Variability studies in cowpea (*Vigna unguiculata* [L.] Walp.) varieties grown in Isparta, Turkey

Estudios de variabilidad en variedades de frijol (*Vigna unguiculata* [L.] Walp.) cultivadas en Isparta, Turquía

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ABSTRACT

Eleven varieties of cowpea (*Vigna unguiculata* [L.] Walp.) selected from nine localities in Turkey were evaluated for variability in yield and yield component characters in 1996 and 1997 cropping seasons using a randomized complete block design with three replications. Significant differences were found among the varieties for agronomic characteristics such as seed yield, biological yield and crop cycle. Factor analysis based on principal components (PC) showed that two factors represented 99.13% of the total variation. PC_1 accounted for 98.69% of the total variance that was highly correlated with seed and pod size factors. PC_2 may be considered as crop cycle and yield/plant. The varieties clustered into two groups by factor and cluster analyses.

Key words: *Vigna unguiculata*, cowpea varieties, factor analysis, cluster analysis.

RESUMEN

Once variedades de frijol (*Vigna unguiculata* [L.] Walp.) seleccionadas en nueve localidades en Turquía se evaluaron para determinar la variabilidad en los caracteres de rendimiento y sus componentes durante los años de producción 1996 y 1997, utilizando un diseño de bloques completos al azar con tres repeticiones. Se observaron diferencias significativas entre las variedades para características agronómicas tales como rendimiento de semillas, rendimiento biológico y ciclo del cultivo. El análisis de factores basado en los componentes principales (PC) mostró que los dos primeros factores representaron el 99,13% de la variación total. PC_1 explicó el 98,69% de la varianza total y estuvo altamente correlacionado con los factores del tamaño de semillas y de las vainas. PC_2 puede ser considerado como el factor del ciclo del cultivo y rendimiento por planta. Los once genotipos examinados se separaron en dos grupos mediante los análisis de factores y de agrupamiento.

Palabras clave: *Vigna unguiculata*, variedades de frijol, análisis de factores, análisis de agrupamiento.

INTRODUCTION

The importance of plant genetic resources and the need for screening adaptive traits can not be overlooked. Their vital significance for their maintenance of genetic improvement and biodiversity has been recognized worldwide (Lester *et al.,* 1986). Adaptation characterization and evaluation is a priority task for successful breeding program.

Cowpea (*Vigna unguiculata* [L.] Walp) as an animal feeding stuff is an important crop and subject to scientific studies especially in some developing and less developed countries. For example there are some studies about breeding of cowpea (Sepetoğlu and Ceylan, 1979; Ceylan and Sepetoğlu, 1983; Altınbaş and Sepetoğlu, 1993). These works have generally focused on to develop quality and yield components of cowpea. Work is also underway on documenting global genetic cowpea resources in certain countries (Singh and Jackai. 1985; Singh and Emechbe, 1990; Singh, 1993; Hall *et al*. 1997; Padi 2004).

Cowpea is an important grain legume in drier regions and marginal areas of the tropics and subtropics, which can be grown in relatively infertile sandy soils with a minimum annual rainfall of 200mm. It is a fast growing, drought resistant crop, which also improves soil fertility by fixing atmospheric nitrogen (Ortiz,1998). The grain is a good source of human protein, while the haulms are valuable source of livestock protein (Fatukun, 2002). Cowpea seeds contain 200-300 g crude protein and 600 g carbohydrate/kg seed. The chemical composition is influenced by environmental and genetic factors (Sultan Singh *et al*., 2006).

Multivariate statistical methods especially cluster analysis as a tool to classify varieties with similar conditions with respect to set of variables has gained increasing interest in recent years. Similar analysis has already been used in some studies (Vaupel and Yashin, 1985; Kahn and Stoffella, 1989; Mathehou *et al*., 1995 and Sabater, 2004).

This study aims to evaluate agronomic characteristics of some cowpea varieties and to classify these varieties according to the variation in those characteristics. Effort has made to examination of the genetic differences among cultivars and to group them into relatively homogenous groups.

MATERIAL AND METHODS

Eleven most important local cowpea varieties grown in Turkey, named for statistical analysis as Karagöz ($V_{1)}$, Akkız (V_2), Burdur (V_3), Aydın (V_4), Bursa (V_5), Denizli (V_6), Antalya (V_7), Fethiye (V_8), İzmir (V_9), Isparta (V_{10}) and Balıkesir (V_{11}), were studied during the 1996 to 1997 production years. Experiments were carried out in Isparta province which is one of the most important regions for cowpea production in Turkey (Anonymous, 1996). The average air temperature of the years 1996-1997 was between 12.5-13.4 ºC and average precipitation was 541.6-496.4 mm (Anonymous, 1997a). The soil was clay-silt, insipid, more limely, average in phosphorus and average in organic matter (Anonymous, 1997b). A randomized complete block design was used with three replications. Plot size was $4 \times 2 = 8\ m^2$. Fertilizers were applied before seeding at 2 kg N/da and 4 kg P/da (1 da = 1000 m^2). Data on different crop characteristics were recorded by following standard procedures.

Factor analysis with principal component (PCA) and cluster analyses were used to determine the suitability of features to characterize the variation of the observations and to determine natural groups from the cultivars studied (Johnson and Wichern, 1992; Jolliffe and Ringrose, 1998; Adam Ding and Gene Hwang, 1999). In the first phase, factor analysis had been used for identification of the number of PCA's. In the second phase, cluster method had been used to determine disparities and similarities. PCA method provides to form new sets which are different from the beginning set. Reflecting of the variables at R is one of advantages of the method. The usual objective of the analysis was to see if the first few components accounted for most of the variation in the original data (Chatfield and Collins, 1980; Jackson, 1991).

The approach used to group varieties was cluster analysis, which is a well-known method within the multivariate statistical approaches (Hair *et al*., 1995). It is based on the minimizing of the variance in the group and maximizing of the variance among groups (Johnson and Wicherin, 1992). The distance between two varieties in which data have been standardized, can be stated as the monotonic transformation of the correlation between the two variables (Kendall, 1980). The theory behind clustering is an expected positive relationship between the variables Euclidean distance and the similarity of the observations. As a result, cluster analysis is driven by the trade-off between minimizing the Euclidean distance of observations within a cluster, and maximizing the Euclidean distance between clusters. The primary purpose of the cluster analysis was to provide delineation of what cropping system constitute them. Agronomic results in this way will be used for subsequent breeding studies.

The graphical displaying of grouping results of the acquired data has been made, carried out with drawing two dimensional diagrams. The analysis filters automatically determined the primary and dominant crops for cluster characterization. The panel data grouped in 15 characteristics of varieties has been evaluated by multivariate statistical methods. It has been determined internally homogenous groups of cowpea varieties on the basis of crop characteristics. For the classifying assessment, we did cluster analysis using a divisive hierarchical algorithm on the matrix of eleven cultivars.

RESULTS AND DISCUSSION

The varieties were classified into 2 categories as follows on the basis of their crop cycles: early varieties had a crop cycle between 97 and 109 days and they were harvested in end of August, while mid-early varieties had a crop cycle between 110 and 120 days and they were harvested by September.

Mean values for each cultivar over 2 years were used in the comparative assessment. Varieties Bursa and Balıkesir were grown in North-west Anatolia region of Turkey while all others were grown in West and/or South Anatolia region. A description of these eleven varieties used is presented in Table 1.

Table 1. Average values of quantitative characteristics of pods and seeds of 11 cowpea (*Vigna unguiculata* [L.] Walp.) varieties grown under Isparta conditions in Turkey over two years (1996 and 1997).

	Quantitative characteristics †														
Vr.‡	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
V_1	56.9	10.6	5.4	7.9	33.7	4.6	158	36.5	21.8	7.3	103	12.6	51.0	0.78	55.3
V_2	70.9	11.5	5.9	8.0	40.5	5.0	137	36.2	19.3	8.7	105	11.9	48.0	0.77	53.2
V_3	49.1	8.9	4.5	6.0	25.9	4.4	178	41.5	17.8	5.7	106	11.6	52.5	0.79	59.3
V_4	62.9	11.2	5.6	6.1	32.4	5.1	188	42.7	21.2	8.1	108	12.1	47.7	0.78	51.2
V_5	50.9	11.6	5.3	6.6	34.2	5.1	150	40.2	19.3	8.0	108	10.8	50.0	0.77	53.3
V_6	55.1	11.5	5.9	7.1	36.6	5.2	158	40.8	19.2	9.2	112	12.1	51.0	0.77	56.0
V_7	49.2	10.5	5.4	5.9	31.2	5.1	174	41.2	18.3	6.7	108	12.3	52.2	0.74	56.2
V_8	65.8	14.6	6.2	7.2	36.9	5.2	174	44.5	22.0	9.0	118	11.0	49.0	0.80	51.2
V_9	68.0	11.8	6.6	7.7	38.0	4.6	177	38.2	19.7	9.9	111	11.6	44.8	0.81	50.2
V_{10}	69.1	13.2	6.8	6.7	35.2	5.3	185	40.5	22.7	9.2	100	12.3	45.5	0.82	50.7
V_{11}	71.6	13.6	6.6	7.6	40.3	5.1	167	40.0	22.2	9.9	113	11.9	44.3	0.78	48.8

† 1. Yield (kg/da), 2. Biological yield (g/plant), 3. Seed yield per plant (g), 4. Pod number per plant, 5. Seed number per plant, 6. Seed number per pod, 7. 1000 seed weight (g), 8. Pod length of plant (cm), 9. Height of first pod (cm), 10. Bunch number, 11. The length of crop cycle (day), 12. Length of pod (cm), 13. Maturation of pod (day), 14. Pod width (cm), 15. Flowering 50%. (1 da = 1000 m^2).

‡ Varieties (Vr.): Karagöz (V_1), Akkız (V_2), Burdur (V_3), Aydın (V_4), Bursa (V_5), Denizli (V_6), Antalya (V_7), Fethiye (V_8), İzmir (V_9), Isparta (V_{10}) and Balıkesir (V_{11}).

Factor analyses indicated two principal components which eigenvalues < 1 accounting for 99.13% of the overall variance. The first and most important principal component (PC_1), accounting for 98.69% of the total variance was characterized by seed and pod size factors. Then, seed and pod size factors which explained 98.69% of the total variance looked sufficient to show differences among the varieties. The seed and pod size parameters as the height of first pod, seed number, 1000 seed weight, biological yield, bunch number, length of plant, weight of pod contributed highly to this factor. Communalities (h_i^2) were generally high level consequently indicating that the similarities among the ecotypes were high (Table 2). Plotting the cultivars over the 1st and 2nd principal components grouped the most yielding varieties in the same area (Akkız and Balıkesir) (Figure 1).

Two principal components showed that results could be explained in two dimensional spaces (R). The second principal component (PC_2) accounting for 0.44 % of the total variance was characterized by the crop cycle and seed yield per plant.

As a result of this analysis, the investigated 11 varieties can be classified into eight groups. Indeed, there is not any standard procedure to determine the final number of cluster exist (Hair *et al*., 1995) instead many criteria and guidelines have been developed. For that reason, the set of varieties was run for different numbers of clusters: two, three, four, five, six, seven and eight clusters. The dendogram produced by cluster analysis grouped the varieties with the most width pod in the same cluster (Fethiye, İzmir and Isparta) (Figure 2). Cultivars were grouped into 3 clusters. Especially, some ecotypes which have the highest crop yield were grouped in same cluster (cultivars Akkız and Balıkesir).

Variety İzmir had a somewhat intermediate position in the cluster analysis (Figure 1). Also this variety had the maximum similarity across other cultivars. However, the most different variety was Bursa.

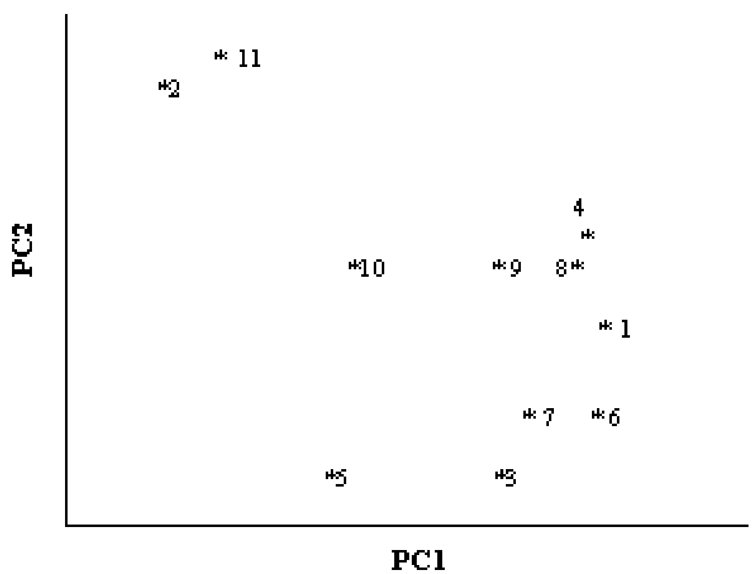
As the agronomical characteristics of included cultivars are recognized by a great variation in all varieties for these experiments, cultivars seem promising.

Table 2. Principal components and communalities rates for 15 variables† of 11 cowpea (*Vigna unguiculata* [L.] Walp.) varieties grown under Isparta conditions in Turkey over two years (1996 and 1997).

Varieties ‡	Principal Component 1	Principal Component 2	Communalities (h_i^2)	Variance Matrix (ε_i, ψ)
V_1	0.997	- 0.121	0.994	0.006
V_2	0.989	0.103	0.977	0.023
V_3	0.994	- 0.723	0.987	0.013
V_4	0.996	0.026	0.992	0.008
V_5	0.990	- 0.970	0.979	0.021
V_6	0.997	- 0.063	0.993	0.007
V_7	0.996	- 0.059	0.991	0.009
V_8	0.995	0.016	0.990	0.010
V_9	0.994	0.021	0.998	0.012
V_{10}	0.992	0.116	0.985	0.015
V_{11}	0.989	0.004	0.979	0.021

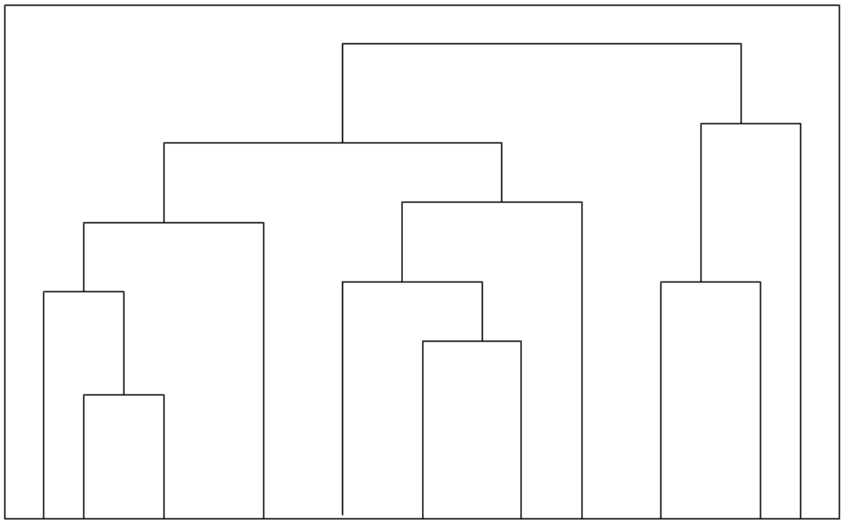
† 1. Yield per plant (kg/da), 2. Biological yield (g/plant), 3. Seed yield per plant (g), 4. Pod number per plant, 5. Seed number per plant, 6. Seed number per pod, 7. 1000 seed weight (g), 8. Pod length of plant (cm), 9. Height of first pod (cm), 10. Bunch number, 11. The length of crop cycle (day), 12. Length of pod (cm), 13. Maturation of pod (day), 14. Pod width (cm), 15. Flowering 50%. (1 da = 1000 m^2).

‡ Varieties (Vr.): Karagöz (V_1), Akkız (V_2), Burdur (V_3), Aydın (V_4), Bursa (V_5), Denizli (V_6), Antalya (V_7), Fethiye (V_8), İzmir (V_9), Isparta (V_{10}) and Balıkesir (V_{11}).



Varieties: Karagöz (1), Akkız (2), Burdur (3), Aydın (4), Bursa (5), Denizli (6), Antalya (7), Fethiye (8), İzmir (9), Isparta (10) and Balıkesir (11).

Figure 1. Principal components (PC), PC_1 and PC_2 based on 15 evaluated traits (see Materials and Methods section) of 11 cowpea (*Vigna unguiculata* [L.] Walp.) varieties grown under Isparta conditions in Turkey over two years (1996 and 1997).



Varieties: Karagöz (1), Akkız (2), Burdur (3), Aydın (4), Bursa (5), Denizli (6), Antalya (7), Fethiye (8), İzmir (9), Isparta (10) and Balıkesir (11).

Figure 2. Dendogram based on 15 evaluated traits (see Materials and Methods section) of 11 cowpea (*Vigna unguiculata* [L.] Walp.) varieties grown under Isparta conditions in Turkey over two years (1996 and 1997).

CONCLUSIONS

On the basis of multivariate cluster analysis classifying of 11 cowpea varieties in eight groups has been suggested. Most of used variables mean values were increasing or decreasing (depending if indicator is positively or negatively correlated with crop data) from the first to the last group. The multivariate analysis clearly showed that there was wide variation among the 11 varieties with regard to important characteristics.

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