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Wood Density and Shrinkage of *Ulmus glabra* in Northwestern of Iran

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Abstract: The aim of this study was to determine some of the wood physical properties of 35-year-old *Ulmus glabra* trees. For this purpose, three normal elm trees were randomly cut down from the Arasbaran-Ardebil site located in northwestern part of Iran. Disks and logs of wood were cut at breast height of stem height. The testing samples were prepared from mature wood to determine physical properties (oven dry density, basic density and volumetric shrinkage). The mean of wood oven-dry density, basic density and volumetric shrinkage were 0.656, 0.575 g cm^{-3} and 12.39 %, respectively. In addition, the relationships between wood density and volumetric shrinkage were determined by linear analyses. It was found that there were weak correlations between oven-dry density and volumetric shrinkage in *Ulmus glabra* wood, although these correlations are positive.

Key words: Basic density · Correlations · Volumetric shrinkage · Ulmus glabra

INTRODUCTION

It is well known that wood is an anisotropic material which presents differential dimensional changes in different structural directions. The magnitude of shrinkage and swelling is affected by the amount of moisture gained or lost by wood when the moisture content fluctuates between zero and fiber saturation point [1, 2]. Kollman and Cote (1968) explained that shrinkage differs in three different directions due to the influence of wood rays and different arrangements of fibrils on cell walls [3]. The volumetric shrinkage and swelling properties are affected by several wood factors, such as the heartwood to sapwood ratio or the fibrillar angle on the S2 layer [4]. However, the most important parameter affecting wood shrinkage is the wood density [5].

Wood formation is attributed to many factors including climate, site and environment, stand conditions, management, genetics and age [6]. Wood density is important as an index of wood quality. It is considered to be one of the most important indices of timber strength properties as it has been positively correlated with such properties as modulus of rupture (MOR) and modulus of elasticity (MOE), maximum crushing strength, hardness and shrinkage and it also has a considerable influence on machinability, conversion and acoustic properties [7]. Wood density is mainly influenced by genotype, ageing of the cambium and growth rate [8].

Ulmus glabra is one of the most important species of the industrial forests of northern forests of Iran. It is distributed from Gorgan (at the northeast) to Arasbaran (at the northwest). Due to development of Dutch elm disease in their habitats, countless numbers of this species have died and its presence in the forest ecosystems is in danger of being eliminated. There is no study in available about elm wood properties. Therefore, the aim of this research was to determine some of physical properties of elm wood and to examine the relationship between wood density and volumetric shrinkage. Also, the results of elm physical properties are comparing with other species in Iran.

MATERIALS AND METHODS

In this research, 3 normal *Ulmus glabra* trees were randomly selected from a forest at the Arasbarn-Ardebil site, which is located in the northwestern part of Iran. From each tree, a disc was cut at breast height of stem height. A 5-cm-thick disc was collected from these logs for evaluation of physical properties such as oven dry density, basic density and volumetric shrinkage. In order to determine the physical properties samples with

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dimensions of 2 × 2 × 2 cm were prepared according to ASTM-D143. Testing samples were taken from mature wood. The physical properties of the specimens were calculated by the following equations:

$$D_0 = P_0 / V_0$$
$$D_b = P_0 / V_s$$
$$\beta_v = (V_s - V_0)/ V_s$$

Where D0 is oven dry density (g cm^{-3}), Db is basic density (g cm^{-3}), β_v is volumetric shrinkage (%), Vs is volume in state of saturate (cm^{-3}), Vo is volume in state of oven-dry (cm^{-3}), P0 is weight in state of oven dry (g) and P_s is weight in state of saturate.

RESULTS AND DISCUSSION

The results of the descriptive statistics of elm wood in terms of their physical properties are shown in Table 1. The mean of dry density, basic density, volumetric shrinkage values were 0.656, 0.575 g cm-3 and 12.39%, respectively. The wood density values of elm wood were comparing with other Iranian species, which are shown in Fig.1. According to this figure, the wood density values of elm wood is less than iron, locust, box, hornbeam, eucalyptus and is more than alder, maple, beech, white willow, popular, walnut, oak and large leaved lime [9]. Highest and lowest of wood density was found in box wood and *Populus nigra* wood among Iranian hardwoods species, respectively. In addition, the values of volumetric shrinkage of elm wood and other hardwood species are shown in Fig. 2. The highest of volumetric shrinkage were found in ash wood.

Basic density is also used to estimate carbon stored in the woody stems of trees [10] and has an appreciable influence on many solid wood properties and conversion processes, including cutting, gluing, finishing, rate of drying and papermaking. Basic wood density influences both the paper-making process and the properties of paper [11] and is an important economic indicator of pulpwood quality [12]. For pulp and paper manufacture, wood in the basic density range of 400-600 kg m-3 is preferred [13], which this index was found in *Ulmus glabra*.

Variation of shrinkage in different directions is due to the cellular structure and physical organization of cellulose chain molecules within the cell walls [14]; the microfibril angle of the S2 layer is an important factor [15]. Yamamoto *et al.* (1992) reported that the presence of a gelatinous layer in fibers results in large shrinkage in the
longitudinal direction [16]. In our study, the relationship between oven dry density and volumetric shrinkage were determined by linear regression models (Fig. 3). It was found positive relations between the wood density and volumetric shrinkage. While these correlations between wood oven dry density and volumetric shrinkage is weak (R2 = 0.248).

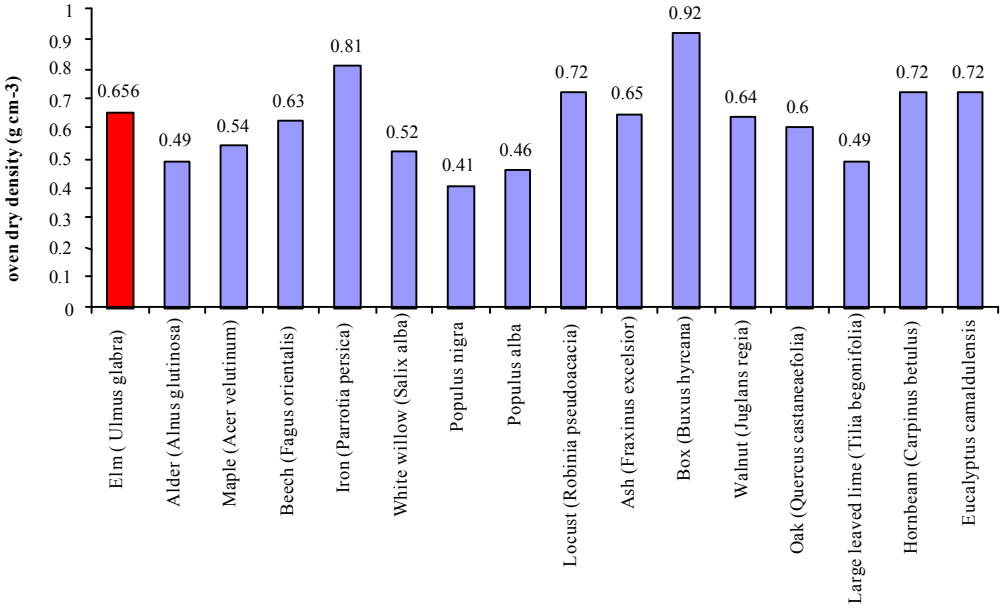

Fig. 1: The wood density values in this studied species and other Iranian hardwoods species

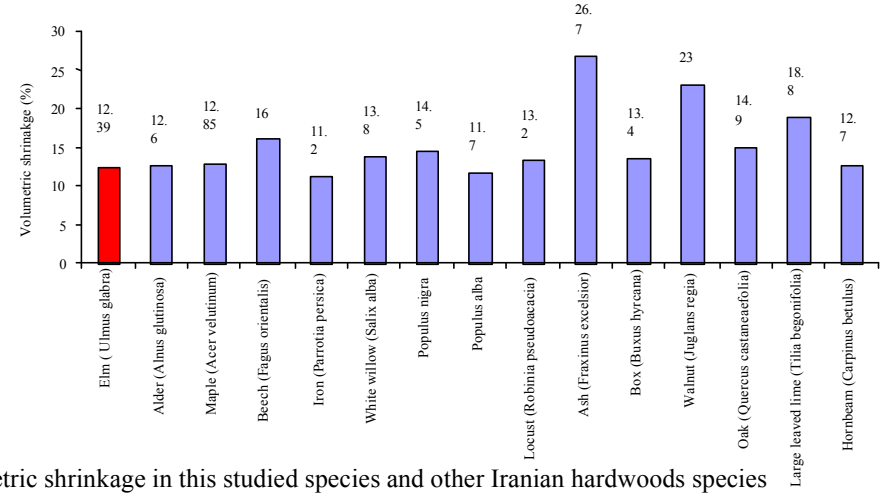

Fig. 2: The volumetric shrinkage in this studied species and other Iranian hardwoods species

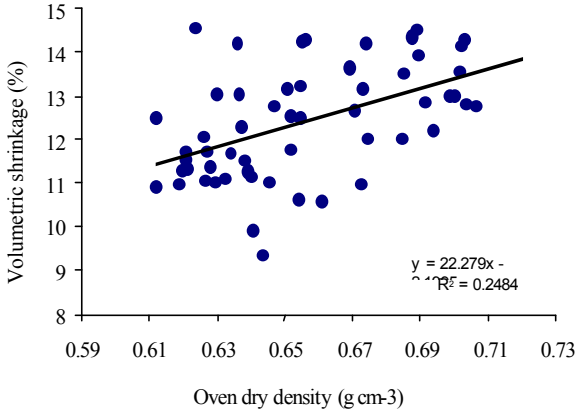

Fig. 3: The relationship between wood properties and volumetric shrinkage

Table 1: The descriptive statistics of physical properties of elm wood

Properties	Oven dry density (g cm^{-3})	Basic Density (g cm^{-3})	Volumetric Shrinkage (%)
N	55	55	55
Average	0.656	0.575	12.39
Standard deviation	0.029	0.022	1.27
Min	0.611	0.532	9.40
Max	0.720	0.615	14.57
C.V (%)	4.55	3.843	10.31

CONCLUSION

In this research, the physical properties (oven dry density, basic density, volumetric shrinkage) of elm wood were determined in northwestern part of Iran. The following results were obtained in the present study:

- The mean of dry density, basic density, volumetric shrinkage values were 0.656, 0.575 g cm^{-3} and 12.39%, respectively. This species due to good basic density is suitable for pulp and paper production.
- There are weak correlations between oven-dry density and volumetric shrinkage in elm wood. However, these correlation coefficients between both items are positive.

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