*Indian J. Genet.*, **54** (4): 381–388 (1994)

# CONTRIBUTION OF DIFFERENT CHARACTERS TOWARDS SEED YIELD IN CHICKPEA (*CICER ARIETINUM* L.)

S. K. BHAMBOTA, B. C. SOOD* AND S. L. GARTAN

*Department of Plant Breeding and Genetics, Himachal Pradesh Krishi Vishvavidyalaya Palampur 176062*

**(Received: June 6, 1994; accepted: November 2, 1994)**

## ABSTRACT

**Correlation analysis revealed positive association of pod bearing branches/plant, pods/plant, and plant height with seed yield in all the four environments individually as well as pooled over environments. Besides, these characters had positive interrelationships with one another in most of the environments. The path analysis at genotypic level revealed that pods/plant and plant height had considerable positive direct effect on seed yield. However, pod bearing branches had negative direct effect but it had high positive indirect effect via pods/plant on seed yield. Selection based on these three characters may contribute considerably to improvement in seed yield. Interestingly, days to maturity had nonsignificant correlation with yield in all the four environments, which provides scope for selection for seed yield in all maturity groups.**

**Key words:** Associations, direct-indirect effects, chickpea.

The study of associations among various traits is useful to breeders in selecting genotypes possessing groups of desired characteristics. It is known that correlation coefficients for a given pair of traits vary with the genotypes studied and the environment where the test is carried out. Singh et al. [1], on the basis of review of 74 studies on correlations among different traits in chickpea covering the period 1915–1983, reported wide variation in the nature and magnitude of correlation coefficients, except for number of pods/plant and 1000-seed weight, which were, in most cases, positively correlated with seed yield. No doubt, the correlation coefficients are helpful in determining the components of a complex trait like yield, but the information on the relative importance of direct and indirect effects of each component character toward seed yield is not provided by such studies. Path coefficient analysis under circumstances serves as an important tool in predicting the direct and indirect causes of association in measuring the effect of a special casual factor. The present study has been undertaken to supplement further informations on these aspects in chickpea.

*Author for correspondence.

## MATERIALS AND METHODS

The experimental material for the present investigation comprised 32 genetically diverse true breeding genotypes of chickpea including C 235 as standard check. The material was grown at the HPKV Experimental Farm of the Research Substation, Berthin in randomised complete block design with two replications each in four environments. One crop raised during rabi 1990–91 constituted the first environment. The second and third environments were created by two dates of sowing at an interval of 15 days during rabi 1991–92. The crop raised during rabi 1992–93 comprised the fourth environment. Each genotypes was sown in two rows of 2 m length, with row-to-row and plant-to-plant spacings of 30 and 10 cm, respectively. The recommended doses of fertilisers, i.e. 20 kg N and 40 kg $P_2O_5$ per hectare were applied at sowing time. The observations were recorded on 10 random plants of each genotype in each replication for 10 quantitative characters (Table 1). The correlation coefficients were computed following Al-Jibouri et al. [2], and path coefficient analysis was done by the method of Dewey and Lu [3]. The homogeneity of correlation coefficients over environments was tested following Rider [4].

## RESULTS AND DISCUSSION

The results show that most of the correlation coefficients were same in magnitude as well as sign in different environments (Tables 1, 2). However, heterogeneity was observed for the association of seed yield/plant with plant height and harvest index. Therefore, the correlated response of these traits is likely to differ over environments. The consistently positive association between seed yield/plant and plant height suggested that selection for plant height may also be practised without any adverse effects of variable environments. On the other hand, association between seed yield/plant and harvest index were at variance in magnitude and sign; being positively associated in rabi 1990–91 but negatively in rabi 1992–93, which suggests that the selection on the basis of harvest index may not give consistent results for grain yield owing to adverse environmental effects.

Many correlation coefficients, like the positive correlation of seed yield/plant with pods/plant, pod bearing branches/plant, plant height, and 100-seed weight; the positive correlation between 100-seed weight and plant height; and negative between 100-seed weight and seeds/pod, which were significant in more than two environments were also significant in the pooled analysis (Table 3). In most of the environments pod bearing branches/plant, pods/plant and plant height were positively correlated with each other as well as with seed yield/plant.

The estimates of genotypic correlation coefficients were similar in sign but higher in magnitude than the ones observed at phenotypic level for most of the traits. Such traits seem to be more prone to environmental fluctuations, which may have diluted the expression of

**Table 1. Phenotypic (P) and genotypic (G) correlation coefficients among different characters of chickpea in rabi 1990–91 and early sowing in 1991–92**

| Characters | | Seed yield per plant | Days to flowering | Days to maturity | Plant height | Pod bearing branches per plant | Pods per plant | Seeds per pod | 100-seed weight | Protein content | Harvest index |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Seed yield/plant | P | | 0.11 | 0.05 | 0.19 | 0.78* | 0.70* | 0.25 | 0.35 | −0.14 | 0.58* |
| | G | | 0.33 | −0.25 | 0.50 | 0.79 | 0.41 | 0.29 | 0.56 | −0.27 | 0.51 |
| Days to flowering | P | 0.17 | | −0.13 | −0.06 | 0.17 | 0.07 | 0.02 | 0.15 | −0.20 | −0.04 |
| | G | 0.27 | | −0.30 | −0.15 | 0.46 | 0.11 | 0.19 | 0.19 | −0.21 | −0.04 |
| Days to maturity | P | −0.05 | −0.18 | | 0.06 | 0.00 | −0.10 | −0.27 | 0.21 | −0.02 | −0.09 |
| | G | −0.05 | −0.34 | | −0.08 | −0.37 | −0.57 | −0.56 | 0.35 | −0.04 | −0.53 |
| Plant height | P | 0.44* | 0.25 | 0.03 | | 0.02 | 0.01 | 0.13 | 0.23 | −0.08 | 0.03 |
| | G | 0.67 | 0.32 | 0.12 | | 0.14 | −0.02 | 0.66 | 0.34 | −0.04 | 0.02 |
| Pod bearing branches/plant | P | 0.79* | 0.16 | −0.10 | 0.40* | | 0.68* | 0.14 | 0.19 | −0.06 | 0.43* |
| | G | 0.95 | 0.22 | −0.21 | 0.43 | | 0.60 | 0.11 | 0.36 | −0.16 | 0.37 |
| Pods/plant | P | 0.87* | 0.15 | −0.09 | 0.25 | 0.77* | | 0.18 | −0.25 | 0.06 | 0.48* |
| | G | 0.87 | 0.23 | −0.13 | 0.32 | 0.96 | | 0.16 | −0.38 | 0.08 | 0.50 |
| Seeds/pod | P | −0.07 | −0.13 | −0.07 | −0.32 | −0.02 | 0.05 | | −0.10 | −0.21 | 0.25 |
| | G | −0.34 | −0.14 | −0.41 | −0.52 | −0.39 | −0.09 | | −0.12 | −0.30 | 0.20 |
| 100-seed weight | P | 0.37* | 0.11 | 0.13 | 0.56* | 0.17 | 0.02 | −0.53* | | −0.10 | −0.11 |
| | G | 0.54 | 0.13 | 0.07 | 0.89 | 0.40 | 0.08 | −0.79 | | −0.11 | −0.14 |
| Protein content | P | −0.46* | −0.21 | 0.02 | −0.16 | −0.40* | −0.40* | −0.08 | −0.12 | | 0.07 |
| | G | −0.62 | −0.20 | −0.02 | −0.18 | −0.62 | −0.63 | −0.11 | −0.14 | | 0.15 |
| Harvest index | P | −0.05 | −0.19 | −0.06 | −0.51* | −0.09 | 0.02 | 0.36* | −0.29 | 0.04 | |
| | G | −0.90 | −0.50 | −1.72 | −1.55 | −0.04 | 0.54 | 1.81 | −2.66 | 0.36 | |

*Significant at 5% level.

Note. Values above and below the diagonal represent correlation coefficients in two environments.

correlations between characters at phenotypic level. This consistency in associations in all the four environments as well as the Z-transformation test for homogeneity necessitate further discussion on the basis of pooled correlations. The path analysis involving pooled correlations of different traits with seed yield is presented in Table 4.

Seed yield/plant was positively associated with pods/plant, pod bearing branches per plant, plant height and 100-seed weight. It was thus apparent that these four traits were important for prediction, selection and assured performance of seed yield in chickpea.

**Table 2. Phenotypic (P) and genotypic (G) correlation coefficients among different characters of chickpea in late sowing in rabi 1991–92 and in rabi 1992–93**

| Characters | | Seed yield per plant | Days to flowering | Days to maturity | Plant height | Pod bearing branches per plant | Pods per plant | Seeds per pod | 100-seed weight | Protein content | Harvest index |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Seed yield/plant | P | | 0.10 | 0.23 | 0.69* | 0.77* | 0.84* | 0.17 | 0.37* | -0.09 | 0.19 |
| | G | | 0.15 | 0.58 | 0.80 | 0.86 | 0.86 | 0.19 | 0.55 | -0.11 | 0.39 |
| Days to flowering | P | 0.22 | | 0.26 | 0.05 | 0.06 | 0.11 | -0.18 | 0.05 | -0.18 | 0.03 |
| | G | 0.53 | | 0.40 | 0.08 | 0.19 | 0.22 | -0.18 | 0.01 | -0.18 | 0.09 |
| Days to maturity | P | 0.30 | 0.62* | | 0.28 | 0.19 | -0.01 | -0.16 | 0.39* | -0.30 | -0.13 |
| | G | 0.66 | 0.73 | | 0.55 | 0.81 | 0.42 | -0.54 | 0.66 | -0.43 | -0.46 |
| Plant height | P | 0.70* | 0.26 | 0.29 | | 0.55* | 0.51* | -0.13 | 0.56* | -0.01 | -0.02 |
| | G | 0.88 | 0.47 | 0.47 | | 0.72 | 0.61 | -0.18 | 0.76 | -0.05 | -0.09 |
| Pod bearing branches/plant | P | 0.82* | 0.06 | 0.17 | 0.48* | | 0.75* | 0.25 | 0.12 | 0.03 | 0.07 |
| | G | 0.69 | 0.17 | 0.35 | 0.59 | | 0.77 | 0.28 | 0.46 | 0.02 | 0.25 |
| Pods/plant | P | 0.88* | 0.08 | 0.22 | 0.54* | 0.90* | | 0.25 | -0.02 | 0.02 | 0.12 |
| | G | 0.76 | 0.27 | 0.39 | 0.65 | 0.91 | | 0.38 | 0.06 | 0.05 | 0.48 |
| Seeds/pod | P | 0.18 | -0.25 | -0.14 | 0.07 | 0.27 | 0.20 | | -0.41* | 0.09 | 0.17 |
| | G | 0.42 | -0.40 | -0.23 | 0.21 | 0.66 | 0.53 | | -0.45 | 0.12 | 0.02 |
| 100-seed weight | P | 0.30 | 0.50* | 0.45 | 0.34 | -0.07 | -0.02 | -0.45* | | -0.12 | -0.11 |
| | G | 0.33 | 0.58 | 0.59 | 0.40 | -0.22 | -0.16 | -0.69 | | -0.14 | -0.14 |
| Protein content | P | -0.25 | -0.14 | -0.30 | -0.11 | -0.14 | -0.10 | -0.33 | -0.07 | | -0.19 |
| | G | -0.32 | -0.15 | -0.38 | -0.10 | -0.16 | -0.07 | -0.45 | -0.06 | | -0.34 |
| Harvest index | P | -0.38* | -0.30 | -0.36* | -0.67* | -0.24 | -0.30 | 0.30 | -0.26 | -0.09 | |
| | G | -0.76 | -0.54 | -0.62 | -0.80 | -0.63 | -0.67 | 0.03 | -0.42 | -0.16 | |

*Significant at 5% level.

Note. Values above and below the diagonal represent correlation coefficients in the two environments.

Among these traits, pods/plant seems to be more important because this character exhibited the highest correlation values in individual as well as pooled environments, and also had maximum positive direct effect (1.53) at genotypic level on seed yield (Table 4). The importance of pods/plant as the major component of seed yield in chickpea has been emphasized repeatedly [5–8].

The positive associations of pod bearing branches, plant height and 100-seed weight with seed yield also demonstrates the importance of these three traits for the improvement

Table 3. Phenotypic (P) and genotypic (G) correlation coefficients among different quantitative characters of chickpea pooled over environments

| Characters | | Days to flowering | Days to maturity | Plant height | Pod bearing branches per plant | Pods per plant | Seeds per pod | 100-seed weight | Protein content | Harvest index |
|---|---|---|---|---|---|---|---|---|---|---|
| Seed yield/plant | P | 0.19 | 0.16 | 0.58* | 0.79* | 0.81* | 0.11 | 0.41* | -0.27 | 0.13 |
| | G | 0.35 | 0.27 | 0.67 | 0.83 | 0.57 | -0.22 | 0.68 | -0.39 | -0.27 |
| Days to flowering | P | | 0.06 | 0.13 | 0.17 | 0.13 | -0.10 | 0.17 | -0.18 | -0.11 |
| | G | | 0.20 | 0.24 | 0.27 | 0.25 | -0.25 | 0.22 | -0.22 | -0.19 |
| Days to maturity | P | | | 0.20 | 0.08 | 0.01 | -0.24 | 0.32 | -0.17 | -0.26 |
| | G | | | 0.31 | 0.26 | -0.09 | -0.55 | 0.56 | -0.24 | -0.80 |
| Plant height | P | | | | 0.40* | 0.36* | -0.03 | -0.50* | -0.09 | -0.25 |
| | G | | | | 0.55 | -0.02 | -0.41 | 0.82 | -0.11 | -0.45 |
| Pod bearing branches/plant | P | | | | | 0.77* | 0.15 | 0.19 | -0.17 | 0.12 |
| | G | | | | | 0.86 | -0.12 | 0.28 | -0.25 | -0.36 |
| Pods/plant | P | | | | | | 0.17 | -0.07 | -0.13 | 0.15 |
| | G | | | | | | -0.00 | -0.11 | -0.18 | 0.02 |
| Seeds/pod | P | | | | | | | -0.39* | -0.17 | 0.20 |
| | G | | | | | | | -0.65 | -0.27 | 0.20 |
| 100-seed weight | P | | | | | | | | -0.11 | -0.22 |
| | G | | | | | | | | -0.11 | -0.51 |
| Protein content | P | | | | | | | | | -0.03 |
| | G | | | | | | | | | -0.00 |

*Significant at 5% level.

of seed yield in chickpea. But the path analysis (Table 4) revealed low direct effects of these three traits on seed yield. The most probable reason for such small direct effect, as recorded in the case of pod bearing branches/plant, might have resulted because of its high and positive indirect effects via pods/plant and harvest index. Similar observations were also reported earlier [9–12]. Likewise, the low direct contribution of plant height to seed yield may be the outcome of its high indirect influences via harvest index and seeds/pod. Similarly, the positive associations of 100-seed weight with seed yield/plant, in spite of its negative direct effect, was mainly due to its high positive indirect effect via seeds/pod, closely followed by harvest index. As harvest index was observed to be heterogeneous in this study, this trait was considered to be less important. The path analysis also revealed that the direct effect of harvest index towards seed yield was negative and high. Thus, plant

**Table 4. Direct (in bold) and indirect effects of different characters on seed yield in chickpea pooled over environments**

| Characters | | Days to flowering | Days to maturity | Plant height | Pod bearing branches per plant | Pods per plant | Seeds per pod | 100-seed weight | Protein content | Harvest index | Correlation with yield |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to flowering | P | **0.003** | 0.002 | 0.013 | 0.019 | 0.088 | -0.012 | 0.075 | 0.015 | -0.013 | 0.19 |
| | G | **-0.572** | -0.558 | 0.238 | -0.441 | 0.381 | 0.553 | -0.193 | 0.412 | 0.529 | 0.35 |
| Days to maturity | P | 0.000 | **0.032** | 0.019 | 0.009 | 0.005 | -0.029 | 0.140 | 0.014 | -0.031 | 0.16 |
| | G | -0.117 | **-2.734** | 0.304 | -0.424 | -0.130 | 1.199 | -0.504 | 0.461 | 2.215 | 0.27 |
| Plant height | P | 0.000 | 0.006 | **0.096** | 0.044 | 0.244 | -0.003 | 0.218 | 0.008 | -0.030 | 0.58 |
| | G | -0.139 | -0.850 | **0.978** | -0.903 | -0.032 | 0.891 | -0.736 | 0.204 | 1.255 | 0.67 |
| Pod bearing branches/plant | P | 0.000 | 0.003 | 0.038 | **0.110** | 0.513 | 0.018 | 0.081 | 0.014 | 0.014 | 0.79 |
| | G | -0.153 | -0.705 | 0.537 | **-1.645** | 1.308 | 0.255 | -0.250 | 0.469 | 1.013 | 0.83 |
| Pods/plant | P | 0.000 | 0.000 | 0.035 | 0.084 | **0.670** | 0.021 | -0.030 | 0.011 | 0.018 | 0.81 |
| | G | -0.142 | 0.232 | -0.021 | -1.406 | **1.530** | 0.007 | 0.096 | 0.341 | -0.064 | 0.57 |
| Seeds/pod | P | -0.000 | -0.008 | -0.003 | 0.016 | 0.116 | **0.120** | -0.169 | 0.014 | 0.024 | 0.11 |
| | G | 0.144 | 1.493 | -0.397 | 0.191 | -0.005 | **-2.195** | 0.583 | 0.513 | -0.548 | -0.22 |
| 100-seed weight | P | 0.000 | 0.010 | 0.048 | 0.020 | -0.046 | -0.046 | **0.436** | 0.009 | -0.026 | 0.41 |
| | G | -0.124 | -1.542 | 0.805 | -0.460 | -0.165 | 1.433 | **-0.893** | 0.210 | 1.416 | 0.68 |
| Protein content | P | -0.000 | -0.005 | -0.009 | -0.018 | -0.085 | -0.021 | -0.047 | **-0.083** | -0.003 | -0.27 |
| | G | 0.124 | 0.662 | -0.105 | 0.405 | -0.274 | 0.591 | 0.098 | **-1.905** | 0.011 | -0.39 |
| Harvest index | P | -0.000 | -0.008 | -0.024 | 0.013 | 0.102 | 0.024 | -0.097 | 0.002 | **0.117** | 0.13 |
| | G | 0.109 | 2.177 | -0.441 | 0.599 | 0.035 | -0.432 | 0.455 | 0.008 | **-2.782** | -0.27 |

Residual effect P = 0.286; G = 0.613.

P and G stand for the phenotypic and the genotypic levels, respectively.

height and 100-seed weight appear to be the components of seeds/pod and influence seed yield via seeds/pod.

The negative associations of 100-seed weight with seeds/pod indicates that improvement in one character will result in reduction of the other. Therefore, for the development of high yielding strains with bold seed in chickpea, the selection programme should be designed in such a way that advancement in one component is not nullified by reduction in the mean values of the other.

The nonsignificant correlation coefficient between days to maturity and seed yield suggests that selection for high yielding genotypes can be practised independently on maturity duration. The low estimates of correlation coefficients and direct and indirect effects recorded for all the remaining characters indicate their negligible contribution to seed yield. However, it may be concluded that among the different traits studied, pods/plant is the major component of seed yield. Therefore, selection for more pods/plant result in the selection of high yielding genotypes. The number of pod bearing branches/plant in combination with pods/plant and seeds/pod were also important components for improvement of seed yield in chickpea indirectly.

Although 100-seed weight is positively associated with seed yield, it was nevertheless a less important trait. These findings are in agreement with some earlier reports [10, 13].

## REFERENCES

1. K. B. Singh, R. S. Malhotra and F. J. Muehlbauer. 1984. An Annodated Bibliography of Chickpea Genetics and Breeding 1 915–1983. ICARDA/ICRISAT, Alepppo, Syria: 195.

2. H. A. Al-Jabouri, P. A. Millar and H. P. Robinson. 1958. Genotypic and environmental variances and covariances in an upland cotton cross of interspecific origin. Agron. J., **50**: 633–636.

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

4. P. R. Rider. 1939. An Introduction to Modern Statistical Methods. John Wiley and Sons, New York.

5. P. P. Sharma and S. R. Maloo. 1988. Correlation and path coefficient analysis in Bengal gram (*Cicer arietinum* L.). Madras agric. J., **75**: 95–98.

6. P. W. Khorgade. 1988. Correlation studies in Bengal gram (*Cicer arietinum* L.) with emphasis on path analysis. Ann. Pl. Physiol., **2**: 204–211.

7. B. D. Chaudhary, P. Singh, A. Kumar and D. P. Singh. 1988. Correlation and multiple regression analysis in chickpea. Crop Improv., **15**: 180–186.

8. R. C. Mishra. 1991. Stability of heritability, genetic advance and character association estimates in chickpea. Intern. Chickpea Newsl., **25**: 10–11.

9. I. B. Singh, H. B. Singh, Y. S. Chauhan and K. N. Singh. 1985. Path coefficient analysis in chickpea. Crop Improv., **12**: 62–63.

10. K. P. Singh, V. P. Singh and B. D. Chaudhary. 1986. Cause and effects analysis of yield components in chickpea. H.A.U. J. Res., **16**: 371–375.

11. T. S. Sandhu, R. K. Gunber and B. S. Bhullar. 1988. Estimation of some genetic parameters in chickpea. Crop Improv., **15**: 57–60.

12. S. P. Singh. 1988. Genetic variability and path coefficient studies in chickpea. Intern. Chickpea Newsl., **18**: 10–12.

13. K. K. Paliwal, S. R. Ramgiri, M. S. Lal, G. K. Kottu and R. Mishra. 1987. Correlation and path coefficient analysis in chickpea. Legume Res., **10**: 47–48.