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Evaluation of selection criteria in *Cicer arietinum* L. using correlation coefficients and path analysis

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Abstract

The study pertaining to the evaluation of selection criteria in chickpea using correlation coefficients and path analysis was carried out in the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad for a period of two years. Experimental material comprised of twenty chickpea genotypes. The genotypes demonstrated highly significant differences (P<0.01) for all the traits studied. The results of correlation analysis revealed that that grain yield plant^{-1} had significant genotypic and highly significant phenotypic relationship with primary branches, pods plant^{-1}, seeds plant^{-1}, seeds pod^{-1} and total biological yield. The path coefficient analysis based on grain yield plant^{-1}, as a dependent variable, exposed that all of the other traits, except days to flowering, days to maturity and secondary branches exhibited positive direct effects. The path analysis confirmed that biological yield followed by number of seeds pod^{-1}, 100-grain weight, had the maximum positive direct influence on grain yield plant^{-1}. Therefore, this study suggested that chickpea improvement progarmme could be based on these characters as selection criteria.

Key words: Chickpea; Correlation coefficients; Path analysis; Selection criteria; Grain yield

Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important Rabi legume crops of Pakistan. Chickpea per acre production in the country is not enough to satisfy the consumer's demand. It is mainly due to the poor genetic composition of the cultivars and nonavailability of good quality seed of varieties with high yield potential and resistance against diseases and insects. Therefore, the development of improved cultivars of chickpea is the need of the day. Determination of correlation and path coefficients between yield and yield criteria is important for the selection of favourable plant types for effective chickpea breeding programmes. Correlation coefficients in general show associations among independent characteristics and the degree of linear relation between these characteristics. It is not sufficient to describe this relationship when the causal association among characteristics is needed (Toker and Cagirgan, 2004). Path analysis is used to know causes. In other words, path analysis is used to determine the amount of direct and indirect effect of the causal components on the effect component. The plus point of path anal-

Table 1. Analysis of variance of different multigenic characters in chickpea genotypes

SOV	*DTF*	*DTM*	*PBrP⁻¹*	*SBrP⁻¹*	*PH*	*PODSP⁻¹*	*SEEDSP⁻¹*	*SEEDPD⁻¹*	*0 GWT*	*BY*	*GYP⁻¹*
Replications	4.61**	0.42	0.123	1.45	0.2288	0.472	1.45	0.25	4.09	0.02	0.17
Genotypes	4.36**	2.71**	0.34**	5.05**	39.54**	28.37**	5.03**	23.29**	163.6**	35.4**	37.88**

*, ** = Significant at P<0.05 and P<0.01 levels, DTF= Days taken to flowering (50%), DTM= Days taken to maturity, $PBrP^{-1}$= Primary plant, $SBrP^{-1}$= Secondary branches per plant, PH= Plant Height, $PODSP^{-1}$= Pods per plant, $SEEDP^{-1}$= Seeds per plant, $SEEDPD^{-1}$= seed GWT=100-grain wt., BY= Total biological yield, GYP^{-1}= Grain yield per plant.

ysis is that it allows the partitioning of correlation coefficient into its components (Dewey and Lu, 1959). The correlation of economic yield components with yield and partitioning of correlation coefficient into its components of direct and indirect effects have been extensively studied. Lokendra et al. (1999), Saleem et al. (1999) Saleem et al. (2002a) Bakhh et al. (2004) and Yucel et al. (2006) reported significant and positive correlation of number of pods $plant^{-1}$ and 100-seed weight with seed yield $plant^{-1}$. Seed yield was positively correlated both phenotypically and genotypically with days to flowering, days to maturity and branches $plant^{-1}$ (Vijayalakshmi et al., 2000; Saleem et al., 2002b Yucel et al. 2006). Erman et al. (1997) reported that pod number $plant^{-1}$, harvest index, and biological yield were the major contributors to seed yield as either direct or indirect effect through other characters. Singh et al. (1997), Yousefi et al. (1997) and Saleem et al. (2002b) reported the highest positive direct effect of number of pods $plant^{-1}$ on seed yield $plant^{-1}$. Kumar and Arora (1991), Noor et al. (2003) and Yucel et al. (2006) determined that biological yield, pods $plant^{-}$, 100 seed mass and plant height were the major yield components for selection in chickpea.
This study was also undertaken to evaluate selection criteria in chickpea breeding programs by means of correlation and path coefficient analysis.

Materials and Methods

Plant material

The study pertaining to the evaluation of selection criteria in chickpea using correlation coefficients and path analysis was conducted in the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during Rabi seasons of years 2004-05 and 2005-06. The experimental material comprised twenty elite chickpea genotypes viz; BRC-27, CS-30, 102, 114, 209, 549, 576, 660, 777,836, 930, 1011, 1012, 1084, 1117-1, 1129, 1230, 5002, Bittal-98 (check) and Paidar-91 (check).

Methodology of experiment

The trial was sown in a triplicate Randomized Complete Block Design (RCBD). Three rows of each entry were grown keeping 30 cm row to row distance. All the recommended agronomic and plant protection practices were followed from sowing till harvest. At maturity ten equally competitive plants were ear marked from each genotype for recording data on number of days to flowering, number of days to maturity, number of primary branches $plant^{-1}$, number of secondary branches $plant^{-1}$, plant height, pods $plant^{-1}$, seeds $plant^{-1}$, seeds pod^{-1}, 100-grain weight (g), total biological yield (g) and grain yield $plant^{-1}$ (g).

Statistical analysis

The collected data were analyzed by the analysis of variance technique to determine significant varietal differences among the 20 genotypes using M-STATC (MSTAT-C development Team, 1989). Genotypic and phenotypic correlations were computed following Kwon and Torrie (1964). Path coefficients were estimated according to Dewey and Lu (1959), where grain yield plant $^{-1}$ was kept as resultant variable and other contributing characters as causal variables.

Results and discussion

Analysis of variance indicated significant differences (P<0.01) for all the traits among genotypes (Table 1). Correlation among the traits may be the consequence of pleiotropy or the genetic linkage among the characters. From the breeder's view point, the type of association of grain yield and its component traits is

Table 2. Genotypic (rg) and phenotypic (rp) correlation coefficients of various quantitative characters in chickpea

	Correlation	*DTF*	*DTM*	*PBrP^{-1}*	*SBrP^{-1}*	*PH*	*PODSP^{-1}*	*SEEDSP^{-1}*	*SEEDPD^{-1}*	*100 GWT*	*BY*	*GYP^{-1}*
DTF	rg	1.000	-0.06	-0.54	-0.417	0.097*	-0.558	-0.582	-0.661	-0.425	-0.351	-0.697
	rp	1.000	-0.01	0.33**	-0.36**	0.0662	-0.459**	-0.485**	-0.546**	-0.37**	-0.285*	-0.57**
DTM	rg		1.000	0.252	0.016	-0.096	0.155*	0.189*	-0.014	0.571	-0.179	-0.052
	rp		1.000	0.183	0.107	-0.066	0.162	0.193	0.014	0.309*	-0.142	-0.004
PBrP^{-1}	rg			1.000	0.407	0.532*	0.650*	0.690*	0.823*	0.537	0.589	0.845*
	rp			1.000	0.275*	0.346**	0.453**	0.454**	0.575**	0.265*	0.405**	0.569**
SBrP^{-1}	rg				1.000	0.380*	-0.197	-0.156	0.188	-0.447	0.551*	0.159
	rp				1.000	0.297*	-0.129	-0.098	0.154	-0.173	0.404**	0.097
PH	rg					1.000	-0.228	-0.266	-0.011	-0.351	0.182*	-0.002
	rp					1.000	-0.215	-0.253	-0.009	-0.260*	0.179	-0.008
PODSP^{-1}	rg						1.000	0.999*	0.857*	0.472*	0.242*	0.856*
	rp						1.000	0.993**	0.846**	0.333**	0.231	0.845**
SEEDSP^{-1}	rg							1.000	0.845*	0.511*	0.228*	0.849*
	rp							1.000	0.842**	0.361**	0.217	0.845**
SEEDPD^{-1}	rg								1.000	0.354	0.659*	1.007*
	rp								1.000	0.354	0.659**	1.007**
100 GWT	rg									1.000	-0.291	0.385
	rp									1.000	-0.224	0.247
BY	rg										1.000	0.651*
	rp										1.000	0.628**
GYP^{-1}	rg											1.000
	rp											1.000

*, ** = Significant at $P<0.05$ and $P<0.01$ levels, DTF= Days taken to flowering (50%), DTM= Days taken to maturity, PBrP^{-1}= Primary branches per plant, SBrP^{-1}= Secondary branches per plant, PH= Plant Height, PODSP^{-1}= Pods per plant, SEEDP^{-1}= Seeds per plant, SEEDPD^{-1}= seed per pod, 100 GWT=100-grain wt., BY= Total biological yield, GYP^{-1}= Grain yield per plant.

Table 3. Direct and indirect effects of different polygenic characters on grain yield per plant in chickpea

Character	***Direct effects***	***Indirect effects***									
		DTF	DTM	PBP^{-1}	$SBrP^{-1}$	PH	$PODSP^{-1}$	$SEEDSP^{-1}$	$SEEDPD^{-1}$	0 GWT	BY
DTF	- 0.087		0.008	-0.052	0.021	0.001	-0.035	-0.030	-0.050	-0.420	-0.432
DTM	-0.122	0.006		0.043	-0.001	-0.001	0.009	0.001	-0.025	0.056	-0.001
$PBrP^{-1}$	0.096	0.047	-0.031		-0.021	0.004	0.041	0.035	0.083	0.053	0.537
$SBrP^{-1}$	-0.052	0.036	-0.002	0.040		0.002	-0.013	-0.008	0.077	-0.044	0.123
PH	0.007	-0.008	0.012	0.051	-0.020		-0.014	-0.014	0.026	-0.034	-0.007
$PODSP^{-1}$	0.063	0.049	-0.020	0.062	-0.010	-0.001		0.051	0.033	0.046	0.560
$SEEDP^{-1}$	0.052	0.051	-0.023	0.066	0.008	-0.002	0.063		0.032	0.050	0.551
$SEEDPD^{-1}$	0.140	0.060	0.002	0.080	-0.009	0.000	0.054	0.043		0.035	0.092
100 GWT	0.098	0.037	-0.070	0.052	0.023	-0.002	0.030	0.026	-0.040		0.231
BY	0.652	0.030	0.022	0.056	-0.028	0.001	0.015	0.011	0.430	-0.029	

DTF= Days taken to flowering (50%), DTM= Days taken to maturity, $PBrP^{-1}$= Primary branches per plant, $SBrP^{-1}$= Secondary branches per plant, PH= Plant Height, $PODSP^{-1}$= Pods per plant, $SEEDP^{-1}$= Seeds per plant, $SEEDPD^{-1}$= seed per pod, 100 GWT=100-grain wt., BY= Total biological yield, GYP^{-1}= Grain yield per plant.

of paramount importance. The genotypic correlations were generally higher than their corresponding phenotypic correlations (Table 2). The lower values of phenotypic correlations may be attributed to lower modifying effect of environment on the association of characters at the gene level (Mamun-Hossain and Joarder, 1987). Path analysis was employed to establish the intensity of independent variables (days to flowering, days to maturity, number of primary branches $plant^{-1}$, number of secondary branches $plant^{-1}$, plant height, pods $plant^{-1}$, seeds $plant^{-1}$, seeds pod^{-1}, 100-grain weight and total biological yield) on the dependent one i.e., grain yield $plant^{-1}$ (Table III). The analysis being a more precise method partitions the direct and indirect effects of individual traits (independent) on grain yield $plant^{-1}$ (dependent). This analysis also helps breeders to identify the characters that could be used as selection criteria in chickpea breeding programme.The results pertaining to correlation revealed that grain yield $plant^{-1}$ had significant genotypic and highly significant phenotypic relationship with pods $plant^{-1}$, seeds $plant^{-1}$, seeds pod^{-1} and total biological yield. These results suggested that improvement of grain yield in chickpea is linked with these traits and selection of these characters might have good impact on grain yield $plant^{-1}$. Lokendra et al. (1999), Saleem et al (1999), Saleem et al. (2002a), Bakhh et al. (2004) and Yucel et al. (2006) also reported similar results. Days to flower initiation showed negative and highly significant correlation with almost all the yield contributing traits whereas, days to maturity exhibited significant association at both genotypic and phenotypic levels only with pods $plant^{-1}$ and seeds $plant^{-1}$. Primary branches revealed positive genotypic and phenotypic association with every character with the exception of secondary branches, 100-grain weight and biological yield while secondary branches displayed significantly positive correlation with plant height and biological yield only at both the levels. Pods $plant^{-1}$ and seeds $plant^{-1}$ exhibited positive and significant genotypic and phenotypic correlation with each other and with 100-grain weight and biological yield (Saleem et al. 1999; Saleem et al. 2002a; Bakhh et al. 2004; Yucel et al. 2006). Seeds pod^{-1} executed significant phenotypic and genotypic relationship with biological yield nevertheless 100-grain weight exhibited no association with any of the character. The path coefficient analysis based on grain yield $plant^{-1}$ as a dependent variable revealed that all traits, except days to flowering, days to maturity and secondary branches exhibited positive direct effects on yield $plant^{-1}$ (Table 3). Similar to the correlation analysis, path analysis of grain yield $plant^{-1}$ and its components demonstrated that biological yield wielded the highest positive direct influence (0.652) on grain yield $plant^{-1}$ followed by number of seeds pod^{-1}, 100-grain weight, primary branches, pods $plant^{-1}$, seeds $plant^{-1}$ and plant height respectively. Singh et al. (1997), Yousefi et al. (1997) Saleem et al. (2002b) and Yucel et al. (2006) also observed direct positive influences of these characters on the dependent variable. This confirmed that number of seeds pod^{-1} and biological yield are direct contributors towards grain yield plant^{-1}. Hence these traits could be explored more confidently as selection criteria for yield improvement in chickpea. Moderate positive direct influence of primary branches, pods plant^{-1}, seeds plant^{-1} and 100-grain weight on grain yield plant^{-1} was fully supported by the significant correlation coefficients of these traits with grain yield. This indicated that these traits could be included in selection criteria list. On the other hand, days to maturity exerted highest negative direct effect (-0.122) on grain yield following days to flowering (-0.087). Yucel et al. (2006) also reported negative direct effects of days to flowering on yield. It was observed that the highest indirect contribution was exhibited by primary branches, pods plant^{-1} and seeds plant^{-1} by most of the yield components; thus, these traits should be given emphasis in selection process. These results were in agreement with the findings of Erman et al. (1997), Singh et al. (1997), Yousefi et al. (1997), Saleem et al. (2002b), Noor et al. (2003) and Yucel et al. (2006).

Most of the traits exerted indirect influence on grain yield plant^{-1} through days to flowering, pods plant^{-1}, seeds plant^{-1}, seeds pod $^{-1}$, 100-grain weight and to a larger extent via primary branches plant^{-1} and total biological yield (Saleem et al., 2002b; Noor et al., 2003; Yucel et al., 2006). The correlation coefficients of all the interdependent variables showed significant association among themselves. Grain yield plant^{-1} had significant genotypic and highly significant phenotypic relationship with pods plant^{-1}, seeds plant^{-1}, seeds pod^{-1} and total biological yield. The independent variables exhibited comparable difference among their direct effects on grain yield. Biological yield followed by number of seeds pod^{-1} and 100-grain weight exercised the highest positive direct influence on grain yield plant^{-1}. These results concluded that improvement of grain yield in chickpea is linked with these traits. So, it is suggested that these parameters should be an integral part of effective selection criteria leading to yield enhancement in chickpea.

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