Path coefficient and correlation analyses of quantitative characters in Chickpea (*Cicer arietinum*)*

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Abstract. A correlation and path-coefficient analyses are conducted for seed yield and yield components in 96 genotypes of Chickpea of different origin. Data are recorded for nine quantitative characters: plant height, first pod height, number of branches on main stem, number of pods per plant, number of seeds per plant, number of seeds per pod, weight of seeds per plant, 100-seed weight, and seed yield from 1 m^2 area. The relations between these characters can be used as selection criteria in a breeding study aimed at improving the high-yielding cultivars for that region.

Key words: Chickpea, correlations coefficient, direct and indirect effects, yield components

Introduction

Chickpea (*Cicer arietinum* L.) is the third most important grain legume in the world after beans and peas, and the first crop in South and West Asia (Toker 2009). Nowadays Chickpea is grown in 50 countries situated mainly in four areas: the Indian Subcontinent, East Africa, the Mediterranean, and Latin America (Singh 1990). In Bulgaria, Chickpea is an old traditional crop used mainly for human consumption and less for fodder. In the passional *The Life of Ivan Rilski* (876-946) it was said that the Saint ate Chickpea (Koinov 1968).

Seed yield of Chickpea is a quantitative character affected by many genetic factors, as well as by environmental fluctuations (Muehlbauer & Singh 1987). In Chickpea breeding programs, selection is based on yield and yield-related characters. Determination of the correlation coefficients between yield and yield criteria is important so as to select favorable plant types for effective Chickpea breeding (Toker 1998). Correlation of coefficients in general shows associations among the independent characteristics and the degree of linear relation between these characteristics, but it cannot provide reasons of association. Therefore, the simple correlation coefficients are not always effective in determining the real relationships among traits (Hardwick & Andrews 1980; Toker & Cagirgan 2004). Path analysis provides a measure of the relative importance of each independent variable for the prediction of changes in the dependent one (Deweyand Lu 1959). Bakhsh & al. (2004) and Yucel & al. (2006) have reported a significant and positive correlation of the number of pods per plant and 100-seed weight with the seed yield of plant. Noor & al. (2003) and Yucel & al. (2006) have determined that biological yield, number of pods per plant, 100-seed weight and plant height were the major yield components for selection in Chickpea.

The objective of this study is to establish the interrelationship and direct and indirect effects of some yield components among themselves and with seed yield in some Chickpea accessions.

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Material and methods

Ninety-six accessions of Chickpea were evaluated for agronomic traits under field conditions at the Konstantin Malkov Institute of Plant Genetic Resources – Sadovo, Bulgaria, during 2009–2013 growing seasons. The accessions were from different countries (Bulgaria, Hungary, India, Syria, Germany, Moldova, Turkey, Uzbekistan, Azerbaijan, and the Ukraine). The experiment was conducted in the randomized block design, in four replications and with 4.2 m^2 plot size. Four rows of 2 meters for each genotype in each replicate were planted with 10 cm intra-row spacing, whereas inter-row distance was kept at 50 cm. Pesticides and fungicides were sprayed to save the crop from infestation of pests and *Ascochyta rabiei*. The agronomic characters were taken after harvesting of the plants. From each accession, 10 plants were collected for biometric measurements. Data were recorded for plant height, first pod height, number of branches on main stem, number of pods per plant, number of seeds per plant, number of seeds per pod, weight of seeds per plant, 100-seed weight, and seed yield from 1 m^2 area.

Phenotypic correlations were calculated by phenotypic variances and covariance. Correlation coefficients were calculated according to Lidansky 1988, whereas a path-coefficient analysis was conducted according to Dewey & Lu 1959.

Results and discussion

Correlation coefficient analysis

Results of the phenotypic correlation coefficients are given in the Table 1.

Seed yield from 1 m^2 area correlated positively and significantly with plant height (r=0.224*), first pod height (r=0.226*), number of branches on main stem (r=0.218*), number of pods per plant (r=0.372**), and number of seeds per plant (r=0.357**). These results are in agreement with the results obtained by Guler Mustafa & al. (2001) and Kobraee & al. (2010). Seed yield from 1 m^2 area had negative and medium significant correlation with 100-seed weight (r=-0.348**). The number of seeds per plant had positive and medium significant correlations with number of branches on main stem (r=0.406**), number of seeds per pod (r=0.536**), weight of seeds per plant (r=0.469**), and seed yield from 1 m^2 area (r=0.357**). A highly significant and positive correlation was found between the number of seeds per plant and number of pods per plant (r=0.922**). The number of pods per plant gave a positive and significant correlation with the number of branches on main stem (r=0.420**), number of seeds per pod (r=0.265**), weight of seeds per plant (r=0.598**), and seed yield from 1 m^2 area (r=0.372**). 100-seed weight was in a negative and significant phenotypic correlation with plant height (r=-0.321**), first pod height (r=-0.318**), number of seeds per pod (r=-0.550**), number of pods per plant (r=-0.618**) and number of seeds per plant (r=-0.743**). The phenotypic correlations between weight of seeds per plant, number of pods per plant and number of seeds per plant were positive and medium significant at the 0.01 level. A highly significant and positive correlation was determined between the plant height and first pod height (r=0.901**). The number of branches on main stem correlated positively and significantly at the 0.05 and 0.01 levels with the first pod height, number of pods per plant, number of seeds per plant, number of seeds per pod, and the yield from 1 m^2 area.

Path coefficient analysis

Traditionally, correlation, regression and path coefficient analyses have been used in determining the character interrelationships and yield criteria for indirect selection (Toker & Cagirgan 2003). Path coefficient analysis helps to determine the contribution of various components of yield to all seed yields in the study of genotypes. It provides an effective way of finding out direct and indirect sources of correlation (Khaliq & al. 2004). Our results showed that the number of seeds per plant (p=0.344), plant height (p=0.147) and number of branches on main stem (p=0.117) had the strongest positive direct effect on the seed yield from 1 m^2 area (Table 2).

The effect of the others traits was negative and aimed at yield reduction, except of the first pod height (p=0.034). The strongest negative direct effect on the seed yield from 1 m^2 area had the number of seeds per pod (p=-0.304), followed by the 100-seed weight (p=-0.179).

The number of pods per plant (p=0.317), number of seeds per pod (p=0.184), weight of seeds per plant (p=0.161), and number of branches on main

Table 1. Phenotypic (rph) correlation coefficients of the studied yield components in Chickpea accessions.

Variable	Plant height, cm	First pod height, cm	Number of branches on main stem	Number of pods per plant	Number of seeds per plant	Number of seeds per pod	Weight of seeds per plant, g	100- seed weight, g	Seed yield from 1 m^2 area, g
Plant height, cm	1	**0.901****	0.073	0.107	0.199	**0.275****	-0.042	**-0.321****	**0.224***
First pod height, cm		1	**0.245***	0.127	0.200	**0.350****	-0.052	**-0.294****	**0.226***
Number of branches on main stem			1	**0.420****	**0.406****	**0.378****	0.162	**-0.421****	**0.218***
Number of pods per plant				1	**0.922****	**0.265****	**0.598****	**-0.618****	**0.372****
Number of seeds per plant					1	**0.536****	**0.469****	**-0.743****	**0.357****
Number of seeds per pod						1	0.011	**-0.550****	0.062
Weight of seeds per plant, g							1	0.131	0.118
100- seed weight, g								1	**-0.348****
Seed yield from 1 m^2 area, g									1

*Correlation is significant at 0.05 level.
**Correlation is significant at 0.01 level.

Table 2. Direct (bold and underlined) and indirect effect of eight characters (independent variables) on the seed yield from 1 m^2 area (dependent variable) in 96 Chickpea genotypes (The last column shows the phenotypic correlations of independent variables with the seed yield from 1 m^2 area).

Variable	Direct and indirect effect								Total indirect effect	rph
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8		
X_1	**0.147**	0.031	0.009	-0.005	0.068	-0.084	0.000	0.057	0.077	0.224
X_2	0.132	**0.034**	0.029	-0.005	0.069	-0.090	0.000	0.057	0.192	0.226
X_3	0.011	0.008	**0.117**	-0.018	0.140	-0.115	0.000	0.075	0.101	0.218
X_4	0.016	0.004	0.049	**-0.042**	0.317	-0.080	-0.001	0.110	0.414	0.372
X_5	0.029	0.007	0.048	-0.039	**0.344**	-0.163	-0.001	0.133	0.013	0.357
X_6	0.040	0.010	0.044	-0.011	0.184	**-0.304**	0.000	0.098	0.366	0.062
X_7	-0.006	-0.002	0.019	-0.025	0.161	-0.003	**-0.002**	-0.023	0.120	0.118
X_8	-0.047	-0.011	-0.049	0.026	-0.255	0.167	0.000	**-0.179**	-0.169	-0.348

X_1 – plant height, cm; **X_2** – first pod height, cm; **X_3** – number of branches on main stem; **X_4** – number of pods per plant; **X_5** – number of seeds per plant; **X_6** – number of seeds per pod; **X_7** – weight of seeds per plant, g; **X_8** – 100-seed weight, g.

stem (p=0.140) via the number of seeds per plant had the highest positive indirect effect on the seed yield from 1 m^2 area.

The 100-seed weight (p=-0.255) had the strongest negative indirect effect on the seed yield from 1 m^2 area via the number of seeds per plant, followed by the number of seeds per plant (p=-0.163) via the number of pods per plant.

A path coefficient analysis offered a slightly different picture from the simple correlation analysis. The correlation analysis indicated the number of pods per plant and the number of seeds per plant as important positive influences on the seed yield from 1 m^2 area, but path coefficient analysis suggested that only the number of seeds per plant had direct positive influence on the seed yield from 1 m^2 area.

The results obtained from 96 Chickpea accessions showed that the seed yield from 1 m^2 area was significantly and positively correlated with the plant height, first pod height, number of branches on main stem, number of pods per plant, and number of seeds per plant. The path coefficient analysis indicated that the direct effects of plant height, number of branches on main stem and number of seeds per plant on the seed yield from 1 m^2 area were most positive, while the direct effect of the first pod height on the seed yield from 1 m^2 area was least positive. The direct effect of the number of pods per plant was least negative. Therefore, the characters of plant height, number of branches on main stem and number of seeds per plant can be used as selection criteria so as to increase the seed yield in Chickpea accessions in the region.

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