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Morphological diversity among fig (*Ficus carica* L.) accessions sampled from the Eastern Mediterranean Region of Turkey

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Abstract: *Ficus carica* L. is one of the most important fruit species in Turkey. For this study, 76 fig accessions were collected from Hatay, in the Eastern Mediterranean Region of Turkey, in 2008 and 2009; the morphological diversity of plants and fruits was evaluated. Of the samples studied, 2 accessions were determined to be first crop (breba) and the other 74 accessions were identified as main crop. The fruit quality characteristics of Bardak and Dolap for the first crop and Kabak 2, Kabak 1, Mor 1, Sarı 1, and Siyah 1 for the main crop were very promising for the fresh fig market. The following fruit characteristics were found to be very successful discriminants for the fig accessions: apical dominancy, lateral shoot formation, leaf shape, number of lobes, length of central lobe, leaf area, and leaf width for plant and leaf characteristics, and fruit length, pH, fruit flesh color *h*°, abscission of the stalk from the twig, fruit width, fruit neck length, fruit weight, and antioxidant capacity. From the plant and fruit characteristics, 37 out of 64 traits were shown to be more useful in separating the fig accessions in the study area. It is suggested that for the nomenclature classification of genetic sources, reproducible parameters should be used as much as possible.

Key words: Cluster analysis, *Ficus carica* L., morphological diversity, principal component analysis

Türkiye'nin Doğu Akdeniz Bölgesi'nden toplanan incir (*Ficus carica* L.) genotipleri arasındaki morfolojik farklılıklar

Özet: *Ficus carica* L. Türkiye'deki en önemli meyve türlerinden biridir. Bu araştırmada, Türkiye'nin Doğu Akdeniz bölgesinde yer alan Hatay'dan 76 incir genotipi 2008 ve 2009 yıllarında toplanmış ve hem bitkilerin hem de meyvelerin morfolojik farklılıkları değerlendirilmiştir. İki genotip yellop ürünü ve 74 genotip ana ürün olarak belirlenmiştir. Yellop ürünü için Bardak ve Dolap ve ana ürünü için Kabak 2, Kabak 1, Mor 1, Sarı 1 ve Siyah 1 genotipleri sofralık incir ticareti için oldukça ümitvar bulunmuştur. İncir genotiplerinin tanımlanmasında bitki ve yaprak özelliklerinden tepe tomurcuğu baskınlığı, yan dal oluşumu, yaprak şekli, lop sayısı, merkezi lop uzunluğu, yaprak alanı ve yaprak genişliği; meyve özelliklerinden meyve uzunluğu, pH, meyve et rengi *h*°, meyve sapının daldan kopma durumu, meyve çapı, boyun uzunluğu, meyve ağırlığı ve antioksidan kapasitesi oldukça başarılı olarak saptanmıştır. Araştırma alanındaki incir genotiplerinin birbirinden ayırt edilmesinde 64 özellik yerine 37'si daha kullanışlı olarak tespit edilmiştir. Genetik kaynakların objektif olarak sınıflandırılmasında mümkün olduğunca tekrar edilebilir parametrelerin kullanılması gerektiği önerilmiştir.

Anahtar sözcükler: Kümeleme analizi, *Ficus carica* L., morfolojik farklılık, temel bileşenler analizi

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Introduction

Fig (*Ficus carica* L.) is one of the most important fruit species of Mediterranean countries. Fig trees are widely distributed throughout Turkey near the Black Sea, the Marmara region, the Aegean and Mediterranean coastal regions, southern Anatolia, and the interior valleys of central Anatolia (Polat and Caliskan 2008). Turkey is the major fig producer and exporter in the world with a total production of 270,830 t of figs (26% of the world production and 36% of exports). Many cultivated and wild forms of fig, primarily used for fresh consumption, can be found in Turkey, and a great diversity of colors, sizes, shapes, and flavors can be observed. The names of these figs are mainly given based on local geographic origin (Bakras, Kilis), fruit size (Büyük Siyahlop), fruit shape (Armut Sapı, Bardak, Kabak), fruit skin color (Siyah, Mor, Sarı), ostiole color (Burnu Kızıl), maturity dates (Erkenci), or the name of the orchard owner (Ahmediye). Researchers may encounter similar, synonym, and homonym accessions because of the interchange of fig plant material from nearby locations.

Local fig plants remain mostly as traditional crops and, as in other Mediterranean countries, important genetic variations have been taking place as a result of biotic and abiotic processes such as urbanization, the extension of intensive crops, and fig mosaic disease (Salhi-Hannachi et al. 2004). Losses in the genetic diversity of crop species due to commercialization have led to the need to preserve the present genetic resources as much as possible, not only for the long-term survival of the species but also to ensure enough variability for breeding programs (Esquinas Alcazar 2005). Unfortunately, there has been little research dealing with the genetic diversity in fig germplasm (Aksoy et al. 2003; Stover and Aradhya 2008; Giraldo et al. 2010; Podgornik et al. 2010; Şimşek and Yildirim 2010; Dalkılıç et al. 2011). To better conserve and utilize genetic resources, characterization designs of morphological variability within the collections and selection of the most significant variables should be carefully performed (Giraldo et al. 2010). Thus far, morphological parameters have been used for the determination of plant diversity. In fact, these parameters are generally influenced by environmental conditions and agronomic practices. Morphological characterization is a highly recommended first step before starting biochemical or molecular studies (Hoogendijk and Williams 2001).

Fig cultivation in the coastal part of the Mediterranean region of Turkey has a long history and a promising future. Fresh fig production in Turkey is seldom found in dedicated orchards, with the exception of those in Bursa, Mersin (Mut), and Hatay (Çalişkan and Polat 2008). Hatay Province, located in the eastern Mediterranean region, contains 224,760 fig trees that produce 6,665 t of fresh fig fruits. In this region, the fig is considered a principal fruit tree along with olive and some other fruit trees. New orchards are especially suitable for the exporting of fresh figs. Most notably, the cultivar Bursa Siyahı has been propagated in commercial nurseries and used in the new plantations. The problem of genetic erosion in local fig germplasm, which may occur due to grafting, therefore usually involves this cultivar.

This study describes and compares the diversity observed in local fig germplasm and evaluates the genetic diversity of fig accessions in the eastern Mediterranean region of Turkey.

Materials and methods

Materials

A total 76 fig accessions, including 2 first-crop accessions and 74 main-crop accessions, were sampled and morphologically described. These accessions were obtained from the province of Hatay in 2008 and 2009 (Table 1). Researchers visited 9 traditional fig zones in Hatay (Altınözü, Antakya, Belen, Dörtyol, Hassa, İskenderun, Kırıkhan, Samandağ, and Yayladağı) where fig trees are cultivated under rain-fed conditions. The climate of the region is a typical Mediterranean climate, with mild temperatures (14-23 °C), rainy weather (500-1100 mm/year) in autumn and winter, and hot, dry summers. In order to assure data traceability, information on the coordinates and elevations of the sampled trees is presented in Table 1. To convert longitude and latitude into degrees (°), minutes (′), and seconds (″), and a hemisphere (north or south and east or west) to decimal degrees, the following formula was used: $d° m' s'' = h \times (d + m/60 + s/3600)$, where $h = 1$ for the northern and eastern hemispheres and $h = -1$ for the southern and western hemispheres (IPGRI and CIHEAM 2003).

Table 1. Origins of the local fig accessions sampled from the Eastern Mediterranean Region of Turkey.

No.	Accession name	Location	Latitude	Longitude	Elevation (m a.s.l.)	No.	Accession name	Location	Latitude	Longitude	Elevation (m a.s.l.)
1	Şami	İskenderun	36.54	–36.04	21	**39**	Siyah 3	Hassa	36.76	–36.47	570
2	Fransavi	İskenderun	36.57	–36.15	3	**40**	Siyah 4	Antakya	36.26	–36.34	90
3	Hılvıni	İskenderun	36.53	–36.04	37	**41**	Siyah 5	Samandağ	36.16	–36.04	131
4	Büyük Siyahlop	İskenderun	36.41	–36.02	500	**42**	Siyah 6	Yayladağı	35.98	–36.02	787
5	Sıhle	İskenderun	36.62	–36.05	37	**43**	Siyah 7	Yayladağı	35.98	–36.16	607
6	Kilis İnciri	Belen	36.49	–36.28	676	**44**	Siyah 8	Yayladağı	35.98	–36.16	608
7	Ahmediye	İskenderun	36.42	–36.03	441	**45**	Mor 1	Antakya	36.24	–36.32	95
8	Burnu Kızıl	İskenderun	36.42	–36.03	453	**46**	Mor 2	Antakya	36.24	–36.34	90
9	Allene Karası	Altınözü	36.15	–36.27	379	**47**	Mor 3	Antakya	36.28	–36.15	218
10	Beyaz Fahli	Altınözü	36.15	–36.27	378	**48**	Mor 4	Hassa	36.84	–36.57	382
11	Kandamık	Altınözü	36.15	–36.26	374	**49**	Mor 5	Altınözü	36.16	–36.27	380
12	Fahli	Altınözü	36.15	–36.27	367	**50**	Mor 6	Kırıkhan	36.57	–36.57	331
13	Fetike	Altınözü	36.16	–36.27	380	**51**	Sultani 1	Altınözü	36.13	–36.20	440
14	Armut Sapı	Altınözü	36.15	–36.27	367	**52**	Sultani 2	Antakya	36.28	–36.15	216
15	Payas	Hassa	36.75	–36.47	569	**53**	Sultani 3	Yayladağı	35.98	–36.17	621
16	Gud Yeniği	Hassa	36.75	–36.47	574	**54**	Kabak 1	Kırıkhan	36.55	–36.57	328
17	Baldır İnciri	Hassa	36.75	–36.47	568	**55**	Kabak 2	Kırıkhan	36.59	–36.55	176
18	Halep İnciri	Dörtyol	36.87	–36.22	61	**56**	Şeble 1	İskenderun	36.57	–36.15	3
19	Erkenci	Antakya	36.24	–36.33	88	**57**	Şeble 2	İskenderun	36.53	–36.05	39
20	Yeşil İncir	Antakya	36.24	–36.32	99	**58**	Kıreni 1	Altınözü	36.13	–36.20	442
21	Şebli	Samandağ	36.17	–36.04	146	**59**	Kıreni 2	Altınözü	36.15	–36.26	304
22	Tınesvit	Samandağ	36.17	–36.04	137	**60**	Sehli 1	Altınözü	36.13	–36.20	441
23	Sütlü Sarı	Antakya	36.29	–36.14	266	**61**	Sehli 2	Altınözü	36.15	–36.27	366
24	Mersinli	Antakya	36.28	–36.15	216	**62**	Meryemi 1	Belen	36.49	–36.26	673
25	Zırhıni	Samandağ	36.16	–36.04	149	**63**	Meryemi 2	Yayladağı	35.98	–36.17	622
26	Bardak	Yayladağı	35.86	–36.14	588	**64**	Kuruye 1	Altınözü	36.15	–36.27	367
27	Dolap	Yayladağı	35.90	–36.11	652	**65**	Kuruye 2	Altınözü	36.14	–36.25	361
28	Şibili	Yayladağı	35.98	–36.02	800	**66**	Kırmızı 1	Antakya	36.24	–36.32	100
29	Karagöz	Yayladağı	35.90	–36.11	652	**67**	Kırmızı 2	Yayladağı	35.98	–36.17	621
30	Beyaz İncir	Yayladağı	35.98	–36.02	789	**68**	Lopkara 1	Yayladağı	35.98	–36.02	800
31	Sarı 1	Kırıkhan	36.45	–36.42	80	**69**	Lopkara 2	Yayladağı	35.98	–36.02	761
32	Sarı 2	Altınözü	36.15	–36.27	369	**70**	Ramlı 1	Yayladağı	35.98	–36.02	813
33	Sarı 3	Hassa	36.75	–36.47	585	**71**	Ramlı 2	Yayladağı	35.97	–36.17	629
34	Sarı 4	Dörtyol	36.90	–36.22	94	**72**	Bığrasi 1	Samandağ	36.15	–36.04	125
35	Sarı 5	Antakya	36.24	–36.32	99	**73**	Bakrasi 2	Antakya	36.29	–36.14	268
36	Sarı 6	Hassa	36.84	–36.57	382	**74**	Bakras 3	Belen	36.49	–36.28	677
37	Siyah 1	Belen	36.49	–36.28	674	**75**	Bığrasi 4	İskenderun	36.53	–36.04	38
38	Siyah 2	Altınözü	36.16	–36.27	379	**76**	Bakrasi 5	İskenderun	36.57	–36.18	3

m a.s.l.: meters above sea level

Morphological observation and analysis

The characterization of plant material was performed using fig descriptors (IPGRI and CIHEAM 2003) with an additional 20 new characteristics (Table 2). A total of 64 morphological characteristics were evaluated, 21 of which were subjective and 43 of which were objective traits. Mature fruits and leaves were collected from 76 different plants. For each plant, 50 first-crop fruits, 50 main-crop fruits, and 50 leaves were randomly collected. There were

Table 2. A list of subjective and objective IPGRI and CIHEAM fig descriptors included in the plant and fruit characters used to characterize local fig accessions sampled from the eastern Mediterranean region of Turkey.

No. of descriptor	Characterization	No. of descriptor	Characterization
7.1.	Biological characters	7.4.10.	Fruit symetry
7.1.1.	Leafing	7.4.11.	Ostiole width
7.1.2.	Crop set fruit	7.4.12.	Drop at the eye
7.1.3.	Beginning of fruit maturation	7.4.13.	Color of liquid drop at the ostiole
7.1.4.	Full maturity (breba and main crop)	7.4.15.	Shape of fruit stalk
7.1.5.	Harvest period	7.4.18.	Abscission of the stalk from the twig
7.2.	Growth descriptors	7.4.19.	Ease of peeling
7.2.1.	Tree growth habit	7.4.20.	Fruit ribs
7.2.2.	Tree vigor	7.4.21.	Fruit skin cracks
7.2.3.	Branching	7.4.27.*	Fruit skin thickness
7.2.3. 1	Apical dominancy	7.4.31	Color formation in the flesh
7.2.3. 2.	Lateral shoot formation on seasonal growth	7.4.35.	Fruit cavity
7.2.9.	Terminal bud color	7.4.38.	Weight of 100-fruitlets
7.2.10.	Seasonal shoot growth in mature trees	7.4.39.	Total soluble solids (TSS)
7.2.10.1.	Shoot length	7.4.40.	Titratable acidity (TA)
7.2.10.2.	Shoot width	7.4.41.	TSS/TA
7.2.11.	Shoot color	7.4.42.	pH
7.2.12.	Tendency to form suckers	8.	Plant descriptors
7.3.	Leaf descriptors	8.2.	Cropping efficiency
7.3.1.	Number of leaves per shoot	8.3.*	Twin fruit ratio
7.3.2.	Leaf shape	9.*	Phytochemical descriptors
7.3.3.	Number of lobes	9.1.	Total phenols
7.3.8.	Leaf length	9.2.	Total anthocyanins
7.3.9.	Leaf width	9.3.	Antioxidant capacity
7.3.10.*	Leaf area with an area meter	9.4.	Fructose
7.3.11.	Length of central lobe	9.5.	Glucose
7.3.12.	Leaf margin dentation	9.6.	Sucrose
7.3.14.	Density of hairs/spicules on leaf upper surface	10 .*	Fruit skin color
7.3.15	Density of hairs/spicules on leaf lower surface	10.1.	L
7.3.16.	Leaf venation	10.2.	a
7.3.17.	Petiole length	10.3.	b
7.3.18.	Petiole thickness	10.4.	C
7.4.	Fruit descriptors	10.5.	$h°$
7.4.1.	Fruit shape	11.*	Fruit flesh color
7.4.4.	Percentage of 2 syconia in the axil of a leaf per shoot	11.1.	L
7.4.5.	Fruit weight	11.2.	a
7.4.6.	Fruit diameter	11.3.	b
7.4.7.	Fruit length	11.4.	C
7.4.8.	Fruit neck length	11.5.	$h°$
7.4.9.	Uniformity of fruit size	12.*	Number of fruit per shoot

*New descriptors

5 replicates performed, each consisting of 10 fruits or leaves. All of the fruit samples were taken at the same level of physiological maturity, as visually determined. Leaf area was determined by means of an area meter (LI-COR Biosciences, USA) due to differences in the number of lobes, width of lobes, and the spaces between the lobes.

The pomological methods used were explained previously by Çalişkan and Polat (2008). Fruit weight (FW; g) was measured with a scale sensitive to 0.01 g (Precisa XB 2200 C, Precisa, UK). Digital calipers (0-150 mm; BTS Tools, Malaysia) were used to determine fruit length (FL; mm) and width (FW; mm), neck length (NL; mm), and ostiole width (OW; mm). The total soluble solids (TSS; %) were determined with a hand-held refractometer (0%-32% Brix; NOW), and pH was determined with a pH meter. Acidity (expressed as citric acid %) was determined by titration with 0.1 N NaOH up to a pH of 8.10. The soluble solid-to-acidity ratio was also calculated. To determine the antioxidant capacity (TAC), the ferric reducing antioxidant power method given by Pellegrini et al. (2003) was used with some modifications. The total anthocyanin (TA) content was calculated according to the pH differential method of Cheng and Bren (1991). Total phenolic (TP) contents of the samples were measured according to the method of Slinkard and Singleton (1977). Sugar contents were determined according to the method described by Camara et al. (1996). Fruit skin and flesh colors were measured with a colorimeter (Chroma Meter CR-300, Minolta Co., Japan) and color parameters were expressed as L^*, a^*, b^*, C^*, and $h°$.

Statistical analysis

The data were subjected to analysis of variance (ANOVA) using SAS (SAS Institute 2005). To evaluate similarity among accessions, cluster analysis was carried out using the software's PROC CLUSTER with the AVERAGE option for the plant and fruit traits. Since the use of different measurement units resulted in completely different types of scales, each of which had unequal weight, the data were standardized so that each variable had a mean of 0 and a standard deviation of 1. This standardization enabled all of the characters to be considered on a comparable scale. Principle coordinate (PC) analysis was carried out using the PRINCOMP procedure and the accessions were plotted on the first 3 PCs.

Results

Morphological analysis

Plant characters and ripening times

Descriptions and periods of fig fruit maturity are summarized in Table 3. Tree growth habits (TGHs), as given by the fig descriptor (IPGRI and CIHEAM 2003), were determined to be erect for Kilis, Karagöz, and Kırmızı 2; spreading for Kandamık, Payas, Şebli, Sarı 1, Siyah 4, Siyah 8, Kabak 2, Şeble 1, Kıreni 2, Meryemi 2, and Bakras 3; and weeping for Hılvıni, Ahmediye, Tinesvit, Zırhıni, Siyah 3, Siyah 6, Siyah 7, Mor 4, and Bakrasi 4. The other main-crop accessions were found to have semierect or open growth habits. The most frequent tree vigor (TV) was intermediate in the 43 main-crop accessions. The TV of the other accessions was either low (14 accessions) or high (17 accessions). Shoot length (SL) and the number of leaves (LN) on the shoots were high for Mor 1 (40.0 cm and 11.2, respectively). The number of fruits (FN) per shoot ranged from 2.4 to 8.1. The highest FN per shoot was noted for Bakrasi 5 at 8.1. The lowest FN per shoot was observed to be 2.4 for Sultani 1.

With regard to the leaf parameters, there were great variations in leaf length (LL), leaf width (LW), the length of the center lobe (CLL), leaf area (LA), petiole length (PL), petiole thickness (PT), leaf shape (LS), and the number of leaf lobes (LLN). For LL, LW, and CLL, the highest values were found for Sehli 1 (27.6 cm), Halep (23.5 cm), and Kıreni 1 (16.1 cm), respectively. The difference between the largest LA (Bakrasi 5, at 371.6 cm^2) and the smallest LA (Sultani 2, at 163.4 cm^2) was 208.2 cm^2. The lowest LL value was determined for Sultani 2 (16.4 cm). The highest PL and PT were observed for Halep (11.4 mm) and Allene Karası (6.6 mm). The LS and the LLN also showed considerable variability. The LS was mainly *G* (23 accessions) with 3 lobes, or *C* (22 accessions) with 5 lobes. The LS was identified as *D* for 14 accessions, *A* for 7 accessions, *B* for 6 accessions, and *F* for 2 accessions. Apical dominancy (AD) was found in about half of the main-crop accessions. Of the first-crop accessions, the TGH of Bardak was determined to be open, whereas Dolap was observed to have a

Table 3. Plant and leaf characteristics of fig accessions sampled from the eastern Mediterranean region of Turkey.

Accession	TGH	TV	SL	LN	FN	LL	LW	CLL	LA	PL	PT	LS	LLN	AD	FM	HP
Main crop																
Şami	Open	Intermediate	24.5	10.4	7.5	23.5	20.7	12.8	280.5	8.2	5.4	C	5	Present	11-31 Aug.	41-60
Fransavi	Open	Low	20.2	6.0	3.7	20.3	17.1	11.4	250.3	8.4	4.8	G	3	Present	11-31 Aug.	41-60
Hılvıni	Weeping	High	15.9	5.8	3.4	19.3	16.5	13.4	219.4	5.1	4.6	A	5	Absent	11-31 Aug.	21-40
Büyük Siyahlop	Semierect	Intermediate	18.5	7.2	3.7	21.3	17.9	13.1	262.7	7.0	5.4	C	5	Present	11-31 Aug.	41-60
Sıhle	Open	High	9.1	6.3	3.9	20.4	17.5	13.3	243.7	5.3	4.8	C	5	Absent	11-31 Aug.	41-60
Kilis	Erect	Low	16.8	9.5	4.7	22.8	21.6	12.5	334.1	7.0	5.0	C	5	Present	1-10 Aug.	21-40
Ahmediye	Weeping	High	11.3	6.9	5.6	23.5	21.2	14.5	332.4	6.1	5.0	G	3	Absent	11-31 Aug.	41-60
Burnu Kızıl	Semierect	Low	9.0	5.4	4.3	19.9	17.4	11.0	283.2	6.0	4.5	G	3	Absent	11-31 Aug.	41-60
Allene Karası	Semierect	Intermediate	11.1	5.8	3.4	23.1	18.9	15.1	280.3	6.7	6.6	D	5	Present	1-10 Aug.	21-40
Beyaz Fahli	Open	Intermediate	22.2	7.5	3.9	21.6	16.7	13.6	253.5	6.0	5.4	A	5	Present	11-31 Aug.	21-40
Kandamık	Spreading	Low	9.4	6.5	3.3	21.5	18.0	12.4	316.1	5.3	5.6	C	5	Present	1-10 Aug.	21-40
Fahli	Semierect	Intermediate	10.9	5.8	2.6	19.0	16.0	12.5	221.2	6.1	5.6	C	5	Present	11-31 Aug.	21-40
Fetike	Open	Intermediate	9.8	6.2	3.0	19.4	16.2	12.3	246.1	7.3	5.2	B	5	Present	11-31 Aug.	40-60
Armut Sapı	Open	Low	6.5	5.8	2.8	17.2	16.1	10.9	195.7	6.5	4.5	D	5	Absent	1-10 Aug.	21-40
Payas	Spreading	Intermediate	8.4	4.8	2.6	19.6	15.9	12.0	223.8	6.8	3.7	B	5	Present	11-31 Aug.	41-60
Gud Yeniği	Semierect	Low	9.2	6.4	4.3	21.1	17.0	14.1	237.3	6.4	4.8	D	5	Present	1-10 Aug.	21-40
Baldır	Open	Intermediate	9.4	5.7	4.1	20.1	15.1	11.5	207.0	9.8	4.1	G	3	Absent	11-31 Aug.	41-60
Halep	Semierect	Intermediate	25.8	6.6	4.5	25.1	23.5	13.5	347.0	11.4	6.4	G	3	Present	11-31 Aug.	41-60
Erkenci	Semierect	Intermediate	8.9	6.6	4.3	20.7	16.2	14.6	223.6	5.8	4.1	C	5	Absent	End of July	21-40
Yeşil İncir	Open	Intermediate	32.1	9.2	5.3	21.6	18.5	12.6	303.2	5.3	5.4	A	7	Present	11-31 Aug.	21-40
Şebli	Spreading	Intermediate	21.8	5.6	3.3	19.9	17.9	11.8	271.2	6.1	4.7	G	3	Absent	11-31 Aug.	21-40
Tınesvit	Weeping	Intermediate	15.0	5.8	4.3	21.7	18.4	13.0	254.9	6.6	4.7	C	5	Absent	11-31 Aug.	21-40
Sütlü Sarı	Open	Intermediate	18.0	7.5	4.2	22.8	19.5	12.4	281.5	6.7	5.1	G	3	Present	11-31 Aug.	21-40
Mersinli	Open	Intermediate	9.6	5.1	3.0	23.0	16.6	14.3	231.6	6.9	5.4	C	5	Present	1-10 Aug.	21-40
Zırhıni	Weeping	High	19.1	7.2	5.1	22.4	19.0	13.3	259.5	8.6	5.1	A	5	Absent	11-31 Aug.	21-40
Şibili	Open	Intermediate	15.7	8.5	6.6	21.6	19.9	12.2	311.8	7.1	5.7	F	5	Absent	11-31 Aug.	>60
Karagöz	Erect	Intermediate	25.8	8.1	5.4	20.8	18.4	10.7	273.9	10.2	4.8	G	3	Present	11-31 Aug.	41-60
Beyaz İncir	Open	Intermediate	14.2	6.3	4.2	21.8	17.3	13.5	280.1	7.4	4.8	D	5	Absent	11-31 Aug.	21-40
Sarı 1	Spreading	Intermediate	20.9	8.2	6.0	23.9	21.0	13.5	336.0	8.1	6.0	C	5	Present	11-31 Aug.	21-40
Sarı 2	Open	Intermediate	16.6	6.9	2.8	19.3	16.5	10.9	287.3	7.4	5.4	D	5	Present	1-10 Aug.	21-40
Sarı 3	Open	Low	7.9	6.8	4.3	20.9	19.0	13.5	259.3	10.1	4.1	B	5	Absent	1-10 Aug.	21-40
Sarı 4	Semierect	High	19.4	10.4	7.2	22.8	21.6	11.9	356.9	9.7	5.0	G	3	Present	11-31 Aug.	41-60
Sarı 5	Open	Intermediate	33.3	10.3	6.4	21.9	18.3	12.2	249.1	5.0	5.0	A	7	Present	11-31 Aug.	21-40
Sarı 6	Open	High	15.4	7.1	4.7	21.2	19.2	12.4	288.1	8.2	5.3	G	3	Absent	1-30 Sept.	21-40
Siyah 1	Open	Low	15.4	6.4	3.8	23.5	20.8	13.5	296.7	8.4	5.4	G	3	Absent	11-31 Aug.	21-40
Siyah 2	Semierect	Low	7.5	4.9	3.1	21.1	17.9	14.0	277.6	6.0	5.6	D	5	Present	11-31 Aug.	21-40
Siyah 3	Weeping	Intermediate	17.8	6.6	5.0	21.8	18.0	14.0	280.4	8.0	4.6	C	5	Present	11-31 Aug.	21-40
Siyah 4	Spreading	Intermediate	19.8	7.0	5.4	22.2	18.6	12.7	301.0	8.5	5.7	C	5	Absent	1-30 Sept.	41-60
Siyah 5	Open	Low	14.9	5.7	3.6	21.6	19.8	12.3	275.5	7.1	4.4	G	3	Absent	11-31 Aug.	21-40
Siyah 6	Weeping	High	22.1	5.0	3.7	19.0	17.2	11.6	221.6	6.7	4.6	C	5	Absent	11-31 Aug.	21-40
Siyah 7	Weeping	High	19.3	7.4	5.2	23.1	18.4	13.8	273.3	11.0	5.2	A	5	Present	11-31 Aug.	21-40
Siyah 8	Spreading	High	32.1	6.4	3.6	20.7	18.1	11.1	262.3	10.4	4.8	G	3	Present	1-30 Sept.	>60

Table 3. (Continued).

Accession	TGH	TV	SL	LN	FN	LL	LW	CLL	LA	PL	PT	LS	LLN	AD	FM	HP
Mor 1	Open	High	40.0	11.2	7.2	22.8	21.8	13.3	320.1	8.5	5.7	D	5	Present	1-30 Sept.	21-40
Mor 2	Open	Intermediate	23.1	7.3	4.4	22.4	18.2	13.8	282.2	7.8	5.3	A	5	Present	1-30 Sept.	41-60
Mor 3	Open	Intermediate	11.8	6.3	5.4	20.5	17.1	12.6	256.4	6.2	4.3	C	5	Absent	11-31 Aug.	21-40
Mor 4	Weeping	Intermediate	29.4	7.4	6.2	20.1	15.8	10.1	246.6	8.2	6.0	G	3	Present	1-30 Sept.	>60
Mor 5	Semierect	Intermediate	15.9	6.1	3.5	19.8	17.2	11.9	259.8	5.4	6.1	D	5	Absent	1-10 Aug.	21-40
Mor 6	Open	High	8.8	5.2	2.7	18.3	16.6	10.9	223.6	5.8	4.8	D	5	Absent	1-10 Aug.	21-40
Sultani 1	Open	Intermediate	7.8	4.4	2.4	18.9	14.8	12.4	204.5	7.1	4.7	B	5	Absent	11-31 Aug.	21-40
Sultani 2	Open	Intermediate	9.4	4.7	2.5	16.4	15.0	11.2	163.4	6.0	3.6	C	5	Absent	11-31 Aug.	21-40
Sultani 3	Open	Intermediate	10.2	5.7	4.1	17.9	15.7	11.5	213.0	7.1	4.3	D	5	Present	11-31 Aug.	21-40
Kabak 1	Open	High	11.5	6.3	4.7	26.6	22.1	15.3	348.6	8.5	5.9	C	5	Absent	1-10 Aug.	41-60
Kabak 2	Spreading	Intermediate	10.6	6.5	4.8	23.4	21.2	12.8	325.8	7.3	5.6	C	5	Absent	1-10 Aug.	41-60
Şeble 1	Spreading	High	26.1	8.8	5.7	20.6	18.8	12.8	278.5	8.1	4.6	C	5	Present	11-31 Aug.	21-40
Şeble 2	Open	Intermediate	26.4	9.1	5.3	21.5	17.5	12.2	269.4	6.9	5.4	C	5	Present	11-31 Aug.	21-40
Kıreni 1	Open	Intermediate	15.2	10.5	2.6	21.0	19.1	16.1	263.4	8.0	5.9	F	5	Absent	11-31 Aug.	21-40
Kıreni 2	Spreading	Intermediate	13.6	6.5	4.5	21.4	18.0	12.6	280.4	9.1	5.8	B	5	Absent	1-10 Aug.	41-60
Sehli 1	Open	Intermediate	9.3	5.2	3.4	27.6	19.5	13.0	276.3	7.4	5.1	C	5	Absent	1-10 Aug.	41-60
Sehli 2	Open	Intermediate	9.0	7.5	2.6	17.1	14.6	11.0	176.6	5.9	5.0	D	5	Absent	1-10 Aug.	21-40
Meryemi 1	Open	Low	18.0	7.1	4.9	19.9	17.9	12.2	221.7	7.5	4.4	B	5	Absent	1-10 Aug.	21-40
Meryemi 2	Spreading	Intermediate	11.9	6.1	3.7	23.4	17.5	14.0	269.6	6.6	5.2	G	3	Absent	11-31 Aug.	21-40
Kuruye 1	Semierect	Intermediate	11.9	4.9	4.2	20.2	17.5	12.4	235.8	6.9	5.1	D	5	Present	11-31 Aug.	41-60
Kuruye 2	Semierect	Intermediate	12.7	7.3	5.2	18.8	16.5	12.1	219.7	5.9	4.8	D	5	Present	11-31 Aug.	41-60
Kırmızı 1	Semierect	Intermediate	31.8	9.7	7.2	21.1	18.8	13.5	264.0	7.5	4.7	C	5	Present	11-31 Aug.	21-40
Kırmızı 2	Erect	Low	8.1	5.1	2.7	16.5	13.7	10.3	172.5	5.2	4.6	G	3	Absent	1-10 Aug.	15-20
Lopkara 1	Open	High	10.9	6.3	5.4	22.8	20.1	13.6	302.6	7.5	5.3	D	5	Absent	11-31 Aug.	21-40
Lopkara 2	Semierect	Intermediate	33.3	7.5	5.2	24.1	21.1	13.2	346.2	9.6	5.5	G	3	Present	11-31 Aug.	21-40
Ramlı 1	Open	High	10.7	5.4	2.7	16.6	14.6	10.0	166.0	4.7	4.1	C	5	Absent	1-10 Aug.	15-20
Ramlı 2	Semierect	Low	9.7	5.4	3.3	17.2	14.1	10.5	166.8	4.8	4.2	G	3	Absent	1-10 Aug.	15-20
Bığrasi 1	Open	High	20.9	7.2	5.3	24.3	22.6	13.2	358.8	7.3	5.3	G	3	Absent	11-31 Aug.	41-60
Bakrasi 2	Open	Intermediate	15.2	4.2	4.2	17.5	17.4	9.8	205.3	5.0	4.3	G	3	Absent	11-31 Aug.	21-40
Bakras 3	Spreading	Low	8.5	7.2	5.9	22.5	20.1	13.1	283.8	7.5	5.2	G	3	Present	11-31 Aug.	41-60
Bakrasi 4	Weeping	High	18.6	7.4	6.1	21.0	21.1	11.0	306.5	7.1	4.5	G	3	Present	11-31 Aug.	41-60
Bakrasi 5	Semierect	Intermediate	25.7	9.4	8.1	23.6	22.5	11.8	371.6	8.9	5.0	G	3	Present	11-31 Aug.	40-60
Mean			16.4	6.8	4.4	21.1	18.2	12.6	265.8	7.2	5.0					
SE			0.87	0.18	0.15	0.26	0.25	0.15	5.50	0.17	0.07					
Breba																
Bardak	Open	Intermediate	21.1	6.0	4.1	19.7	19.4	11.3	261.0	7.5	4.2	G	3	Absent	16-30 June	21-40
Dolap	Semierect	Intermediate	11.5	6.1	3.9	18.0	16.7	10.6	215.0	7.2	4.4	G	3	Absent	16-30 June	21-40
Mean			16.3	6.1	4.0	18.9	18.1	10.9	238.0	7.4	4.3					
SE			4.78	0.04	0.14	0.84	1.37	0.36	23.00	0.18	0.12					

Abbreviations used: Tree growth habit (TGH), tree vigor (TV), shoot length (SL; cm), number of leaves on a shoot (LN), number of fruits on a shoot (FN), leaf length (LL; cm), leaf width (LW; cm), length of center lobe (CLL; cm), leaf area (LA; cm^2), petiole length (PL; cm), petiole thickness (PT; mm), leaf shape (LS), number of leaf lobes (LLN), apical dominancy (AD), full maturity (FM), harvesting period (HP; days).

semierect growth habit. These accessions showed similar plant characteristics with the exception of their leaf lengths and areas.

Full maturity (FM) times were observed between 1 and 10 August (19 accessions) and between 1 and 30 September (6 accessions) in main crops. In general, these accessions were fully matured between 15 and 31 August (48 accessions). The first crop fruits of Bardak and Dolap matured in late June. The harvesting period (HP) of first-crop accessions (21-40 days) was shorter than that of the main-crop accessions (15-60+ days). Kırmızı 2, Ramlı 1, and Ramlı 2 were the main crops that showed the shortest harvest periods.

Fruit characters

Important fruit quality parameters of the fig accessions are given in Table 4. The average fruit weight (FW) of the main-crop figs ranged from 12.3 to 99.4 g. The FW and fruit diameter (FD) of Kabak 2 (99.4 g and 61.1 mm, respectively) were found to be higher than the others. The FW and FD were lowest in Kırmızı 2 (12.3 g and 27.7 mm, respectively). The fruit length (FL) ranged from 28.4 (Kırmızı 2) to 56.3 mm (Şami). The fruit shape index (width/length) values revealed different groups: with an index value of 0.9-1.0, 49 accessions were determined to be globose; 12 accessions were found to be oblong, with values of 0.7-0.8; and 15 accessions had values >1.1, making them oblate. The neck length (NL) was longest on Şibili (13.0 mm). No neck was observed for Gud Yeniği. Ostiole width (OW) was greatest in Beyaz Fahli (21.0 mm), whereas the lowest OW was recorded in Siyah 5 (0.6 mm). The fruit skin thickness (FST) ranged between 0.6 mm (Siyah 5) and 2.3 mm (Sarı 1). The total soluble solids (TSS) and TSS/acidity indices ranged from 16.0% to 27.1% and from 51.4 to 230.6, respectively. Different fruit skin colors, such as green, yellow, purple, brown, and black, were measured in the main crops. The most frequent fruit skin color of the main crops was green, while the pulp was pink (Table 4).

Bardak and Dolap were the only first crops found in the study area. The FW of these accessions were greater than 80 g. The FD, FL, NL, OW, TSS, and TSS/acidity values for Bardak were higher than those for Dolap. The color of the fruit skin in both of these accessions was green while the pulp color was white.

Principal component analysis

Plant and leaf characters

Principal component (PC) results indicated that the first 3 PCs accounted for as much as 43.1% of the total variation (Table 5). PC1, PC2, and PC3 accounted for 23.7%, 10.4%, and 9.0% of the total variation, respectively. The important variables included in PC1 were LW, LA, FN, LL, LN, SL, leaf margin dentations, the density of hairs/spicules on the leaf's upper surface, PT, PL, AD, and lateral shoot formation. The LLN, LS, CLL, tendency to form suckers, LL, leaf margin dentations, and PT were the variables of PC2. Lateral shoot formation, AD, TGH, TV, and shoot width were the most important variables for PC3 (Table 5).

Fruit characters

The results of PC analysis for pomological characters are presented in Table 6. The first PC made up 19.7% of the variation while the second made up 12.9% and the third made up 11.1%, for a total of 43.7%. The FD, FW, fruit skin color values (L*, a*, C*, and b*), fructose, glucose, and TAC were the most important variables of PC1. Values for pH, fruit flesh color *h*°, titratable acidity, TAC, TSS/TA, TA, fruit flesh color L*, and fruit skin and flesh color b* had the greatest effect on PC2. The FL, abscission of the stalk from the twig, NL, fruit skin color values (C*, a*, b*, L*, and *h*°), FS, fruit flesh color a*, firmness of the fruit skin, and FST were the significant parameters included in PC3 (Table 6).

Cluster analysis

Genetic distance matrices of the accessions ranged from 0.02 to 0.53. The lowest distance values were observed between Sarı 1 and Kabak 2 (0.02), Beyaz İncir and Meryemi 2 (0.03), Büyük Siyahlop and Mor 3 (0.03), Baldır and Sultani 3 (0.03), and Ramlı 1 and Ramlı 2 (0.04) (data not shown).

Cluster analysis using the unweighted pair group method with arithmetic mean (UPGMA) based on morphological distance analysis revealed that the 76 accessions could be divided into 5 main groups (Figure). Group I included 56 accessions and could be further separated into 4 subgroups that were found to have different morphological characteristics.

Table 4. Fruit characteristics of fig accessions sampled from the eastern Mediterranean region of Turkey.

Accession	FW	FD	FL	Index	NL	OW	FST	TSS	TSS/Acidity	FS	Skin color	Pulp color
Main crop												
Şami	53.1	49.1	56.3	0.9	9.0	4.1	1.8	20.6	176.3	Globose	Green	Amber
Fransavi	48.9	46.1	46.4	1.0	5.3	4.0	1.4	19.8	77.1	Globose	Green	Red
Hılvıni	21.6	33.3	32.4	1.0	3.4	1.3	1.2	22.7	163.9	Globose	Green	Amber
Büyük Siyahlop	40.4	41.3	42.8	1.0	4.6	5.1	1.3	20.6	141.4	Globose	Purple	Amber
Sıhle	38.2	40.6	45.7	0.9	7.2	1.9	1.4	22.5	117.9	Globose	Brown	Amber
Kilis	71.6	55.5	47.1	1.2	4.1	3.5	1.1	20.2	81.1	Oblate	Green	Amber
Ahmediye	78.2	52.6	52.3	1.0	4.7	1.3	1.6	20.8	115.3	Globose	Green	Pink
Burnu Kızıl	52.5	46.2	44.5	1.0	3.0	8.1	1.2	19.0	68.5	Globose	Green	Red
Allene Karası	45.6	47.0	38.7	1.2	4.0	6.2	1.3	19.2	129.6	Oblate	Black	Amber
Beyaz Fahli	40.7	47.2	36.2	1.3	3.5	21.0	1.1	23.7	127.5	Oblate	Green	Pink
Kandamık	58.1	49.2	39.4	1.2	1.9	1.9	1.1	20.0	94.2	Oblate	Green	Pink
Fahli	37.0	42.1	34.9	1.2	3.9	6.0	1.4	23.4	127.8	Oblate	Green	Pink
Fetike	59.4	49.0	42.9	1.1	5.7	8.3	1.6	20.5	156.3	Globose	Green	Pink
Armut Sapı	34.0	40.0	41.1	1.0	6.0	4.6	1.5	20.0	87.6	Globose	Yellow	Pink
Payas	18.9	32.5	31.0	1.0	0.5	1.9	1.2	20.4	108.4	Globose	Green	Dark red
Gud Yeniği	32.7	40.2	29.8	1.4	0.0	5.4	1.0	22.5	131.5	Oblate	Green	Amber
Baldır	40.5	42.3	39.6	1.1	5.6	3.2	1.6	20.5	81.1	Globose	Green	Red
Halep	56.2	50.3	44.6	1.1	8.1	4.5	1.6	18.4	110.9	Globose	Green	Amber
Erkenci	39.6	41.8	44.8	0.9	5.7	4.9	1.6	20.9	150.0	Globose	Brown	Amber
Yeşil İncir	66.5	51.8	43.0	1.2	2.3	3.3	1.9	22.5	70.9	Oblate	Green	Dark red
Şebli	38.6	39.1	42.3	0.9	2.3	3.7	1.0	23.5	155.1	Globose	Brown	Amber
Tınesvit	37.1	38.4	51.4	0.7	8.5	1.5	1.5	22.0	119.5	Oblong	Brown	Amber
Sütlü Sarı	51.1	47.0	50.2	0.9	7.5	2.4	1.4	20.4	168.6	Globose	Yellow	Pink
Mersinli	56.6	48.5	44.6	1.1	2.9	4.9	1.4	20.7	123.9	Globose	Yellow	Red
Zırhıni	22.9	34.7	46.6	0.7	7.1	1.3	1.1	22.4	118.2	Oblong	Brown	Red
Şibili	42.9	41.7	49.5	0.8	13.0	4.7	1.1	20.2	172.8	Oblong	Purple	Pink
Karagöz	46.6	42.9	47.4	0.9	5.8	1.1	1.2	20.2	69.5	Globose	Purple	Dark red
Beyaz İncir	46.8	45.7	41.7	1.1	5.1	5.8	1.4	20.4	79.0	Globose	Green	Dark red
Sarı 1	81.6	56.7	50.3	1.1	9.5	4.5	2.3	18.4	75.9	Globose	Yellow	Dark red
Sarı 2	62.3	50.1	52.8	0.9	7.8	6.7	1.8	19.7	199.8	Globose	Yellow	Pink
Sarı 3	54.3	48.6	43.1	1.1	8.3	6.8	1.7	20.8	104.1	Globose	Yellow	Pink
Sarı 4	37.5	38.0	40.3	0.9	4.0	5.9	1.9	17.5	82.0	Globose	Green	Pink
Sarı 5	74.0	53.8	44.1	1.2	3.1	3.0	2.0	21.4	80.7	Oblate	Yellow	Red
Sarı 6	87.4	58.7	48.4	1.2	4.3	5.1	1.4	23.6	132.0	Oblate	Yellow	Amber
Siyah 1	58.4	50.2	47.6	1.1	5.5	2.5	1.7	19.9	107.9	Globose	Brown	Red
Siyah 2	36.0	42.5	36.5	1.2	2.7	3.8	1.0	21.9	102.4	Oblate	Black	Pink
Siyah 3	24.8	36.1	31.3	1.2	0.5	3.2	1.0	19.7	59.5	Oblate	Black	Dark red
Siyah 4	80.4	55.4	47.5	1.2	3.7	6.0	1.5	18.3	55.1	Oblate	Black	Red
Siyah 5	21.3	32.6	36.1	0.9	2.8	0.6	0.6	22.3	117.7	Globose	Black	Pink
Siyah 6	29.0	38.0	44.6	0.9	6.4	2.2	1.4	22.4	156.2	Globose	Brown	White
Siyah 7	35.6	38.8	47.8	0.8	7.8	2.4	1.8	21.0	91.5	Oblong	Brown	Pink
Siyah 8	40.1	40.6	44.3	0.9	5.0	1.1	1.2	21.5	67.2	Globose	Purple	Dark red
Mor 1	66.8	52.2	50.7	1.0	8.2	3.6	2.1	20.7	100.0	Globose	Brown	Red
Mor 2	65.3	49.9	48.4	1.0	3.3	4.6	1.8	19.4	104.8	Globose	Purple	Pink
Mor 3	36.2	39.5	47.4	0.8	7.4	2.0	1.7	20.8	147.1	Oblong	Brown	Amber
Mor 4	46.6	44.1	43.7	1.0	4.6	1.9	1.1	21.8	64.3	Globose	Purple	Red
Mor 5	30.9	37.0	38.3	1.0	2.7	3.6	1.3	22.6	204.3	Globose	Purple	Amber
Mor 6	45.3	45.7	36.1	1.3	2.5	2.8	1.4	18.5	108.1	Oblate	Brown	Red
Sultani 1	35.3	40.1	40.4	1.0	4.2	3.2	1.9	25.5	170.5	Globose	Yellow	Pink
Sultani 2	50.4	46.6	46.7	1.0	6.0	5.0	2.2	23.0	114.7	Globose	Yellow	Red
Sultani 3	44.1	45.8	43.7	1.0	6.3	3.5	1.3	19.2	81.9	Globose	Green	Red
Kabak 1	81.7	55.8	54.5	1.0	8.0	2.2	1.7	17.9	51.4	Globose	Green	Dark red
Kabak 2	99.4	61.1	46.4	1.3	7.5	4.6	2.2	19.0	81.2	Oblate	Green	Dark red
Şeble 1	51.9	43.7	50.8	0.9	3.9	5.0	1.7	19.1	105.9	Globose	Brown	Pink
Şeble 2	50.7	44.5	46.8	1.0	4.7	6.7	1.2	19.4	99.5	Globose	Brown	Pink
Kıreni 1	47.7	46.9	43.4	1.1	3.9	10.3	1.8	21.2	112.1	Globose	Yellow	Pink
Kıreni 2	69.7	51.8	52.4	1.0	6.4	4.4	1.3	22.0	195.4	Globose	Yellow	Pink
Sehli 1	33.7	38.1	43.0	0.9	5.5	2.1	1.4	23.4	107.3	Globose	Brown	Amber
Sehli 2	23.1	32.2	38.9	0.8	4.8	2.1	1.2	24.3	144.0	Oblong	Brown	Amber
Meryemi 1	55.3	49.2	50.1	1.0	8.7	6.8	1.8	19.2	94.4	Globose	Yellow	Dark red
Meryemi 2	47.6	45.5	39.4	1.2	3.1	5.1	1.2	20.6	77.7	Oblate	Green	Pink
Kuruye 1	25.2	34.5	42.2	0.8	7.0	2.6	1.5	23.0	145.8	Oblong	Brown	Amber
Kuruye 2	21.2	30.9	43.4	0.7	8.7	2.0	1.4	24.5	230.6	Oblong	Brown	Amber
Kırmızı 1	28.6	36.9	46.9	0.8	7.9	1.3	1.6	22.4	149.6	Oblong	Brown	Red
Kırmızı 2	12.3	27.7	28.4	1.0	1.7	2.8	1.5	27.1	136.8	Globose	Brown	Red
Lopkara 1	30.5	35.4	42.7	0.8	6.8	1.4	1.9	22.4	161.1	Oblong	Brown	Pink
Lopkara 2	54.4	46.6	47.1	1.0	5.8	6.3	1.7	19.5	69.5	Globose	Black	Red
Ramlı 1	24.6	33.3	37.9	0.9	5.4	4.9	1.1	20.0	145.4	Globose	Green	Pink
Ramlı 2	18.0	29.7	34.6	0.9	2.3	4.4	0.9	22.3	127.8	Globose	Green	Pink
Bığrasi 1	29.3	37.0	37.3	1.0	2.0	3.4	1.0	21.2	74.2	Globose	Green	Pink
Bakrasi 2	22.4	37.5	36.6	1.0	1.3	4.6	1.2	19.7	90.2	Globose	Green	Red
Bakras 3	34.0	38.8	39.7	1.0	2.8	2.8	1.2	20.4	82.0	Globose	Green	Pink
Bakrasi 4	45.0	43.0	47.0	0.9	4.5	4.4	1.8	16.0	63.6	Globose	Green	Pink
Bakrasi 5	39.3	41.8	49.8	0.8	3.4	5.0	1.7	19.5	100.9	Oblong	Green	Pink
Mean	45.5	43.5	43.5	1.0	5.0	4.1	1.5	21.0	114.8			
SE	2.18	0.86	0.73	0.02	0.28	0.32	0.04	0.24	4.48			
Breba												
Bardak	84.6	56.5	58.8	1.0	5.2	2.0	2.1	15.8	83.6	Globose	Green	White
Dolap	81.4	53.9	57.3	0.9	5.2	0.7	1.7	15.0	75.9	Globose	Green	White
Mean	83.0	55.2	58.1	1.0	5.2	1.4	1.9	15.4	79.8			
SE	1.61	1.27	0.71	0.01	0.02	0.63	0.22	0.38	3.86			

Abbreviations used: fruit weight (FW; g), fruit diameter (FD; mm), fruit length (FL; mm), neck length (NL; mm), ostiole width (OW; mm), fruit skin thickness (FST; mm), total soluble solids (TSS; %), fruit shape (FS).

Table 5. Eigenvalues and results of the first 3 principle component (PC) analyses for the plant and leaf characteristics in 76 fig accessions.

Characters	**PC1**	**PC2**	**PC3**
Tree growth habit	0.02	0.12	0.32
Tree vigor	0.09	0.11	0.29
Tendency to form suckers	–0.01	0.24	0.16
Cropping efficiency	0.17	–0.11	–0.03
Apical dominancy	0.20	0.05	–0.49
Lateral shoot formation	–0.20	–0.05	0.49
Terminal bud color	0.07	0.00	0.04
Shoot color	–0.03	–0.05	0.18
Twin fruit ratio	0.07	–0.12	0.06
Leaf length	0.30	0.21	0.16
Leaf width	0.34	0.05	0.19
Length of central lobe	0.14	0.43	0.11
Leaf area	0.34	0.09	0.13
Petiole length	0.21	0.00	0.06
Petiole thickness	0.22	0.20	–0.02
Shoot length	0.28	–0.08	–0.08
Shoot width	0.03	–0.05	0.26
Number of leaves per shoot	0.30	0.04	–0.12
Number of fruits per shoot	0.32	–0.06	0.03
Leaf venation	–0.11	–0.06	–0.19
Leaf shape	0.07	–0.48	0.14
Number of lobes	–0.08	0.48	–0.14
Leaf margin dentation	0.25	–0.21	–0.02
Density of hairs/spicules on leaf’s upper surface	0.23	–0.18	–0.02
Density of hairs/spicules on leaf’s lower surface	0.16	–0.18	0.00
Eigenvalue	6.15	2.70	2.33
Variance (%)	23.7	10.4	9.0
Cumulative variance (%)	23.7	34.1	43.1

Subgroup IA included the accessions Şami, Sarı 2, Kıreni 2, and Sarı 6, with similar fruit size and ostiole width. Subgroup IB (13 accessions) was also separated into 3 subgroups according to fruit skin color. Specimens Fransavi, Mor 4, Karagöz, and Siyah 8, all of which had a green-purple color, were in the same subgroup, whereas others with a yellow skin color were grouped into 2 subgroups. The pairs Fransavi and Mor 4, and Beyaz İncir and Meryemi 2, were very similar to each other. Only the Bardak and Dolap accessions, which were first crops, were classified in the same subgroup from the IB subgroup. Subgroup IC consisted of 17 accessions, of which the pairs Büyük Siyahlop and Mor 3, and Şeble 1 and Şeble 2, showed very similar morphological characters. Generally, the accessions in this group had purple and brown skin color, except for Sütlü Sarı and Kıreni 1. The subgroup ID consisted of 22 accessions with yellow-green colors and small and medium fruit sizes. With the exception of Mor 1, there were 12 accessions in Group II with yellow-green fruit skin color. In this group, accessions were found to have large fruit size and high TSS values for good table fig quality.

Table 6. Eigenvalues and results of the first 3 principle component (PC) analyses for the fruit characteristics in 76 fig accessions.

Characters	**PC1**	**PC2**	**PC3**
Fruit weight	0.26	–0.12	–0.17
Fruit diameter	0.28	–0.13	–0.14
Fruit length	0.16	0.04	–0.36
Fruit shape	0.16	–0.18	0.21
Weight of 100-fruitlets	0.02	0.06	0.07
Fruit neck length	0.05	0.12	–0.28
Ostiole width	0.09	0.02	0.12
Fruit skin thickness	0.19	0.03	–0.20
Shape of fruit stalk	0.01	–0.11	0.14
Abscission of the stalk from the twig	–0.07	0.11	0.30
Ease of peeling	–0.03	0.00	0.10
Fruit skin cracks	–0.10	0.04	0.03
Firmness of the fruit skin	–0.13	0.01	0.21
Fruit ribs	–0.11	0.06	0.16
Fruit cavity	–0.10	0.17	–0.08
Color formation in the flesh	0.00	0.05	0.10
Uniformity of fruit size	–0.17	0.19	0.02
Fruit symmetry	0.16	–0.17	0.00
Fruit skin color L*	0.26	0.18	0.20
Fruit skin color a*	–0.24	–0.11	–0.22
Fruit skin color b*	0.23	0.20	0.21
Fruit skin color C*	0.24	0.17	0.23
Fruit skin color *h*°	0.18	–0.08	0.20
Fruit flesh color L*	0.10	0.24	–0.02
Fruit flesh color a*	0.16	–0.08	0.21
Fruit flesh color b*	0.12	0.20	0.08
Fruit flesh color C*	0.16	0.14	0.12
Fruit flesh color *h*°	0.03	0.31	–0.07
Total soluble solids (TSS)	–0.22	0.10	0.14
pH	–0.05	0.32	–0.14
Titratable acidity (TA)	0.12	–0.27	0.13
TSS/TA	–0.17	0.25	–0.09
Antioxidant capacity	–0.20	–0.26	0.08
Total phenols	–0.19	–0.22	0.07
Total anthocyanins	–0.11	–0.25	0.00
Fructose	–0.21	0.08	0.13
Glucose	–0.21	0.10	0.14
Sucrose	–0.15	0.10	0.14
Eigenvalue	7.47	4.89	4.22
Variance (%)	19.7	12.9	11.1
Cumulative variance (%)	19.7	32.6	43.7

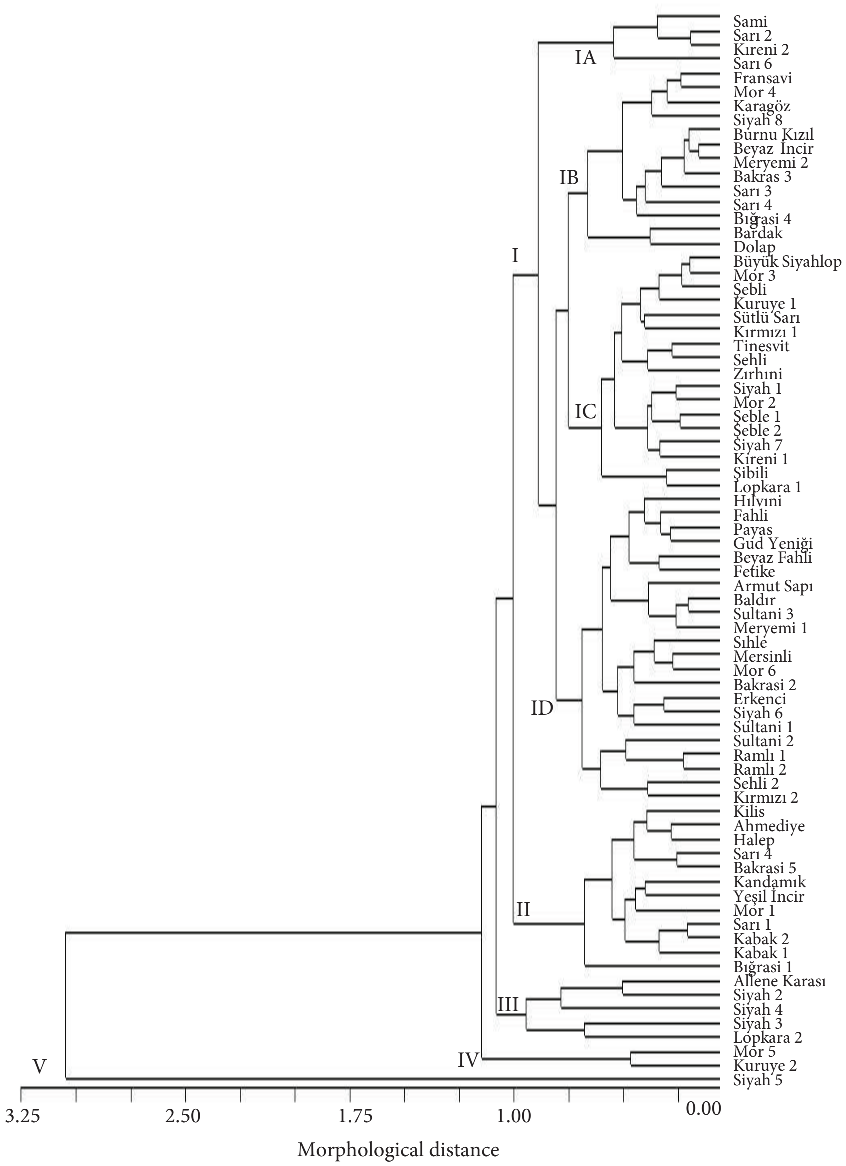

Figure. UPGMA dendrogram based on morphological distances of fig accessions from Hatay, in the eastern Mediterranean region of Turkey.

Allene Karası, Siyah 2, Siyah 4, Siyah 3, Lopkara 2, and Mor 5, with black and purple fruit skin colors, were classified in the same group (Group III). The accessions had medium-sized fruit, thin fruit skin, high TSS values, a medium leaf area, high total antioxidant capacity, high total phenol content, and high total anthocyanins.

Group IV consisted only of Mor 5 and Kuruye 2, both of which had brown skin. These accessions showed higher results for TSS, total phenol, fructose, glucose, and sucrose than the other groups. Siyah 5, with a dark black skin color, was included in Group V. Siyah 5 was found to be the smallest in terms of fruit weight, fruit size, ostiole width, and acidity, whereas it was higher in terms of TSS content, total antioxidant capacity, total phenol, and total anthocyanins.

Discussion

For a sustainable increase in fig production, there is a need to develop new table figs while considering the maturity period, quality, and preferences of the consumer. The table figs found in Turkey, mostly local cultivars or accessions, are grown in the Mediterranean, Marmara, Black Sea, and southeastern regions. There are numerous local cultivars with a variety of sizes, shapes, ripening times, skin and pulp colors, and taste. Both morphological characterization and the protection of this genetic diversity for future generations are very important.

In this study, plant and fruit characteristics of the local fig accessions were identified. Figs ripen once or twice per year, depending on the accession. The first crop (breba) appears in the spring on wood from the previous year. The second crop matures in the fall on the growth and is known as the main crop (Stover et al. 2007). In the present study, 2 accessions (Bardak and Dolap) were determined to be first crops and the other 74 accessions were main crops. The first crops matured after 15 June, which is late for breba. The full maturation of the main crops was found to be very promising on account of the extension of the marketing period, as very early (Erkenci), early (19 accessions), and late (6 accessions).

With regard to the fruit widths given in the fig descriptor list (IPGRI and CIHEAM 2003), 27.6% of the samples were large (50-60 mm) or very large (>60 mm). Fruit skin color of fresh figs is especially important for consumer preferences, and fruit skin and flesh color are used to determine ripening time. These characteristics are also used together with other features in determining the selection of accessions used in breeding studies (Tsantili 1990; Sacks and Shaw 1994). Fresh figs with pink and red flesh color are preferred by consumers. In this study, fig accessions commonly had the pink and red flesh colors desired. When our results were compared to previous studies performed in diverse ecological conditions in Turkey, differences were detected for some of the pomological traits. Aksoy et al. (2003) found FW, NL, and TSS values in the ranges of 31.5-76.0 g, 0.0-21.6 mm, and 15.2%-26.0%, respectively. In another study, the ranges of fig accessions for FW, FD, FL, and TSS were 23.0-84.0 g, 36.0-56.0 mm, 30.0-56.0 mm, and 12.0%-21.3%, respectively (Koyuncu 2004). Similarly, Çalişkan and Polat (2008) reported FW, FD, FL, NL, OW, and TSS values of 22.2-52.5 g, 31.9-44.2 mm, 30.2-45.8 mm, 1.0-8.9 mm, 1.1-4.9 mm, and 20.1%-27.4%, respectively. The fig accessions used in this study had much higher FW and TSS values (99.4 g and 27.1%), but TSS values were lower than those reported by Çalişkan and Polat (2008). These differences could be due to genotypic diversity or environmental effects on fruit characters.

The PC analysis indicated that there were great variations among accessions in terms of plant and fruit traits. Accessions with similar parameters sampled from different locations were clustered in the same groups. We can say that such clustering was observed due to the high number of selected accessions, as well as the presence of synonym, homonym, and similar accessions in the eastern Mediterranean region of Turkey. Çalişkan and Polat (2008) pointed out that random selection from natural populations increases the genetic diversity, whereas cultivars of different geographic origins exhibit high genetic similarity. Previous studies have shown that fig cultivars have a rather narrow genetic base (Khadari et al. 1995; Papadopoulou et al. 2002; Salhi-Hannachi et al. 2006). It is possible that the same name was given to several genetically different fig cultivars with similar morphological characteristics in this region.

Only 11 out of 26 plant traits were able to successfully distinguish different accessions. The number and shape of lobes (Saddoud et al. 2008), tree growth habit, size of the tree, degree of branching, number of lobes per leaf (Giraldo et al. 2010), leaf length, leaf width, leaf area, density of hairs/spicules on the leaf's upper surface, and petiole thickness (Podgornik et al. 2010) were the traits used for the discrimination of fig accessions. In addition, it can be very useful to use AD, LS, FN, and LN for the identification of fig germplasm.

In the fig accessions, 26 of 38 fruit characters were able to explain 47.3% of the total variation. The most important discriminators of fig fruits were the fruit weight, fruit length, fruit diameter, fruit skin and flesh color (Saddoud et al. 2008; Aljane and Ferchichi 2009; Podgornik et al. 2010), fruit shape (Giraldo et al. 2010; Podgornik et al. 2010), firmness of the fruit skin (Saddoud et al. 2008; Podgornik et al. 2010), fruit skin cracks (Saddoud et al. 2008), production type, skin firmness (Giraldo et al. 2010), fruit neck length (Aljane and Ferchichi 2009; Podgornik et al. 2010), abscission of the stalk from the twig (Podgornik et al. 2010), stalk diameter, neck diameter, ostiole diameter, ostiole opening, and flesh thickness (Aljane and Ferchichi 2009). When our results were compared to those of previous studies, we detected that additional variables, such as TAC, TP, TA, glucose, and fructose, could be used as successful parameters.

The subjective traits used in separating fig accessions can also be used as important variables for selection studies. More objective conversion of these visual traits into unbiased values results in more successful results in the discrimination of different accessions. For example, the use of a colorimeter instead of a color chart should be preferred in descriptive and selective research in order to obtain more reproducible results. The TSS, pH, acidity, TSS/acidity, TAC, TP, TA, fructose, and glucose contents of the fig fruits were also found to be very important traits for the diversity of accessions. In describing the genetic sources of fig accessions, not only the subjective traits but also phytochemical properties can be used as successful criteria.

Cluster analysis using UPGMA based on morphological and phytochemical distance analysis revealed that the Sarı 1 and Kabak 2, Ramlı 1 and Ramlı 2, Fransavi and Mor 4, and Beyaz İncir and Meryemi 2 accessions were similar to each other. The Bardak and Dolap accessions, which had breba fruits, were in the same subgroup. Siyah 5, with small fruit and a dark black color, was grouped separately. Valizadeh and Valdeyron (1979) and Hilling and Lezzoni (1988) indicated that morphological and fruit quality characteristics, as well as biochemical parameters, can be successfully used for discriminating different accessions. In characterization research, however, especially with a large number of accessions, traits that are dependent on environmental conditions, such as morphological and fruit quality characteristics, were not found to be very useful (Papadopoulou et al. 2002; Khadari et al. 2003; Baraket et al. 2009). We know that morphological traits are one of the most essential variables for fig germplasm research, but the outcomes obtained from that sort of study have been limited due to the inconvenience of establishing reference accessions in fig breeding programs. To overcome these limitations, large-scale DNA-based polymerase chain reaction methods using random amplified polymorphic DNA (RAPD) and simple sequence repeat (SSR) markers have been successfully designed for figs (Cabrita et al. 2001; Salhi-Hannachi et al. 2004; Chatti et al. 2007; Saddoud et al. 2007; Ikegami et al. 2009; Aradhya et al. 2010; Dalkılıç et al. 2011). Therefore, the characterization of local fig accessions from the eastern Mediterranean region of Turkey with RAPD and SSR markers is required for more reliable classification of fig germplasms.

The results presented in this paper are the first data on the plant and fruit quality characters in fig accessions from the eastern Mediterranean region of Turkey. In terms of fruit quality characters, the Bardak and Dolap accessions from the first crop and Kabak 1, Kabak 2, Mor 1, Sarı 1, and Siyah 1 accessions from the main crop were found to be very promising for the cultivation of fresh figs. Results of the PC analysis showed that there were very great variations among accessions with regard to plant and fruit traits (with a total of 64 traits). From those plant and fruit characters, 37 out of 64 traits were shown to be more useful in separating fig accessions from the eastern Mediterranean region of Turkey.

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