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ASSOCIATIONS OF SOME CHARACTERS WITH GRAIN YIELD IN CHICKPEA (*CICER ARIETINUM* L.)

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Abstract

The aim of this study was to determine relationship between yield and yield components and the effect of importance of yield component on yield in chickpea by using statistical procedures. Five statistical procedures including; path analysis, regression analysis, multivariate regression analysis, principal component analysis and dendogram analysis were used to study the relationship between chickpea grain yield and its components. Results showed that plant height, biological yield per plant and pods per plant can be considered as the most important yield variables in chickpea. High yield of chickpea plants can possibly be obtained by selecting breeding materials with high plant height, biological yield per plant and pods per plant.

Introduction

Chickpea, (*Cicer arietinum* L.) as an one of the most important food legume, has been commonly used for human nutrition and it is second most important among pulses in the world and being is cultivated on more than 11 million hectares with annual production of 9 million tons (Anon., 2007). Having high protein content, it is so rich in zinc, dietary fiber, calcium, magnesium, phosphorus, potassium, iron and vitamins (Güler *et al.,* 2001; Pekşen & Artık, 2005). One of the origins of the chickpea is probably South-eastern region of Turkey, where is important source of chickpea production (Noor *et al*., 2003). Total acreage, production and yield of chickpea in Turkey 500 283 ha, 505 366 tones, 1010 kg/ha, respectively (Anon., 2007). Due to detailed and heavy breeding programs, tremendous increase took place in chickpea yield and production and yield from 693 kg ha^{-1} ascended to 786 kg ha^{-1} in recent 30 years (Anon., 2009).

Determination of importance and effectiveness of yield components are main target. Besides, relationship between yield characters and yield may change in various trials and agronomical and breeding programs. Determining and processing effective yield components and relationships between them causes significant yield increase and leads better results. Chand *et al*., (1975), Katiyar *et al*., (1977), İslam & Begüm (1985), Malik *et al*., (1988), Khan *et al*., (1989) and Gravaes & Helms (1992) reported that grain yield had possitive relationship with plant height, number of branches, number of pods per plant and 100 seed mass. Different statistical techniques have been used, including correlation, regression, path analysis and principal components analysis to evaluate yield and yield components. Correlation analysis provides the information on correlated response of important plant characters and therefore, leads to directional model for yield (Ali & Tahir, 1999). But it is not sufficient to describe relationship when the casual relationship among variables is needed (Korkut *et al*., 1993). Path analysis is used when one wants to know causes. In other words, path analysis is used to determine the amount of direct and indirect effects of the variables on the effect component (Güler *et al*., 2001).

Regression technique was first discussed by Yates & Cochran (1938) and later by Finlay & Wilkinson (1963) to measure stability and then was improved by Eberhart & Russel (1966). Regression coefficient, deviation from regression and coefficient of determination have been the most widely used in stability parameters which use three selection indices as selection criteria to identify stable varieties (Eberhart & Russell, 1966).

The principal components analysis is a multivariate statistical technique for exploration and simplifying complex data sets. The ability of this procedure to transform a number of possibly correlated variables into a smaller number of variables called principal components has been demonstrated by Everitt & Dunn (1992). Each principal component is a linear combination of the original variables, and so it is often possible to ascribe the meaning to what the components represent (Leilah & Al-Khateeb, 2005). Cluster analysis is a class of statistical techniques that can be applied to data that exhibit “natural” groupings. Cluster analysis sorts through the raw data and groups them into clusters. A cluster is a group of relatively homogeneous cases or observations. Objects in a cluster are similar to each other. They are also dissimilar to objects outside the cluster, particularly objects in other clusters.

Grain yield of chickpea is a quantitative character, affected by both various genetic factors and environmental fluctuations (Muehlbauer & Singh, 1987). Both factors determines plant charecteristics. Taking in to considerations or putting agenda to only yield could leads misleading. It is therefore essential that together with grain yield, some essential yield components should be evaluated with each other in selection and evaluations. For determining which criteria are the more effective path analysis answers well to this question. For this reason, Gebeyehou *et al*., (1982) and Garcia del Moral *et al.,* (1991) determined the direct and indirect effects of various plant characteristics on yield and yield components by using path analysis in durum wheat and barley cultivars respectively. Phadnis *et al*., (1970) studied relationships among various plant characteristics and yield in chickpea and, determined yield components which should be primarily examined in plant breeding.

The aim of this study was to determine relationship between yield and yield components and the effect of importance of yield component on yield in chickpea and effectiveness of yield component on yield interms of different statistical analyses.

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Material and Methods

This research was conducted within the experimental field of Research and Application Farm, Faculty of Agriculture, University of Ankara (Haymana) during 2002/2003. Long period average precipitation is 146.14 mm, average temperature is 12.56°C (March-July). Relating to 2002 and 2003 total precipitations are 228.7 mm (March-July) and 139.2 mm (April-July). Average temperature is 13.9 and 16.4 in the first and second vegetation periods. The soil had 2.10% organic matter, 37.8% clay, 20.0% sand, 42.0% silt, 7.1 pH, 0.231 mmhos cm^{-1} electrical conductivity, 0.14% N, 8.14 ppm P_2O_5, 249 ppm K_2O in 2002 and 1.58% organic matter, 26.0% clay, 26.0% sand, 48.0% silt, 7.8 pH, 0.296 mmhos cm^{-1} electrical conductivity, 0.18% N, 31.76 ppm P_2O_5, 332 ppm K_2O in 2003.

Two soil tillage methods (moldboard plow and rotary tiler), three weed control methods (weed check, hand weeding and herbicide application) and three phosphorus doses (30, 60 and 90 kg ha^{-1}) were used. Data, obtained from all factor combinations were used in determination of relationship between yield and yield components. Data were analyzed according to randomized complete block design with 27 replications. Years were assumed as factors and each year constituted of 27 replication. Hence, it was assumed that all kinds of effects could be seen in determination of yield and yield components. The genotype, Gökçe was used as research material. Gökçe was shown on March 18 in first year and April 16 in second year due to climatic conditions. Sowing was made in 5 m long rows with 30 x 6 row spacing.

Plant height, biological yield per plant and pods per plant were done on five plants which had been randomly chosen in the mid-row of each plot at harvest time. Harvest index and dry weed biomass were determined at each plot in the 0.25 m^2 area. Each plot was harvested, blended and grain yield (kg ha^{-2}) was estimated (Tosun & Eser, 1975; Aydın, 1988). Grain protein content (%) was determined by microkjeldahl method (Kjeldahl, 1883; Bremner, 1960).

Statistical analysis were performed by using MSTAT-C (Freed & Eisensmith 1989), TARİST (Açıkgöz *et al.,*, 1994) and SPSS (Anon.. 2001) statistical analysis software programs.

Results and Discussions

The results of analysis of variance and means of parameter for the chickpea in 2002 and 2003 are presented in Table 1. The effects of years were determined significant at 5% for important yield components, such as grain yield, plant height, biological yield per plant and pods per plant. In second year, grain yield, plant height, biological yield per plant and pods per plant were higher than first year. Grain yield was observed as 1331.9 kg ha^{-1} and 2053.1 kg ha^{-1} at first year and second year, respectively. Plant height was 37.9 cm at second year and 31.8 cm at first year. Biological yield per plant ranged from 8.74 g to 11.73 g with low value for first year and high value for second year. Second year gave the higher pods per plant (16.7), whereas first year had the low (12.9). In second year, important yield components investigated were higher compared with the first year. There was a variation in weather conditions experienced by the chickpea crops in the study. Effective rainfall (April + May) in 2003 (133.7 mm) was greater than in 2002 (108 mm). The effects of effective rainfall were apparent for high grain yield, plant height, biological yield per plant and pods per plant in 2003. In second year, grain protein content were higher than first year shorter maturation period in 2003 could have caused this situation.

Table 1. Means of parameters in chickpea.

	1. year	2. year	Mean	F	LSD
Grain yield	1331,9 ± 60,0 b	2053,1 ± 185,5 a	1692,5 ± 413,8	30,2*	564,5
Plant height	31,8 ± 1,94 b	37,9 ± 0,28 a	34,8 ± 3,57	28,2*	4,95
Biological yield per plant	8,74 ± 0,69 b	11,73 ± 0,63 a	10,2 ± 1,74	71,5*	1,52
Pods per plant	12,9 ± 1,11 b	16,7 ± 0,79 a	14,8 ± 2,24	19,9*	3,64
Harvest index	57,2 ± 0,78	54,8 ± 0,76	56,0 ± 1,48	7,71	
Grain protein content	20,9 ± 1,09	24,1 ± 0,76	22,5 ± 1,89	10,5	
Dry weed biomass	1193,0 ± 242,3	994,0 ± 435,1	1093,5 ± 333,3	0,27	

The correlation coefficients were partitioned into direct and indirect effects (Table 2). Results of path analysis showed that pods per plant and grain protein content had high positive direct effects (3.8506 and 0.6808) on grain yield. Nevertheless, high negative direct effects belonged to plant height (-3.3226), biological yield per plant (-1.0752), harvest index (-0.8520) and dry weed weight (-0.4825). The highest positive indirect effects on grain yield were observed with plant height (4.2257) and biological yield per plant (1.9791). The highest negative indirect effects on grain yield were determined in pods per plant (-2.9412). Plant height, biological yield per plant, pods per plants and grain protein content seemed to have the greatest importance in relation to chickpea grain yield. On the other hand, harvest index and dry weed weight have to negative effects on grain yield. Katiyar (1979) and Tomar *et al.,* (1982) stated that path coefficient analysis have shown that pod number and seed size have the largest direct effects on yield. Katiyer *et al.,* (1981) examined the relationships among the characteristics which affected yield within 25 chickpea genotypes and found that the number of the pods plant had the highest direct effect on yield. Bakhsh *et al.,* (1998) reported that harvest index and biological yield to have maximum direct effect on grain yield. Noor *et al.,* (2003), Bhavani *et al.,* (2008) stated that positive and significant relationships were between seed yield and pods per plant and 100 seed weight.

Table 2. Path coeffecient for grain yield of chickpea.

Plant Height		
Correlation Coefficient		0,909*
Direct Effect	Path Coefficient	%
	-3,3226	34,4673
Indirect Effect	Path Coefficient	%
via Biological yield per plant	-1,0458	10,8485
via Pods per plant	3,7671	39,0781
via Harvest index	0,6396	6,6348
via Grain protein content	0,6318	6,5541
via Dry weed weight	0,2330	2,4172
Biological Yield per Plant		
Correlation Coefficient		0,909*
Direct Effect	Path Coefficient	%
	-1,0752	11,2971
Indirect effect	Path Coefficient	%
via Plant height	-3,2317	33,9545
via Pods per plant	3,7682	39,5915
via Harvest index	0,6346	6,6678
via Grain protein content	0,5956	6,2576
via Dry weed weight	0,2124	2,2315
Pods per Plant		
Correlation Coefficient		0,914*
Direct Effect	Path Coefficient	%
	3,8506	40,4696
Indirect effect	Path Coefficient	%
via Plant height	-3,2506	34,1628
via Biological yield per plant	-1,0522	11,0584
via Harvest index	0,5656	5,9440
via Grain protein content	0,5692	5,9818
via Dry weed weight	0,2268	2,3835
Harvest Index		
Correlation Coefficient		-0,769
Direct Effect	Path Coefficient	%
	-0,8520	11,5848
Indirect effect	Path Coefficient	%
via Plant height	2,4943	33,9164
via Biological yield per plant	0,8009	10,8903
via Pods per plant	-2,5561	34,7567
via Grain protein content	-0,6012	8,1742
via Dry weed weight	-0,0498	0,6776
Grain Protein Content		
Correlation Coefficient		0,808
Direct Effect	Path Coefficient	%
	0,6808	7,6934
Indirect effect	Path Coefficient	%
via Plant height	-3,0833	34,8410
via Biological yield per plant	-0,9406	10,6282
via Pods per plant	3,2190	36,3737
via Harvest index	0,7523	8,5004
via Dry weed weight	0,1738	1,9633
Dry Weed Weight		
Correlation Coefficient		-0.550
Direct Effect	Path Coefficient	%
	-0,4825	10,2586
Indirect effect	Path Coefficient	%
via Plant height	1,6046	34,1157
via Biological yield per plant	0,4733	10,0623
via Pods per plant	-1,8099	38,4799
via Harvest index	-0,0880	1,8709
via Grain protein content	-0,2452	5,2127

Regression and determination coefficients of chickpea are given Figs. 1,2 & 3. Very high determination coefficient (R^2) between grain yield and plant height, biological yield per plant and pods per plant were found. The high values of the determination coefficients indicate that the more critical determinants of grain yield were plant height, biological yield per plant and pods per plant. Grain yield correlated positively with plant height and grain yield increased with increasing plant height up to 35 cm and then increased beyond this point. Grain yield showed positive and linear relationship with biological yield per plant and pods per plant. The association of plant height, biological yield per plant and pods per plant with grain yield has important implications for attaining high grain yield. Hasanuzzaman *et al.,* (2007) also observed that seed yield and pods plant was found positive, linear and significant relationship while they studied on the regression in chickpea. Relationships between independent characters and grain yield were determined by multivariate regression analysis. We found estimated equation for grain yield. Formula is: $\hat{Y}$: -1077 + 28 plant height + 59 biological yield per plant + 81 pods per plant, R^2: 60.8%.

The purpose of principal component analysis (PCA) is to reduce the dimensionality of a data set consisting of a large number of interrelated variables, while retaining as much as possible of the variation present in the data set. This is achieved by transforming to a new set of variables, the principal components (PCs), which are uncorrelated, and which are ordered so that the first few retain most of the variation present in all of the original variables (Jolliffe, 2002).

Results of principal component analysis are presented in Table 3 and graphically shown in Fig. 4. Increase in the number of components was associated with a decrease in eigenvalues. This trend reached its maximum at two factors. Variables could be grouped in two components and these components account for 93.2% of the total variation of grain yield. Results showed that PC_1 is correlated with plant height, biological yield per plant, pods per plant and grain protein content. PC_2 is correlated with harvest index and dry weed weight. Data in Table 3 show that PC_1 accounted for about 77.5% of the variation in grain yield; PC_2 for 15.7%. So, plant height, biological yield per plant, pods per plant, harvest index, grain protein content and dry weed weight shown to be the important variables affecting greatly grain yield.

Hierarchical cluster analysis with chickpea variables was used and resulted in a dendogram (Fig. 5). These methods start with the calculation of the distance of each variable in relation to other variables. Groups are then formed by the process of agglomeration division. In this process , all variables start individually in groups of one. Close groups are then gradually merged until finally all variables make a single group. Repeated splitting of the groups will result in all evaluated variables being in groups of their own. For quantitative characters, number of clusters were chosen from the hierarchical analysis (Leilah & Al-Khateeb, 2005). In this study cluster analysis and dendogram are given in Table 4 and Fig. 5. The similarity level increased as the number of cluster increased. In distance of 0.897% and similarity level of 55.16%, all variables could be agglomerated in two clusters. Cluster 1 included plant height, biological yield per plant, pods per plant and grain protein content while cluster 2 included harvest index and dry weed biomass. The study results proved that plant height, biological per plant and pods per plant were the variables most closely related to grain yield.

Table 3. Eigenvalue of the correlation matrix for the characters in chickpea by the principal component analysis.

	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6
Plant height (X_1)	0.459	-0.036	0.195	-0.276	-0.319	0.757
Bio. yield p.p. (X_2)	0.451	-0.008	0.330	0.350	0.747	0.083
Pods per plant (X_3)	0.443	-0.085	0.489	0.129	-0.483	-0.555
Harvest index (X_4)	-0.380	-0.467	0.572	-0.513	0.216	-0.035
Grain prot. cont. (X_5)	0.440	0.172	-0.317	-0.711	0.245	-0.333
Dry weed biom. (X_6)	-0.226	0.863	0.432	-0.131	0.014	0.00
Eigenvalue	4.6510	0.9428	0.3153	0.0742	0.0168	-0.0000
Proportion	0.775	0.157	0.053	0.012	0.003	-0.000
Cumulative (%)	77.5	93.2	98.5	99.7	100	100

Table 4. Similarity and distance level of characters.

Step	Clusters (No.)	Similarity level	Distance level
1	6	98.93	0.021
2	5	98.92	0.022
3	4	96.40	0.072
4	3	95.72	0.086
5	2	55.16	0.897
6	1	31.99	1.360

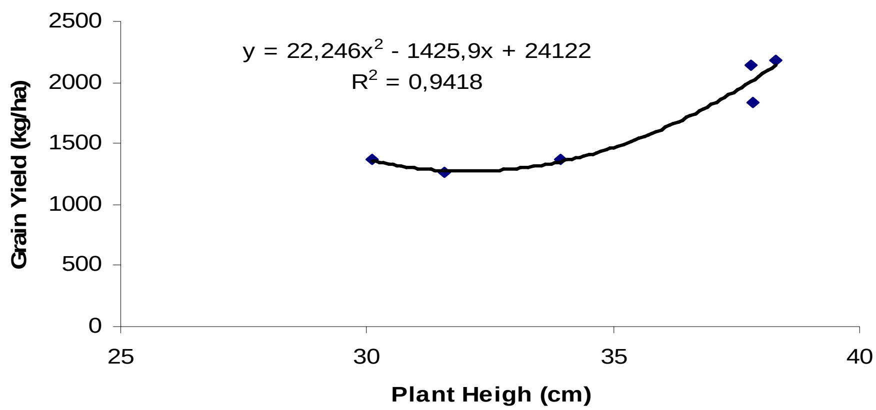

Fig. 1. Relationships between grain yield and plant height in chickpea.

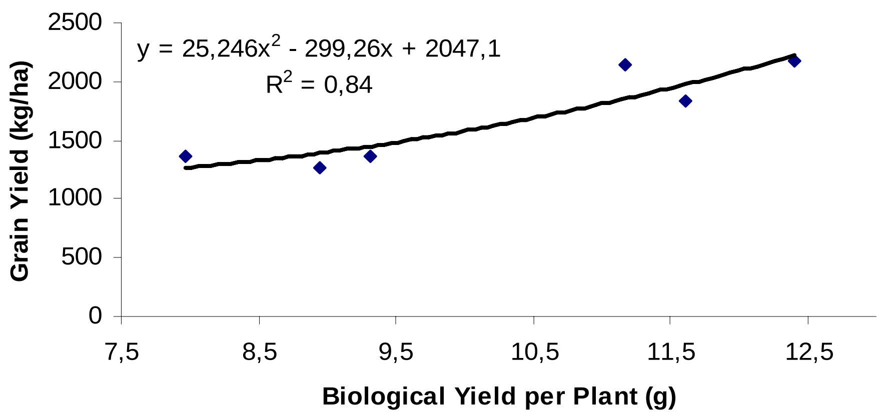

Fig. 2. Relationships between grain yield and biological yield per plant.

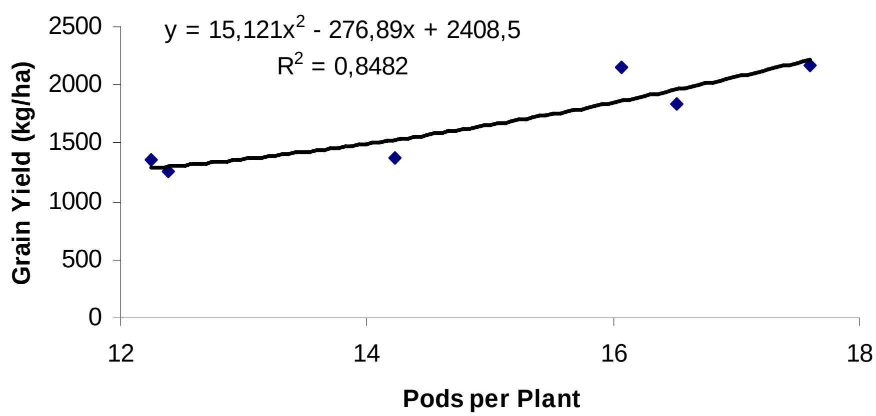

Fig. 3. Relationships between grain yield and pods per plant in chickpea.

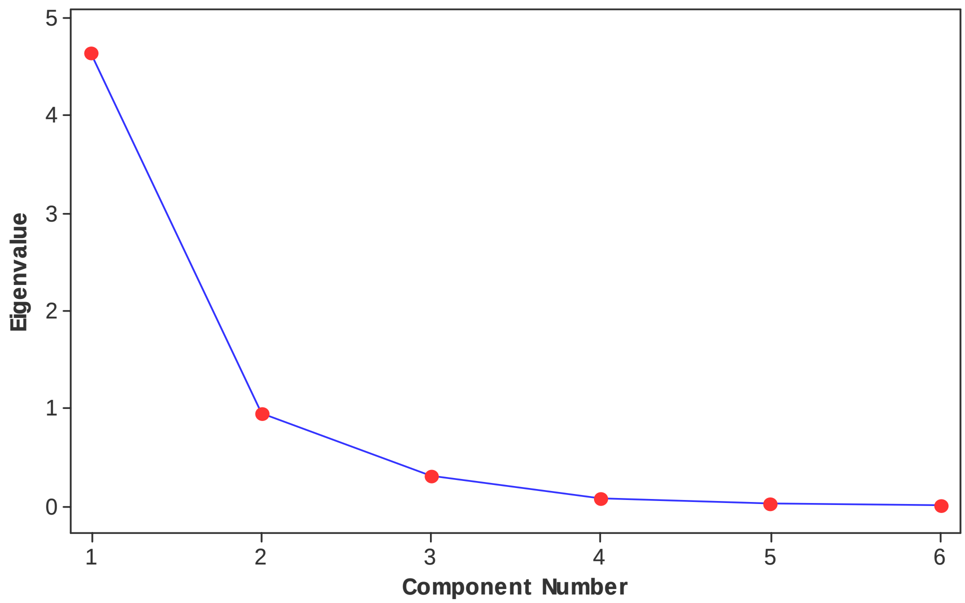

Fig. 4. Screen plot showing eigenvalues in response to number of components for the estimeted variables of chickpea.

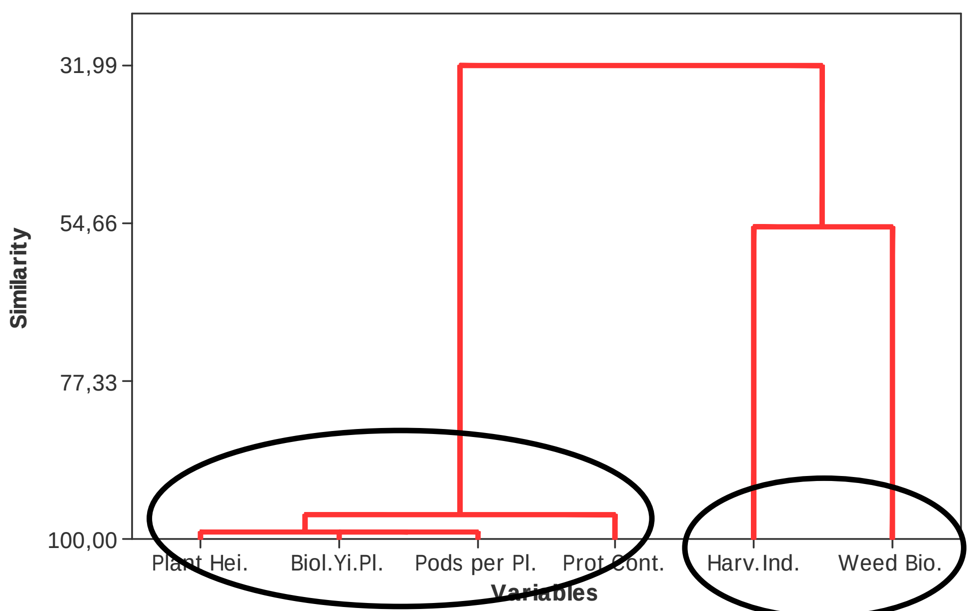

Fig. 5. Similarity levels of the estimated 6 chickpea characters using the dendogram analysis. Showing cluster 1 (including plant height, biological yield per plant, pods per plant and grain protein content), cluster 2 (including harvest index and dry weed biomass).

Conclusions

It is concluded that plant height, biological yield per plant and pods per plant are the most important yield variables to be considered in chickpea. Thus, high yield of chickpea plants can possibly be obtained by selecting breeding materials with high plant height, biological yield per plant and pods per plant.

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