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Status of natural Turkish hazel (*Corylus colurna* L.) populations in Turkey

Türkiye'deki doğal Türk fındığı (Corylus colurna L.) popülasyonlarının durumu

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Abstract

Location and climate information of 18 natural Turkish hazel populations in Turkey is reported. Populations are small (mean area = 206 ha) and are found at 700 m to 1600 m above sea level. Mean annual temperature is 8.83 °C and (range: 6.9 − 11 °C) and mean annual precipitation is 654.28 mm (range: 477 − 952 mm) at population locations. The species is of interest in Turkey for plantation in arid and semi-arid regions but only three of the 18 population locations are classified as semi-arid. The rest of the populations are located in more humid environments. The genetic structure of these populations should be determined and a comprehensive gene conservation program should be put in place. A through genetic testing (provenance and/or progeny tests) should be conducted to determine suitable seed sources and families for plantation in semi-arid environments.

Özet

Bu çalışmada Türkiye'deki 18 doğal Türk fındığı popülasyonunun konum ve iklim verileri irdelenmiştir. İncelenen popülasyonlar küçüktür (ortalama alan = 206 ha) ve deniz seviyesinden 700 ila 1600 m arasında bulunmaktadır. Popülasyon konumlarında yıllık ortalama sıcaklık 8.83°C (aralık: 6.9 − 11 °C) ve yıllık ortalama yağış 654.28 mm (aralık: 477 − 952 mm) olarak belirlenmiştir. Türün Türkiye'deki kurak ve yarı-kurak alanların ağaçlandırılmasında kullanılması yönünde bir ilgi vardır ancak incelenen popülasyonların sadece üçü yarı-kurak sahalarda bulunmaktadır. Diğer popülasyonlar daha nemli bölgelerde bulunmaktadır. Bu popülasyonların genetik yapısı belirlenmeli ve kapsamlı bir gen koruma programı gündeme alınmalıdır. Ayrıntılı köken (orijin) ve/veya döl denemeleri ile yarı-kurak sahaların ağaçlandırılmasında kullanılabilecek tohum kaynakları ve aileler belirlenmelidir.

INTRODUCTION

Natural distribution of Turkish hazel (*Corylus colurna* L.) is within southeast Europe, Caucasus, Asia Minor and western Himalayas, but it has been grown widely as ornamental shade tree in Europe and the US for many centuries. In Turkey it is mainly found in the western Black Sea region as small groups usually mixed with other forest tree species, such as *Quercus* sp., *Tilia* sp., *Fagus* sp. and *Abies* sp. (Sarıbaş 1998). While mainly found in forested areas, Turkish hazel has not been considered as an important forest tree species due to its very small overall distribution. As a result, it has not been included in forest management plans and thus unplanned utilization resulted in significant decline of the natural populations, both in number and size.

In recent years, however, there is an increasing demand for Turkish hazel for both its environmental services and nuts. With its fast growth rate, wide ecological range, extensive root system, and lack of major pest or disease treat, Turkish hazel can help preventing soil erosion (Shaw et al. 2014). The species is also a valuable urban tree due its phytoremediation properties (Popek et al. 2013) and high cooling potential (Gillner et al. 2015). Different parts of the plant are valuable source of natural pharmacological compounds (Ceylan et al. 2013; Riethmüller et al. 2014). Its wood is decorative and has favorable mechanical properties (Korkut et al. 2008; Zeidler 2012; 2013). In addition, the nuts with high oil content (Erdogan and Aygun 2005) are not only a quality nutrition source for wildlife (Vander Wall 2001) but also used in confectionary industry (Miletić et al. 2005).

While there is an increased interest for Turkish hazel in Turkey, information on its current distribution is not complete. Information comes either from botanical reports or from descriptive studies of Turkish hazel populations. A total of 14 natural populations (three of which are designated protected areas) were described in the last two decades by Genç et al. (1998), Arslan (2005), Polat (2014), Polat and Güney (2015), and Ayan et al. (2016). There are, however, reports of other natural populations in botanical records and by local people. Therefore, information on rest of Turkish hazel distribution is sparse, not well documented or outdated. This is also the case other wild *Corylus* species because nearly all research and conservation efforts are focused on conserving cultivated forms of *Corylus avellana* (Molnar 2011). Therefore documentation and description of natural Turkish hazel populations is essential for their conservation especially in the presence of anthropogenic pressure and unplanned utilization.

Polat (2014) suggests that Turkish hazel may be a suitable species in erosion control efforts in Turkey. In the presence of climate change most of land subject to erosion control efforts will be drier sties (Nearing et al. 2004). Therefore climatic characterization of natural Turkish hazel population locations is of interest. Thus, the goals of this study are (1) to document present Turkish hazel populations in Turkey and (2) to examine climatic conditions at the population locations for their suitability in reforestation of semi-arid and/or degraded landscapes.

METHODS

Natural populations of Turkish hazel in Turkey were located based on botanical records, literature and information gathered from field foresters and local people. Each site reportedly having a Turkish hazel population was visited and periphery geographic coordinates, elevation and aspect were recorded using a Garmin® GPS receiver (Olathe, KS, USA). Approximate area covered by each population was measured on Google Earth Pro (http://www.google.com/earth/download/gep/agree.html) using the peripheral trees.

In order to determine climate type at each population location climate data were extracted from WorldClim (Hijmans et al. 2005). WorldClim is interpolated climate surfaces for global land areas at a spatial resolution of 1 km^2 and provides monthly mean, minimum and maximum temperatures and precipitation for given geographic coordinates. Data extraction was based on approximate center coordinates of each population.

Climate type at each population location was determined by both Erinç (1965) Aridity Index (EAI, Equation 1) and Thornthwaite (1948) Climate Classification (TCC, Equation 2) methods. Both methods are based on precipitation and temperature but Thornthwaite's method also takes potential evapotranspiration into account (Thornthwaite and Mather 1957).

EAI is calculated as

$$I_m = \frac{P}{T_{om}}, \qquad \text{Eq. (1)}$$

where I_m is aridity index, P is total annual precipitation (mm), and T_{om} is annual mean maximum temperature (°C).

TCC index is calculated as

$$I_m = \frac{100s - 60d}{n}, \qquad \text{Eq. (2)}$$

where I_m is the index value, s is the annual water surplus (mm), d is the annual water deficit (mm), and n is the annual potential evapotranspiration. Climate types based on I_m values for both methods are given in table 1.

Table 1 Climate types based on index (I_m) values for Erinç and Thornthwaite methods.

Erinç		Thornthwaite	
I_m	Climate type	I_m	Climate type
> 55	Very humid	> 100	Very humid
43–55	Humid	100–20	Humid
37–43	Semi-humid–Humid	20–0	Semi-humid
23–37	Semi-humid	0– -20	Semi-humid–Semi-arid
8–23	Semi-arid	-20– -40	Semi-arid
< 8	Arid	<-40	Arid

RESULTS

In addition to 14 Turkish hazel populations that have been recently described in the literature, four populations have been located based on botanical records (Table 2).

Majority of the Turkish hazel's natural distribution in Turkey is in the Western Black Sea region (in Bolu, Düzce, Kastamonu, Karabük and Sinop provinces), forming an arc-like shape over the northwest (Fig. 1). Except for Oğuzlar population, within population elevation range is less than 200 m, but elevation ranges from 702 m to 1,598 m among populations.

The populations are found on southerly and northerly aspects almost equally, and their size ranges from 10 ha to 1,166 ha (Table 2). Average mean annual temperature and average annual precipitation are 8.83 °C (range: 6.9 – 11 °C) and 654.28 mm (range: 477 – 952 mm), respectively. Both EAI and TCC provided similar climate types for population locations ranging from semi-arid to very humid (Table 3).

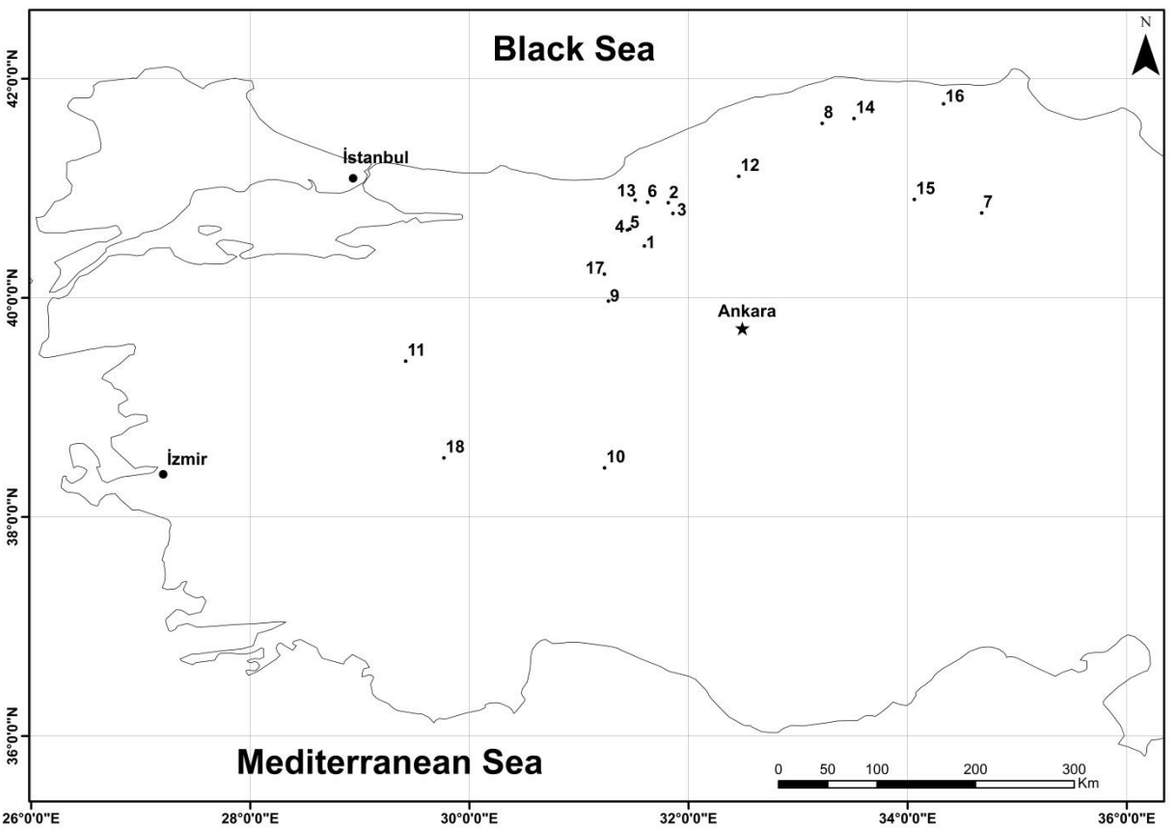

Figure 1 Locations of natural Turkish hazel (*Corylus colurna*) populations in Turkey (see Table 2 for population numbers).

Table 2 Locations of natural *Corylus colurna* populations in Turkey.

No	Population	Province	Township	Forest Management[1]	North to south coordinate range (N)	West to east coordinate range (E)	Elevation range (m)	Status[2]
1	Seben[3]	Bolu	Seben	Bolu–Seben–Seben	40.47885–40.46174	31.59979–31.59126	1101–1282	NS
2	Merkeşler[3]	Bolu	Bolu	Bolu–Bolu–Çele	40.87300–40.85823	31.80365–31.82502	702–893	NS
3	Muratlar[3]	Bolu	Bolu	Bolu–Bolu–Sazakiçi	40.77242–40.76686	31.85116–31.86536	808–891	NS
4	Pelitcik[3]	Bolu	Bolu	Bolu–Bolu–Belkaraağaç	40.63139–40.61210	31.45960–31.47442	1025–1256	NS
5	G.Felakettin[3]	Bolu	Bolu	Bolu–Bolu–Belkaraağaç	40.61985–40.61347	31.42326–31.44245	1025-1256	NS
6	Kale[3]	Bolu	Bolu	Bolu–Bolu–Kale	40.87515–40.87155	31.62031–31.62864	1223–1344	NPA
7	Oğuzlar[3]	Çorum	Oğuzlar	Amasya–İskilip–Oğuzlar	40.78008–40.76318	34.66620–34.68140	884–1403	GCF
8	Pınarbaşı[3]	Kastamonu	Pınarbaşı	Kastamonu–Pınarbaşı–Kurtgirmez	41.59443–41.59054	33.21830–33.22283	1063–1120	NS
9	Çatacık	Eskişehir	Mihalıççık	Eskişehir–Mihalıççık–Çatacık	39.97614–39.96756	31.26485–31.27012	1098–1223	NS
10	Dereçine[4]	Afyonkarahisar	Sultandağı	Eskişehir–Afyonkarahisar–Çay	38.44960–38.44374	31.22824–31.23966	1573–1722	GCF
11	Budağan[5]	Kütahya	Tavşanlı	Kütahya–Tavşanlı–Tavşanlı	39.42922–39.41689	29.41806–29.42671	1416–1598	NS
12	Yenice[3]	Karabük	Yenice	Zonguldak–Yenice–Kavaklı	41.16619–41.10973	32.40218–32.47995	1104–1439	NS
13	Yığılca	Düzce	Yığılca	Bolu–Yığılca–Boğabeli	40.89215–40.89208	31.51209–31.51342	1357–1360	NS
14	Ağlı[6]	Kastamonu	Ağlı	Kastamonu–Küre–Ağlı	41.64092–41.62802	33.50961–33.51842	1151–1326	NS
15	Tosya	Kastamonu	Tosya	Kastamonu–Tosya–Yeşilgöl	40.91296–40.89668	34.04393–34.06040	944–1147	NS
16	Türkeli	Sinop	Türkeli	Kastamonu–Türkeli–Çatak	41.77470–41.76948	34.32656–34.33597	1174–1191	NS
17	Nallıhan[3]	Ankara	Nallıhan	Ankara–Nallıhan–Erenler	40.21677–40.21546	31.23133–31.23523	1446–1561	NS
18	Sivaslı[7]	Uşak	Sivaslı	Denizli–Uşak–Sivaslı	38.54090–38.53758	29.76527–29.77040	1390–1619	NS

[1] Regional Forest Directorate–Forest Management Directorate–Forest Management Unit.

[2] NS: Natural stand, NPA: Nature protection area, GCF: Gene conservation forest.

[3] Arslan (2005).

[4] Genç et al. (1998).

[5] Polat (2014).

[6] Ayan et al. (2016).

[7] Polat and Güney (2015)

Table 3 Key environmental details of population locations.

No	Population	Approximate area (ha)	Annual mean temperature (°C)	Annual precipitation (mm)	EAI[1]	Climate type based on EAI	TCC[2]	Climate type based on TCC	Aspect
1	Seben	112	9.3	596	41.53	Semi-humid – Humid	-8.93	Semi-humid – Semi-arid	S
2	Merkeşler	268	10.7	588	36.58	Semi-humid	-17.76	Semi-humid – Semi-arid	S
3	Muratlar	65	11.0	568	34.49	Semi-humid	-19.78	Semi-humid – Semi-arid	N
4	Pelitcik	151	9.1	634	44.70	Humid	-5.35	Semi-humid – Semi-arid	S
5	G.Felakettin	106	9.7	609	40.78	Semi-humid – Humid	-10.04	Semi-humid – Semi-arid	S
6	Kale	43	7.8	762	61.00	Very humid	16.77	Semi-humid	N
7	Oğuzlar	1,166	9.9	477	30.66	Semi-humid	-23.54	Semi-arid	S-SE
8	Pınarbaşı	52	8.2	736	56.25	Very humid	9.51	Semi-humid	S
9	Çatacık	60	9.8	491	32.97	Semi-humid	-20.67	Semi-arid	N
10	Dereçine	112	7.4	585	45.97	Humid	2.85	Semi-humid	N
11	Budağan	950	7.7	919	72.55	Very humid	40.88	Humid	N
12	Yenice	350	6.9	952	83.88	Very humid	49.52	Humid	S-SE
13	Yığılca	10	8.7	717	53.14	Humid	4.42	Semi-humid	N
14	Ağlı	100	8.2	685	52.76	Humid	3.32	Semi-humid	S
15	Tosya	27	9.7	496	33.48	Semi-humid	-20.82	Semi-arid	N
16	Türkeli	30	8.1	678	54.60	Humid	3.18	Semi-humid	N
17	Nallıhan	21	7.6	632	51.00	Humid	6.22	Semi-humid	N
18	Sivaslı	84	9.1	652	44.25	Humid	-0.05	Semi-humid – Semi-arid	N
	Mean	205.94	8.83	654.28					

[1]Erinç's Aridity Index.

[2]Thornthwaite's Climate Classification.

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DISCUSSION

Information on Turkish hazel's natural distribution in Turkey is sometimes unreliable. For example, presence of the species around Trabzon and Rize in the eastern Black Sea region (Anşin and Özkan 1993) and Kazdağı (Mount Ida) in the west (Polat 2014) were reported but we did not find any Turkish hazel individuals in these regions. This is mainly because information on its distribution is mostly based on botanical records (such as Yaltırık (1982)), where presence of single or very small number of individuals are sufficient. When these individuals are removed from the recorded area, as a result of natural or artificial causes, information becomes obsolete for most conservation purposes. In addition, Turkish hazel is shade intolerant pioneer species and cannot compete with other species in mature mixed stands. In fact the larger populations reported in this study are where Turkish hazel is found in open landscapes (Fig. 2).

Finally, most of the Turkish hazel habitats are owned and managed by the General Directorate of Forestry following management plans updated every 10 years for each management unit. Until 1990's the forests are managed mainly for wood production and broad leaved species with small overall distribution and wood volume such as Turkish hazel are regarded as nuisance in timber production and described as one of "other broad leaved species" in the management plans. Thus, otherwise comprehensive management plans have not kept a record of these species resulting in lack of record and unplanned utilization. The new plans are now ecosystem based with a multipurpose approach and are expected to contain species level information for all tree species in management units (Asan 1990).

Research on flora of Turkey has gained impetus in recent years. As a result, floristic records are updated regularly as new research results are published. Many researchers found individuals or small groups of Turkish hazel. Aydınözü (2008) and Akalın Uruşak et al. (2013) report presence of Turkish hazel individuals near Dereköy and Demirköy in the Eastern Thrace. We identified three populations in Kastamonu province but Demirbaş Özen et al. (2013) reports sporadic individuals from Ağlı towards Black Sea. Similarly, in the close vicinity of Sivaslı population included in this study, Kargıoğlu (2003) and Semenderoğlu and Aytaç (2012) reported Turkish hazel individuals in Afyon and Kütahya, respectively. These locations were not included in our analyses because number of Turkish hazel trees in these reports is not sufficiently large enough to be considered as population.

One of the main reasons behind the revived interest in Turkish hazel in Turkey is its alleged suitability for plantation in arid or semi-arid regions and for restoration of degraded lands. While the populations investigated in this study are in seemingly diverse environments, none of the locations is arid. Seben, Oğuzlar, Çatacık, Budağan and Tosya populations are more inland and in drier habitats. Microclimatic conditions at these locations are probably favorable for Turkish hazel in these locations. Based on TCC, of the 18 populations investigated in this study, only three are found in semi-arid environments and six are classified as semi-humid – semi-arid (Table 3). According to EAI, the aridity index ranges from semi-humid to very humid in the studied population locations. Indeed, in forestry for an area to be considered as arid and semi-arid annual mean precipitation should be less than 300 mm and 600 mm, respectively (Boydak and Çalışkan 2015). The lowest mean annual precipitation is recorded in Oğuzlar with 477 mm, well above aridity threshold. Since there is no Turkish hazel natural population in arid environments, utilization of this species in arid environments can be dismissed. It can probably be planted in semi-arid environments given the seed source is properly selected. Thus, common garden experiments are required to evaluate genetic variation among and within these populations.

Although limited, recent studies indicate presence of considerable amount of variation among natural Turkish hazel populations for germination (Aygun et al. 2008; Arslan 2009; Arslan et al. 2013), fatty acid composition (Erdogan and Aygun 2005), and growth and phenology (Özpay Palazoğlu et al. 2015). These variations reflect macroclimatic diversity in population locations. Among the studied populations only three are protected for gene conservation purposes (Table 2). Since the populations are small, disjunct and separated by long distances there is no core area and thus multiple populations need to be

preserved in order to conserve genetic inheritance of Turkish hazel (Shepherd and Perrie 2011).

Climate change is a threat for Turkish hazel populations in Turkey. Species with disjunct distribution are more vulnerable to the effects of climate change and their preservation usually require *ex situ* conservation measures (St Clair and Howe 2011). Ability of *Corylus avellana* has been shown to shift distribution in northern Europe due to heavy nuts and pockets of populations in the presence of climate change (Seppa et al. 2015). There is no information on speed of Turkish hazel's response to climate change and the rate of this response is shaped by genetic variation, migration potential, and phenotypic plasticity (Alfaro et al. 2014). Therefore, immediate assessment of genetic structure of these populations and implementation of a comprehensive gene conservation program are essential.

Figure 2 A Turkish hazel (*Corylus colurna*) tree in Çatacık population (population 9) in open landscape.

CONCLUSIONS

Current distribution of Turkish hazel (*Corylus colurna*) in Turkey is within the north-west region of the country. A total of 18 small disjunct populations were identified. While most of the population locations are humid, none is arid. Therefore, Turkish hazel's rehabilitation potential of degraded landscapes in arid environments is limited. Due to very small overall distribution and disjunct structure of the natural populations, immediate assessment of genetic variation and rapid implementation of conservation measures are essential for protection of Turkish hazel natural populations in Turkey.

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