INTERRELATIONSHIPS AMONG YIELD AND YIELD CONTRIBUTING TRAITS IN CHICKPEA (Cicer arietinum L.)

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ABSTRACT

Twenty chickpea genotypes including four varieties were evaluated for the existence of genetic variability and to know the interrelationship among yield traits under study during 2013-2014, at University of Agriculture, Faisalabad. The experiment was carried out in a randomized complete block (RCB) design with three replications. Data were recorded on number of days taken to flowering, number of primary branches plant⁻¹, number of secondary branches plant⁻¹, plant height, number of days taken to maturity, number of pods plant⁻¹, numbers of seed pods -¹, total plant weight, Number of grains plant⁻¹, 100-seed weight and grain yield plant⁻¹. The obtained data were analyzed for genetic variability parameters, correlation and path coefficient analysis. The height broad sense heritability estimates were obtained for 100-seed weight (0.977), plant height (0.971), total plant weight (0.971) and number of primary branches plant⁻¹. Genetic advance was higher for plant height (9.054), total plant weight (9.054), number of pods plant⁻¹ (6.414) and 100-seed weight (2.941). The phenotypic coefficient of variation (PCV) was invariably slightly higher than their corresponding genetic coefficient of variation (GCV) due to influence of environment on character expression. Heritability estimates were higher for all characters except number of days taken to maturity and number of grains per plant, which exhibited moderate heritability. Hundred seed weight, plant height, total plant weight and primary branches per plant would be the suitable selection criteria to accomplish better grain yield in chickpea.

Keywords: Chickpea; genetic variability; heritability; grain yield.

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INTRODUCTION

Chickpea (Cicer arietinum L.) commonly known as gram belongs to the family leguminosae is a major pulse crop that contributes about 12 % of the world pulse production (Khan et al., 2011). It has the ability to fix the atmospheric nitrogen and improve soil fertility that ultimate lower the cost of production (Ali et al., 2008). It is the third most important pulse crop after dry bean and peas with a wide distribution across the tropics, sub tropics and temperate regions (Singh, 1997). It is an important source of dietary protein of the pre-dominant population of Indian sub-continent (Viveros et al., 2001). The Asian region contributes 70% to the total world’s chickpea production (Malik et al., 2010). In Pakistan, it is cultivated on 0.98 million hectares with production of 0.67 million tons (Anonymous, 2012-13).
For any breeding program the genetic variability play an important role as it provide opportunity to plant breeder for selection of high yielding genotypes. Meanwhile, the information of yield and its association with yield contributing parameter provide the basis for the effective selection of improved varieties (Saleem et al., 2005). Information of the genetic variation with the help of suitable parameters such as genetic advance, heritability estimate and genetic coefficient of variation are the prime requirements of an effective breeding program. The concept of heritability determines the difference observed among the characters is due to environmental influence or a result of genetic makeup. Genetic advance gives an idea of possible improvement of new population through selection, when compared to the parent population. The genetic advance depends upon the amount of genetic variability and magnitude of the epistasis effect of the environment (Gul et al., 2013).

Some of the attributes are significantly associated among themselves and with grain yield. The analysis of relationships among these characters and their associations with grain yield is essential to establish selection criteria (Atta et al., 2008). Progress in any breeding program depends upon the nature and magnitude of variability present in the parent population. Assessment of the extent of genetic variability within chickpea is fundamental for chickpea breeding (Qureshi et al., 2004).

During chickpea breeding, the main consideration must be heritability along with genetic advance as alone is not a good indicator of the amount of desirable genetic variability (Noor et al., 2003). The information regarding genetic variability, heritability and association of various characters provide a basis to the plant breeders to breed the chickpea genotypes possessing higher yield potential. Selection based on grain yield a polygenic character, is usually not very efficient, but selection based on its component characters could be more efficient.

Grain yield is the main consideration and the most complex trait for breeder point of view as it dependent upon the interaction of genetic makeup of plant and environment. Apart from direct selection for grain yield, the objective of enhanced yield may, in most situations, be more effectively fulfilled on the basis of performance of yield and its components. These components may contribute directly or indirectly to the overall yield (Zeeeshan et al., 2013). Path coefficient analysis is one of the reliable statistical techniques to quantify the interrelationships of different yield components (Mushtaq and Saleem, 2013). The present study was initiated with the prime objective of estimating mutual relationships among different quantitative traits and the type and extent of their contribution to ultimate seed yield.

MATERIALS AND METHODS
Twenty chickpea genotypes including four varieties obtained from different national institutions were planted in the randomized complete block design (RCBD) with three replications, in the experimental field of Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, during 2013-14. Each genotype was planted in a separate plot which was consisted of three rows of four meter length, with a plant-to-plant and row-to-row distance of 10 and 30 cm, respectively. The plots were separated by a distance of 60 cm. Recommended cultural practices were carried out to maintain healthy crop growth (Reference??). Number of days to flowering at the time when at least 50% flowering was recorded for yield and its various yield contributing traits including, number of primary branches\(^1\), number of secondary branches\(^1\), plant height, number of days taken to maturity, number of pods plant \(^1\), total numbers of grain per
pods, total plant weight, Number of grains plant\(^{-1}\), 100-seed weight and grain yield plant\(^{-1}\). The data were subjected to analysis of variance to test the level of significance among the genotypes for different characters under study (Steel and Torrie, 1980). Genetic parameters, genetic correlation coefficients were computed according to the methods followed by Singh and Chaudhary (1985). The significance of genotypic correlation coefficients was tested with the help of standard errors as suggested by Reeve and Rao (1981) whereas path coefficient analysis was conducted according to Dewey and Lu (1959).

RESULTS AND DISCUSSION

Genotypes differed for all the characters recorded, indicating a considerable range of genetic variability (Table 1). The maximum grain yield was recorded in the variety PB-2008, while the lowest yield was obtained from the genotype 3019. The phenotypic coefficient of variation (PCV) was invariably slightly higher than their corresponding genetic coefficients of variations (GCV) due to influence of environment on character expression (Table 2). Uddin et al. (1990), Noor et al. (2003), Arshad et al. (2004), Ozcelikand Bozoglu (2004) and Idrees et al. (2006) have reported similar results in chickpea. Estimates of broad sense heritability varied from 0.945 in number of primary branches plant\(^{-1}\) to 0.977 for 100 seed weight.

The genetic advance (5% selection intensity) was the highest for total plant weight (9.054), plant height (9.054), number of pods plant\(^{-1}\) (6.414), 100 grain weight (2.941) and grain yield plant\(^{-1}\) (2.908), while it was the lowest for number of grains plant\(^{-1}\) (0.046) and number of secondary branches plant\(^{-1}\)(0.211). It indicated that improvement could be achieved through simple selection from total plant weight, plant height and number of pods plant\(^{-1}\). Heritability alone is not useful but this statistic along with genetic advance is valuable (Yadav et al., 2003). For number of primary branches plant\(^{-1}\), number of grains pods\(^{-1}\) and number of secondary branches plant\(^{-1}\), high heritability was associated with low genetic advance, indicating the influence of dominant and epistatic genes for these characters. High genetic advance of total plant weight and plant height coupled with high heritability, indicated that additive genes effect were important in determining these characters.

Table 1. Analysis of variance parameters for 20 genotypes of chickpea (Cicer arietinum L.)

| Character                                | Mean ±SE | Range       | CV (%) | h (%) | G.A. *       |
|------------------------------------------|----------|-------------|--------|-------|--------------|
| Number of days taken to flowering        | 111.62±9.71 | 113.3-124.7 | 1.53   | 76.12 | 2.232        |
| Number of primary branches plant\(^{-1}\) | 2.894±0.045 | 3.384-2.299 | 7.35   | 94.45 | 0.694        |
| Number of secondary branches plant\(^{-1}\) | 5.915±0.0535 | 5.43-640      | 3.90   | 65.82 | 0.211        |
| Plant height (cm)                        | 70.185±3.84 | 58.6-81.74   | 2.82   | 97.12 | 9.050        |
| Number of days taken to maturity         | 154.891±2.75 | 160.7-166.01 | 1.04   | 49.0  | 0.922        |
| Number of pods plant\(^{-1}\)            | 5.915±9.740 | 50.5-69.60   | 5.10   | 88.02 | 6.414        |
| Number of seed pods\(^{-1}\)             | 1.631±0.007 | 1.527-1.727  | 5.21   | 48.50 | 0.047        |
| Total plant weight (g)                   | 69.808±3.841 | 39.1-57.70   | 2.81   | 97.11 | 9.054        |
| Number of grain plant\(^{-1}\)           | 112.040±36.5 | 91.9-123.1   | 5.39   | 86.19 | 0.047        |
| 100-grain weight (g)                     | 19.691±0.313 | 16.87-25.13  | 2.83   | 97.74 | 2.941        |
| Grain yield plant\(^{-1}\)(g)            | 21.295±2.70 | 17.20-26.72  | 7.71   | 84.96 | 2.9080       |

Mean ±SE= Mean± Standard Error; CV (%) = coefficient of variability; h (%) = heritability in Broad sense; G.A.* = Genetic Advance (5% selection intensity)
Correlation coefficient and path analysis

The genotypic and phenotypic correlation coefficients revealed that the genotypic correlations were greater than phenotypic for most of the characters (Table 3). Grain yield plant$^{-1}$ was positive and significantly correlated with total plant weight, number of pods plant$^{-1}$, number of grains plant$^{-1}$ and 100 grain weight but it was negatively correlated with number of grains plant$^{-1}$. The days taken to maturity show negative and highly significant correlation with grain yield plant$^{-1}$.

Table 2. Genetic parameters for various quantitative characters in 20 chickpea lines

| Genotypes | DF  | DM  | PH  | PB  | SB  | WP  | PP  | SP  | GP  | HGW | FY  |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Noor-2009 | 121.76 | 166.01 | 81.74 | 3.833 | 6.16 | 58.63 | 68.60 | 1.550 | 104.3 | 16.87 | 21.32 |
| 290       | 121.40 | 164.50 | 66.67 | 3.065 | 5.43 | 67.23 | 59.63 | 1.650 | 115.1 | 19.60 | 20.92 |
| 1276      | 120.16 | 164.34 | 72.03 | 2.631 | 5.80 | 62.90 | 57.10 | 1.727 | 123.1 | 18.30 | 18.26 |
| 6001      | 120.00 | 164.23 | 58.63 | 3.701 | 5.76 | 81.73 | 61.90 | 1.713 | 122.1 | 18.87 | 22.04 |
| 1017      | 119.16 | 164.00 | 67.24 | 2.963 | 6.10 | 68.67 | 69.60 | 1.653 | 115.4 | 18.13 | 21.96 |
| PB-2000   | 118.83 | 163.80 | 67.47 | 2.765 | 5.83 | 72.03 | 61.53 | 1.633 | 114.3 | 21.00 | 21.95 |
| 210       | 118.73 | 163.83 | 65.23 | 3.232 | 5.80 | 65.83 | 56.07 | 1.623 | 112.3 | 20.50 | 19.83 |
| 1286      | 117.83 | 163.60 | 66.83 | 2.334 | 6.06 | 67.47 | 66.10 | 1.577 | 99.50 | 21.56 | 24.43 |
| 1288      | 117.66 | 163.50 | 78.50 | 3.232 | 6.40 | 76.57 | 65.93 | 1.607 | 109.0 | 19.97 | 23.47 |
| 3019      | 117.50 | 163.50 | 68.66 | 3.834 | 6.30 | 75.53 | 50.50 | 1.653 | 115.9 | 18.60 | 17.20 |
| 6060      | 117.43 | 163.33 | 69.01 | 2.400 | 5.53 | 65.23 | 64.23 | 1.690 | 120.6 | 17.80 | 19.34 |
| CH-7      | 116.40 | 163.21 | 67.13 | 2.299 | 6.10 | 69.00 | 67.73 | 1.553 | 105.5 | 20.87 | 23.03 |
| 6009      | 116.26 | 162.71 | 80.74 | 2.400 | 5.61 | 60.67 | 57.30 | 1.550 | 99.97 | 18.83 | 19.96 |
| 220       | 116.00 | 162.30 | 60.87 | 3.466 | 5.56 | 78.87 | 61.70 | 1.710 | 91.90 | 17.00 | 21.40 |
| 214       | 115.83 | 162.15 | 65.72 | 2.503 | 6.13 | 66.83 | 61.30 | 1.600 | 121.4 | 18.27 | 21.32 |
| 114       | 115.83 | 161.60 | 76.59 | 2.431 | 5.60 | 80.74 | 54.47 | 1.713 | 115.0 | 17.80 | 17.27 |
| 1031      | 115.40 | 161.50 | 78.85 | 3.202 | 6.40 | 65.73 | 63.73 | 1.527 | 122.6 | 23.83 | 24.71 |
| 1159      | 115.33 | 161.30 | 65.85 | 2.931 | 6.23 | 67.13 | 53.80 | 1.640 | 97.23 | 20.63 | 19.48 |
| 7020      | 115.26 | 161.19 | 75.53 | 2.400 | 5.66 | 66.67 | 63.70 | 1.537 | 114.4 | 20.46 | 21.29 |
| PB-2008   | 113.33 | 160.72 | 62.90 | 2.365 | 5.83 | 78.50 | 62.93 | 1.710 | 121.2 | 25.13 | 26.72 |

* = significance at 0.05 and ** = significant at 0.01 probability level, respectively.

DF= days to flowering; DM= days to maturity; PH= plant height; PB= primary branches; SB= secondary branches; WP= weight of plant; PP= pods plant$^{-1}$; SP= seed plant$^{-1}$; GP= grains plant$^{-1}$; HGW= 100 grain weight; FY= grain yield plant$^{-1}$

The estimation of contribution by the individual character in the grain yield, which showed that number of grains pods$^{-1}$ had maximum positive direct effect on grain yield plant$^{-1}$ followed by 100 grain weight, number of grain plant$^{-1}$, number of secondary branches, number of days taken to maturity, number of primary branches, number of days taken to flowering while characters like plant height and total plant weight had negative direct effects on grain yield.

An overall appraisal of the correlation matrix and path coefficient analysis reveals that number of grains plant$^{-1}$ and number of pods plant$^{-1}$ exerted great influence both directly and indirectly on grain yield. Correlation between numbers of grains plant$^{-1}$ and grain yield was greatly reduced owing to the indirect negative influence of number of pods plant$^{-1}$. If maximum grain yield is to be obtained, a compromise is made during selection for these two traits and other traits have to give consideration. Suitable recombination might be obtained through biparental mating, mutation breeding or diallal selective mating to break undesirable linkage (Ghafoor et al., 1990).
Table 3. Estimates of Genotypic ($r_g$) and Phenotypic ($r_p$) correlation coefficients of various character combinations

| Character | NPB | NSB | PH | NDM | NPP | NSP | TPW | NGP | HGW | GYP |
|-----------|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|
| NDF G     | 0.4868* | 0.3283* | -0.3730 | 0.0995* | 0.1731* | 0.1344* | -0.3021 | 0.2020 | -0.6019 | -0.2720 |
| P         | 0.3277* | 0.2902* | -0.2282 | 0.0812 | 0.1436 | 0.1052 | -0.2714* | 0.0228 | -0.5099** | -0.2658* |
| NPB G     | -0.1674 | 0.4605 | -0.0333 | -0.0751 | -0.1047 | 0.3265* | 0.3136 | 0.1056 | 0.1024 |
| P         | -0.1175 | 0.3440** | -0.0258 | -0.0829 | -0.0963 | 0.2981* | 0.2364 | 0.0928 | 0.1012 |
| NSB G     | -0.1672 | 0.3246* | 0.0233 | 0.1104 | 0.5086* | -0.0834 | 0.4591* | 0.3438 |
| P         | -0.1082 | 0.2912* | 0.0485 | 0.1016 | 0.3573** | -0.1044 | 0.3750** | 0.2886* |
| PH G      | 0.6960* | 0.1141* | 0.1185* | -0.3300 | -0.1750 | -0.1571 | -0.1448 |
| P         | 0.4551** | 0.0925 | 0.0930 | -0.3181* | -0.1275 | -0.1579 | -0.1315 |
| NDM G     | -0.0131 | -0.1836 | -0.8430 | -1.0995 | -0.6318** | -0.6188 |
| P         | 0.0125 | -0.0601 | -0.5451** | -0.5929** | -0.4515** | -0.3405** |
| NPP G     | 0.9999* | 0.1680* | -0.1792 | 0.1059* | 0.7068* |
| P         | 0.9762** | 0.1929 | -0.0774 | 0.1043 | 0.6859 |
| NSP G     | 0.2788* | -0.1117 | 0.1613* | 0.7344* |
| P         | 0.3073* | -0.0193 | 0.1541 | 0.7223** |
| TPW G     | 0.8335* | 0.5298* | 0.55705* |
| P         | 0.5179** | 0.4939** | 0.5640** |
| NGP G     | 0.1371 | -0.0318 |
| P         | 0.0712 | 0.0068 |
| HGW G     | 0.8075* |
| P         | 0.7342** |

*Significant (0.05 probability level); **Highly significant (0.01 probability level)

NDF= Number of Days to Flowering, NPB= Number of Primary Branches, NSB= Number of Secondary Branches, PH= Plant Height (cm), NDM= Number of days to maturity, NPP= Number of Pods plant$^{-1}$, NSP= Number of Seed pod$^{-1}$, TPW= Total Plant Weight (g), NGP= Number of Grains plant$^{-1}$, HGW=100-Grain Weight, GYP= Grain Yield plant$^{-1}$ (g)
Table 4. Direct (bold) and indirect (not bold) effect of yield components in chickpea

| Character | DF      | DM       | PH       | PB       | SB       | WP       | PP       | SP       | GP       | 100GW    | GY       |
|-----------|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| DF        | **-0.0195** | 0.0095   | 0.0794   | 0.0064   | -0.0079  | 0.0059   | 0.0034   | 0.0039   | 0.0027   | -0.0117  | -0.2916  |
| DM        | 0.0369  | **-0.0759** | 0.0528   | -0.0127  | -0.0127  | -0.064   | -0.0009  | -0.0834  | -0.0139  | -0.0479  | -0.6947  |
| PH        | -0.0204 | -0.1428  | **-0.2051** | 0.0069   | -0.0666  | -0.068   | -0.2341  | 0.0358   | -0.0243  | 0.3223   | 0.0784   |
| PB        | 0.01583 | -0.008   | -0.0016  | **-0.0483** | 0.0222   | 0.0158   | -0.0036  | 0.0152   | -0.005   | 0.005    | 0.0542   |
| SB        | -0.0318 | -0.0142  | 0.0276   | 0.0392   | **-0.0852** | 0.0433   | 0.019    | -0.0071  | 0.0094   | 0.039    | 0.2587   |
| WP        | 0.02993 | 0.0836   | 0.0327   | -0.0324  | -0.0504  | **-0.099** | -0.0167  | -0.8257  | -0.2762  | -0.0525  | 0.6814   |
| PP        | 0.07081 | -0.0054  | 0.0467   | -0.0308  | 0.0092   | 0.0687   | **-0.0409** | -0.0732  | 0.409    | 0.0434   | 0.1042   |
| SP        | 0.01784 | -0.0971  | -0.0155  | 0.0277   | -0.0074  | 0.0737   | -0.0159  | **-0.8832** | -0.0099  | 0.0121   | 0.0519   |
| GP        | 0.03686 | -0.0503  | 0.0325   | -0.0287  | 0.0303   | 0.0765   | 0.2743   | -0.0606  | **-0.2743** | 0.0443   | 0.2256   |
| 100GW     | -0.4476 | -0.4698  | -0.1169  | 0.0785   | 0.3414   | 0.3934   | 0.7878   | 0.0102   | 0.1199   | **-0.7436** | 0.744    |

DF= Days to Flowering; DM= Days to Maturity; PH= Plant Height; PB=Primary Branches; SB= Secondary Branches; WP= Weight of Plant; PP= Pods Plant⁻¹; SP= Seed Plant⁻¹; GP= Grains Plant⁻¹; 100GW= 100 Grain Weight; GY= Grain Yield Plant⁻¹
The results obtained from the above discussion suggested that plant height, total plant weight, primary branches plant\(^{-1}\) and 100- seed weight gave more yield when selection was based on these characters. Genetic potential of genotypes revealed highly significant differences for all the studied traits. Genotype 4009 and 1288 had maximum total plant weight. Genotype 1017 and variety Noor-2009 had maximum pods plant\(^{-1}\). Genotype 1115, 210 and Variety PB-2008 had maximum 100-grains weight. These genotypes can safely be used in future chickpea breeding programs for further exploitation of their genetic variability.

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