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Full Length Research Paper

Agro-morphological characterization of the Turkish lentil landraces

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A collection of lentil landraces comprising 39 genotypes from the south east Anatolia region of Turkey and 7 commercial varieties, were evaluated for 23 (8 qualitative and 15 quantitative) agro-morphological characteristics. A wide range of diversity of almost all of the plant characteristics that were studied was recorded for the lentil genotypes. Principal component analysis (PCA) was performed for 12 quantitative traits. The first three principal components accounted for 73.13% of the total variation. PC_1 was positively related to the biological yield, the weight of the pods/plant, the number of the pods/plant, the number of the seeds/plant and the weight of the seeds/plant. PC_2 was closely correlated with the flowering duration, days to maturity and the diameter of the seed and was negatively correlated to days of flowering. PC_3 was positively related to the plant height, the length of the internodes and the protein content and was negatively related to the 100 seed weight. Following the analysis of the agronomic characteristics over the first and second principal components, the lentil landraces formed 4 - 5 different groups.

Key words: Lentil, landraces, agro-morphological, characterization.

INTRODUCTION

The lentil (*Lens culinaris* Medik) is a self-pollinating diploid (2n = 2x = 14) food-legume and is one of the most ancient domesticates (Zohary, 1972; Erskine, 1997). The lentil was domesticated with cereals and other pulse crops in the fertile crescent area of the near east and then spread throughout southern Europe, the middle east, northern Africa and across the Indo-Gangetic plain before 100 BC (Summerfield et al., 1982). The earliest evidence of lentil cropping is through its association with wheat and barley at Mureybit in Syria, 8500 - 7500 BC, at Hacilar and Cayonu in Turkey, 7500 - 6500 BC and at other sites from western Iran to Palestine before 7000 BC (Cubero, 1981; Ford et al., 2007).

The lentil is an important dietary crop with a high content of proteins, micronutrients and vitamins that are important in human food. The mature vegetative parts serve as excellent fodder for animals (Sarker and Erskine, 2006). In dry areas with an insufficient rainfall, the crop is generally grown in rotation with cereals to break the cereal disease cycles and to fix atmospheric nitrogen, thus reducing the demand of other cereal crops for nitrogen fertilizers (Fikiru et al., 2007).

The collection, description and availability of a wide range of genetically diverse crops are essential prerequisite for initiating a meaningful breeding program (Berdahl et al., 1999; Naghawi and Johansouz, 2005; Poonam et al., 2006). In the last three decades, several studies have been conducted on the collection and description of lentil germplasms and landraces in the world. These collections have been utilized in lentil breeding programs (Erskine and Witcombe, 1984; Erskine et al., 1989; Fikiru et al., 2007). The largest and most representative collection of lentil landraces is maintained by the international center for agricultural research in the dry areas (ICARDA) (3351 accessions), and large collections are also held in the USA (2807), Russia (2857), Australia (2847) and Turkey (1435) (Ford et al., 2007). Several of the lentil landraces that have exhibited significantly superior root and shoot traits and yield were considered to be valuable

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germplasms for breeding a drought-tolerant cultivar (Sarker et al., 2005).

The Middle East and western Asia, including Turkey, has been identified as one of the origin of genetic sources of the lentil (Erskine et al., 1998; Ferguson and Robertson, 1999; Ford et al., 2007). The south east Anatolia region of Turkey is rich in lentil genetic resources and landraces, farmers in this region commonly grow landraces (Bicer and Sakar, 2004, 2008). Although lentil landraces were very important in this region, there have been only limited investigations conducted on this crop until now.

The objective of this study was to determine agro-morphological characterization of lentil landraces collected from the south eastern Anatolia region of Turkey.

MATERIALS AND METHODS

This study was conducted in 2005 - 2006 growing period at the research fields of Çukurova University's Vocational School of Kozan. The research materials were comprised of 39 lentil landraces and 7 varieties from the south east Anatolia region of Turkey collected by Dicle University, Agricultural Faculty, Field Crops Department and Southeastern Anatolian Research Institute. The collection and registration information is shown in Table 1.

Each accession was sown by hand in 2 m long rows with a 25 cm row spaced at a 300 seeds m^2 sowing rate. Observations were made and recorded as a single value for each plot on the days to flowering (days from sowing to appearance of 50% flowers), the flowering duration (days from appearance of first flowers to the end of flowering) and the days to maturity (days from sowing to physiological maturity). The relative agro-morphological plant characteristics of the seedling stem pigmentation, the leaf pubescence, the tendril length, the plant height, the biological yield, the weight of pods/plant, the number of pods/plant, the number of seeds/plant, the weight of seeds/plant, the diameter of seed (average of 10 seeds from 10 plant), the 100 seed weight (computed dividing the weight of seeds/plant to number of seeds/plant) were recorded from 10 randomly chosen plants from each plot and the protein content (3 x 0.2 g seed samples was analysed from each landraces) was determined. All of the observations were made according to the methods of IBPGR and ICARDA (1985) and Stoilova and Pereira (1999).

Simple statistics of the mean, the coefficient of variation and the range were computed using the recorded data, with MS office excel software. A principal component analysis (PCA) was performed for 13 traits using the JMP statistical software (SAS Institute, 2004). A correlation matrix was used to define the patterns of variation between the first 3 principal component scores and the 13 quantitative traits.

RESULTS

The frequency distribution of the lentil landraces and the varieties showed a large degree of variation in the quailtative plant characteristics (Table 2). Most of the landraces showed seedling stem pigmentation with pubescent leaves and a low degree of pod shedding and pod dehiscence. Almost one-half of the landraces (51%) had white flowers with blue veins while the other half had violet flowers. Most of the landraces had a brown testa pigment with different testa patterns.

The means, the coefficient of variations (CVs) and the ranges for the quantitative plant characteristics in the 39 lentil landraces and the 7 varieties are presented in Table 3. According to these data, the lentil landraces had a high variation for the all of the characteristics that were analyzed. High CVs were obtained for the flowering duration, the biological yield and the weight of the pods/plant, the number of pods/plant, the number of seeds/plant, the weight of the seeds/plant and the 100 seed weight. The contribution of the agronomic characteristics in the principal component and scatter diagrams for the first 2 principal components are shown in Table 4 and Figure 1. The first 3 principal components explain the 73.13% of total variance. Principal 1, which is the most important component, accounts for 39.56% of the total variation and is positively related to the biological yield, the weight of the pods/plant, the number of pods/plant, the number of seeds/plant and the weight of the seeds/plant. Principal 2 accounted for 59.02% of the total variation and the main characteristics of this component were positively correlated to the flowering duration, the days to maturity and the diameter of the seed but were negatively correlated to the number of days to flowering. Principal 3 accounted for 73.13% of the total variation and was positively related to the plant height, the length of the internodes and the protein content.

Figure 1 shows that the first and second PCA components allow the lentil landraces 4-5 groups for the researched traits. The landraces have a higher value for the yield components since the weight of the pods/plant, the number of the pods/plant, the number of the seeds/plant and the weight of the seeds/plant replaced the right side of principal 1. Some of the lentil landraces that have a higher flowering duration and larger days to maturity replaced the upper side of principal 2.

DISCUSSION

The main breeding aims were to develop new cultivars that are resistant to biotic stress factors and that are suitable to mechanical harvesting with a high and stable yield of lentils. The collection, description and utilization of genetic resources for agronomic and morphological plant characteristics are important to conduct successful and effective breeding programs for the majority of crops (Duvick, 1984; Lázaro et al., 2001; Naghavi and Johansouz, 2005). The results of this study showed that the Turkish lentil landraces collection had a significant variation in agronomic and morphological plant characteristics. More variations were obtained for the agronomical characteristics than were obtained for the morphological traits. Most of the landraces had seedling-stem pigmentation with a low degree of pod shedding and pod dehiscence. Two groups were observed for the flower color, one group had white flowers with blue veins while the other group had violet flowers. Almost all of the land-

Table 1. Information on collection site and record no of Lentil Landraces of south east Anatolia region of Turkey.

Row number	Name of population	Accession no.	Site name
Landraces			
1	Adiyaman 1	BM 285-1	Adıyaman, between Kahta-Siverek
2	Adiyaman 2	BM 561	Adiyaman, Kahta-Susuk
3	Batman	BM 105	Batman
4	Diyarbakir 1	BM 285-2	Diyarbakır, Hazro
5	Diyarbakir 2	BM 91	Diyarbakir, Oglakli- Karacadag
6	Diyarbakir 3	BM 278	Diyarbakir, Cinar
7	Diyarbakir 4	BM 448	Diyarbakir, Kulp-Ozbek
8	Diyarbakir 5	BM 552	Diyarbakir, between Dicle-Ergani
9	Diyarbakir 6	BM 549	Diyarbakir, between Dicle-Ergani
10	Diyarbakir 7	BM 76	Diyarbakir, Karacadag
11	Diyarbakir 8	BM 601	Diyarbakir, Silvan-Yukaribagpinar
12	Diyarbakir 9	BM 711	Diyarbakir, Kucukkadikoy
13	Diyarbakir 10	BM 34	Diyarbakir, Silvan
14	Diyarbakir 11	BM 585	Diyarbakir, Ergani, Cayonu
15	Diyarbakir 12	BM 760	Diyarbakir
16	Diyarbakir 13	BM 734	Diyarbakir
17	Gaziantep 1	BM 199	Gaziantep
18	Gaziantep 2	BM 201	Gaziantep, between Birecik-Nizip
19	Kahramanmaras 1	BM 187	Kahramanmaras, Pazarcik-Golbasi
20	Kahramanmaras 2	BM 117	Kahramanmaras, Pazarcik
21	Mardin 1	BM 365	Mardin, Kiziltepe
22	Mardin 2	BM 383	Mardin, Omerli-Anittepe
23	Mardin 3	BM 670	Mardin, between Kiziltepe-Viransehir
24	Mardin 4	BM 221	Mardin, between Kiziltepe-Viransehir
25	Mardin 5	BM 143	Mardin, between Kiziltepe-Viransehir
26	Mardin 6	BM 645	Mardin, Kiziltepe-Akziyaret
27	Mardin 7	BM 246	Mardin, Kiziltepe-Ova
28	Siirt	BM 399	Siirt, Besiri-Yolkonak
29	Sanliurfa 1	BM 306	Sanliurfa, Harran-Koruklu
30	Sanliurfa 2	BM 312	Sanliurfa, Hilvan
31	Sanliurfa 3	BM 329	Sanliurfa, Suruc
32	Sanliurfa 4	BM 152	Sanliurfa, between Viransehir-Sanliurfa
33	Sanliurfa 5	BM 20	Sanliurfa, Siverek
34	Sirnak 1	BM 462	Sirnak, Kumcati
35	Sirnak 2	BM 479	Sirnak, Idil-Karalar
36	Sirnak 3	BM 498	Sirnak, Silopi-Basaran
37	Sirnak 4	BM 500	Sirnak, Silopi-Basaran
38	Sirnak 5	BM 499	Sirnak, Silopi-Basaran
39	Sirnak 6	BM 409	Sirnak, Cizre-Hacibey
Varieties			
40	Firat 87	Regional cultivar	
41	Yerli Kirmizi	Regional cultivar	
42	Cagil-2004	Regional cultivar	
43	Ciftci	Regional cultivar	
44	Kafkas	Regional cultivar	
45	Emre	Regional cultivar	
46	Ozbek	Regional cultivar	

Table 2. Characterization and evaluation of morphological plant characteristics of lentil landraces and cultivars.

Morphological characteristics	Classes	Frequencies	
		Landraces	Cultivars
Seedling stem Pigmentation	+: present	0.87	0.86
	0: absent	0.13	0.14
Leaf pubescence	0: absent	0.00	0.00
	3: slight	0.97	0.85
	7: dense	0.03	0.15
Tendril length	1: rudimentary	0.05	0.00
	2: prominent	0.95	1.00
Pod shedding	0: none	0.97	1.00
	3: low	0.03	0.00
	5: medium	0.00	0.00
	7: high	0.00	0.00
Pod dehiscence	0: none	0.82	0.71
	3: low	0.18	0.29
	5: medium	0.00	0.00
	7: high	0.00	0.00
Flower color	1: white	0.00	0.00
	2:white with blue veins	0.51	0.71
	3: blue	0.00	0.00
	4: violet	0.49	0.29
	5: pink	0.00	0.00
	6: other	0.00	0.00
Ground color of testa	1: green	0.00	0.00
	2: grey	0.08	0.00
	3: brown	0.85	0.57
	4: black	0.00	0.43
	5: pink	0.07	0.00
Pattern of testa	0: absent	0.35	0.29
	1: dotted	0.25	0.14
	2: spotted	0.07	0.29
	3: marbled	0.23	0.14
	4: complex	0.10	0.14

races had the prominent tendril. Piergiovanni et al. (1998) and Lázaro et al. (2001) also found that mediterranean collections are characterized by pubescent leaves, white flowers with blue veins, a high plant height and large seeds.

The principal component analysis (PCA) demonstrated that the first 3 principal components could explain the total variance that was observed to a large degree. PC1 is defined by the biological yield, the weight of the pods/ plant, the number of pods/plant and the weight of seeds/ plant. This is an indication of the importance of the yield components. The scatter diagram of the lentil landraces showed that there was high a level of phenotypic diversity. The local lentil landraces have principally differed for yield and yield components. Bicer and Sakar (2004) have also concluded that there is a significant variation for the agronomic characteristics between some of the lentil landraces of the south eastern Anatolian region of Turkey. In addition to this, a considerable genetic diversity was obtained among the landraces following a molecular characterization study that used an inter-simple sequence repeat (ISSR) and an amplified fragment length polymorphism (AFLP) on this collection (Toklu et al., 2009). According to the agro-morphological diversity results, some promising landraces were identified with superior plant characteristics, such as seed size, plant height, first-pod height, stem-strength, resistance to lodging and early maturation. Diyarbakır 7 (10 numbered genotype in the Figure 1) was selected from the Karacadag/Diyarbakir population and had significant differences in the important plant traits when compared to the other landraces. The promising landraces which has

Table 3. Mean, coefficient of variation (CVs) and range for agronomical plant characters of lentil landraces and cultivars.

Plant characteristic	Landraces			Cultivars		
	Mean	CV(%)	Range	Mean	CV(%)	Range
Days to flowering	100.7	8.8	83 - 120	98.4	7.8	83 -105
Flowering duration (days)	16.1	38.0	7 - 29	17.4	32.3	13 - 29
Days to maturity	41.8	19.2	30 - 61	39.4	10.3	35 - 46
Plant height (cm)	48.2	9.1	42 - 58	44.9	15.8	35 - 53
Length of the internodes (cm)	2.3	11.5	1.84 - 2.98	2.1	10.1	1.85 - 2.45
Number of branches	8.0	28.0	4.1 - 12.6	7.5	38.5	5.1 - 13.8
Biological yield (g/plant)	2.0	31.5	1.0 - 3.93	1.7	43.0	1.21 - 3.31
Weight of pods/plant (g)	0.8	47.0	0.17 - 1.43	0.6	32.5	0.23 - 0.81
Number of pods/plant	20.7	43.3	6.8 - 42.2	15.2	42.8	6.0 - 26.2
Number of seeds/plant	20.6	43.2	6.7 - 38.8	13.8	34.2	5.1 - 20.6
Weight of seeds/plant	0.6	47.8	0.12 - 1.09	0.4	31.0	0.18 - 0.60
Diameter of seed (mm)	4.4	6.5	3.99 - 5.14	4.4	4.6	4.06 - 4.60
100-seed weight (g)	2.9	18.8	1.68 - 4.03	3.0	9.1	2.58 - 3.33
First pod height (cm)	30.2	15.0	21.7 - 41.6	29.5	17.0	21.9 - 36.5
Protein content (%)	27.4	7.7	22.7 - 31.9	25.6	3.8	23.6 - 26.5

Table 4. Correlation coefficients between the first three principal components and the agronomical plant characters.

Character	Prin 1	Prin 2	Prin 3
Eigen value	5.14	2.52	1.83
Proportion of variance (%)	39.56	19.45	14.11
Cumulative variance (%)	39.56	59.02	73.13
Days to flowering	-0.185	-0.448	0.038
Flowering duration (days)	0.183	0.461	0.015
Days to maturity	0.267	0.406	0.031
Plant height (cm)	0.048	0.244	0.607
Length of the internodes (cm)	-0.074	-0.059	0.535
Biological yield (g/plant)	0.364	-0.178	0.207
Weight of pods/plant (g)	0.414	-0.168	-0.057
Number of pods/plant	0.389	-0.248	0.019
Number of seeds/plant	0.396	-0.250	0.018
Weight of seeds/plant	0.414	-0.141	-0.069
Diameter of seed (mm)	0.178	0.301	-0.034
100-seed weight (g)	0.175	0.247	-0.322
Protein content (%)	0.072	-0.006	0.430

superior for important plant characteristics could be successfully utilized in breeding programs that are aimed at improving the yield and the yield components of the lentil. In a breeding study, we used the lentil genotype that was selected from the Karacadag population, which had a higher plant height, a shorter time to flowering, resistance to lodging, a higher first pod height and resistance to the fusarium and macrosperma types of seeds. This genotype was integrated in a breeding program and used as a parent in some crosses.

In conclusion, this study has demonstrated that the south east Anatolian region of Turkey has a rich potential for lentil genetic resources. This study has described high phenotypic diversity for several important plant characteristics of the landraces. However, additional research and a description of the lentil genetic resources of Turkey still need to be conducted.

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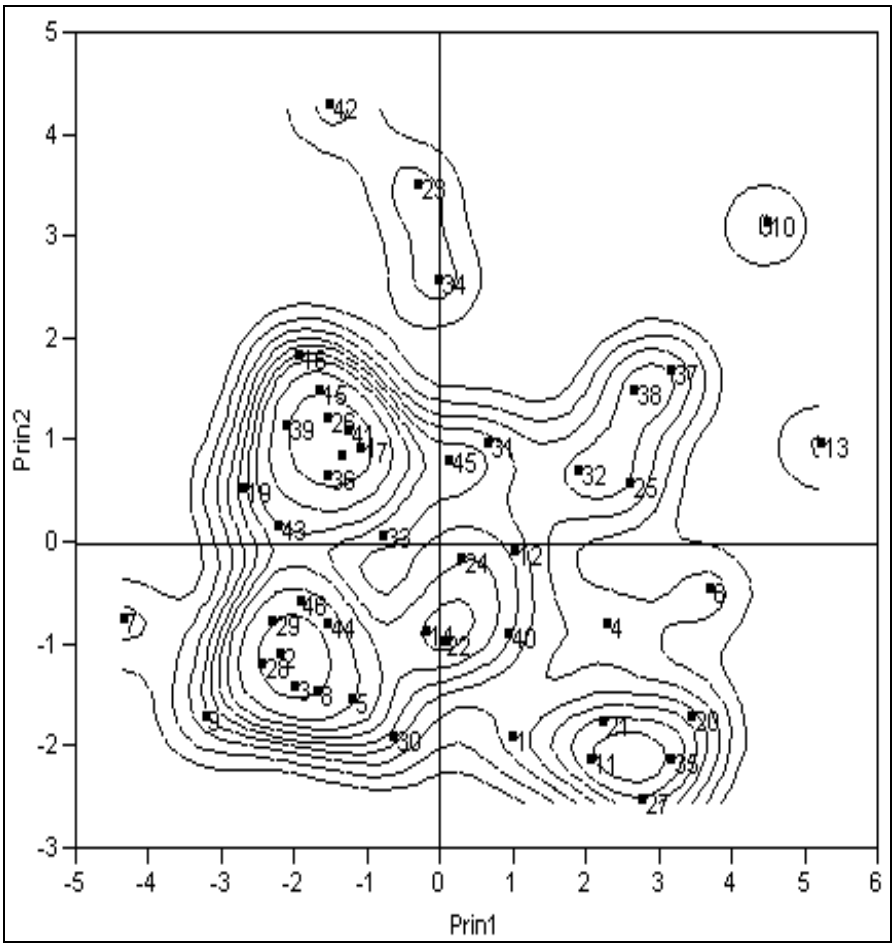

Figure 1. Scatter diagram of the lentil landraces.

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