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Evaluation of Selection Criteria in Winter Chickpea Using Correlation Coefficient and Path Analysis

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Abstract: This study was conducted to determine the relationships among seed yield and yield components, and their direct and indirect effects of contributing characters to seed yield in winter chickpea genotypes in 2011 and 2012 under Diyarbakır (GAP International Agricultural Research and Training Center) conditions. Five chickpea (Diyar 95, Arda, Yaşa 05, İnci and Aksu) cultivars were used in the study. The study was carried out in the Randomized Complete Block Design with four replications. The cultivars showed significant differences for all examined plant characteristics excluding number of primary branches and number of seeds pod-1 ($p < 0.01$ and $p < 0.05$). Highly significant and positive ($p < 0.01$) correlations were found between grain yield with plant height, primary branches per plant, number of full pods per plant and seeds per plant, while 100-seed weight was negatively and significantly ($p < 0.05$) correlated with seed yield. Path coefficient analysis results indicated that number of full pods per plant (1.048), plant height (0.352), seeds per plant (0.334) and seed per pod (0.332) were the major yield contributing characters due to their high direct and positive effects on grain yield. It was found that plant height and number of primary branches plant-1 had the highest indirect effect on grain yield via number of pod per plant. As a result, it was determined that plant height, number of pods plant^{-1}, number of seeds pod^{-1} and number of seeds plant^{-1} can be good selection criteria for high grain yield in winter kabuli type chickpea breeding studies.

Key words: Chickpea (*Cicer arietinum* L.), Correlation, Grain yield, Selection criteria, Path analysis.

Kışlık Nohutta Korelasyon Katsayısı ve Path Analizi Kullanarak Seleksiyon Kriterlerinin Değerlendirilmesi

Özet: Bu araştırma kışlık nohut genotiplerinde tane verimi ve verimle ilgili özellikler arasındaki ilişkiler ve bu özelliklerin tane verimi üzerindeki doğrudan ve dolaylı etkilerini belirlemek amacıyla 2011 ve 2012 yıllarında Diyarbakır (GAP Uluslararası Tarımsal Araştırma ve Eğitim Merkezinde) koşullarında yapılmıştır. Araştırmada beş nohut (Diyar 95, Arda, Yaşa 05, İnci ve Aksu) çeşidi kullanılmıştır. Çalışma Tesadüf Bloklar Deneme desenine göre dört tekrarlamalı olarak yürütülmüştür. Çeşitler, incelenen karakterlerden bitkide ana dal sayısı ve baklada tane sayısı hariç bütün özellikler bakımından önemli ($p < 0.01$ ve $p < 0.05$) farklılıklar göstermişlerdir. Tane verimi, yüz tane ağırlığı ile olumsuz ve önemli ($p < 0.05$) ilişki gösterirken, tane verimi ile bitki boyu, bitkide ana dal sayısı, bitkide dolu bakla sayısı ve bitkide tane sayısı arasında olumlu ve çok önemli ($p < 0.01$) ilişkiler bulunmuştur. Path analizi sonuçları tane verimine katkıda bulunan başlıca özelliklerin doğrudan ve olumlu etkilerinden dolayı bitkide dolu bakla sayısı (1.048), bitki boyu (0.352), bitkide tane sayısı (0.334) ve baklada tane sayısı (0.332) olduğunu göstermiştir. Tane verimine en yüksek dolaylı etki bitkide bakla sayısı vasıtasıyla bitki boyu ve bitkide ana dal sayısında bulunmuştur. Sonuç olarak bitki boyu, baklada tane sayısı, bitkide bakla ve tane sayısının kışlık kabuli tip nohut ıslah çalışmalarında, yüksek verim için iyi bir seleksiyon kriterleri olabileceği gösterilmiştir.

Anahtar kelimeler: Nohut, Korelasyon, Tane verimi, Seleksiyon kriteri, Path analizi,

Introduction

Chickpea breeding studies mainly concentrate on achieving optimum yield level by developing cultivars with high yield that comply with various ecologic conditions. Grain yield, is the most important

characteristic for plant breeders, is a complex characteristic created by reciprocal interactions between different phonologic stages during the vegetation period of plants and physiologic and morphologic characteristics at these stages. Breeding of high-yielding genotypes depends on knowing how and to what extent these characteristics are affected and defining the causes of variations in grain yield in a certain environment (Baker et al., 1968). Determining the relationships between grain yield and the factors affecting yield only according to correlation coefficient and managing breeding studies based on these findings might not always give promising results. Since a relationship between two variables can sometime be dependent on a third variable, it might not be adequate to explain the cause and effect relationship between yield and yield parameters using correlation coefficient (Boerma and Cooper, 1975). A variation in one of the two parameters that have a positive or negative effect on yield level independently from each other can result in decreasing or increasing variations in the other parameter and it is impossible to identify these types of indirect effects using correlation coefficient (Chauhan and Singh, 1998). Therefore, path analysis, which determined direct and indirect effect of each characteristic on yield by separating correlation coefficient between yield and yield parameters into direct and indirect effects, makes the relationship between the characteristics more understandable and feasible, allowing the researchers to make a more effective selection (Comstock and Moll, 1963; Raju et al., 1978).

The effects of grain yield characteristics on grain yield and the interactions between these characteristics can vary according to ecologic conditions and cultural practices in addition to genotypic structure. Chickpea (*Cicer arietinum* L.) is one of the most commonly cultivated species among edible grain legumes plants produced in Turkey (TÜİK 2013). This species is traditionally sown in summer to avoid anthracnose (*Ascochyta rabiei*) disease. Low-yielding problem is the case for this species. On the other hand, determining high yield potential in winter sowing conditions requires breeding of genotypes that are appropriate for winter sowing. The performance of chickpea genotypes can show annual variations in terms of grain yield and other characteristics due to potential deviations such as high or low temperature or precipitation in growth and development process which extends to a longer period in winter sowing. This study attempted to determine the traits to achieve optimum yield levels in chickpea by examining the relationships between grain yield and yield related characteristics in some chickpea genotypes using path analysis to contribute to winter sown chickpea breeding studies.

Materials and Methods

The experiment was conducted during the winter seasons of 2010-11 and 2011-12, in the GAP International Agricultural Research And Training Center, in the Diyarbakır. The experiment was designed according to Randomized Complete Block Design (RCBD) with four replications and five chickpea cultivars (Diyar 95, Arda, Yaşa 05, İnci and Aksu originated in Turkey) were used as experimental materials. Each variety was sown in 4 rows, 5 m in length, with 45 cm inter-row spacing; there were 45 plants per square metre. Trails were sown in the first week of December in both years. Before sowing, 40 kg ha^{-1} N and 60 kg ha^{-1} P_2O_5 fertilisers were applied.

The data, which consists of 9 different characters, including days to 50% flowering (DTF), plant height (PH), first pod height (FPH), primary branch number (PBN), number of pods per plant (FPN), seeds number (SN), 100 seed weight (SW), number of seed per pod (SPOD), and grain yield (GY) were recorded (Şehirali et al 1988). Data on grain yield and days to 50% flowering were recorded from the whole plot, but all the other yield components data were recorded from randomly selected 10 plants in each plot. The data were analysed according to the RCBD over years. In order to determine the relationships between examined traits and grain yield per ha, correlation coefficients were calculated with the JMP5.0.1 program. Path coefficients were calculated according to Dewey and Lu (1959), where grain yield per ha was kept as resultant variable and other contributing characters as causal variables.

Soil analysis results of trial area were given in Table 1. The soil of the research area was 20-40 cm deep and clayey-loamy. Depending upon soil depth, pH, calcium, and available phosphorus concentration and organic substance were 8.02-8.07, 7.41% - 7.93%, 33.8 -39.5 kg ha^{-1}, and 1.2% - 1.66%, respectively (Table 1).

Table 1. Soil Analysis Results of Trial Area

Soil Property	Year	
	2011	2012
pH	8.07	8.02
Calcium (%)	7.41	7.93
Organic substance (%)	0.15	1.66
P_2O_5 (kg/ha)	39.5	33.8
The soil texture	clayey-loamy	clayey-loamy

The Southeastern Anatolia Region is one of Turkey's seven census-defined geographical regions, and is characterized by a continental climate. In this region, summers are dry and hot, but winters are cool and rainy. Rainfall in the region is variable both within and among years. Monthly average temperature, humidity and total precipitation records during the study years and the long-term averages, are summarized in Table 2. According to the long-term averages from 6 decades of records (during the chickpea growing season) there is a yearly total precipitation of 449 mm and a mean temperature of 10.6 °C. Most precipitation of the first year was in spring months, while the second year mostly in winter months.

Table 2. Climatic data of research site of Diyarbakır province

Years	Months							
	November	December	January	February	March	April	May	June
	Monthly Average Temperature (° C)							
2010/2011	11.1	6.5	3.5	4.7	9.0	13.0	17.7	25.5
2011/2012	6.4	2.3	2.4	1.9	5.1	15.2	19.6	27.7
1954 - 2013	8.9	3.7	1.6	3.5	8.3	13.7	19.1	26.3
	Monthly Mean Relative Humidity (%)							
2010/2011	41.1	68.9	73.4	69.5	56.4	75.7	67.6	38.0
2011/2012	58.8	73.9	84.4	68.2	59.2	58.5	58	27.8
1954 - 2013	68.0	77.0	77.0	73.0	66.0	63.0	56.0	23.0
	Total Monthly Precipitation (mm)							
2010/2011	0.0	48.0	40.0	49.9	46.6	209.0	80.1	13.6
2011/2012	73	40.2	78.3	74.4	44	26.2	41	7
1954 - 2013	52.6	72.5	70.1	66.9	67.0	68.0	43.3	8.5

*Diyarbakır Meteorology Regional Directorate (2013)

Results and Discussion

The study compared yield and some yield characteristics in winter chickpea cultivars. Results of analysis of variance for all examined characteristics based on two-year results are presented in Table 3. The homogeneity test was performed for the year combined. It was concluded that between the years showed a homogeneous distribution for investigated traits. Analysis of variance indicated significant differences ($P<0.01$ and $p<0.05$) for all the traits excluding PH, FPN, SPOD among genotypes.

Table 3. Analysis of variance of different multigenic characters in chickpea

Sources of Variation	d.f	GH	DTF	PH	FPH	PBN	FPN	SPOD	SW	SP
Genotypes	4	16261.9 **	59.40* *	14.80n s	19.81* *	0.78 **	9.70 ns	0.03 ns	37.8 **	3.38 ns
Replications	3	202.2	1.40	10.4	9.1	0.02	8.05	0.06	0.86	3.66
Eror	12	549.2	0.81	9.7	3.2	0.09	6.09	0.02	0.80	2.17
Total	19									

*, **, ns :Significant at P<0.05 and P<0.01 levels, ns: no significant.
GH :grain yield per hectare, DTF: days to 50% flowering, PH: plant height, FPH: first pod height, PBN: primary branches per plant, FPN : number of full pods per plant, SPOD: seed per pod, 100 SW :100-seed weight., SP= seeds per plant

Correlation coefficient analysis

Correlation coefficients for the examined characteristics were given in Table 4.

Table 4. The correlation coefficients among the characters examined in chickpea (*Cicer arietinum* L.)

Traits	**GY**	**DTF**	**PH**	**FPH**	**PBP**	**FPN**	**SPOD**	**SW**
DTF	0.014ns							
PH	0.584**	0.272ns						
FPH	0.247ns	0.209ns	0.771**					
PBP	0.622**	0.170ns	0.734**	0.540**				
FPN	0.821**	-0.003ns	0.413**	0.165ns	0.475**			
SPOD	-0.245ns	0.023ns	-0.176ns	-0.074ns	-0.328*	-0.378*		
SW	-0.383*	-0.144ns	0.071ns	0.243ns	0.126ns	-0.419**	-0.189ns	
SP	0.680**	-0.049ns	0.361*	0.204ns	0.395**	0.829**	0.103ns	-0.279ns

* : Significant at P<0.05 , **: P<0.01 level, ns: no significant
GY =Grain yield per hectare, DTF= Days to 50% flowering, PH= Plant height, FPH= First pod height, PBP= Primary branches per plant, FPN = Number of full pods per plant, SPOD= Seed per pod, SW =100-Seed weight, SP= seeds per plant

According to our findings, there are positive and significant relationships between grain yield and plant height (r= 0.584), number of primary branches (r= 0.622), number of pods per plant (r= 0.821) and number of seeds per plant (r= 0.680); while there are negative and significant relationships with 100 grain weight (r= -0.383). Singh et al. (1990), Çiftçi et al. (2004), Talebi et al. (2007) and Yucel et al. (2010) also reported similar results. Güler et al. (2001) reported that significant and positive relationships were found between seed yield per plant and seed number and pod number per plant.

We found a positive and high correlation between plant height and first pod height; number of primary branches, number of pods per plant and number of seeds per plant. It was found that there was a positive and significant relationship between number of primary branches and number of pods per plant and number of seeds per plant. On the other hand, there was a negative and significant relationship with number of seeds per pod. These results suggest that any positive increase in such traits will improve the seed yield of chickpea, and are in agreement with the findings of Raval and Dobariya (2003), Obaidullah et al**.** (2006), Saleem et al. (2002), Toker and Cagirgan (2004), Yücel et al. (2006), Farshadfar et al. (2008), Amjad et al. (2009) and Zali et al. (2011). There was a positive and significant relationship between number of pods per plant and number of seeds per plant; however, there was a negative and significant relationship between number of seeds per pod and 100 grain weight (Table 4).

Path coefficient analysis

Grain yield was considered as the dependent variable. Path coefficient analysis results on direct and indirect effects of examined yield parameters on grain yield are presented in Table 5.

Correlation coefficient calculated between the two variables can include the effect of variables only and their effects with other variables (indirect effects). "Path analysis" should be used to identify the parts caused by the relationship with other variables in correlation coefficient that is calculated between the variables (Singh et al., 1988).

Table 5. The direct, indirect effect, and % contribution of various characters to grain yield in chickpea (*Cicer arietinum* L.)

Traits	**Direct effect**	**Indirect effects**							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
DTF (1)	-0.116 (1)	-	0.096	-0.043	0.048	-0.004	0.008	0.004	0.021
	34.3% (2)		28.2%	12.7%	14.1%	1.0%	2.3%	1.2%	6.2%
PH (2)	0.352	-0.032	-	-0.158	0.206	0.433	-0.059	-0.002	-0.157
	25.2%	2.3%		11.3%	14.7%	31.0%	4.2%	0.2%	11.2%
FPH(3)	-0.205	-0.024	0.271	-	0.152	0.174	-0.024	-0.007	-0.088
	21.7%	2.6%	28.7%		16.0%	18.4%	2.6%	0.7%	9.4%
PBP (4)	0.281	-0.020	0.258	-0.111	-	0.498	-0.109	-0.004	-0.171
	19.4%	1.4%	17.8%	7.6%		34.3%	7.5%	0.3%	11.8%
FPN (5)	1.048	0.000	0.145	-0.034	0.133	-	-0.125	0.012	-0.359
	56.4%	0.0%	7.8%	1.8%	7.2%		6.8%	0.7%	19.3%
SPOD (6)	0.332	-0.003	-0.062	0.015	-0.092	-0.396	-	0.006	-0.045
	35.0%	0.3%	6.5%	1.6%	9.7%	41.7%		0.6%	4.7%
SW (7)	-0.029	0.017	0.025	-0.050	0.035	-0.439	-0.063	-	0.121
	3.7%	2.2%	3.2%	6.4%	4.5%	56.4%	8.1%		15.5%
SP (8)	0.334	-0.003	-0.062	0.015	-0.092	-0.395	-0.045	0.005	-
	34.9%	0.2%	6.5%	1.6%	9.7%	41.7%	4.7%	0.6%	

GY :grain yield per hectare, DTF: days to 50% flowering, PH: plant height, FPH: first pod height, PBP: primary branches per plant, FPN : number of full pods per plant, SPOD: seed per pod, SW :100-seed weight, SP: seeds per plant

It is understood from the Table 5 that, of the examined yield parameters, plant height, number of primary branches, number of pods per plant and number of seeds per plant had significant positive direct effects on grain yield; while they had negative effects on flowering time, first pod height and 100 grain weight. Number of pods per plant had the highest direct effect (p=1.048), followed by plant height (p= 0.352), number of seeds per plant (p=0.334) and number of seeds per pod (p=0.332). Results of path coefficient analysis showed that number of primary branches and plant height had positive and significant indirect effects on grain yield via number of pods per plant.

These results were in agreement with the study carried out by Yücel et al. (2006). However, they had negative direct effects on number of seeds per plant, 100 grain weight and number of seeds per pod. İndirect effects of examined the characters on grain yield via flowering time, first pod height, number of seeds per pod and 100 grain weight has been insignificant (Table 5).

Conclusion

The correlation coefficient revealed that important characters influencing grain yield (kg ha^{-1}) were plant height, primary branches per plant, number of full pods per plant, seeds per plant and 100-seed weight. However, 100-seed weight showed a negative association with grain yield. Path coefficient analysis for yield components in winter chickpea cultivation revealed that plant height, primary branches per plant, number of full pods per plant, seed per pod and seeds per plant had direct effect on grain yield. The highest direct effect on grain yield was number of full pods per plant (1.048), and the ratio of the direct effect on seed yield is 56.4%. The second and the third highest positive direct effect on grain yield were seed per pod and seeds per plant, respectively. On the basis of these results it was suggested that pods per plant, seeds per plant and plant height can be considered as priority selection criteria in breeding studies while making selection for higher yield potential in winter chickpea.

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