



Assessment of effectiveness degrees of the factors affecting the yield of some chickpea (*Cicer arietinum*) genotypes by path analysis

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ABSTRACT

The objectives of this study were to define direct and indirect correlations between the factors and the yield of four chickpea (*Cicer arietinum* L.) genotypes and to assess their effectiveness proportions in the ecological conditions of Erzurum by path analysis. The experiment was conducted on arid lands of Erzurum and Aziziye-94, İpik, Cagatay and Yasa genotypes were used in this two-year experiment. Path analysis indicated the highest direct and positive effect of pod number (1.095), first pod height (0.574), and 100- seed weight (0.254) on seed yield. On the other hand, it indicated the direct and negative effect of plant length (-0.341), branch number (-0.383), seed number/pod (-1.311) on seed yield.

Key word: Chickpea, Path analysis, Yield

Chickpea (*Cicer arietinum* L.) is an important grain legume crop of the dry areas of West Asia. It is an important source of dietary protein and a self-pollinated, diploid annual grain legume crop (Bharadwaj *et al.* 2010). Hence, *Cicer arietinum* is an important food stuff for Turkey. Yield of chickpea is affected by many factors as season, soil properties, genotype and years (Üstün and Gülümser 2003). To minimize the effects of the factors on the yield and to select the right genotype will contribute to the production of an economical and high quality product. Some factors have a direct impact on the yield while others have an indirect impact. So, it is important to know from which factor the yield of the selected material is affected and to which degree it is affected (Topal and Esenbuga 2000). It is necessary to explain cause and effect relationship in this respect. However, coefficients of correlation may not be satisfactory to explain this relation. So, the effectiveness degree of the factors directly or indirectly affecting the yield could be measured using the path analysis method. The standard partial regression coefficients in this analysis are the path coefficients at the same time and show the effectiveness degrees.

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MATERIALS AND METHODS

This study was conducted as a field trial at the experimental research station of the Eastern Anatolia Agricultural Research Institute in Erzurum with a two year period in the growing season of 2008 and 2009. The study was conducted with four chickpea genotypes; Aziziye-94, Isik, Cagatay and Yasa, obtained from the Eastern Anatolia Agricultural Research Institute (Erzurum), the Anatolian Agricultural Research Institute (Eskisehir) and the Black Sea Agricultural Research Institute (Samsun) were used in the experiment. The experimental design was completely randomized by block design in a factorial arrangement with three replications. The samples were taken from each parcel in a way that the number of the plants would be five. Plant length, branch number, first pod height, pod number per plant, seed number per pod, 100-seed weight and yield per seed were measured for each plant.

The effectiveness degrees of the factors affecting the yield were assessed by the path analysis through the analysis of partial regression and correlation. The effectiveness degrees between the yield as the dependent variable (Y), and plant length, branch number, pod number, seed number/pod, first pod height and 100-seed weight as the independent variables (Xi), were defined as the path coefficients and marked as P. The marks of the dependent variable and independent variables are shown below:

Y : Yield, X1: plant length, X2: branch number, X3: pod number, X4: seed number/pod, X5: first pod height, X6: 100-seed weight

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Each variable directly or indirectly correlates with each other. The direct correlation of the independent variable, X_i , with the dependent variable, Y , is shown as $P_{Y\bar{Y}}$ and the correlation of the independent variable, X_i , via the independent variable, X_j , with the dependent variable, Y , (an indirect correlation) is shown as r_{ijPY_i} . Accordingly, the direct and indirect correlations between the yield of chickpea and the factors affecting yield are formulated below. This formula is also separated into the components of the coefficient of correlation between yield and the factors.

$$\begin{aligned} rY1 &= PY1 + r12PY2 + r13PY3 + r14PY4 + r15PY5 + r16PY6 \\ rY2 &= r21PY1 + PY2 + r23PY3 + r24PY4 + r25PY5 + r26PY6 \\ rY3 &= r31PY1 + r32PY2 + PY3 + r34PY4 + r35PY5 + r36PY6 \\ rY4 &= r41PY1 + r42PY2 + r43PY3 + PY4 + r45PY5 + r46PY6 \\ rY5 &= r51PY1 + r52PY2 + r53PY3 + r54PY4 + PY5 + r56PY6 \\ rY6 &= r61PY1 + r62PY2 + r63PY3 + r64PY4 + r65PY5 + PY6 \end{aligned}$$

In the equations, PY_i is the path coefficient between the independent variable, i , and, the dependent variable, Y_i ; r_{ijPY_i} is the correlation of i 'th independent variable via j 'th independent variable with Y (dependent variable) that is, the quantity of the indirect correlation. Additionally, rYX_i is the coefficient of correlation between X_i 'th independent variable and Y (dependent variable); rX_{ij} is the coefficient of correlation between the independent variables. The effectiveness proportions are the proportions within the total correlation of direct and indirect correlations between Y and X_i (Topal and Esenbuga 2000). The total of direct and indirect correlations show the coefficient of correlation between Y and X_i . There are a direct correlation and indirect correlations in each equation and the number of indirect correlations is one less than the number of the independent variables.

The multiple linear equation of regression between the yield of chickpea (Y) and independent variables ($X_1, X_2, X_3, X_4, X_5, X_6$) correlating with the yield is shown below:

$$Y = a + bY1X1 + bY2X2 + bY3X3 + bY4X4 + bY5X5 + bY6X6$$

$X_1, X_2, X_3, X_4, X_5, X_6$ are independent variables, and $bY1, bY2, bY3, bY4, bY5, bY6$ are the partial coefficients of regression. The partial coefficients of regression show the correlation of the factor examined with Y (the dependent variable) when the correlations of other factors with Y are fixed, and (a) shows error. As the value of the error is taken as zero (0), it is not added to the calculation.

RESULTS AND DISCUSSION

The correlations between the variables and the direct and indirect effectiveness degrees between the factors, the path coefficients (P) and the effectiveness portions are shown in Table 1 and 2, respectively. Correlation coefficients between yield (Y) and plant length (X_1) was 0.441*. The direct effect of plant length (X_1) on yield (Y) was negative (-0.341). On the other hand, it was found that the indirect effect of plant length via the first pod height on the yield was the highest

effect (0.431). The findings are in dissonant with findings of Pathak *et al.* (2011), Savur and Ceylan (2011), Pek°en and Glmser (2005).

It is clearly seen that these findings are of high importance when compared with the proportions of direct effect. Findings correspond to the agronomical characteristics of a chickpea plant, for plant height (X_1) is an important factor affecting yield (Y). The calculation of the direct and indirect correlation of plant height with yield was given below:

$$\begin{aligned} rY1(0.441^*) &= (-0.341) + (-0.237x-0.383) + (-0.168x1.095) + \\ &\quad (-0.275x-1.311) + (0.751x0.574) + (0.332x0.254) \\ &= -0.341 + 0.090 + -0.183 + 0.360 + 0.431 + 0.084 \end{aligned}$$

The direct effect of branch number on yield was negative (-0.383). The finding is in accordance with finding of Pathak *et al.* (2011), but it is dissonant Savur and Ceylan (2011). Similarly, the indirect effect of the seeds per pod via branch number on yield was negative and the highest effect (-0.723).

The increase in branch number (X_2) may result in increase of yield. The direct effect of pod number on yield was very high (1.095). The finding is higher than previous finding of Pathak *et al.* (2011), but it is lower than Savur and Ceylan (2011). But, the indirect effect of pod number via seed number/pod on yield was negative (-1.293). The quantity of the direct effect of the seed number/pod (X_4) on yield (Y) reaches such a high percentage as 46.66%, which naturally affects the pod number. There was a negative direct effect between seed number/pod and yield (-1.311). The result is similar to findings of Pek°en and Glmser (2005), Savur and Ceylan (2011). While the indirect effect of seed number per pod via pod number on yield was positive (1.058), the direct effect of seed number/pod on yield was negative.

It is seen that there were significant correlations among seed number/pod (X_4), pod number (X_3), branch number (X_2) and yield. The effectiveness degrees of these factors are shown in the equations given below:

$$\begin{aligned} rY2(-0.491^*) &= (-0.237x-0.341) + (-0.383) + (0.595x1.095) + \\ &\quad (0.552x-1.311) + (0.073x0.575) + \\ &\quad (0.623x0.254) \\ &= 0.080 + -0.383 + 0.651 + -0.723 + 0.041 + \\ &\quad -0.158 \\ rY3(-0.434^*) &= (-0.168x-0.341) + (-0.595x-0.383) + (1.095) \\ &\quad + (0.967x-1.311) + (-0.064x0.574) + \\ &\quad (-0.215x0.254) \\ &= -0.057 + -0.227 + 1.095 + -1.263 + -0.036 + \\ &\quad -0.054 \\ rY4(-0.498^*) &= (-0.275x-0.341) + (0.552x-0.383) + \\ &\quad (0.967x1.095) + (-1.311) + (-0.101x0.574) + \\ &\quad (-0.277x0.254) \\ &= 0.093 + -0.211 + 1.058 + -1.311 + -0.057 + \\ &\quad -0.070 \end{aligned}$$

It was found that the first pod height had a significant correlation with yield. Especially, it is very important to bind the first pod height at a high level in the lands which are

Table 1 The coefficients of correlation between yield and factors affecting on yield

	Plant length	Branch number	Pod number	Seed number	First pod height	100-seed weight
Branch number	-0.237					
Pod number	-0.168	0.595**				
Seed number/pod	-0.275	0.552**	0.967**			
First pod height	0.751**	0.073	-0.064	-0.101		
100-seed weight	0.332	-0.623**	-0.215	-0.277	-0.039	
Yield	0.441*	-0.491*	-0.434*	-0.498*	0.343	0.484*

Table 2 The path coefficients and the percentages of the factors' direct and indirect effects and chickpea yield

Direct effect	Indirect effect	P	Effect portion (%)	r
X1		-0.341	22.90	0.441*
	X2	0.090	6.04	
	X3	-0.183	12.29	
	X4	0.360	24.17	
	X5	0.431	28.94	
	X6	0.084	5.64	
X2		-0.383	18.81	-0.491*
	X1	0.080	3.92	
	X3	0.651	31.97	
	X4	-0.723	35.51	
	X5	0.041	2.01	
	X6	-0.158	7.76	
X3		1.095	40.08	-0.434
	X1	-0.057	2.02	
	X2	-0.227	8.30	
	X4	-1.293	46.22	
	X5	-0.036	1.31	
	X6	-0.054	1.97	
X4		-1.311	46.66	-0.498*
	X1	0.093	3.30	
	X2	-0.211	7.50	
	X3	1.058	37.61	
	X5	-0.057	2.02	
	X6	-0.070	2.48	
X5		0.574	53.74	0.343
	X1	-0.256	23.97	
	X2	-0.027	2.52	
	X3	-0.070	6.55	
	X4	0.132	12.35	
	X6	-0.009	0.84	
X6		0.254	20.73	0.484
	X1	-0.113	9.22	
	X2	0.238	19.42	
	X3	-0.235	19.18	
	X4	0.363	29.63	
	X5	-0.022	1.79	

r: Correlation coefficient, P: path coefficient

cultivated by mechanized methods (Aycicek and Yildirim 2002). The results of this study indicated that the direct of the first pod height (X5) on yield (Y) was positive (0.574). This finding between the first pod height and yield was the highest data. The direct and the indirect correlations of the interaction are given in the equation below:

$$\begin{aligned} rY5(0.343) &= (0.751x-0.341) + (0.073x-0.383) + \\ &\quad (-0.064x1.095) + (-0.101 \times -1.311) + (0.574) \\ &\quad + (-0.039x 0.254) \\ &= -0.256 + -0.027 + -0.070 + 0.132 + 0.574 + \\ &\quad -0.009 \end{aligned}$$

It was founded that the direct effect of 100-seed weight on yield was 0.254. The results showed that 100-seed weight was not most effective factor on yield. The finding is in accordance with findings of Pathak *et al.* (2011), Özveren *et al.* (2006) and Amine *et al.* (2002).

Except for the percentage of correlation of 100-seed weight (X6) via seed number per pod (X4) with yield (Y), the percentages of correlation of 100-seed weight via the other factors with yield were close to each other.

It was founded that the indirect effect of 100-seed weight (X6) via seed number per pod (X4) on yield was high (0.363). The equation is given below:

$$\begin{aligned} rY6(0.484*) &= (0.332x-0.341) + (-0.623x-0.383) + \\ &\quad (-0.215x1.095) + (-0.277x-1.311) + \\ &\quad (0.039x0.574) + (0.254) \\ &= -0.113 + 0.238 + -0.235 + 0.363 + -0.002 + \\ &\quad 0.254 \end{aligned}$$

Some environmental factors are considered to be effective in negative correlation between branch number and yield, for some diseases, pests and irregular rainfall resulted in the decrease of the seed number/pod (X4) during the experimental years.

It is noted that low yield of chickpea is attributed to its susceptibility to several fungal, bacterial and viral diseases (Usha and Dubey 2010).

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