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Determining Relationships among Yield and Some Yield Components Using Path Coefficient Analysis in Chickpea (*Cicer arietinum* L.)

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Abstract: This research was conducted to determine the relationship among yield and some yield components using correlation and path coefficient analysis. The experiment was carried out in Yüzüncü Yil University Experimental Field between 2000 and 2002. In this study, 14 chickpea cultivars were used. The experiment was designed in Randomized Block Design with three replications. Positive and significant relationships were found among seed yield and plant height, number of branches, number of pods per plant, biological yield, harvest index and number of seeds per plant. Negative and non-significant relationship was determined between seed yield and 1000-seed weight. According to path coefficient analysis, there were strong direct effects of the biological yield, harvest index and number of seeds per plant on the seed yield, p.c : 0.783 and p.c: 0.441, respectively.

Key words: Chickpea, path coefficient, correlation, yield, yield components

INTRODUCTION

Chickpea is the most important pulse crop of Turkey grown in 650.000 ha^{-1} and with 590.000 ton production potential[1]. Chickpea is used widely in human nutrition because of its high protein level (18-30%). The main objective of growing chickpea is to get high yield with increased quality. Because genotypic and environmental factors are main components that determine yield and quality in plants, primary aim in selection of breeding criteria should focus on effects of genotypic factors. Because of its major role in human nutrition, it is essential to know the relationships between yield and its components in chickpea breeding programs.

Yield is a complex character associated with many interrelated components. Generally, correlation coefficients show relationships among independent characteristics and the degree of linear relation between these characteristics. However, path analysis is needed to clarify relationships between characteristics deeply because correlation coefficients describe relationships in a simple manner[2]. Path coefficient analysis separates the direct effects from the indirect effects through other related characters by partitioning the correlation coefficient[3]. Path analysis is used when we want to determine the amount of direct and indirect effects of the causal component on the effect component[4]. Eser *et al.*[5], Erman *et al.*[6] and Phadnis *et al.*[7] determined the direct and indirect effects of various plant characteristics on yield and yield components using path analysis in various chickpea cultivars and determined yield components which should be primarily examined in chickpea breeding. Kumar and Arora[8] determined that biological yield per plant, pods per plant, 100-seed mass and plant height were the major yield components for selection in chickpea. However, Eser *et al.*[5] stated that 100 seed weight, number of seeds per plant, number of pods per plant and number of branches per plant were the major yield components for selection in chickpea. As in previous studies, plant breeder found well-qualified varieties or certain characteristics using path analysis at the terminal selection stage of breeding. In this study, relationships among yield and yield components were examined to determine the association of seed yield with its components and some developmental traits, using path coefficient analysis.

MATERIALS AND METHODS

This study was carried out in rainfall conditions between 2000 and 2002 at the Experimental Field of the Department of Field Crops, Faculty of Agriculture, Yüzüncü Yil University, Van, Turkey. The study site had sandy loam clay soil. Some soil properties and climatic data related to research location are summarized in Table 1 and 2, respectively.

Table 1: Some soil properties of the research area

Texture	Sandy loamy clay
pH	7.52
Organic matter (%)	0.46
Available N (%)	0.02
P_2O_5 content (mg kg^{-1})	5.50
Lime (%)	14.20
Salt (%)	0.02

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Table 2: Meteorological data at the experimental site including vegetation period (2000-2002)

	Rainfall (mm)			Temperature (°C)			Relative humidity (%)		
Months	2000	2001	2002	2000	2001	2002	2000	2001	2002
April	36.2	32.6	107.4	9.5	9.6	6.9	64.8	65.2	69.5
May	23.9	28.0	54.8	14.3	19.6	12.3	53.2	49.1	57.6
June	3.3	4.5	20.4	19.4	19.6	17.9	48.1	49.1	49.5
July	0.2	6.8	3.1	25.4	23.1	22.6	41.3	52.6	46.4
August	----	---	---	22.9	24.0	22.2	42.3	41.3	39.5

The experiment was conducted using 14 chickpea cultivars which are registered in Turkey. The cultivars included Canitez-87, Eser -87, Akçin - 91, ILC-482, Izmir-92, Menemen-92, Aydin-92, Damla-89, Aziziye, Diyar-95, Gökçe, Küsmen-99, Uzunlu-99 and Er-99. The field experiment was established in Randomized Block Design with three replications. Each plot was 6 m^2(4x15 m) and planted with 30x5 cm row spacing (approximately. 66 seeds/m^2) in the middle of April in all of the study years. Characters were examined on ten plants randomly selected in the mid-rows of plots. Seed yield (kg ha^{-1}) plant height (cm), biological yield (kg ha^{-1}), straw yield (kg ha^{-1}), number of branches/plant, number of pods/plant, harvest index (%) and 1000-seed weight (g) were recorded. Phenotypic correlations between examined characters were calculated in the usual manner and path coefficient analysis was carried out according to the method of Dewey and Lu[9]. The path coefficient is known as a standardized partial-regression coefficient and separates the direct and indirect effects of a correlation coefficient. Hence, path analysis plays an important role in determining the degree of relationship between yield and yield components.

RESULTS

Simple correlation coefficients calculated among examined characteristics are given in Table 3. Positive significant relationships were found between seed yield and plant height (r= 0.256**), number of pods per plant (r= 0.706**), number of branches per plant (r= 0.689**), biological yield (r= 0.868**), straw yield (r= 0.566**), harvest index (r= 0.793**). The relationship between seed yield and 1000-seed weight was negative (r= -0136) but not significant.

The direct and indirect effects of seven examined characters on seed yield were estimated by path coefficient (Table 4). Biological yield had the greatest direct effect on seed yield (p.c.= 0.783). Also, its indirect effects on seed yield were positive through number of branches, number of pods/plant, harvest index and 1000-seed-weight, but negative and low through plant height and straw yield. The main reason for strong direct effect of biological yield was due to the strong positive correlation (r= 0.868) of this character with seed yield.

The second highest direct effect on seed yield was of the harvest index (p.c.= 0.441). Harvest index had negligible positive indirect effects on seed yield via most of the observed characters except for the biological yield (p.c. = 0.332). The indirect effects through 1000-seed weight and straw yield were negative and negligible.

Plant height (p.c.=0.078) and number of pods per plant (p.c.= 0.051) were the third highest positive direct contributors to seed yield following biological yield and harvest index. Plant height had positive and high indirect effects on seed yield via biological yield (p.c.=0.384). However, it had negative indirect effects via straw yield (p.c.= -0.063), number of pods/plant (p.c.= - 0.016) and harvest index (p.c.= -0.016). Plant height had negligible positive indirect effects on seed yield via number of branches (p.c.= 0.002) and 1000-seed weight (p.c.= 0.011). Number of pods per plant had positive and high indirect effects via biological yield and harvest index as p.c.= 0.484 and p.c.= 0.240, respectively. It had positive and negative indirect effects via other examined characters but these effects were negligible (Table 4).

Number of branches had a low but positive direct effect on seed yield (p.c. = 0.009). The indirect effects on seed yield were positive and high via biological yield (p.c.= 0.496) and harvest index (p.c.= 0.217). It had a low and positive indirect effects via number pods/plant (p.c.= 0.043), but a low and negative indirect effects via plant height (p.c = -0.021), straw yield (p.c.= -0.053) and 1000-seed yield (p.c.= -0.002).

Straw yield had the highest negative direct effect on seed yield (p.c.= -0.119). It had positive and high indirect effect on seed yield via biological yield (p.c.= 0.675), positive negligible indirect effects via number of branches per plant, number of pods per plant, harvest index (%) and 1000-seed weight and negative indirect effect via plant height (p.c.= - 0.041)

The correlation between 1000-seed weight and seed yield was negative non-significant (r= -0.136). The direct effect of seed weight on seed yield was positive and low (p.c.= 0.027). 1000-seed weight had the highest negative indirect effect on seed yield via harvest

Table 3: Correlation coefficients among the characteristics in 14 chickpea cultivars

Characters	1	2	3	4	5	6	7	8
Seed yield (kg ha^{-1})	1.000							
Plant height (cm)	0.256**	1.000						
Biological yield (kg ha^{-1})	0.868**	0.490**	1.000					
Straw yield (kg ha^{-1})	0.566**	0.532**	0.862**	1.000				
Number of branches/Plant	0.689**	0.269**	0.633**	0.448**	1.000			
Number of pods/Plant	0.706**	0.321**	0.618**	0.382**	0.849**	1.000		
Harvest index (%)	0.793**	-0.036	0.423**	0.049	0.491**	0.543**	1.000	
1000-seed weight (g)	-0.136	0.410**	0.069	0.223*	0.062	-0.163	-0.337**	1.00

**Significant at 1%; * Significant at 5%

Table 4: Path analysis showing direct and indirect effects of seven characters on chickpea yield

	Indirect effects							
Characters	1	2	3	4	5	6	7	Correlation value with yield
Plant height (cm)	(0.078)	0.384	-0.063	0.002	-0.016	-0.016	0.011	0.256**
Biological yield (kg ha^{-1})	-0.038	(0.783)	-0.103	0.006	0.031	0.187	0.002	0.868**
Straw yield (kg ha^{-1})	-0.041	0.675	(-0.119)	0.004	0.019	0.022	0.006	0.566**
Number of branches/Plant	-0.021	0.496	-0.053	(0.009)	0.043	0.217	-0.002	0.689**
Number of pods/Plant	-0.025	0.484	-0.046	0.007	(0.051)	0.240	-0.001	0.706**
Harvest index (%)	0.03	0.332	-0.006	0.004	0.028	(0.441)	-0.009	0.793**
1000-seed weight (g)	-0.032	0.054	-0.027	-0.001	-0.008	-0.149	(0.027)	-0.136

**Significant at 1 %; Figures in parentheses are direct effect on seed yield

index (p.c.= - 0.149). The indirect effects via plant height (p.c.= -0.032), biological yield (p.c.= 0.054), straw yield (p.c.= -0.027 and number of branches (p.c.= - 0.008) were negligible.

DISCUSSION

The results of the present study showed that even though the relationships (correlations) among some characters were statistically significant (Table 3), the path coefficient values were found non-significant (Table 4). According to these results; linear relations among examined characters are insufficient in plant breeding programs.

Similarly, Singh and Singh[10], Kumar and Arora[8], Akdağ and Şehirali[11], Erman *et al.*[6] showed positive and significant relationships between seed yield and biological yield, number of pods/plant, harvest index and also negative relationships between seed yield and 1000-seed weight. Eser *et al.*[12] stated that 1000 seed weight, number of seeds/plant and number of primary and secondary branches can be proposed as primary selection criteria for chickpea breeding. Erman *et al.*[6] demonstrated the highest direct and indirect effects of number of pods/plant, biological yield and harvest index on seed yield using path coefficient analysis. Katiyar[13] and Tomar *et al.*[14] using path coefficient analysis indicated that number of pods per plant and seed size had the largest direct effect on seed yield. Katiyar *et al.*[15], reported that the number of pods had the highest direct effect on yield. In addition, Güler *et al.*[4] reported that the number of seeds/ plant had the highest direct effect on seed yield. In our research, the highest and positive relationships observed between seed yield and biological yield (r= 0.868**), harvest index (r= 0.793**) and number of pods/plant (r= 0.706**) were similar to the results of Kumar and Arora[8], Erman *et al.*[6]. Biological yield, harvest index, plant height and number of pods/plant had high positive direct effect on seed yield as p.c.= 0.783, p.c.= 0.441, p.c.= 0.078 and p.c.=0.051, respectively (Table 4).

In conclusion, determining the linear relations (correlations) among components affecting seed yield was insufficient to indicate selection criteria in chickpea breeding activities. Also, it was essential that the levels of direct and indirect effects of the causal components to be determined.

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