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Effect of Altitude Index on Growth Rate and Physical Properties of Hornbeam Wood (Case Study in Mashelak Forest of Iran)

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Abstract: Hornbeam (*Carpinus betulus*) is one of the most important species between the broad leaf trees of Iran's Northern Forests regarding its vast distribution and large percentage of coverage. For this purpose, nine normal hornbeam trees from three different elevation altitudes (Mashelak forest) located at Noshahr city (300, 750, 1350 meter) in western part of Mazandaran province were selected. From each tree, three disks were selected at beast height, 5m and 10m of stem height. According to the relegated standard (ISO-3131) the specimens were prepared from these disks to measure the main properties such as oven-dry density, basic density, volumetric shrinkage and volumetric swelling and Then date were statistically analyzed. ANOVA indicated that there is significant difference between altitude indexes and annual ring width, while these factors hadn't effect on the physical properties.

Key words: *Carpinus betulus* · Oven-dry density · Basic density · Volumetric shrinkage · Volumetric swelling

INTRODUCTION

Wood density is a commonly used wood quality indictor that is related to other wood properties such as timber strength and shrinkage, as well as pulp yield and properties [1, 2]. Wood density is mainly influence by genotype, ageing of the cambium and growth rate [3-6]. In conifers, increasing growth rate usually leads to a greater increase in early wood than in latewood formation and also delays the transition from juvenile wood to mature wood [6]. There are different results between growth rate and wood density in diffuse-porous hardwoods [1, 7]. Trees from cold climates at higher latitudes or high elevations usually develop into slow growing individuals, with straight stems and small limbs with relatively right-angled brunches, making them better adapted to ice and snow. Wood from trees growing at high elevations has lower specific gravity and shorter fibers than trees growing at lower elevations. This rule is more applicable to conifers than it is to the hardwoods [7]. The genus Carpinus of Betulaceae comprises approximately 35 woody species, which are widely distributed in Europe, eastern Asia and North and Central America, although the greatest concentration of species diversity occurs in China [8]. Hornbeam (*Carpinus betulus*) is a native diffuse porous hardwood species in Caspian forests and grows in mixed stands with oak and beech and with iron wood in some areas. The species require a warm climate for good growth and occurs at elevations up to 1000 m above sea level [9]. It is classified as a medium density hardwood and thus, it is heavy, semi-hard to hard, high in volumetric shrinkage and low in cleavage strength properties. Hornbeam, having superior technological properties and having high usage potential, is an important species in lumber industry. Mostly, it is used for tool handles, levers, fuel wood, furniture and papermaking industrials. When treated with preservatives, hornbeam wood is suitable substitution for beech wood in railway ties productions [10]. Hornbeam (*Carpinus betulus*) is one of the most important hardwood species between the broad leaf trees of Iran's Northern Forests regarding its vast distribution and large percentage of coverage (about 33%) that use in pulping and papermaking industrials in Iran country [11]. The specific objectives of the present study are: a) to examine the variation of Physical properties in classes of altitude in three altitudes and b) Relationship between annual ring width (growth rate) and oven dry density in hornbeam wood.

MATERIALS AND METHODS

In this research, nine normal trees hornbeam (*Carpinus betulus)* from three different elevation altitudes (Mashelak forest) located at Noshahr city (300, 750, 1350 meter) in Mazandaran province were employed.

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Table 1: The characteristics of the test areas and trees

Altitude (Meter)	300	750	1350
Slope%	20	20	20
Stand type	Mixed	Mixed	Mixed
Age	70	70	70
Rainfall mm/year	1345	1300	1300
Temperature	6-25	6-25	6-25

Discs were taken at breast height. The specimens were taken from radial axis from the pith to the bark to determine the Physical properties according ISO-3131 standard. The characteristics of the trees and the district that the samples are shown in Table 1. The physical properties of the specimens were calculated by the following equations:

$$D_0 = P0 / V0 \quad (1)$$

$$D_b = P0 / Vs \quad (2)$$

$$\beta v = (V_s - V_o) / V_s \quad (3)$$

$$\alpha_v = (V_s - V_0) / V_0 \quad (4)$$

Where D_0 is oven dry density (g cm^{-3}), D_b is basic density (g cm^{-3}), âv is volumetric shrinkage (%), á $_v$ is volumetric swelling (%), V_s is volume in state of saturate (cm^{-3}), V_o is volume in state of oven-dry (cm^{-3}), P_0 is weight in state of oven dry (g) and P_s is weight in state of saturate.

Statistical Analysis: In order to determine the relationship between the experimental variable (altitude index parameters) and wood properties, all the data measured were subjected to an analysis of variance and Duncan's mean separation test.

RESULTS AND DISSCUSION

The descriptive statistic result for oven dry density, basic density and volumetric shrinkage and volumetric swelling of hornbeam wood are shown in Table 2. Although by increasing of altitude, the values of mentioned properties increased, but analysis of variance (ANOVA) results indicated that there is not significance different between altitude indexes and mentioned properties. The mean of wood density were determined 0.684 g cm^{-3} in the present site, which is lower than Chalous (Hossinzade 2000, o.736 g cm^{-3}) and Sari site (Nakheai 1997, 0.701 g cm^{-3}) [12, 13].

The descriptive statistic result for annual ring width of hornbeam wood is shown in Table 3. ANOVA indicated that there is significant difference between annual ring width and altitude indexes. By increasing of altitude index, the annual ring width value was decreased. The relationship between wood density (oven-dry density) and annual ring width (growth rate) is shown in Figure 1. Annual ring width (growth rate) had not effect on wood density in hornbeam wood. Coefficient correlation between wood density and annual ring width was determined R^2 = 0.0017. This result was reported by Parsapajouh (1998) and Panshin (1980) [14, 1].

Table 2: Value of physical properties of hornbeam wood

Altitude (meter)	Oven-dry density (gr/cm^3)	Basic density (gr/cm^3)	Volume Swelling %	Volume Shrinkage %
300	0.673	0.565	18.06	15.73
750	0.682	0.574	19.06	15.80
1350	0.697	0.581	19.73	16.27
N	214	214	214	214
Mean (total)	0.684	0.573	15.93	19.26
Min (x_{min})	0.87	0.71	28.18	39.23
Max (x_{max})	0.49	0.45	2.88	2.96
Stdev	0.067	0.045	4.26	6.14
C.V %	9.79	7.85	26.74	31.87

Table 3: Value of annual ring width of hornbeam wood

Altitude (Meter)	300	750	1350
Mean (mm)	3.49	2.680	1.92
Min (x_{min})	5.90	4.450	2.60
Max (x_{max})	2.05	1.750	1.25
Stdev	0.91	0.635	0.35
C.V %	26.07	23.690	18.22

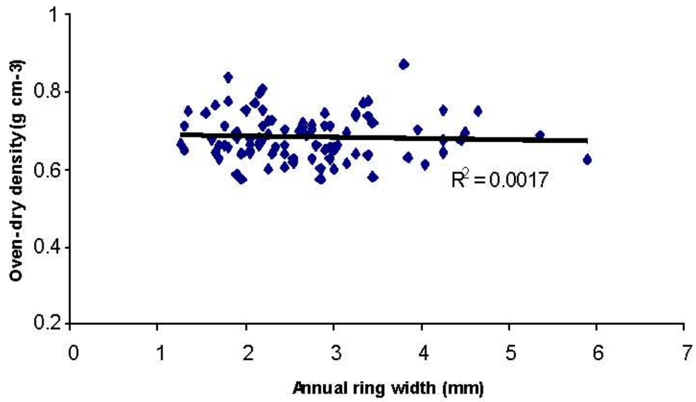

Fig. 1: The relationship between growth rate and wood density in hornbeam wood

CONCLUSION

- ANOVA indicates that there are no significant difference between altitude index and wood physical properties.
- ANOVA indicates that there are significant difference between altitude index and annual ring width.
- There isn't relationship (R^2=0.0017) between annual ring width and wood density.
- The annual ring width in low altitude (300 meter) is higher than other altitude indexes. It is advisable to plant this species in the low altitude.
- Trees grown in three different altitude indexes can be use in furniture industrials due to same wood density.

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