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Full Length Research Paper

Morphological and chemical diversity among hawthorn (*Crataegus* spp.) genotypes from Turkey

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Anatolia had been known to have rich hawthorn gene pool including diverse genotypes adapted to different local conditions in different regions of the country. Long-term seed propagation and also human selection revealed a great diversity of hawthorn plants in Anatolia. In this study, the morphological (fruit weight, dimensions, fruit skin color, flesh/seed ratio, plant habits and thorn situation) and chemical (pH and soluble solid content) characteristics of 21 selected hawthorn genotypes belongs to *Crataegus monogyna* ssp*. monogyna* Jacq*, Crataegus monogyna* ssp*. azarella* Jacq*, Crataegus pontica* K.Koch*, Crataegus orientalis var. orientalis* Pallas Ex Bieb*, Crataegus pseudoheterophylla* Pojark*, Crataegus meyeri* Pojark*, Crataegus aronia var. dentata* Browicz*, Crataegus aronia var. aronia* Browicz*, C. x bornmuelleri* Zabel and *Crataegus aronia* L. had been determined. A wide variation was found among genotypes in both intra and inters level on most of morphological and chemical properties. Fruit weight varied from 0.65 to 4.19 g among genotypes. Fruit skin color were determined as light green, yellow, light orange, orange, red and dark red. SSC (soluble solid content) of genotypes ranging from 6.40 to 16.0%. In general, most of the genotypes had tree form and also had various degree of thorn on its plants.

Key words: *Crataegus* spp., fruit characteristics, selection.

INTRODUCTION

The hawthorn (*Crataegus* spp.) belongs to *Rosaceae* family and it is estimated that they include 150 to 1200 species (Christensen, 1992). It is usually multi-branched ranging from shrubs to small trees, even normal size trees can reach a height of up to 10 m. However average hawthorn trees have height between 2 to 5 m (Grieve, 1982; Brown, 1995; Wichtl, 1996). It is one of the native plants of Turkey's flora and prefers the forest margins of lower and warmer areas (Yilmaz et al., 2010).

In Turkish, all hawthorn species are called 'Alic'. *Crataegus* is a complex genus including many hybrids and apomictic populations. Turkey is one of the richest in terms of hawthorn genetic resources in the world. In Turkey, hawthorns are aggressive pioneers of distributed sites, and often cover overgrazed pastures and abandoned farm fields. They are moderately intolerant and are found in the under story of open woodlands or in open pasture land, or at the edges of hedgerows. Hawthorns are sometimes considered nuisance weeds on farm land, and can be difficult to remove permanently (Ercisli, 2004).

Hawthorn fruit refers to the bright coloured berries of *Crataegus* species and are a rich source of flavanoids, vitamin C, glycoside, anthocynaidin, saponin, tannin, and antioxidants (Ljubuncic et al., 2005). Fruits are usually eaten fresh. Leaves are used as a tea surrogate (Cao et al., 1995). All *Crataegus* species found in Turkey have long been used as a folk medicine (Baytop, 1984). Many species are used as ornamentals. In arid regions, the trees are planted in forest belts and windbreaks. The trees are suitable as frost-resistant rootstocks for pear and quinces. Fruits ripen in late summer and are highly

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attractive to birds, which consume the fruit and disperse the seeds. There is a great variation in terms of fruit color of *Crataegus* species distributed in Turkey. For instance, *Crataegus pentagyna* has black or blackish-purple fruit, *Crataegus tanacetifolia* yellow, sometimes suffused with red, *Crataegus orientalis* reddish-orange, *Crataegus pontica* yellow to orange, *Crataegus atrosanguinea* deep red, *Crataegus curvisepala* dark purple, *Crataegus stevenii* red, *Crataegus monogyna* red or brownish-red and *Crataegus microphylla* bright red (Browicz, 1972).

Fruits of our native species are often used in the treatment of weak heart conditions, especially if this is accompanied by high blood pressure (Baytop, 1984).

Previously, studies in Turkey points to great phenotypic biodiversity among the hawthorn plants grown in different part of Turkey (Demiray, 1986; Donmez, 2004; Ozcan et al. 2005; Turkoglu et al. 2005; Donmez, 2007). They are well adapted to the climatic and soil conditions, but they differ in numerous morphological traits, productivity, and fruit quality.

The objective of this study was to determine the morphological and chemical diversity on hawthorn genotypes grown in Turkey.

MATERIALS AND METHODS

Plant materials

A total of 21 hawthorn genotypes were used in this study (Table 1). These genotypes previously selected from Malatya region in Turkey according to high fruit yield, attractive fruits and free of pest and disease characteristics. The Malatya region has 12.6°C annual average temperature, and 495 mm annual precipitation. Fruits were sampled from hawthorn genotypes in 2007 and 2008 years. The parameters studied were fruit weight, fruit length, fruit width, flesh/seed ratio, fruit skin colour, soluble solid content (SSC) and pH. Skin color of fruits was measured by using a CR-400 chromometer (Konica Minolta, Japan) and the color of the fruit surface was determined for the *L* (lightness), *a* (green chromaticity) and *b* (yellow chromaticity) values. SSC were determined by extracting and mixing one drops of juice from the each fruit into a digital refractometer (Kyoto Electronics Manufacturing Co. Ltd., Japan, Model RA-250HE) at 22°C. The pH measurements were made using a digital pH meter (WTW Inolab Level 1, Germany) calibrated with pH 4 and 7 buffers.

Statistical analysis

The experiment was a completely randomized design with five replications. Data were subjected to analysis of variance (ANOVA) and means were separated by Duncan multiple range test at P<0.01 significant level.

RESULTS

The study revealed that 21 hawthorn genotypes belong to 6 different taxa. Of them, a total of 4 belong to *Crataegus aronia var. aronia,* 3 belong to *C. pontica* and *C. orientalis var. orientalis,* 2 belong to *C. monogyna* ssp. m*onogyna, Crataegus meyeri, C. aronia and Crataegus .x bornmuelleri* and 1 belong to *C. monogyna* ssp. *azarella, Crataegus pseudoheterophylla and C. aronia var. dentata* in Malatya, respectively.

In this present study, we determined statistically important differences on the all fruit characteristics of hawthorn genotypes. The means of fruit and plant characteristics were presented in Tables 1 and 2.

As can be seen on Table 1, considerable variations were recovered for all traits (p<0.01). The average fruit weight of 21 hawthorn genotypes was between 0.65 to 4.19 g and several genotypes had >4.0 g fruit weight (e.g., 44AK09-1, 44HE08-7, 44DA20-2) which belongs to *C. orientalis var. orientalis*, *C. aronia var. aronia* and *C. x burnmuelleri*, respectively.

Fruit length means ranged from 10.06 mm (44HE08-2) to 18.07 mm (44DA20-2). Flesh/seed ratio of genotypes ranged from 3.23 (44YE16-4) to 9.29 (44AK07-1). Among the species, *C. monogyna* ssp*. monogyna* and *C. monogyna* ssp. *azarell*a had dark red fruits*, C. pontica* and *C. orientalis* had light green to orange fruits. On the other hand, *C. pseudoheterophylla* had dark red, *C. meyeri* had red, *C. aronia var. dentata* had red, *C. aronia var. aronia* had yellow and light orange and *C. burnmuelleri* had red fruits (Table 1).

There were significant differences among hawthorn genotypes and species in terms of the pH, soluble solids, plant habits and thorn situation. Among taxa *C. aronia var.* dentata (44AR17-1) and *C. aronia var. aronia* (44AR18-4) had the highest SSC values (equally 16.0%). *C. monogyna* ssp. m*onogyna, C. pontica* and *C. aronia var dentata* were found to be thornless. *C. monogyna* ssp*. monogyna* and *C. meyeri* had the highest pH value followed by *C. pontica*, *C. monogyna* ssp *azarella* and *C. aronia*, respectively (Table 2).

DISCUSSION

The study revealed that the determined hawthorn genotypes are belongs to 6 different taxa. These results indicating that Malatya region is very rich in terms of hawthorn biodiversity. In our study, we found the differences on all fruit characteristics of hawthorn genotypes. Balta et al. (2006) found that among *Crataegus* taxa, *C. tanacetifolia* had the highest fruit weight (4.99 g) followed by *C. orientalis* (3.48 g), *C. pontica* (3.31 g), *C. aronia* (2.63 g) and *C. meyeri* (1.36 g), respectively.

Turkoglu et al. (2005) reported that fruit weight and flesh/seed ratio among hawthorn genotypes were between 0.29 and 4.21 g and 4.82 and 9.69 g. We recovered dark red, light green, orange, yellow, red, light orange fruit colors. Fruit colour directly affects the appearance and the consumer acceptability of the fruits. The yellow fruit skin colour is not favourable by consumers.

There were significant differences among hawthorn genotypes and species in terms of chemical contents.

Table 1. Some fruit characteristics of hawthorn (*Crataegus* spp.) genotypes sampled from Malatya, Turkey.

Species	Genotypes	Fruit properties			Fruit skin color	Flesh/seed ratio
		weight (g)	length (mm)	width (mm)		
C. aronia var. *aronia*	44AR18-4	3.87bc	15.51d-g	19.16bc	Yellow	4.22c-f
C. aronia var. *aronia*	44AR18-5	2.03ef	13.75ijk	15.29e	Yellow	4.39c-f
C. aronia var. *aronia*	44AR18-6	1.72fgh	12.32lmn	14.07e-h	Yellow	4.03c-f
C. aronia var. *aronia*	44HE08-7	4.06bc	17.59ab	19.72b	Orange	4.81c-f
C. orientalis var. *orientalis*	44HE08-1	3.90bc	18.01a	19.52b	Orange	5.32bcd
C. orientalis var. *orientalis*	44HE08-6	3.86bc	15.40d-h	20.32a	Yellow	4.03c-f
C. orientalis var. *orientalis*	44AK09-1	4.06bc	16.41cd	19.45b	Yellow	3.76def
C. pontica	44AK06-3	3.00d	14.81f-i	17.31d	Light orange	3.75def
C. pontica	44DA05-2	2.66d	14.83f-i	17.46d	Orange	6.44b
C. pontica	44YE16-3	1.42gh	11.54n	13.25ghi	Light green	4.21c-f
C. monogyna ssp. *monogyna*	44AK02-1	1.38gh	13.38jkl	12.69hij	Red	3.78def
C. monogyna ssp. *monogyna*	44AK06-1	0.65j	11.62n	10.45kl	Red	3.70a
C. meyeri	44AK09-3	1.51gh	11.67mn	13.29f-i	Red	3.61ef
C. meyeri	44DA20-1	1.74fg	12.05mn	14.44efg	Red	4.94b-e
C. X *bornmuelleri*	44HE08-2	1.37gh	10.06o	13.04ghi	Red	4.60c-f
C. X *bornmuelleri*	44DA20-2	4.19a	18.07ab	20.39b	Yellow	4.48c-f
C. aronia	44YE16-2	1.99ef	14.31g-j	15.20e	Red	4.45c-f
C. aronia	44YE16-4	2.83d	14.39g-j	17.70d	Yellow	3.23f
C. pseudoheterophylla	44AK09-2	0.67j	10.37o	9.88i	Dark red	5.29bcd
C. aronia var. *dentata*	44AR17-1	2.24e	14.25hij	15.02e	Red	4.29cdef
C. monogyna ssp. *azarella*	44AK07-1	0.91ij	11.79mn	11.41jk	Dark red	9.29a

Table 2. Some fruit characteristics of hawthorn (*Crataegus* spp.) genotypes sampled from Malatya, Turkey.

Species	Genotypes	pH	Soluble solid content (%)	Thorn	Plant habit	Altitude (m)	Coordinates
C. aronia var. *aronia*	44AR18-4	3.06ab	16.00a	Dense	Tree	1423	038°52'N 038°12'E
C. aronia var. *aronia*	44AR18-5	2.90ab	15.00a	Medium	Tree	1423	038°52'N 038°12'E
C. aronia var. *aronia*	44AR18-6	3.02ab	14.40a	Medium	Tree	1423	038°52'N 038°12'E
C. aronia var. *aronia*	44HE08-7	2.95ab	8.40def	Medium	Tree	1617	038°39'N 037°57'E
C. orientalis var. *orientalis*	44AK09-1	2.97ab	6.40h	Dense	Tree	1466	038°25'N 037°56'E
C. orientalis var. *orientalis*	44HE08-1	2.95ab	9.00c-f	Thornless	Tree	1617	038°39'N 037°57'E
C. orientalis var. *orientalis*	44HE08-6	3.04ab	10.40bc	Medium	Tree	1617	038°39'N 037°57'E
C. pontica	44AK06-3	3.08ab	9.60cde	Thornless	Tree	1476	038°25'N 037°53'E
C. pontica	44DA05-2	3.04ab	8.00d-h	Thornless	Tree	1530	037°78'N 037°37'E
C. pontica	44YE16-3	3.62ab	8.20d-g	Medium	Tree	1359	038°15'N 038°10'E
C. monogyna ssp. *monogyna*	44AK02-1	3.43ab	7.80e-h	Thornless	Tree	1570	038°20'N 037°44'E
C. monogyna ssp. *monogyna*	44AK06-1	3.70a	8.20d-g	Medium	Tree	1476	038°25'N 037°53'E
C. meyeri	44AK09-3	3.25ab	12.00b	Dense	Tree	1466	038°25'N 037°56'E
C. meyeri	44DA20-1	3.70a	8.00d-h	Medium	Tree	1671	038°41'N 037°33'E
C. x *bornmuelleri*	44HE08-2	3.11ab	8.60def	Few	Tree	1617	038°39'N 037°57'E
C. x *bornmuelleri*	44DA20-2	3.38ab	8.40def	Medium	Tree	1671	038°41'N 037°33'E
C. aronia	44YE16-2	3.55ab	8.40def	Medium	Tree	1359	038°15'N 038°10'E
C. aronia	44YE16-4	3.06ab	8.00d-h	Medium	Tree	1359	038°15'N 038°10'E
C. pseudoheterophylla	44AK09-2	3.55ab	9.70cd	Few	Shrub	1466	038°25'N 037°56'E
C. aronia var. *dentata*	44AR17-1	2.82b	16.00a	Thornless	Tree	1219	038°50'N 038°14'E
C. monogyna ssp. *azarella*	44AK07-1	3.62ab	8.00d-h	Few	Shrub	1470	038°25'N 037°50'E

The difference in fruit weights and dimensions of germplasm under same geographical conditions may be a result of the genotypic effects. Higher fruit weight along with higher flesh ratio is the most important desirable fruit characteristics in hawthorn breeding programmes (Ercisli, 2004). Previously fruit length and width of hawthorn genotypes in Turkey ranged from 7.96 to 23.9 mm and 8.00 to 22.78 mm (Asma and Birhanli, 2003; Turkoglu et al. 2004; Balta et al., 2004).

In some studies conducted in different region of Turkey, total soluble solids and pH values of hawthorn genotypes ranged from 11.66 to 24.00% and 3.12 to 4.09, respectively (Balta et al., 2004; Ozcan et al., 2005; Turkoglu et al., 2005). The difference among studies could be effects of environmental conditions where howthorn plants grow. However our study was conducted in common environment conditions, therefore the difference among genotypes is natural results of genotypic effect.

As a conclusion, this investigation clearly indicates wide biodiversity occurred among hawthorn germplasm found in common field in Turkey. Fruit weight, SSC and color were highly varied among genotypes. As well known, the primary objective of germplasm resource conservation is the maintenance of genetic diversity. The results showed that hawthorn genotypes should be a priority for conservation action so as to maintain biodiversity. Moreover, since commercial howthorn cultivars do not exist, these results could be important to use these genotypes as breeding material in future traditional breeding or advanced biotechnology studies. In addition, a wide range of agronomic characteristics, such as pest and disease resistance of these selected genotypes could be incorporated into a finished hawthorn cultivar.

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