Europ.J.Hort.Sci., **69** (3). S. 125–131, 2004, ISSN 1611-4426. © Verlag Eugen Ulmer GmbH & Co. Stuttgart

Evaluation of Black Mulberry (*Morus nigra* L.) Genotypes from Lakes Region, Turkey

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Summary

Valuable genotypes were identified in the existing genetic resource of black mulberry (*Morus nigra* L.) in Mahmatlar and Eğirdir at Lake Eğirdir (Mediterranean region) of Turkey. First, native black mulberry genotypes were surveyed for fruit and tree characters and second, twenty-eight pre-selected genotypes were evaluated as potential candidates for conservation of *M. nigra* germplasm. Flowering started in the beginning of April. Harvesting period was between first week of July and September. The leaf shape of all genotypes was unlobed, dentate and cordate and the leaves (except from M-22 and M-23) had dark-green colour. Values between 3.74 g and 5.67 g was found for average fruit weight, 15.73–17.42 mm for fruit diameter, 21.66–27.04 mm for fruit length, 13.11–16.23 % for soluble solid, 1.35–1.86 % for acidity and 2.8–23.0 μg g^{-1} for vitamin C. All genotypes had an attractive black-purple colour and medium-large sized fruits.

Zusammenfassung

Bewertung von Genotypen der schwarzen Maulbeere der Lakes Region, Türkei. Innerhalb der in Mahmatlar und Eğirdir am Eğirdirsee (türkische Mittelmeerregion) vorhandenen genetischen Ressourcen der schwarzen Maulbeere (*Morus nigra* L.) wurde nach wertvollen Genotypen gesucht. Hierfür wurden im ersten Schritt die Frucht- und Baummerkmale einheimischer Genotypen ermittelt und im zweiten Schritt 28 selektierte Genotypen als mögliche Kandidaten für eine Erhaltung der Genotypen näher untersucht.

Die Blüte begann Anfang April. Die Erntezeit reichte von der ersten Juliwoche bis in den September. Die Blätter aller Genotypen waren ungelappt, gezähnt und herzförmig und mit Ausnahme von M-22 und M-23 dunkelgrün. Für das durchschnittliche Fruchtgewicht wurden Werte zwischen 3.74 und 5.67 g, für den Fruchtdurchmesser 15.73–17.42 mm, für die Fruchtlänge 21.66–27.04 mm, für die lösliche Trockensubstanz 13.11–16.23 %, für den Säuregehalt 1.35–1.86 % und für das Vitamin C 2.8–23.0 μg g^{-1} gemessen. Die Früchte aller Genotypen waren schwarz-violett und mittelgroß.

Key words. Fruit characteristics – germplasm – *Morus nigra* – mulberry – vitamin C

Introduction

The genus *Morus* is a member of the Moraceae family, and consists of 12 species. They have been wide spread under varied climatic condition ranging from temperate to subtropical regions of the Northern Hemisphere. The mulberries are deciduous thornless trees and shrubs. Notable cultivars are mentioned under the species *M. alba, M. nigra* and *M. rubra*. Black mulberry (*M. nigra*) is a native plant in Asia, Armenia and the Southern Caucasus region as far as Persia and is now cultivated throughout Europe (YALTIRIK 1982, 1988; VERHEIJ and CORONEL 1991; WESTWOOD 1995).

The black mulberry has been cultivated for its fruits worldwide (REICH 1991; VERHEIJ and CORONEL 1991; TUTIN 1996). Before the superiority of the white mulberry leaves to feed for silkworms (*Bombyx mori* L.) was recognized, black mulberry had been cultivated widely in Italy. It is the most produced mulberry species in Greece (DE CANDOLLE 1967). The black mulberry fruits are consumed as fresh or they are cooked or preserved. The delicious slightly acid flavour makes fruits an excellent dessert that can be eaten in quantities. The fruit is juicy and refreshing (REICH 1991).

The black mulberry (Turkish name 'Kara Dut') is widely grown in Anatolia (GOKMEN 1973; YALTIRIK 1982; ANSIN and OZKAN 1993). Isparta Province in Lakes Region situated in the Mediterranean of Turkey has rich genetic resources of native mulberry due to favourable climatic conditions. Especially, the Mahmatlar district in this region has variable black mulberry sources, and they are cultivated in gardens for its delicious edible fruits.

There is a notable consumption of this fruit in Turkey as well as in other countries of the world. The black mulberry fruits are used in various confectionary products such as jam, marmalade, pulp, paste, and also for medicinal purposes to treat mouth lesion (BAYTOP 1984; OZYURT 1992). The Aegean and Mediterranean regions are main cultivation areas of Turkey, the fruits are gathered when ripe, sometimes dried on the tops of the houses under the sun and stored or kept in deep freezers for winter uses.

In recent years, there have been studies on drying characters (MASKAN and GOGUS 1998), pharmacological

functions (BARMAN et al. 1980; NOMURA 1999), flavour characteristics (ELMACI and ALTUG 2002), quality characteristics (GERASOPOULOS and STAVROULAKIS 1997) and genetic diversity (SHARMA et al. 2000) in different species of *Morus* L., especially *M. alba*. The species *M. nigra*, which is used for its fruits, displays less diversity than *M. alba* (GOKMEN 1973). To the best of our knowledge, there exist no reports regarding the diversity of morphological and agronomical characters of black mulberry. This study was aimed at determining the diversity of fruit and tree characteristics of black mulberry (*M. nigra* L.) from the Lakes Region and preserving them as genetic resources.

Material and Methods

Plant material and sampling

The study was conducted on the native black mulberry population of the Eğirdir county and Mahmatlar district (Isparta province) situated at the Lake Eğirdir in the Mediterranean region of Turkey during 2000 and 2002 (Fig. 1). The research material consisted of seedling trees on which no technical and cultural practices were previously performed. During the first experimental year, the present population were surveyed at the vegetation period for some tree characteristics and disease-free trees were marked. At harvest season, trees which produced fruits below the average of 3.5 g were discarded and 28 *Morus nigra* genotypes were selected for trait evaluation. In the following years (2001–2002) some tree, leaf, and fruit characteristics of these genotypes were evaluated phenologically and morphologically: For leaf traits, leaves were collected from 1-year old shoots after fruit harvesting. Twenty leaves were used for measurement of leaf characteristic. Sampling was done in the medium part of branches. For characterization of fruits traits, fruits were harvested (about 2 kg/tree) from different sides of the trees with 15 days intervals at two times in every trial year and immediately brought to the laboratory in ice-boxes. For fruit dimensions measurements 30 fruits were used. The gen-

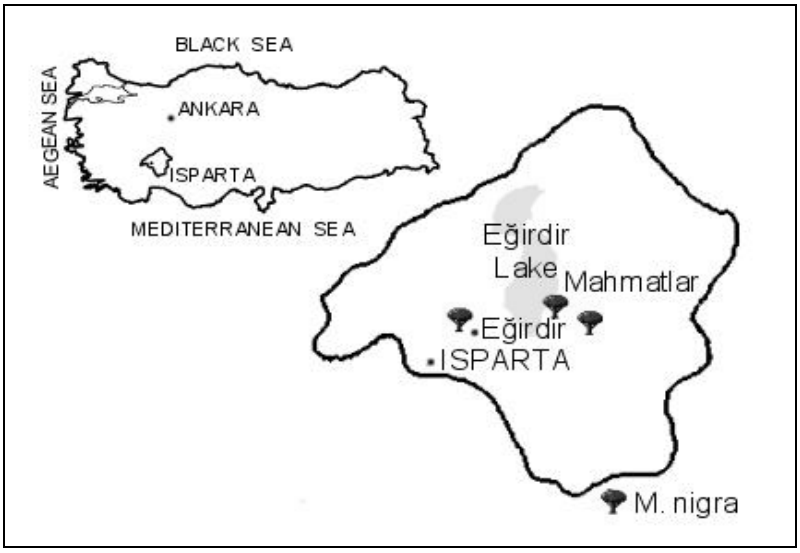


Fig. 1. Geographical sites of *M. nigra* trees in this study.

Table 1. The list of tree, leaf and fruit characters, and their determinations

Traits	Determination of characters
Altitude of site	By hand GPS (Magellan GPS 315, Taiwan)
Trunk circumference (m)	Stem diameter at 75 cm above ground level
Tree height (m)	From the level of soil to top of tree
Tree crown width (m)	From the widest sides, on an average of two measurements
Leaf length (cm)	From the base of leaf petiole to the tip of terminal
Leaf width (cm)	At the widest part of leaf
Leaf weight (g)	Weighing leaves
Leaf colour	Dark green, green or light green by observation
Leaf shape	Lobed or unlobed, dentate or undentate and cordate or acuminate
Leaf petiole length (cm)	From the base of leaf petiole to starting point of leaf
Leaf petiole width (mm)	At the central part of leaf petiole
Fruit width (mm)	By digital micrometer (0.01 sensitivity)
Fruit length (mm)	By digital micrometer (0.01 sensitivity)
Fruit weight (g)	By 0.01 g sensitivity balance (Scaltec, SBA-51)
Fruit colour (L^*, a^*, b^*)	With a Minolta CR-300 chromameter (Minolta, Japan)

otypes were named as "M" (Mahmatlar black mulberry genotypes). Table 1 shows the traits surveyed in this study.

Phenological characteristics

The dates of bud burst, appearance of flowers, fruit colouring, beginning of harvest, and the end of harvest for each genotype were observed according to LALE (1992).

Chemical analysis in black mulberry fruits

Fruit juice was extracted with a kitchen–blender and filtered. Soluble solids were determined with a digital refractometer (Atogo, PR 32, Japan). pH and total acidity was measured by the Aoac methods (1995). Total acidity was determined by titration with 0.1 N NaOH to pH 8.1 and expressed as % malic acid.

Vitamin C quantification was performed with HPLC. The analysis was carried out in Shimadzu class LC-VP HPLC system with class LC-VP software, a pump (LC-6AD), and a UV-VIS detector (SPD-10A VP). The SGE column wakosil II 5CI8RS 5 µm (250x4.6 mm I.D.) was used. The chromatographic conditions were as follows: flow rate, 0.8 mL min-1; volume injected, 20 µL; column temperature, ambient; detection wavelength 254 nm; mobile phase, deionized water (pH 3-H_3PO_4). Mulberry fruits (10 g), which are diluted with 10 mL 2 % H_3PO_4, were homogenized (Ultra-Turrax) and filtered. 1.5 mL elution solution (0.01 M KH_2PO_4, pH 8.00) was added on 1.5 mL filtrate. 1 mL of this solution was transferred from preconditioned Sep-pak C18 cartridges (Waters) with 3 mL methanol and 10 mL H_2O and taken to the tube. The cartridge was washed with 2mL extraction solution. The eluates were mixed and used for HPLC separation.

Statistical analysis

Descriptive statistics were computed for quantitative characters. All statistical analyses were performed using SPSS computer statistical program (ANONYMOUS 1999). The data were presented as the mean ± standard deviation.

Results and Discussion

Fig. 2 shows the phenologic properties of 28 selected genotypes from Mahmatlar and Eğirdir (Isparta). All the black mulberry genotypes were healthy and free from fungal diseases. The bud burst dates of genotypes ranged from 20 April to 30 April. All genotypes except from M-19, 22 and 28 started flowering on the first days of April. The fruit colouring time varied from 5–16 June. Harvest began at the first week of July and finished in early September.

On the other hand, genotypes had a range of 9–32 m for tree height, 5.25–16.30 m for tree crown width and 1.00–9.20 m for trunk circumferences. Some researchers reported that black mulberry trees were up to 10 m with short trunk and widely spreading round crown (YALTIRIK 1982, 1988; REICH 1991; VERHEIJ and CORONEL 1991; TUTIN 1996). The genotypes of *M. nigra* located both sites of Lake Eğirdir are at almost the same altitudes ranging from 909 m to 1042 m (Table 2).

As for the leaf characters, leaf shape of all genotypes were unlobed, dentate and cordate. In generally, leaf colours were dark-green with the exception of M-3, M-22, and M-23 (green). Leaf vessel was observed as 'much' and 'medium'. Descriptions of leaf characteristics related to leaf shape and colour by YALTIRIK (1982, 1988), VERHEIJ and CORONEL (1991), LALE (1992), TUTIN (1996) were in agreement with our results. According to these authors, black mulberry leaves were cordate at base, usually undivided and dark green. Leaf weights were between 0.81 g (M-6) and 2.50 g (M-14). The weight of leaf was not yet reported in literature. The leaf length and width values ranged from 8.43 to 11.62 cm and 8.76 cm to 11.82 cm, respectively. For the leaf petiole length, genotype M-15 had the longest leaf petiole (2.91 cm), genotype M-3 was found to have the shortest leaf petiole (2.10 cm). Leaf petiole widths were between 0.83 mm and 2.68 mm. As for the leaf length, leaf width, leaf petiole length, and width results

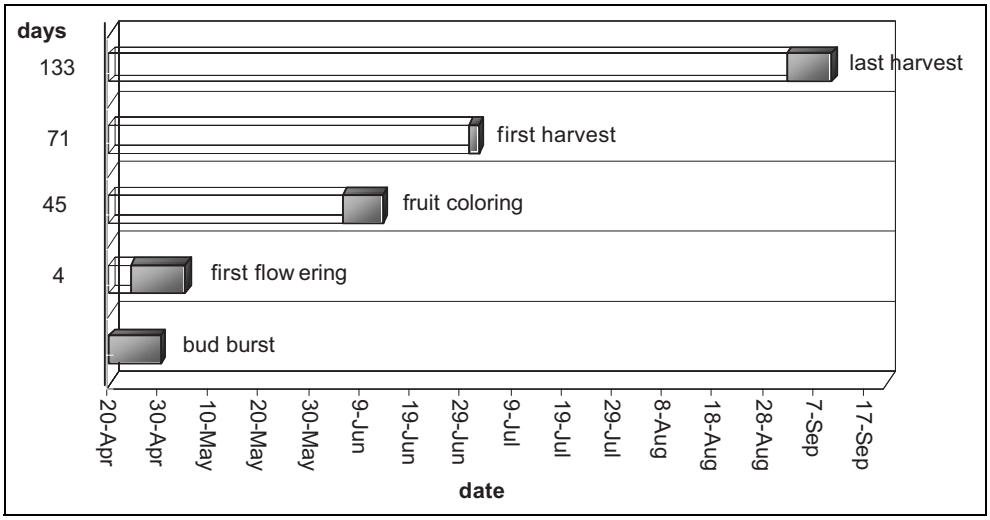


Fig. 2. The phenological observations on native black mulberry tree.

Table 2. Some leaf and tree characteristics of native black mulberry tree

Geno-types	Altitude of site (m)	Tree height (m)	Tree width (m)	Tree circum (m)	Leaf length (cm)	Leaf width (cm)	Leaf weight (g)	Leaf colour	Petiole length (cm)	Petiole width (mm)	Leaf vessel
M-1	1042	15	16.30	9.20	11.00±1.10	10.19±0.97	1.43±0.60	dark green	2.33±0.44	1.89±0.41	medium
M-2	947	12	7.10	2.30	10.48±1.49	9.97±0.69	1.26±0.35	dark green	2.50±0.44	1.78±0.36	much
M-3	911	11	12.35	4.80	9.54±1.46	8.93±0.76	0.87±0.17	dark gren	2.10±0.55	1.58±0.36	much
M-4	923	11	8.50	2.70	10.33±1.44	9.43±0.98	1.24±0.39	dark green	2.24±0.28	1.65±0.30	much
M-5	910	18	11.75	2.30	10.73±1.39	10.70±1.36	1.33±0.30	dark green	2.41±0.46	1.83±0.34	much
M-6	937	15	11.30	5.80	9.08±1.28	9.16±0.65	0.81±0.20	dark green	2.11±0.32	1.63±0.37	much
M-7	932	20	17.10	7.50	9.89±1.29	9.77±0.97	1.21±0.57	dark green	2.38±0.28	1.53±0.50	much
M-8	931	20	14.10	2.30	11.09±1.98	11.28±1.38	2.37±0.78	dark green	2.85±0.48	0.95±0.14	much
M-9	931	15	5.85	1.60	10.64±0.82	10.53±0.51	1.87±0.29	dark green	2.30±0.43	2.37±0.23	much
M-10	930	17	12.15	3.10	9.96±0.92	10.21±0.62	2.12±0.51	dark green	2.27±0.42	0.83±0.13	much
M-11	925	13	7.15	2.80	9.45±1.36	10.22±1.29	1.78±0.46	dark green	2.43±0.38	2.34±0.31	much
M-12	929	16	8.35	1.60	10.29±1.10	9.50±2.24	1.77±0.26	dark green	2.57±0.50	2.36±0.24	medium
M-13	928	12	6.70	1.00	10.08±0.77	10.44±1.57	1.55±0.20	dark green	2.73±0.57	2.30±0.18	much
M-14	928	17	5.25	1.00	10.34±1.09	11.51±1.07	2.50±0.39	dark green	2.44±0.41	2.59±0.19	much
M-15	928	18	5.30	1.20	10.81±0.63	10.63±0.64	1.75±0.23	dark green	2.91±0.41	2.33±0.27	medium
M-16	928	16	7.50	1.30	11.08±1.06	10.88±0.85	2.41±0.51	dark green	2.41±0.31	2.68±0.21	much
M-17	918	18	7.65	5.60	9.79±1.51	9.93±1.10	1.21±0.26	dark green	2.37±0.47	1.81±0.46	much
M-18	943	25	11.20	3.00	10.24±0.82	10.24±0.69	1.76±0.29	dark green	2.56±0.31	2.25±0.18	medium
M-19	943	12	10.15	2.80	10.72±1.22	10.36±1.00	1.89±0.41	dark green	2.48±0.41	2.39±0.31	much
M-20	929	25	11.40	3.20	10.77±0.80	10.11±0.94	2.09±0.69	dark green	2.63±0.28	2.48±0.35	much
M-21	930	32	8.25	2.45	9.97±1.14	9.83±0.74	1.64±0.32	dark green	2.44±0.26	2.15±0.20	much
M-22	909	28	7.30	1.90	8.43±0.88	8.76±0.97	1.10±0.25	green	2.15±0.41	1.71±0.21	medium
M-23	937	9	5.90	1.50	9.68±0.76	9.89±0.77	1.77±0.35	green	2.44±0.45	2.18±0.33	medium
M-24	939	25	10.95	2.90	8.94±0.64	9.25±0.82	1.32±0.30	dark green	2.32±0.34	2.17±0.21	medium
M-25	928	18	6.00	1.40	9.99±0.48	9.64±0.51	1.72±0.24	dark green	2.63±0.28	2.33±0.23	medium
M-26	928	12	8.60	1.50	9.91±0.51	10.08±1.03	1.52±0.25	dark green	2.55±0.49	2.13±0.34	medium
M-27	928	22	10.85	2.55	9.60±1.12	9.87±0.88	1.74±0.27	dark green	2.51±0.59	2.27±0.30	much
M-28	920	12	8.95	4.30	11.62±1.14	11.82±1.84	2.28±0.67	dark green	2.71±0.33	2.53±0.48	much

Table 3. Fruit dimensions and fruit colour traits of native black mulberry genotypes from Mahmatlar (2001, 2002)

Geno-types	Fruit width (mm)			Fruit lenght (mm)			Fruit weight (g)			Fruit colour (L)			(a)			(b)		
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean
M-1	16.60	16.09	16.34±0.47	25.94	24.36	25.15±1.31	3.74	4.66	4.20±0.26	25.88	28.39	27.14±1.38	6.15	7.80	6.98±1.30	1.47	1.67	1.57±0.40
M-2	15.40	16.1	15.75±0.60	22.02	25.33	23.68±1.97	4.07	4.95	4.51±0.38	25.29	26.45	25.87±0.72	6.82	8.73	7.78±1.20	1.55	1.77	1.66±0.35
M-3	17.27	16.92	17.09±0.40	25.37	25.63	25.50±0.88	4.43	5.28	4.85±0.31	25.05	27.92	26.49±0.96	9.82	7.96	8.89±1.37	2.39	1.71	2.05±0.41
M-4	17.82	15.80	16.81±0.51	27.07	23.43	25.25±1.04	3.64	4.21	3.93±0.34	24.36	28.22	26.29±1.11	6.22	9.14	7.68±1.39	1.43	2.65	2.04±0.88
M-5	16.84	16.91	16.87±0.86	25.65	26.19	25.92±1.76	5.34	5.92	5.63±0.43	24.22	27.37	25.79±1.42	6.65	6.82	6.73±1.56	1.60	1.35	1.47±0.41
M-6	16.49	16.81	16.65±0.86	24.76	26.25	25.50±1.10	4.24	5.11	4.68±0.28	24.32	28.04	26.18±0.91	7.26	7.23	7.24±1.46	1.77	1.61	1.69±0.39
M-7	15.61	16.61	16.11±0.58	24.17	24.82	24.50±1.28	4.04	4.74	4.39±0.26	25.53	27.26	26.39±1.12	7.35	7.24	7.30±1.40	1.71	1.54	1.62±0.42
M-8	16.48	16.47	16.47±0.41	22.83	25.56	24.19±1.01	4.87	5.14	5.01±0.41	24.53	27.42	25.98±0.78	7.50	6.58	7.04±1.16	1.52	1.28	1.40±0.24
M-9	17.65	15.96	16.81±0.32	26.36	23.51	24.93±0.91	4.10	4.59	4.34±0.34	24.76	27.00	25.88±0.84	7.49	7.38	7.44±1.72	1.72	1.56	1.64±0.50
M-10	16.51	16.39	16.45±0.41	24.57	25.36	24.97±1.58	4.15	3.51	4.58±0.45	26.14	27.99	27.07±1.06	5.60	5.57	5.59±1.66	1.11	1.29	1.20±0.55
M-11	16.79	17.17	16.98±0.51	26.82	27.27	27.04±1.72	5.30	5.72	5.51±0.51	23.94	28.11	26.03±0.96	7.04	8.06	7.55±0.96	1.51	1.80	1.66±0.27
M-12	16.99	15.86	16.42±0.66	25.05	24.68	24.87±1.55	3.71	4.80	4.25±0.47	24.53	27.24	25.88±1.09	10.1	7.54	8.84±1.38	2.74	1.75	2.25±0.59
M-13	16.50	16.69	16.60±0.58	25.81	25.23	25.52±1.24	4.57	5.21	4.89±0.41	24.66	27.62	26.14±0.99	6.24	6.15	6.19±1.38	1.59	1.37	1.48±0.39
M-14	15.73	16.69	16.21±0.58	23.68	25.31	24.49±1.11	4.55	5.32	4.93±0.31	24.71	26.82	25.77±0.52	7.65	6.92	7.29±1.33	1.81	1.37	1.59±0.39
M-15	16.17	16.77	16.47±0.35	22.65	25.37	24.01±1.32	4.08	5.00	4.54±0.32	25.39	26.80	26.10±0.87	6.59	6.17	6.38±0.90	1.52	1.32	1.42±0.26
M-16	16.55	16.50	16.53±0.56	24.29	26.47	25.38±1.35	4.58	5.36	4.97±0.25	26.05	26.84	26.44±0.70	9.00	6.31	7.65±1.23	2.07	1.52	1.79±0.43
M-17	16.64	17.66	17.15±0.51	25.51	26.34	25.92±0.94	5.14	5.87	5.51±0.45	26.92	27.24	27.08±1.16	6.42	6.45	6.43±1.13	1.45	1.36	1.40±0.32
M-18	16.72	16.85	16.79±0.47	24.39	26.54	25.46±0.88	4.72	5.61	5.17±0.32	25.92	29.00	27.46±1.83	6.02	6.68	6.35±0.96	1.45	1.40	1.42±0.28
M-19	15.37	17.71	16.54±0.55	22.28	27.02	24.65±1.61	5.19	5.86	5.53±0.38	24.08	27.64	25.86±0.88	8.66	7.61	8.13±1.19	2.13	1.64	1.89±0.37
M-20	16.99	16.68	16.83±0.65	25.72	25.02	25.37±1.09	4.46	5.00	4.73±0.36	25.27	26.94	26.11±0.91	7.33	9.17	8.25±1.63	1.72	2.03	1.88±0.44
M-21	17.44	16.97	17.21±0.50	26.42	25.64	26.03±1.41	4.43	5.39	4.91±0.27	24.65	27.94	26.30±0.77	5.77	8.43	7.10±1.08	1.29	1.86	1.57±0.28
M-22	17.04	17.14	17.0±90.66	24.57	26.20	25.38±1.15	4.46	5.50	4.98±0.40	26.60	28.27	27.43±1.01	11.8	9.93	10.9±3.14	3.55	2.28	2.92±1.41
M-23	15.50	16.81	16.15±0.59	23.40	25.02	24.21±0.89	4.10	5.04	4.57±0.42	24.98	27.28	26.13±1.04	6.52	6.43	6.47±0.71	1.54	1.60	1.57±0.52
M-24	16.98	15.98	16.48±0.44	24.91	24.40	24.65±1.11	3.87	4.76	4.31±0.32	25.41	27.82	26.62±0.80	8.01	9.20	8.60±1.47	2.82	2.10	2.46±1.55
M-25	16.53	16.35	16.44±0.35	23.63	22.90	23.26±1.08	3.95	4.36	4.15±0.33	25.55	26.84	26.19±0.77	6.10	4.95	5.53±1.01	1.52	1.02	1.27±0.29
M-26	17.30	17.35	17.33±0.80	24.83	25.53	25.18±0.78	4.48	5.41	4.95±0.37	25.71	27.71	26.71±1.57	5.85	6.26	6.05±1.00	1.47	1.27	1.37±0.20
M-27	15.54	15.92	15.73±0.56	21.26	22.07	21.66±1.41	3.55	3.94	3.74±0.46	25.50	26.45	25.98±2.34	7.86	7.78	7.82±2.14	1.91	1.95	1.93±0.75
M-28	17.15	17.68	17.42±0.74	27.42	26.63	27.02±1.53	5.25	6.09	5.67±0.37	25.28	27.60	26.44±1.01	6.76	6.42	6.59±1.34	1.75	1.35	1.55±0.46

the observed values were similar to those reported in literature (YALTIRIK 1982, 1988; LALE 1992).

The dimensions and chemical properties of the fruits for each genotype were determined as average of first and second harvest for each trial year and the average of two experimental years as value with standard deviation (Table 3 and 4).

With regard to dimensions, the genotypes had a range of 15.73–17.42 mm for fruit diameter, 21.66–27.04 mm for fruit length. The genotypes had 3.74 g–5.67 g average fruit weight. M-28 had the highest fruit weight (5.67 g), followed by M-5 (5.63 g), M-19 (5.53 g), M-11, and M-17 (5.51 g), M-18 (5.17 g), and M-27, who had the lowest (3.74 g). GERASOPOULOS and STAVROULAKIS (1997) reported that fruit weight of the cv. 'Mavromournia' (*M. nigra*) mulberry varied between 4 g and 7 g depending on harvest stage. Mean fruit weights of many of our research genotypes were similar to cv. 'Mavromournia' mulberry fruits. In a study carried out in İzmir province (Western Anatolia) fruit length, fruit width, and fruit weight was reported as 2.70 cm, 1.56 cm and 3.32 g (LALE and OZCAGIRAN 1996). On the other hand, the cultivar 'Black Persian' had dimensions over 2.54 cm for fruit length and almost same as diameter. 'Kaester' which originated in Los Angeles (United States of America) has 3.81 cm for fruit length, 1.27 cm for fruit diameter (REICH 1991; ANONYMOUS 1997). For the physical characters of fruits, our genotypes had larger dimensions than those reported for 'Black Persian' and 'Kaester'. With regard to external colour, all genotypes have almost the same colour (L*a*b*). While the lowest L* (the highest dark colour) was obtained from genotype M-14, M-22 genotype has the highest red colour (a*=10.90) (Table 3).

The highest value for soluble solid was 16.23 % (M-23) and the lowest was 13.11 % (M-22). In a study carried out in Canakkale (eastern of Anatolia), GUVEN and BASARAN (1979) found total soluble solid as 14.20 %, and others reported 15.5 % (LALE and OZCAGIRAN 1996) and 15 % (HULME 1971). WOODROOF and LUH (1975) and HOLLAND et al. (1992) reported 85 % for water content. The range of pH was between 3.22 and 3.47. The total acidity of the genotypes varied between 1.35 % and 1.86 %, M-22 had the highest acidity. LALE and OZCAGIRAN (1996) reported total acidity as 2.24 %, and pH as 3.31, GUVEN and BASARAN (1979) reported them as 1.48 % and 3.70, respectively. Also ELMACI and ALTUG (2002), who studied on flavour evaluation of black mulberry from Aegean region of Turkey recorded that total acidity were between 1.51 % and 1.79 % and pH values between 3.60 and 3.80. Our results related to pH and total acidity values were simi-

Table 4. Soluble solids, pH, acitidity and vitamin C concentration (with HPLC) in native black mulberry fruits

Genotypes	Soluble solids (%)			pH			Acitidity (%)			Vit. C (μg g^{-1})
	2001	2002	Mean	2001	2002	Mean	2001	2002	Mean	2002
M-1	17.25	14.83	16.04±1.71	3.53	3.36	3.45±0.12	1.59	1.66	1.63±0.04	15.73±0.22
M-2	15.00	13.63	14.32±0.97	3.44	3.15	3.29±0.20	1.43	1.80	1.62±0.26	4.32±0.21
M-3	15.25	12.75	14.00±1.77	3.56	3.12	3.34±0.31	1.32	1.95	1.63±0.44	20.60±0.73
M-4	14.38	14.33	14.35±0.04	3.51	3.17	3.34±0.24	1.51	1.88	1.70±0.27	15.30±0.60
M-5	15.88	14.92	15.40±0.67	3.44	3.30	3.37±0.10	1.69	1.84	1.76±0.11	3.68±0.21
M-6	15.25	13.25	14.25±1.42	3.55	3.17	3.36±0.27	1.42	1.87	1.65±0.32	21.00±0.70
M-7	14.50	14.53	14.51±0.02	3.58	3.35	3.47±0.16	1.35	1.67	1.51±0.23	13.40±0.60
M-8	15.50	15.00	15.25±0.35	3.53	3.38	3.45±0.10	1.42	1.42	1.42±0.00	11.34±0.20
M-9	14.63	12.63	13.63±1.41	3.38	3.22	3.30±0.11	1.73	1.65	1.69±0.06	4.79±0.21
M-10	15.38	15.28	15.33±0.07	3.52	3.39	3.45±0.09	1.43	1.42	1.43±0.00	4.25±0.21
M-11	15.50	12.83	14.16±1.89	3.49	3.15	3.32±0.24	1.49	1.78	1.63±0.20	7.50±0.01
M-12	14.00	14.70	14.35±0.49	3.62	3.28	3.45±0.24	1.26	1.61	1.43±0.25	17.90±0.37
M-13	17.13	13.98	15.55±2.23	3.51	3.39	3.45±0.09	1.52	1.50	1.51±0.01	14.60±0.62
M-14	14.75	14.18	14.46±0.41	3.59	3.24	3.42±0.24	1.42	1.72	1.57±0.21	3.19±0.22
M-15	13.25	14.25	13.75±0.71	3.42	3.38	3.40±0.03	1.54	1.51	1.52±0.02	3.56±0.22
M-16	14.00	13.68	13.84±0.23	3.39	3.33	3.36±0.05	1.48	1.52	1.50±0.03	9.20±0.61
M-17	14.50	15.90	15.20±0.99	3.55	3.39	3.47±0.11	1.29	1.42	1.35±0.09	2.80±0.22
M-18	16.38	14.45	15.41±1.36	3.51	3.25	3.38±0.19	1.55	1.68	1.61±0.09	13.15±0.20
M-19	15.88	14.63	15.25±0.88	3.51	3.19	3.35±0.22	1.47	1.84	1.65±0.26	5.30±0.20
M-20	16.00	12.75	14.38±2.3	3.43	3.28	3.35±0.11	1.56	1.58	1.57±0.02	12.50±044
M-21	16.13	14.18	15.15±1.38	3.42	3.23	3.33±0.14	1.55	1.67	1.61±0.08	18.20±0.64
M-22	14.50	11.73	13.11±1.96	3.34	3.10	3.22±0.17	1.82	1.90	1.86±0.05	23.00±0.83
M-23	16.50	15.95	16.23±0.39	3.40	3.33	3.36±0.04	1.84	1.56	1.70±0.20	6.39±0.19
M-24	15.38	13.55	14.46±1.29	3.43	3.25	3.34±0.13	1.54	1.66	1.60±0.08	15.14±0.21
M-25	15.50	14.03	14.76±1.04	3.68	3.23	3.45±0.32	1.34	1.65	1.49±0.22	4.50±0.06
M-26	13.88	15.45	14.66±1.11	3.47	3.33	3.40±0.10	1.58	1.59	1.58±0.01	10.60±0.01
M-27	16.88	13.73	15.30±2.23	3.53	3.02	3.27±0.36	1.71	1.98	1.85±0.19	6.40±0.06
M-28	13.00	14.60	13.80±1.13	3.55	3.30	3.43±0.17	1.34	1.67	1.50±0.23	14.69±0.21

lar to those of these reports. Vitamin C contents are shown in Table 4. Vitamin C content was between 2.80 μg g^{-1} and 23.0 μg g^{-1} in fresh weight. Although vitamin C contents of different berry fruits were reported, there were no reports in black mulberry fruits in literature. Only ascorbic acid contents of different *Morus* sp. leaves were determined (CHAKRABARTI and SINGHAL 1996; SINGHAL and ROOPA 1998).

Conclusions

The mulberry fruits have called little attention, since the world-wide use of mulberry tree generally concentrated on sericulture. The high fresh weight, black-purple colour, and extraordinary taste of black mulberry fruit will increase consumer attraction in the near future. We think that our study will be a base to further researches, which are required in post-harvest handling and consuming properties. It is necessary to determine both fruit and other agronomical characters of native mulberries for breeding researches. Also, black mulberry fruits can be used particularly for sustainable production in marginal areas. In our evaluation, a population of native black mulberry was evaluated with respect to some fruit and tree characters. This investigation delivers some insight in the phenotypic diversity of this species, which is the base for preserving genetic resources and using this diversity in plant breeding.

Acknowledgement

The authors thank The Research Fund of Süleyman Demirel University for their financial support and Prof. Dr. G. Alsancak for excellent technical assistance in the HPLC analyses.

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Received June 23, 2003 / Accepted April 19, 2004

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