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The Influence of Trees's Age on the Physical Properties and Fiber Length of *Eucalyptus camaldulensis* in the Zabol Region at Iran

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Abstract: The easy plantation, growth rate and other advantages caused *Eucalyptus Camaldulensis* to be spread to different parts of the world and to be planted in many countries. In order to examine the properties of *Eucalyptus Camaldulensis*, ten healthy trees of two age groups of 14 and 20 years old, were sampled from Agriculture Research Center of Zabol city and their physical properties and fiber length were measured using the standard ASTM-D143 and Franklin method respectively. The analysis of variance (ANOVA) indicated that the trees's age and radial axis had significantly effect on the oven-dry density, basic density, volumetric shrinkage, volumetric swelling and fiber length. The increase of the trees's age would increase the mentioned properties of eucalyptus wood. The values of wood density, volumetric shrinkage and volumetric swelling along radial axis from the pith to the bark were decreased while fiber length was increased.

Key words: Eucalyptus Camaldulensis · Oven dry density · Basic density · Fiber length · Volumetric swelling · Volumetric shrinkage

INTRODUCTION

Some of the eucalyptus species have become important sources for wood fibre and are planted worldwide for the pulpwood industry. Wood basic density is used to estimate carbon stored in the woody stems of trees [1] and has noticeable influence on many solid wood properties and conversion processes, including cutting, gluing, finishing, rate of drying and paper making. It provides a good but not always direct indication of the strength, stiffness and toughness of timber [2]. Basic wood density influences both the paper-making process and the properties of paper [3] and is an important economic indicator of pulpwood quality [4]. For the pulping industry it affects freight costs, pulp production for a given mill size, chemical and power consumption and paper quality [5]. Density is therefore one of the most studied wood characteristics in eucalyptus. Fiber length is one of the quality parameters for pulpwood and it has been extensively studied in relation to tree age and within-tree position [6]. Fibre dimensions are determined by the dimensions of the cambial fusiform cells from which they are derived and by processes that occur during cell differentiation [7].

Due to increasing wood consumption and the development of pulp and paper production, plantations of fast-growing tree species managed with short rotations have a growing importance for the sustainability of industrial wood raw material. The eucalyptus has a higher priority for plantation forestry due to their adaptation capability to wide ecological conditions and various usage areas. *Eucalyptus Camaldulensis Dehnh* was one of the hardwood species planted in many parts of Iran and it has shown good adaptation to environmental conditions.

Several studies have reported on the physical, mechanical and chemical properties of E. microtheca [8], CMP paper production form E. *Camaldulensis* Dehnh in Mazandaran (north of Iran) and Fars sites (center of Iran) in Iran [9], NSSC and Kraft paper production form E. microtheca [10] and variations of wood density and fibre dimension of E. *Camaldulensis* in Pasand-Behshahr site in north part of Iran [12]. There is no available studies on the wood basic density and fibre length in southeast of Iran (Sistan province). The difference between Sistan sites with other sites is that, in this region there is 120 days winds. Their speed of winds is about 75 km/h. the value of rainfall is alittle and the value of vaporing is about 4000 to 5000 mm. Therefore, the aim of this research was to determine the effect of age on the physical and fiber length properties of *Eucalyptus Camaldulensis* in Sistan site.

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MATERIALS AND METHODS

In this research, number of 10 healthy *Eucalyptus Camaldulensis* Dehnh trees were randomly selected from a plantation at the Sistan site for both old groups (14 and 20 years-old). This site is located in the southeast of Iran. The latitude and longitude for this site were 31° 05′ 12″ N and 61° 25′ 57″ E. The annual rainfall and annual average temperature were 41 mm and 22°C, respectively. The altitude of this site was 477 m. From each of the trees; a disc was taken from breast height (1.3 meter) of both age groups. Testing of samples was taken along radial direction from the pith to the bark. Number of samples from 20 year-old was 10 and from 14 year-old was 7.

Wood Physical Properties: The samples for testing were randomly prepared from these discs to evaluation wood density according to the ASTM-D143 standard. Oven-dry measurements were taken after the specimens were dried to constant weight in an oven at 103 ± 2°C. The dimensions were measured in both green and dry conditions by a slide caliper and mass measured on an electric balance to an accuracy of 0.01 g. Basic density was determined from green volume (using the water displacement method) and oven-dry mass. If the specimens were be face collapse during oven drying, it was replaced with a new sample. The physical properties of the specimens were calculated by the following equations:

$$D_o = P_o / V_o$$
$$D_b = P_s / V_s$$
$$\beta v = (V_s - V_o)/ V_s$$
$$\alpha_v = (V_s - V_o)/ V_o$$

Where D_o is oven dry density (g. cm^{-3}), D_b is basic density (g. cm^{-3}), βv is volumetric shrinkage (%), α_v is volumetric swelling (%), V_s is volume in state of saturate (cm^{-3}), V_o is volume in state of oven-dry (cm^{-}), ^3P_o is weight in state of oven dry (g) and P_s is weight in state of saturate.

Fiber Length: For separating wood fiber was use from Jeffrey's solution (10% nitric acid: 10% chromic acid: water, 1:1:18). The value of fiber length (measuring a minimum 30 fibres for one sample) is expressed by Olympus microscope with image analyzer.

To determine the effect of age of trees and radial axis on the wood physical properties and fiber length, statistical analysis was conducted using the SPSS programming method in conjunction with the analysis of variance (ANOVA) techniques.

RESULTS

Wood Density: Results of statistics test showed that the age of trees, radial position and also interaction effects between radial position and age of trees had significantly effect on the oven dry density and basic density of Eucalyptus. Wood density variations in radial position from the pith to the bark for both age groups (14 and 20 year-old) are shown in Figures 1 and 2. The values of wood density were increased in radial position from pith to the bark in both age groups. This item in 20 year-old is more than 14 year-old.

Volumetric Shrinkage: Results of statistics test showed that the age of trees, radial position and also interaction effects between radial position and age trees had significantly effect on the volumetric shrinkage in Eucalyptus. Volumetric shrinkage variations in radial position from the pith to the bark for both age groups (14 and 20 year-old) are shown in Figure 3. The values of volumetric shrinkage were increased in radial position from pith to the bark in both age groups. This item in 20 year-old is more than 14 year-old.

Volumetric Swelling: Results of statistics test showed that the age of trees, radial position and also interaction effects between radial position and age trees had significantly effect on the volumetric swelling in Eucalyptus. Volumetric swelling variations in radial position from the pith to the bark for both age groups (14 and 20 year-old) are shown in Figure 4. The values of volumetric swelling were increased in radial position from pith to the bark in both age groups. This item in 20 year-old is more than 14 year-old.

Fiber Length: Results of statistics test showed that the age of trees, radial position and also interaction effects between radial position and age trees had significantly effect on the fiber length in Eucalyptus. Fiber length variations in radial position from the pith to the bark for both ages grouping (14 and 20 year-old) are shown in Figure 5. The values of fiber length were increased in radial position from pith to the bark in both age groups. This item in 20 year-old is more than 14 year-old.

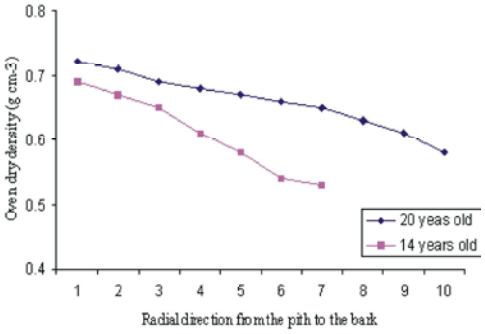

Fig. 1: The effect of age and radial position on oven dry density

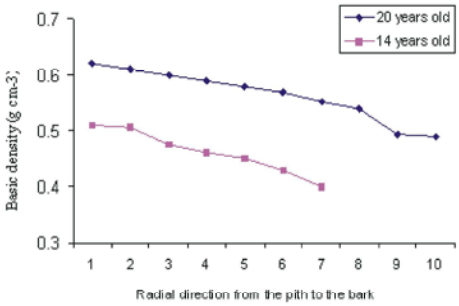

Fig. 2: The effect of age and radial position on the basic density

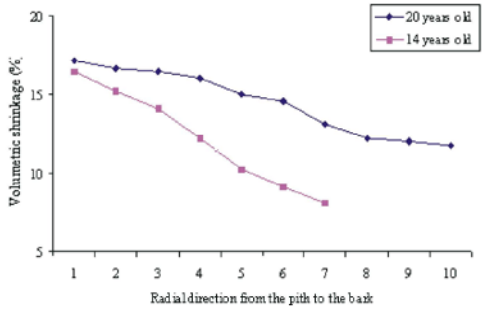

Fig. 3: The effect of age and radial position on the volumetric shrinkage

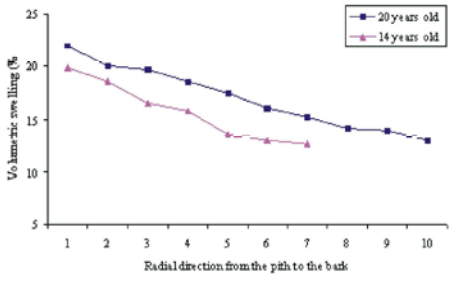

Fig. 4: The effect of age and radial position on the volumetric swelling

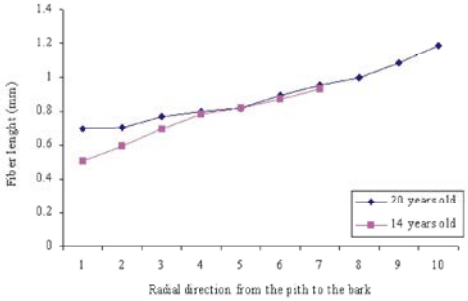

Fig. 5: The effect of age and radial position on the fiber length

DISCUSSION

In general, the variations of density in wood species have a closed relation with thickness of cell walls and its percentage, the number of vessels, fibers and wood rays. Increasing fibers and rays in wood tissue, thickness of cell walls and decreasing the number of vessel lead to increasing density. The variation of wood density in some wood species is independent with annual ring width and early to late wood ratios. Increasing annual ring width increases the density of ring porous hardwoods and decreases the density of softwood. Also, increasing the value of saved chemical materials in the cell cavity and walls of wood cells cause to increase wood density [12]. In this research, the variations of oven-dry density and basic density in this species decreases along radial direction from the pith to the bark. Therefore, decreasing the oven-dry density and basic density along radial axis is related to chemical and anatomical fundamental of wood [5].

The specialist of wood and paper industrials believes that juvenile wood at top of stem height than base of stem trees in each old age group. In other hands, juvenile wood is more on top of the tree. But the preparation of the juvenile wood to the all tree decreases a lot with increasing the old-age of tree from weighting and volume. Investigations show that 85% of the volume of 15 years old trees, juvenile wood includes 30% percent of the all tree [5]. It seems that, this occurs for the eucalyptus species too. So because of that the value percentage of juvenile wood at 14 year-old group is more than 20 year-old group.

The variation of wood density adapt with shrinkage and swelling variation. It means that by increasing the wood density the value of shrinkage and swelling

increases [13, 14]. So the value of these properties increases because of the more density at 20 year-old group. According to the relationship between wood density and volumetric swelling and volumetric shrinkage, we can say that wood density is the main reason of these variations.

Fiber properties in three groups from the length are [15]: 1- short fiber: with less length than 0.9 mm, 2- the fiber length is between 0.9 - 1.9 and 3- fiber length are more than 1.9 (tall fibers). So according to the above classification, the fibers of eucalyptus wood are at the first class for 14 and 20 year-old.

CONCLUSION

- ANOVA analysis indicate that the effect of age and radial direction on the wood density, volumetric shrinkage and volumetric swelling were significant in eucalyptus.
- The wood physical properties and fiber length in 20 year-old is more than 14 year-old.
- This species due to good wood density and fiber length is suitable for pulp and paper production, but these properties in 20 year-old is better than 14 year-old.

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