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VARIATION AND INTER-RELATIONSHIPS OF QUANTITATIVE TRAITS IN CHICKPEA (*CICER ARIETINUM* L.)

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Abstract

Thirty two chickpea genotypes were evaluated for days to flowering, days to maturity, plant height, primary branches, secondary branches, pods per plant, 100 seed weight and grain yield per plant. Genetic parameters, correlations, path coefficients and partial regressions were estimated for all the traits. Analysis of variance revealed significant differences among the genotypes for all the characters. Broad sense heritability estimates for various traits ranged from 39 – 97%. Grain yield per plant showed highly significant positive correlation with days to maturity, primary branches, secondary branches and 100 seed weight and significant positive correlation with pods per plant. Path coefficient analysis revealed that pods per plant and 100 seed weight had the highest direct effect on grain yield per plant followed by secondary branches. The total variability calculated through multiple correlation in the population for yield improvement accounted by secondary branches, pods per plant and 100 seed weight was 88.6% compared to 89.4% accounted by the all characters. The pods per plant and 100 seed weight showed highly significant and secondary branches showed significant partial regression coefficients with grain yield per plant. Results revealed that more number of secondary branches, pods per plant and bold seed size are major yield contributing factors in selecting high yielding chickpea cultivars.

Introduction

Chickpea (*Cicer arietinum* L.) is the most important grain legume crop of Pakistan and serves as a major source of vegetable protein in the daily diet. It is grown on about 1.03 million hectares with annual production of about 0.76 million tones (Anon., 2004-2005). The average yield of this crop in Pakistan is generally low because of drought, susceptibility to diseases and low yield potential of varieties. The profitable yield can only be obtained through genetic improvement for resistance to biotic and abiotic stresses and high yield potential. Genetic improvement is a prerequisite for such improvement (Arshad *et al.,* 2002). Selection on the basis of grain yield, a polygenically controlled complex character, is usually not very efficient, but selection based on its component characters could be more efficient.

The variability of a biological population is an outcome of genetic constitution of the individuals making up of that population in relation to prevailing environments. A survey of genetic variability with the help of suitable parameters such as genetic coefficient of variation, heritability estimates and genetic advance are absolutely necessary to start an efficient breeding programme. Some of the characters are highly associated among themselves and with seed yield. The analysis of the relationships among these characters and their associations with seed yield is essential to establish selection criteria. When more characters are involved in correlation study it becomes difficult to ascertain the characters which really contribute toward yield. The path coefficient analysis under such situations helps to determine the direct contribution of these characters and their indirect contributions *via* other characters (Singh *et al.,* 1990).

Arshad *et al.,* (2004) reported high heritability coupled with high genetic advance for secondary branches, biological yield and grain yield in chickpea. Primary branches per plant, pods per plant and 100 seed weight had a highly significant correlation with yield (Khedar & Maloo, 1999). Arshad *et al.*, (2002) found that plant height, number of pods per plant and biological yield were major components contributing to seed yield.

The study of associations among various traits is useful to breeders in selecting genotypes possessing groups of desired characteristics. Hence, in this investigation, exotic as well as local genotypes were used and an attempt was made to see the inheritance, relationship of yield and its components and their implication in selection of better genotypes of chickpea.

Materials and Methods

The experimental material consisted of 32 (9 exotic (ICRISAT), 23 local) chickpea genotypes. The homozygosity was ensured by selfing the testing material for several years. The experiment was planted during rabi 2003-04 at Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad in a randomized complete block design with four replications. Each plot consisted of four rows of 4 m length with 30 cm and 15 cm spacing between and within rows, respectively. The recommended agronomic practices were followed to get a good crop. The days to flowering (50% plants flowered) and maturity (90% pods per plant matured) were recorded on plot basis. At maturity five guarded plants were selected at random to record data on plant height (cm), primary branches, secondary branches, pods per plant, 100 seed weight (gm) and grain yield per plant (gm).

The mean data were subjected to analysis of variance to test the level of significance among the genotypes for different characters according to Steel & Torrie (1980). Genotypic and phenotypic variances, genotypic and phenotypic coefficient of variability, broad sense heritability and correlation coefficients were computed according to the method suggested by Singh & Chaudhary (1985). Genetic advance in terms of percentage of means was estimated as described by Brim *et al*., (1959). The methodology proposed by Dewey & Lu (1959) was used to perform path analysis for grain yield and its components keeping grain yield as resultant variable and its components as causal variables. Multiple correlation and regression analysis and selection of best regression equation was done through backward elimination procedure described by Draper & Smith (1966).

Results

a. Genetic variability: Analysis of variance (Table 1) revealed highly significant differences between genotypes for all the characters under study, indicating the scope for selection of various morphogenetic traits from these highly diversified genotypes. The results regarding genotypic and phenotypic variance, genotypic and phenotypic coefficient of variability, broad sense heritability and genetic advance expressed as percentage of mean for eight characters are presented in Table 2. Pods per plant was found as the maximum variable character with the variability ranging between 60.85 to 146.50 followed by yield per plant (16.84 to 39.56), plant height (58.10 to 76.52) and 100 seed weight (10.83 to 27.40). Genotypic and phenotypic variances were high for pods per plant (302.65 and 543.73) followed by grain yield per plant with values of 36.66 and 58.31, respectively. Genotypic coefficients of variation were high (>20) in 100 seed weight (22.56) and grain yield per plant (21.40), whereas, phenotypic coefficients of variation were high for grain yield per plant (28.99), secondary branches (26.83), pods per plant (23.87) and 100 seed weight (22.87). Lowest estimates of genotypic (1.43) and phenotypic (1.73) coefficients of variation were recorded for days to maturity.

Table 1. Range, mean, mean squares and standard error of means for 8 quantitative characters of 32 chickpea genotypes.

Character	Range	Mean	Mean squares	Standard error of mean
Days to flowering	107.25 – 120.75	114.83	49.073**	0.87
Days to maturity	158.00 – 168.50	165.08	24.976**	0.81
Plant height	58.10 – 76.52	67.10	86.214**	1.99
Primary branches	4.50 – 7.10	5.59	1.623**	0.33
Secondary branches	4.40 – 11.65	8.45	13.316**	0.77
Pods per plant	60.85 – 146.50	97.66	1451.706**	7.76
100 seed weight	10.83 – 27.40	20.60	87.053**	0.38
Grain yield per plant	16.84 – 39.56	28.28	168.322**	2.32

** Highly significant

The maximum broad sense heritability estimate was for 100 seed weight (97.3) and the minimum for primary branches (38.9). Across traits, days to flowering, days to maturity, grain yield per plant, pods per plant, secondary branches and plant height showed relatively high heritability values (>50%). Estimates of genetic advance (as % of mean) ranged from 2.42% for days to maturity to 45.85% for 100 seed weight. Generally, days to flowering, days to maturity, plant height and primary branches depicted genetic advance values lower than 15%. In contrast, secondary branches, pods per plant, 100 seed weight and grain yield per plant showed relatively high (>25%) genetic advance expectations.

b. Correlation coefficient analysis: The phenotypic and genotypic correlations for yield and yield components are presented in Table 3. Grain yield per plant had highly significant and positive genotypic correlations with days to maturity (0.694), primary branches (0.573), secondary branches (0.808) and 100 seed weight (0.633). Grain yield per plant also exhibited highly significant positive phenotypic correlations with these traits. Pods per plant displayed positive and significant genotypic correlation (0.410) and highly significant phenotypic correlation (0.526) with grain yield.

The yield components exhibited varying trends of association among themselves. Days to flowering showed negative and non-significant genotypic correlations with primary branches, secondary branches and pods per plant and positive non-significant correlations with days to maturity and 100 seed weight. Days to maturity had highly significant positive association, both genotypic (0.710) and phenotypic (0.530) with secondary branches, significant with pods per plant (0.428 and 0.356, respectively) and significant genotypic correlations with primary branches (0.379) and 100 seed weight (0.391). Non-significant correlation of plant height with other yield traits was observed. Primary branches exhibited positive, highly significant and significant genotypic correlation with 100 seed weight (0.472) and days to maturity (0.379), respectively. This trait also showed significant, positive genotypic (0.394) and phenotypic correlation (0.427) with secondary branches. Secondary branches were strongly and positively correlated both genotypically and phenotypically with days to maturity (0.710 and 0.530, respectively) and pods per plant (0.588 and 0.592, respectively) and positive and significantly with primary branches (10.394 and 0.427, respectively). Pods per plant had strong positive association with secondary branches and days to maturity. Hundred seed weight revealed positive genotypic correlation with days to maturity (0.391) and primary branches (0.472).

c. Path coefficient analysis: The genotypic correlation coefficients of various yield-contributing characters with grain yield per plant were further partitioned into direct and indirect effects (Table 4). Hundred seed weight (0.689) exhibited the highest positive direct effect followed by pods per plant (0.545) and secondary branches (0.278). Direct effect of days to flowering (0.016), plant height (0.089) and primary branches (0.137) were positive and low. The direct effect of days to flowering and its correlation with grain yield per plant was positive (0.083) but negligible. The indirect effect via plant height and 100 seed weight were positive. The direct effect of days to maturity (-0.068) with grain yield was negative but the correlation coefficient was positive (0.694) and it was mostly due to the positive indirect effects via secondary branches (0.197), pods per plant (0.233) and 100 seed weight (0.27).

Direct effect was positive and low and correlation coefficient was negative between plant height and grain yield per plant. The indirect effect of all the traits was negative except days to flowering and 100 seed weight and both were low. Primary branches revealed positive association (0.573) with grain yield but the direct effect was low (0.137), although positive. Indirect effect via secondary branches (0.109), pods per plant (0.050) and 100 seed weight (0.326) were positive. Hundred seed weight exerted maximum positive indirect effect on primary branches. Direct effect (0.278) and correlation coefficient (0.808) of secondary branches with grain yield were positive and high. The indirect effect via pods per plant (0.321) and 100 seed weight (0.225) was also positive and high.

Pods per plant exhibited a high positive direct effect (0.545) as well as the significant correlation coefficient (0.410). The indirect effect via primary branches (0.012) and secondary branches (0.163) were positive. The highest positive direct effect (0.689) and highly significant positive correlation coefficient (0.633) was recorded between 100 seed weight and grain yield per plant. Most of the indirect effects of this trait on grain yield were low.

d. Multiple correlation and regression analysis: The joint association through multiple correlation of all the eight characters studied with yield was highly significant (Table 5). However, the highly significant multiple correlation of characters (0.941), *via*., secondary branches, pods per plant and 100 seed weight, with yield was found close to the multiple correlation of all characters (0.946). The estimate of determination (R^2) indicated that the total variability accounted by all the characters considered together was 89.4%, whereas 88.6% of the total variability for yield per plant could be accounted if selection was based only on the secondary branches, pods per plant and 100 seed weight.

Partial regression analysis of grain yield on the basis of all yield components are given in Table 6a. Yield showed highly significant partial regression coefficient with pods per plant (0.5612) and 100 seed weight (0.6671). The selection of best regression equation done through backward elimination procedure revealed that secondary branches, pods per plant and 100 seed weight were the most effective variables contributing to the grain yield. The partial regression coefficients of pods per plant (0.5824) and 100 seed weight (0.7186) were highly significant and that of secondary branches (0.2241) was significant (Table 6b). The best regression equation to bring the maximum improvement in the grain yield has been shown as under:

$$Y = -18.36 + 0.22X_5 + 0.58X_6 + 0.71X_7$$

where, X_5: Secondary branches, X_6: Pods per plant, X_7: 100 seed weight

Table 5. Multiple correlation analysis of grain yield per plant on the basis of all yield components (Col. 1) and on the basis of secondary branches, pods per plant and 100 seed weight (Col. 2).

	Col. 1	Col. 2
Multiple correlation	0.946**	0.941**
Coefficient of determination (R-square)	0.894	0.886
Adjusted R-square	0.864	0.873
Standard error	2.396	2.308

** Significant at 1% level

Table 6a. Partial regression analysis of grain yield with its components in chickpea.

Yield components	Partial regression coefficient (B)	S.E (B)	"t"
Days to flowering	-0.0016	0.0725	-0.023
Days to maturity	0.0008	0.0979	0.008
Plant height	0.0514	0.0713	0.722
Primary branches	0.1000	0.0812	1.231
Secondary branches	0.2148	0.1158	1.854
Pods per plant	0.5612**	0.1175	4.775
100 seed weight	0.6671**	0.1105	6.036

** Significant at 1% level

Table 6b. Partial regression analysis of grain yield with secondary branches, pods per plant and 100 seed weight in chickpea.

Yield components	Partial regression coefficient (B)	S.E (B)	"t"
Secondary branches	0.2241*	0.1032	2.155
Pods per plant	0.5824**	0.1038	5.606
100 seed weight	0.7186**	0.0880	8.165

* and ** significant at 5% and 1% levels respectively

For yield, 88.6% of total variability could be taken into account if the selection is based on the number of secondary branches, pods per plant and 100 seed weight. Thus, indicating that more emphasis should be laid on the improvement of these three components for increasing the grain yield in chickpea. Regression analysis also confirmed the results obtained through path analysis, as these three traits had the maximum direct effect. Days to maturity and primary branches although showed high total correlation with grain yield, but could not be included in selection criteria due to their low direct effects and high indirect effects *via* secondary branches, pods per plant and 100 seed weight.

Discussion

The considerable range of variation recorded in all the traits provides a good opportunity for improving grain yield in chickpea. Maximum variable trait was found to be pods per plant followed by yield per plant, plant height and 100 seed weight. Genotypic and phenotypic variances were highest for pods per plant and grain yield per plant. Phenotypic variances were larger as compared to genotypic variances for all the traits indicating the influence of environmental effect. Genotypic coefficients of variation were high in 100 seed weight and grain yield per plant. Phenotypic coefficients of variation were high for grain yield per plant, secondary branches, pods per plant, and 100 seed weight, this is in agreement with Agrawal (1985). Broad sense heritability estimates were generally high for all the traits except primary branches. Jeena & Arora (2000) also reported high heritability estimates for secondary branches, pods per plant, 100 seed weight and seed yield per plant, which support the present findings. The heritability values alone provides no indication of the amount of genetic progress that would result in selecting the best individual, but heritability estimated along with the genetic advance is more useful (Johnson *et al.*, 1955). High heritability associated with high genetic advance in case of secondary branches, pods per plant, 100 seed weight and grain yield per plant indicates that additive gene effects are more important in determining these characters and the improvement can be done through mass selection based on phenotypic values. Similar findings have been reported by Vivek *et al.,* (1999) and Mishra & Yadav (1994). High heritability for days to flowering, days to maturity and plant height coupled with low genetic advance indicates non-additive (dominance and epistasis) gene effects. Therefore, there seems a limited scope of improvement in these traits.

Grain yield per plant displayed significant and positive correlations with days to maturity, primary branches, secondary branches, pods per plant and 100 seed weight. The significant positive correlation of primary branches, secondary branches, number of pods per plant and 100 seed weight with grain yield, have been reported by Singh *et al.,* (1999) and that of days to maturity by Singh *et al.,* (1990) in chickpea. Bakhsh *et al.,* (2006) also reported that primary branches and number of pods per plant in chickpea were positively correlated with grain yield at all the three locations. Days to flowering showed negative and non-significant genotypic correlations with primary branches, secondary branches and pods per plant and positive non-significant correlations with days to maturity and 100 seed weight. Arshad *et al.,* (2004) also reported negative non significant correlation of days to flowering with pods per plant and positive non significant correlation with days to maturity, at both levels. Days to maturity had significant positive association with secondary branches, pods per plant, primary branches and 100 seed weight. Highly significant positive correlation of days to maturity with primary branches, pods per plant and 100 seed weight has been reported by Singh *et al.*, (1990). Primary branches exhibited positive, highly significant and significant genotypic correlation with 100 seed weight and days to maturity, respectively. This trait also showed significant, positive genotypic and phenotypic correlation with secondary branches as reported by Khan & Qureshi (2001). Secondary branches were strongly and positively correlated with days to maturity, pods per plant and primary branches. Pods per plant had strong positive association with secondary branches and days to maturity. These results are in close agreement with the findings of Singh *et al.,* (1990). Hundred seed weight revealed positive genotypic correlation with days to maturity and primary branches.

Hundred seed weight exhibited the highest positive direct effect followed by pods per plant and secondary branches. Similar findings have been reported by Khan & Sharma (1999). The indirect effect of days to flowering *via* plant height and 100 seed weight were positive. The indirect selection for this trait *via* 100 seed weight will be effective. The direct effect of days to maturity with grain yield was negative but the correlation coefficient was positive. Since the direct effect was negative, so the direct selection for this trait to improve yield will not be desirable. However, improvement in secondary branches, pods per plant and 100 seed weight may help to compensate the negative effect of days to maturity, which was negligible. Direct effect was positive and low and correlation coefficient was negative between plant height and grain yield per plant. Khattak *et al.,* (1999) reported negative and low direct effect as well as negative correlation of plant height with grain yield in mungbean. The indirect effect of all the traits was negative except days to flowering and 100 seed weight and both were low. So, the direct or indirect selection for this trait to improve yield will not be effective. Primary branches revealed positive association with grain yield but the direct effect was low, although positive. Hundred seed weight exerted maximum positive indirect effect. Hence the indirect selection of 100 seed weight will be effective for this trait. Direct effect and correlation coefficient of secondary branches with grain yield were positive and high. Bakhsh *et al.,* (1998) also observed similar type of results in the parental lines of chickpea. The indirect effect *via* pods per plant and 100 seed weight were also positive and high. The direct selection of this trait as well as indirect traits; pods per plant and 100 seed weight will be effective. Pods per plant exhibited a high positive direct effect as well as the significant correlation coefficient that indicates the true relationship and direct selection through this trait will be effective. Bakhsh *et al.,* (1999) also reported positive direct effect of number of pods per plant and its positive association with grain yield in the F_1 progenies of chickpea and their findings support the present results. The highest positive direct effect and highly significant positive correlation coefficient was recorded between 100 seed weight and grain yield per plant. Hassan *et al.,* (2005) reported positive association and high direct effect of 100 seed weight with grain yield and their findings confirms the present results. The direct selection for this trait will be effective.

The estimate of determination (R^2) indicated that the total variability accounted by all the characters considered together was 89.4%, whereas 88.6% of the total variability for yield per plant could be accounted if selection was based only on the secondary branches, pods per plant and 100 seed weight. Thus these three traits were the key contributors to yield per plant in this study. The findings of this study are almost consistent with the results obtained by Wadud & Yaqoob (1989). Our results contradicted with those of Ali *et al.,* (1999) who reported that 92% variability in yield was accounted by the plant height, number of secondary branches, pods per plant and elliptic index of leaf, under normal field conditions. Yield showed highly significant partial regression coefficient with pods per plant and 100 seed weight. The findings are almost consistent with the results obtained by Khattak *et al.,* (1999) in mungbean. The selection of best regression equation revealed that secondary branches, pods per plant and 100 seed weight were the most effective variables contributing to the grain yield. Regression analysis also confirmed the results obtained through path analysis, as these three traits had the maximum direct effect. Ghafoor *et al.,* (1990) and Khattak *et al.,* (1995,1997, 1999) have reported in mash and mungbean, respectively, that 1000 seed weight and pods per plant as the best selection indices for developing high yielding genotypes.

Conclusion

The present study revealed that grain yield per plant had strong and positive genotypic correlation with secondary branches, pods per plant and 100 seed weight, with maximum direct effects. Multiple correlation indicated that the total variability accounted by these traits was 88.6%. Regression analysis also indicated secondary branches, pods per plant and 100 seed weight as the most effective variables contributing to the grain yield. So, it is concluded that these three traits may be considered as the selection criteria for the improvement of grain yield.

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