. Gupta.

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

Filippetti, A. and C.F. Margano. 1983. Variability for plant and seed characters in a collection of *Cicer arietinum* L. *Genetica Agraria*, 37: 169.

Ghafoor, A., and M. Zubair and B.A. Malik. 1990. Path analysis in mash (*Vigna mungo* L.). *Pak. J. Bot.*, 22: 160-167.

Gupta, S. N., L. Rai and Y.S. Tamar. 1972. Correlation and path coefficient in mung bean (*Vigna radiata* L.). *Haryana Agric. Univ. Res.*, 12: 287-291.

Jain, K.C., B.P. Pandya and K. Pande. 1981. Genetic divergence in chickpea. *Indian J. Genet.*, 41: 220-225.

Katiyar, R. P. 1979. Correlation and path analysis of yield components in chickpea. *Indian J. Agric. Sci.*, 49: 35-38.

Khan, M. A. and M.A. Chaudhry. 1975. Interrelationship between yield and other plant characters in gram (*Cicer arietinum* L.). *J. Agric. Res.*, 13: 589-592.

Malik, B. A., I.A. Khan and M.R. Malik. 1988. Genetic variability and correlations among metric traits in chickpea. *Pak. J. Agric. Res.*, 9: 352-354

Naidu, M. R., B.S. Dhiya, P. Singh and M. Bali. 1986. Yield components as early generation selection criteria for improving seed yield in chickpea. Abst. p. 42 [(O, Keeffe, L. E. and F.J. Muehlbauer, (Eds.). International Food Legume Conference. College, Agric. Univ., Idaho.

Rani, Y.U. and J.S. Rao. 1981. Path analysis of yield components in black gram. *Indian J. Agric. Sci.*, 51: 378-381.

Ram, C. M S. Chowdhry, S. Chandra and D.S. Jatasra. 1980. Association in segregating populations of chickpea. *Indian J. Genet.*, 40: 117-121.

Salimath, P. M. and P.N. Bhat. P.N. 1983. Selection response in early generations in chickpea. In: *Proc. XV Int. Congress of Genetics*, Dec. 12-21., Abst. No. 1089. Oxford and IBH publishing Company, New Delhi, India.

Singh, S.P. 1988. Genetic variability and path coefficient studies in chickpea. *Plant Physiology*, 40: 48-53.

Steel, R. G. D. and J.S. Torrie. 1960. *Principles and procedures of statistics*. McGraw Hill Book Co. Inc.,New York.

Tomar, G. S., Y. Mishra and S.K. Rao. 1982. Path analysis and its implications in selection of high yielding chickpea (*Cicer arietinum* L.). *Indian J. Plant Physiol.*, 25:127-132.

(Received for publication 25 January 1997)