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Variation of Physical and Biometrical Properties of Salix Wood along the Stem

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Abstract: In this study, the variation of physical and biometrical properties of *Salix* wood which was cultivated in the north of Iran was studied along the stem from the base upwards. To measuring the mentioned traits, the test specimens were prepared from five stands at different height levels (5, 25, 50 and 75% of the total tree height) based on ASTM-D143 standard. The, the data were statistically analyzed with a significant difference of 95% confident level with SPSS software. Statistical analysis showed the height of tree had significant effect on physical and biometrical properties of *Salix* wood. The result indicated that, within the tree, the fiber length, fiber diameter, fiber wall thickness, dry density, basic density and volumetric shrinkage of *Salix* wood decreased along the stem from the base upwards. However, the lumen diameter and porosity increased with increase of height of tree. Also, the physical and biometrical properties of *Salix* wood changes in the present experiment may be due to the trees which have entered the wood maturity phase and thus displayed a corresponding the variation in different height of tree.

Key words: *Salix* Wood · Height of Tree · Fiber Dimension · Density · Porosity · Shrinkage · Maturity

INTRODUCTION

Salix is a species of willow native to Europe and western and central Asia. The name derives from the white tone to the undersides of the leaves. It is a medium-sized to large deciduous tree growing up to 10-30 m tall, with a trunk up to 1 m diameter and an irregular, often leaning crown. It is dioecious, with male and female catkins on separate trees; the male catkins are 4-5 cm long, the female catkins 3-4 cm long at pollination, lengthening as the fruit matures. When mature in mid summer, the female catkins comprise numerous small (4 mm) capsules each containing numerous minute seeds embedded in white down which aids wind dispersal. Willows are fast-growing, but relatively short-lived, being susceptible to several diseases, including watermark disease caused by the bacterium *Brenneria salicis* and willow anthracnose, caused by the fungus *Marssonina salicicola*. These diseases can be a serious problem on trees grown for timber or ornament [1].

The fast growing and early maturing species such as willow (*Salix spp.*) represent a potentially large source of timber production. The willows are easily propagated by cutting and planting and subsequent treatments are generally not very difficult [2]. Willow (*Salix spp.*) tree improvement programs have emphasized improvements in the growth, forms, adaptability and disease resistance [1-2]. Willow wood is also used in the manufacture of boxes, brooms, cricket bats (grown from certain strains of white willow), cradle boards, chairs and other furniture, dolls, flutes, poles, sweat lodges, toys, turnery, tool handles, veneer, wands and whistles. In addition tannin, fiber, paper, rope and string, can be produced from the wood [1].

The wood properties have been reported to depend on such factors as climatic, provenance, ecological conditions, as well as wood positions in different parts of tree, between and within species [3]. Wood properties such as density and fiber length determine the end-product quality in industrial processes and are both positively correlated with tear strength [4]. Wood basic density is considered one of the most important features in genetic improvement programmers and is one of the most often studied wood quality traits [3-5]. It is a complex feature influenced by cell wall thickness, the proportion of the different kind of tissues and the

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percentages of lignin, cellulose and extractives [5]. Both wood density and fiber length determine whether the quality of raw material is suitable for a specific use in the paper industry. Fiber length also has impacts on paper characteristics, such as strength, optical properties and surface quality.

Considering the increasing demand for new species from fast-growth plantations as alternative timbers for hardwood and because there is little or no information about the variation of wood biometrical dimensions, density, shrinkage and above mentioned properties within stem, even though these characteristics are a means of assessing the pulp and paper making and the dimensional stability of wood. Thus, the aim of the present study was to investigate the variation of physical and biometrical properties of *Salix* wood along the stem.

MATERIALS AND METHOD

The sample site was located approximately 17 kilometers to the North of Dr. Bahramnia experimental plantation in the south-western of Gorgan, Iran. A total of five trees from the willow (*Salix spp.*) were chosen. All trees were randomly selected, taking into account the stem straightness and the absence of obvious decay. The characteristics of site location and willow trees are listed in Table 1. The willow (*Salix spp.*) trees were cut for the study in August 2010. Less than two hours after the harvest, the trees were bucked at three meter intervals and 4-cm-wide slabs were cut through the cross sections of the separated pieces. The slabs were taken directly to the freezer, to avoid losing their moisture content. Consequently, the sample disks were taken at different height levels: 1.3 m, 4.5 m, 9 m and 13.5 m of the total tree height.

Table 1: The characteristics of site location and *Salix* trees

Type of climate	Mediterranean
Geographic position	36° 45′ N, 54° 24′ E
Altitude (m)	300
Mean annual temperature (°C)	18
Annual rainfall (mm)	525
Type of clay	spodosols
Tree diameter (mm)	195
Tree height (m)	18
Tree ages	9

These specimens were soaked in the distilled water for 72 hours to ensure the moisture content above the fiber saturation point. At this point, the dimensions in all three principal directions were taken with a digital caliper to the nearest 0.001 mm. Samples were weighed to the nearest 0.001 g for saturated weight and the saturated volume was calculated based on these dimension measurements. The specimens were subsequently placed in a conditioning room at 20 °C and 65% relative humidity (RH) with to reach approximately 12% moisture content. Once this state was reached, the samples were weighed again and dimensions were measured in all three directions. Finally, the samples were oven dried at 103 °C until a constant oven-dry weight was attained. The same measurements were taken on the oven-dry specimens after samples were cooled by the room temperature. Thus, wood density, longitudinal, radial and tangential directions were measured for each specimen. The values of the wood oven-dry, basic density, porosity and volume shrinkage in percentage were calculated using the following equations [6]:

$$D_O = (M_O \div V_O) \times 100 \quad (1)$$

where D_O, M_O and V_O are the oven dried density, weight and volume of specimen respectively.

$$D_B = (M_O \div V_S) \times 100 \quad (2)$$

where D_B is the basic density, M_O is the oven dried weight and V_S is the saturated volume of specimen.

$$C = (1\text{-}0.67\,D_O) \times 100 \quad (3)$$

Where C is the porosity, D_O is the oven-dry density.

$$B_V = [(V_S\text{-}V_O)/V_S] \times 100 \quad (4)$$

where B_V is the volume shrinkage, V_O is the oven dried dimensions and V_S is the saturated dimensions.

Samples for biometrical dimensions measurements were macerated in a mixture of parts of 50% glacial acetic acid and 50% volume of hydrogen peroxide in a 64°C oven for 24 hours [7]. After maceration samples were washed with distilled water and the 2×2×10 mm splinters were shaken gently in the distilled water until the individual fibers of the wood were separated. From each splinter 2 slides were prepared and 10 whole fibers on each slide were measured. Each slide was projected on an Olympus research microscope at a 1 × eyepiece and 4 × objective lens for fibers length and at a 10 × objective lens for cross-sectional dimension. Firstly image of fibers was calibrated on monitor board with screw micrometer and fibers dimensions were determined with special plastic slide rule. Special transfer ratio was determined on the basis of microscope magnification and monitor magnification with special milimetric lame and on the monitor board.

The statistical analysis was conducted using SPSS programming method in conjunction with the analysis of variance (ANOVA) techniques. Duncan's Multiply Range Test (DMRT) was used to test the statistical significance at $\alpha = 0.05$ level.

RESULT AND DISCUSSION

Statistical analysis showed the height of tree had significant effect on biometrical properties of *Salix* wood. The pattern of variation of fiber length, fiber diameter, fiber wall thickness and lumen diameter as a function of the height in the stem is shown in figures 1-2. Within the tree, the fiber length, fiber diameter and fiber wall thickness of *Salix* wood decreased along the stem from the base upwards. However, the lumen diameter increased with increase of height of tree. It is well established that, the height of near the bottom of tree (juvenile wood) with thinner cell walls and smaller cell dimensions as a compared with the height of near the top of tree (mature wood). This is supported by the fact that the juvenile wood has higher fiber length, fiber diameter, fiber wall thickness compared to the mature wood. The lumen diameter of juvenile wood was also found to be lower than the mature wood [8-11].

Statistical analysis showed the height of tree had significant effect on physical properties of *Salix* wood. The pattern of variation of wood density, porosity and shrinkage as a function of the height in the stem is shown in figures 3-4. Within the tree, the dry density, basic density and volumetric shrinkage of *Salix* wood decreased along the stem from the base upwards. However, the porosity increased with increase of height of tree. Some researchers have found that the wood density increase with age or distance from pith and with height or distance from the bottom of tree [8-9]. This is supported by the fact that the juvenile wood is usually known to be of the lower density

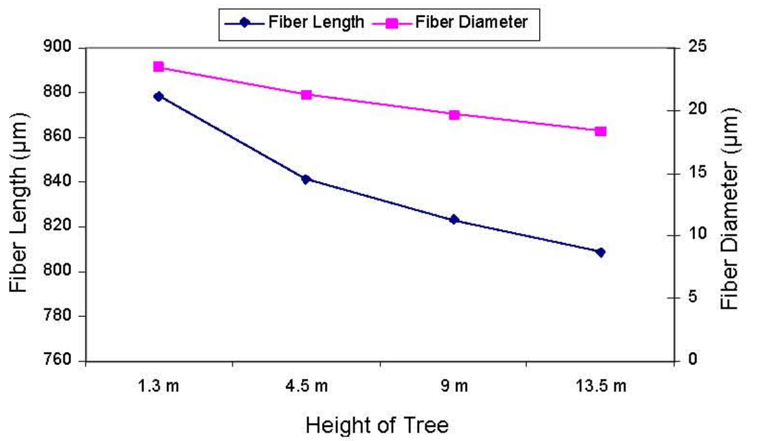

Fig. 1: Variation of fiber length and fiber diameter of Salix wood along the stem

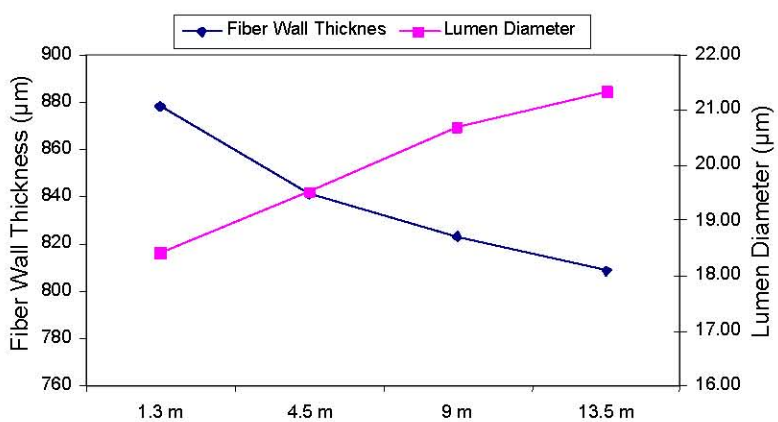

Figure 2. Variation of fiber wall thickness and lumen diameter of Salix wood along the stem

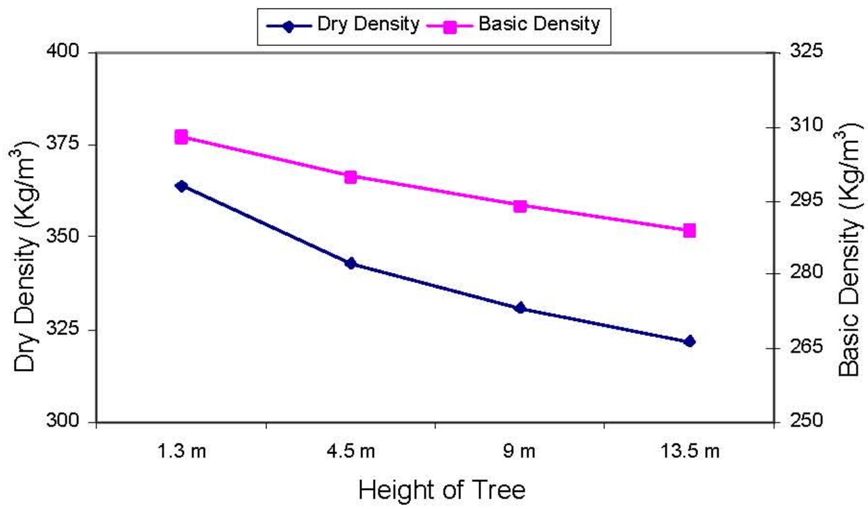

Fig. 3: Variation of dry density and basic density of Salix wood along the stem

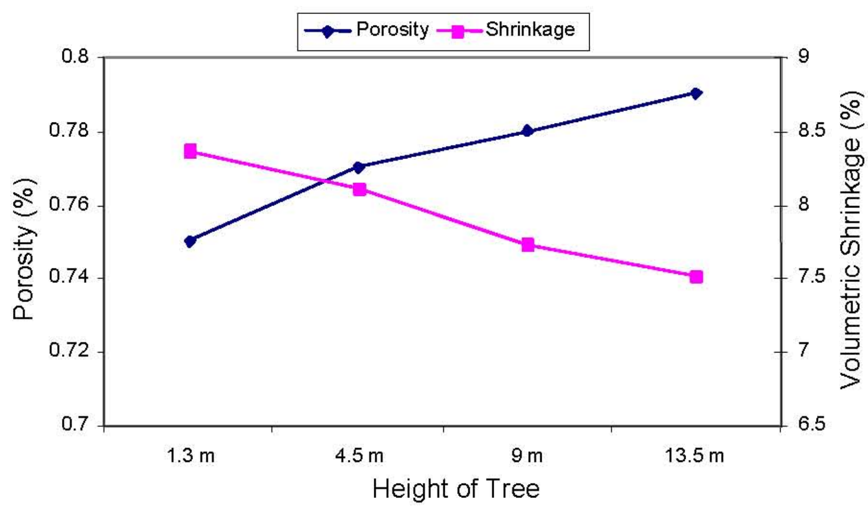

Fig. 4: Variation of porosity and volumetric shrinkage of Salix wood along the stem

than the mature wood [10]. The wood density changes in the present experiment may be due to the trees which have entered the wood maturity phase and thus displayed a corresponding increase in wood density [11]. Changes in the wood shrinkage with height or distance from the bottom of tree are likely related to the variation of the wood density, which often displays an inverse pattern of changes [8-11].

CONCLUSION

The following conclusions could be drawn from the results of the present study:

- Statistical analysis showed the height of tree had significant effect on physical and biometrical properties of *Salix* wood.
- Within the tree, the fiber length, fiber diameter, fiber wall thickness, dry density, basic density and volumetric shrinkage of *Salix* wood decreased along the stem from the base upwards. However, the lumen diameter and porosity increased with increase of height of tree.
- The physical and biometrical properties of *Salix* wood changes in the present experiment may be due to the trees which have entered the wood maturity phase and thus displayed a corresponding the variation in different height of tree.

REFERENCES

1. Monteoliva, S., G. Senisterra and R. Marlats, 2005. Variation of wood density and fiber length in six willow clones (*Salix SPP.*). IAWA J., 26(2): 197-202.

2. Yanchuk, AD., B.P. Dancik and M.M. Micko, 1984. Variation and heritability of wood density and fiber length of trembling aspen in Alberta. Canadian Silviculture Genet, 33: 11-16.
3. Koch, P., 1985. Utilization of hardwoods growing on southern pine sites, Vol. 1, USDA Forestry, 605: 465-548.
4. Haygreen, J.G. and J.L. Bowyer, 1982. Forest products and wood science: An introduction. The Iowa State University Press, Ames, U.S.A., pp: 105-135.
5. Einspher, D.W., M.K. Benson and J.R. Peckham, 1967. Variation and heritability of wood and growth characteristics of five-year old quaking aspen. Genet. Phys. Notes Inst. pap. chem. no 1. Applcton.
6. Annual Book of ASTM Standards, 1986. Vol. 4, American Society for Testing Materials, Philadelphia.
7. Franklin, F.L., 1946. A rapid method for softening wood for microtome sectioning.
8. Zobel, B.J. and J.P. Van Buijtenen, 1989. Wood variation, its causes and control. Spring-Verlag, Berlin, Heidelberg, New York.
9. Dadswell, H.E., 1958. Wood structure variations occurring during tree growth and their influence on properties. Wood and Fiber Sci. J., 1: 1-24.
10. Zobel, B.J., 1998. Juvenile wood in forest trees. Spring Series in Wood Science, 485.
11. Panshin, A.J. and C. De Zeeuw, 1980. Textbook of wood technology, 4ed New York, Mc Graw-Hill, 722.