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A NOTE ON PREDICTION OF WOOD PROPERTIES IN YELLOW-POPLAR[1]

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ABSTRACT

Increment core samples were taken from fifteen yellow-poplar trees at breast height and determinations of specific gravity and fiber length were made on selected individual growth rings. Juvenile wood and mature wood of different growth rates were compared. The results show mature wood specific gravity uncorrelated with growth rate and mature wood fiber length increasing with increasing growth rate. The extremely low correlation obtained between juvenile wood and mature wood properties within the same tree indicates that no predictive relationship exists for use in selection at a very early age.

Keywords: Liriodendron tulipifera, yellow-poplar, wood quality, juvenile wood, specific gravity variation, fiber length variation, earlywood, latewood.

INTRODUCTION

The variability of wood properties within a tree in the radial direction has been studied for a number of species. Such studies have proved to be of great value as relationships between wood properties and product properties have been documented and accepted by both wood products technologists and timber producers. Although patterns of wood properties have been studied in a number of species, much information concerning the interrelationships of the various wood properties with growth and with each other is still lacking. The objective of this study was to examine the variation and interrelationships of specific gravity, fiber lengths, and growth rates in juvenile and mature wood of yellow-poplar (*Liriodendron tulipifera*). This information is necessary to determine what criteria are useful for selection of yellow-poplar trees for increased wood quality.

Previous work

Several conflicting patterns of within-tree variation of specific gravity have been reported for yellow-poplar. Panshin and de Zeeuw (1970) report specific gravity in yellow-poplar as either an increase from pith to bark, an increase through the juvenile wood followed by a constant period or a decrease in the mature wood, or a decrease from pith to bark. Taylor (1965) reported an increase in specific gravity through age 20, followed by a leveling off or a decrease in the mature wood. Erickson (1949), Thorbjornsen (1961), and Koch et al. (1968) have reported an increase of specific gravity from the pith outward. Thorbjornsen (1961) found little difference in average wood density between stands of yellow-poplar, and little indication of a relation between density and growth rate. He concluded that density variation in yellow-poplar may have a significant level of genetic control.

Radial variation of fiber length in yellow-poplar has been shown to follow a pattern of a period of rapid increase from the pith outward followed by a period of a more gentle increase (Taylor 1965, 1968; and Thorbjornsen 1961). Taylor also found the within-ring variation of fiber length to be significantly large and to vary linearly across the ring and suggested that careful sampling is necessary to measure the same point within each ring. Thorbjornsen con-

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cluded that fiber lengths in yellow-poplar are strongly related to environmental conditions.

EXPERIMENTAL PROCEDURES

Sampling was done within a single natural occurring stand of mixed yellow-poplar and oak on the Oak Ridge Forest, Oak Ridge, Tennessee. This study area has been described in detail by Buckner (1972).

Fifteen dominant or co-dominant trees were selected throughout the stand. Trees with excessive crook or lean or an asymmetrical crown were rejected. One 11-mm-diameter increment core was taken from each tree at breast height along the radius from bark to pith and parallel to the ground contour. The number of rings at breast height varied from 31 to 66 in the trees sampled.

Six growth rings were sampled from each core as follows: The third ring from the pith in the juvenile wood and a wide and a narrow ring in the outer, mature wood portion of the tree (beyond age 20) were sampled for fiber length. The wide and narrow rings in the mature wood were chosen so that they were near the same age. The average age difference of the two mature wood samples within a tree was 5 years; the maximum was 12 years. The wide and narrow rings were randomized as to being nearer or farther from the pith. This sampling procedure was followed to allow blocking across the age–wood property effect, with randomization within the block, in the analysis of variance.

The next ring out from each of the rings sampled for fiber length was selected for specific gravity determinations by the maximum moisture method (Smith 1954). Ring width, distance from pith, and ring number were recorded for each ring sampled.

A 100-μm-thick microtomed section was taken near the inner and outer edge of each growth ring to be sampled for fiber length. Care was taken not to include either the terminal parenchyma or the first several rows of cells on each side of the terminal parenchyma band. These sections were macerated in Jeffrey's solution method as described by Johanson (1940). Fiber lengths were measured directly using an Eberback 1700 microprojector and wet mounts. Fifty randomly selected fibers were measured from each earlywood and latewood section, resulting in 100 measurements for each ring.

A randomized complete block experimental design was employed in analyzing radial variation of specific gravity. Orthogonal contrasts were used in the analysis of variance to make two specific comparisons—juvenile wood versus mature wood, and wide ring mature wood versus narrow ring mature wood (Table 1).

RESULTS AND DISCUSSION

Juvenile wood specific gravity averaged 0.38, while mature wood specific gravity was 0.44. Wide-ring mature wood specific gravity averaged 0.45; narrow-ring, 0.44. The difference between core wood and mature wood specific gravity was highly significant while the difference between the two mature wood samples of similar ages representing different growth rates was essentially zero.

The data were tested for the existence of a predictive relationship between juvenile and mature wood specific gravity within the same tree. Table 2 shows that a linear correlation coefficient of 0.06 was obtained between juvenile wood and mature wood specific gravity. A significant correlation coefficient of 0.56 was found between the two mature wood samples. Trees therefore show a tendency towards an overall high or low specific gravity in mature wood, but juvenile wood specific gravity does not predict mature wood specific gravity.

Average ring width for mature wood was 4.2 mm for wide rings and 1.8 mm for narrow rings.

Mean fiber lengths of the samples were quite variable, ranging from 0.8 mm to 2.06 mm. Table 3 shows the mean fiber lengths obtained at each radial position.

TABLE 1. *Analysis of variance of specific gravity of individual rings by radial position at breast height*

Source	df	SS	MS	F
Positions	2	0.035300	0.017650	8.97**
Wide vs. narrow	1	0.001613	0.001613	0.820
Core vs. mature	1	0.033640	0.033640	17.1**
Blocks	14	0.052300	0.003736	
Error	28	0.055100	0.001968	
Total	44	0.142700		

** Significant at 1% level of probability

Some patterns of variation were distinctive. An analysis of variance similar to that used for specific gravity was used to compare mean fiber lengths (Table 4). Juvenile wood had much shorter fibers than mature wood. Earlywood fibers were much shorter than latewood fibers. Most of the fiber length difference between wide and narrow rings occurred in the latewood; earlywood fiber lengths were not greatly different between wide and narrow rings.

Linear regression of latewood fiber lengths of mature wood versus ring width for all trees showed a nonsignificant correlation coefficient of 0.32. However, the analysis of variance showed wide rings to have significantly longer fibers than narrow rings of similar age within the same tree. Graphs of fiber length versus growth rates of individual trees showed that most of the variation between trees was in the overall level of the fiber length and that the slope of the fiber length versus growth rate curve was fairly constant. Clearly, any research that deals with the fiber length–growth rate relationship should employ a multivariate type analysis to separate between-tree and within-tree variation, rather than a simple regression analysis.

Juvenile wood and mature wood earlywood, latewood, and average fiber lengths were compared by tree to determine if they were correlated. No correlations existed (Table 2). No indication was found that relationships could be developed that

TABLE 2. *Linear correlation coefficients for specific gravity and fiber length*

Relationship	
Latewood mature wood fiber length vs. ring width	0.32
Specific gravity vs. ring width (all samples)	0.13
Specific gravity vs. ring width (juvenile wood only)	0.41
Wide ring specific gravity vs. narrow ring specific gravity	0.56*
Juvenile wood specific gravity vs. mature wood specific gravity	0.055
Juvenile fiber length vs. mature wood fiber length	0.09

* Significant at 5% level of probability

TABLE 3. *Mean fiber lengths by radial position in tree*

Position	Mean fiber length (mm)
Ring 3, earlywood	1.04
Ring 3, latewood	1.31
Mature wood, narrow ring, earlywood	1.39
Mature wood, narrow ring, latewood	1.59
Mature wood, wide ring, earlywood	1.44
Mature wood, wide ring, latewood	1.79

TABLE 4. *Analysis of variance of fiber length by radial position in tree*

Source	df	SS	MS	F
Positions	5	4.8653	0.9731	57.9**
Comparisons*				
(1)	1	0.2294	0.2294	13.6**
(2)	1	1.1289	1.1289	67.2**
(3)	1	0.0785	0.0785	4.7
(4)	1	2.8905	2.8905	206.5**
(5)	1	0.5387	0.5387	38.47**
Blocks	14	0.8703	0.0622	
Error	70	1.1730	0.0168	
Total	89	6.9038		

* Comparisons
(1) Within mature wood (wide vs. narrow ring)
(2) Within mature wood (earlywood vs. latewood)
(3) Within mature wood (interaction)
(4) Juvenile wood vs. mature wood
(5) Within juvenile wood (earlywood vs. latewood)
** Significant at 1% level of probability

would allow one to predict at a very early age, the ultimate fiber length or specific gravity of the mature tree.

CONCLUSIONS

Within the range of growth rates studied, mature wood specific gravity was unaffected by growth rate while mature wood fiber length increased significantly with increased growth rate. No predictive relationship was discovered that would allow selection of trees for either fiber length or specific gravity at a very early age. Selection of trees with rapid growth rates in both juvenile wood and adult wood is consistent with the goals of obtaining higher overall specific gravity and fiber length.

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