WOOD PROPERTY DIFFERENCE BETWEEN TWO STANDS OF SYCAMORE AND BLACK WILLOW

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ABSTRACT

Wood properties of natural stands of willow and sycamore growing along the southern reaches of the Mississippi River were investigated. Properties of mature wood measured were specific gravity, fiber dimensions, and the proportional volume of xylem tissue composed of vessels, fibers and parenchyma.

There are no statistically significant differences between measured properties of sycamore stands, and willow stands vary significantly only in fiber length and the proportion of vessels and ray tissue present.

Correlation analysis revealed that there is no significant relationship between diameter growth rate and specific gravity for either species. Specific gravity is positively related to fiber wall thickness in willow, but there is little relationship among these properties in sycamore. The specific gravity of sycamore is, however, positively related to ray content. This relationship is important to tree breeders, because selection of high specific gravity phenotypes may result in an increase of ray tissue in select material.

Additional keywords: *Platanus occidentalis*, *Salix nigra*, wood quality, specific gravity, tissue volumes, fiber length, ring width, fiber diameter, fiber wall thickness.

INTRODUCTION

Both black willow (*Salix nigra* Marsh) and sycamore (*Plantanus occidentalis* L.) are widely distributed throughout the Eastern United States. Both species, however, attain maximum growth and form class along the lower reaches of the Mississippi River. Unmanaged natural stands of black willow in the Mississippi Delta have been estimated to yield 66 cords of pulpwood or 28,000 board feet of sawtimber per acre at 35 years of age (U.S.D.A. 1965). Mississippi Delta sycamore occasionally occurs in pure stands; however, it is commonly associated with pecan, elm, ash, sugarberry, cottonwood, willow, and sweetgum. Under forest conditions, sycamore has a relatively small crown and a long, slightly tapered bole that may be clear of branches for 70 to 80 feet.

Interest in the properties of wood has intensified as researchers have studied the relationships between wood and fiber qualities and various end uses of wood. Specific gravity, cell dimensions, and volumetric composition are among the properties that have been studied. Efforts have been devoted primarily toward using this knowledge to estimate wood quality of the existing timber supply and to establish tree improvement programs. Increased demands for hardwoods, especially for quality hardwoods, have recently placed emphasis on the need for such studies.

Information on wood property variation of various hardwoods has been reviewed (DeZeeuw 1965; Dinwoodie 1961; Lee 1972; Spurr and Hyvarinen 1954; Taylor 1968). An intensive study of within-tree variation of black willow (Wooten and Taylor 1968) showed that:

1. Specific gravity increases slightly with increasing height in the tree.
2. Fiber length, vessel volume, fiber wall thickness, and fiber diameter increase with distance from the pith.
3. Ray volume is constant throughout the stem.
4. Slow growth zones have a high proportion of vessel tissue.

A similar within-tree variation study of sycamore (Taylor 1969a) showed that:

TABLE 1. *Minimum, average, and maximum values of wood properties of mature wood of natural willow stands at two locations along the Mississippi River*

WOOD PROPERTY	STAND LOCATION Catfish Point minimum	(average)	maximum	Yuccatan Peninsula minimum	(average)	maximum
Specific Gravity	0.30	(0.36)	0.42	0.30	(0.35)	0.41
Vessel Volume (%)	31	(36)	42	31	(40)	46
Fiber Volume (%)	42	(52)	59	45	(50)	58
Ray Volume (%)	9	(12)	15	5	(9)	13
Fiber Length (mm)	0.88	(1.04)	1.17	0.96	(1.11)	1.21
Ring Width (in)	0.11	(0.19)	0.29	0.07	(0.17)	0.29
Fiber Diameter (μm)	23	(25)	30	22	(25)	30
Double Fiber Wall Thickness (μm)	6.6	(7.4)	8.7	6.5	(7.5)	8.6

1. Specific gravity is altered by differences in the relative proportion of tissue types. It increases with increases in the proportion of fibers and rays and decreases with increased vessel volume.
2. Fiber length and diameter increase curvilinearly with age and decrease linearly with tree height.
3. The proportion of xylem tissue composed of vessels increases, accompanied by a decrease in fibrous tissue, from breast height to 60 feet.
4. The proportion of ray tissue is unaffected by height.

For both species it was concluded that:

1. Normal variations in growth rate have little or no effect on specific gravity.
2. Specific gravity increases with age in the lower bole and decreases with age at heights above 40 feet.
3. Holocellulose content increases slightly with age during early growth increments.
4. Tree-to-tree differences are significant for the important properties of specific gravity, cell diameter, fiber length, and proportion of ray tissue.

This study evaluates wood property differences among natural stands growing at two locations along the Mississippi River.

PROCEDURE

Natural stands of willow and sycamore were located on Yuccatan Peninsula (between Vicksburg and Natchez, Mississippi) and approximately 100 miles north on Catfish Point (near Greenville, Mississippi). The willow stand on Yuccatan Peninsula was 27 years old, 103 feet tall, and 14 inches in diameter at breast height. The Catfish Point stand was 33 years old, 108 feet tall, and 14 inches in diameter at breast height. The sycamore stands at Yuccatan and Catfish Point were, respectively, 34 and 32 years old, 119 and 98 feet tall, and 17 and 14 inches in diameter at breast height. In each of the stands, 20 sample trees with no visible evidence of disease or damage were selected for property evaluations. Sample trees were dominant or co-dominant trees with straight, nonleaning boles, and well-formed crowns. Within these requirements, trees were chosen to represent the range of diameters in the stand.

Large (11-mm) increment cores were removed from the southern radius at breast height of the sample trees. The core length from pith to bark was measured and a segment of mature wood (rings 22–24) was isolated. The specific gravity of each core segment was determined by measuring its green volume and oven-dry weight. The proportion of vessels, fibers, and paren-

TABLE 2. *Minimum, average, and maximum values of wood properties of mature wood of natural sycamore stands at two locations along the Mississippi River*

WOOD PROPERTY	STAND LOCATION					
	Catfish Point			Yuccatan Peninsula		
	minimum	(average)	maximum	minimum	(average)	maximum
Specific Gravity	0.42	(0.46)	0.51	0.41	(0.46)	0.51
Vessel Volume (%)	31	(38)	47	34	(39)	41
Fiber Volume (%)	34	(42)	50	39	(41)	46
Ray Volume (%)	16	(19)	24	15	(20)	24
Fiber Length (mm)	1.70	(1.92)	2.16	1.81	(1.92)	2.06
Ring Width (in)	0.03	(0.14)	0.25	0.06	(0.18)	0.34
Cell Diameter (μm)	24	(28)	30	24	(27)	30
Double Wall Thickness (μm)	11.5	(13.8)	15.8	12.6	(14.5)	16.0

chyma, expressed as a percent of the total xylem volume, was measured by the procedure described by Taylor (1973).

Sample rings (rings 5, 13, and 23 of each sample tree) were macerated by Franklin's method (Franklin 1945). The lengths of 50 whole fibers from each sample ring were measured according to the procedure proposed by Taylor (1975). The fiber width (as proposed by Tamolang et al. 1960) and wall thickness of 30 randomly selected fibers from each sample ring were measured by means of an eyepiece micrometer on a light microscope (Taylor 1973). Statistical calculations indicated that 95% of the time the average fiber length value obtained by measuring 50 fibers was within ± 3% of the true mean fiber length of fibers in the sample ring.

RESULTS AND DISCUSSION

Average wood property values for mature wood (rings 22–24) of sample trees in each location are presented in Tables 1 and 2.

Differences in the average specific gravity, fiber volume, ring width, cell diameter, and wall thickness of mature wood of willow stands at Yuccatan Peninsula and Catfish Point (Table 1) were not statistically significant. However, the average vessel volume (40.2%) for willow at Yuccatan Peninsula was significantly greater than the average vessel volume (35.6%) of willow at Catfish Point. Similarly, the average ray volume and fiber length differences between stands were statistically significant.

There was no significant difference in measured wood properties of sycamore between the two stands (Table 2). However, there were large differences among trees within stands, and tree-to-tree differences have been shown to be significant in sycamore (Lee 1972; Taylor 1969a).

The relationship of various wood properties to one another was evaluated by correlation analysis. Correlation coefficients of properties for each stand are presented in Table 3.

There is no significant relationship between diameter growth rate (ring width) and specific gravity for mature wood of either willow or sycamore (Table 3). This agrees with previous within-tree studies of these species (Lee 1972; Taylor 1969a; Wooten and Taylor 1968) which indicated no relationship between growth rate and specific gravity. This result indicates that growth stimulating cultural practices such as thinning, irrigation, or fertilization would not significantly affect the specific gravity of mature wood. Hence, any silvicultural practice that would increase growth rate should be favored. It also suggests that breeding programs designed to produce fast

TABLE 3. *Simple correlation coefficients for selected wood properties in natural stands of willow and sycamore*

WOOD PROPERTY	WILLOW		SYCAMORE	
	Catfish Point	Yuccatan	Catfish Point	Yuccatan
Specific Gravity Vs Ring Width	0.07	0.13	0.12	0.07
Specific Gravity Vs Vessel Volume	-0.46*	-0.58**	-0.43*	-0.33
Specific Gravity Vs Ray Volume	-0.13	-0.08	0.60**	0.25
Specific Gravity Vs Fiber Volume	0.55**	0.40**	0.27	0.23
Specific Gravity Vs Fiber Diameter	-0.24	-0.09	-0.52*	-0.07
Specific Gravity Vs Fiber Wall Thickness	0.87**	0.86**	0.07	0.06
Ring Width Vs Vessel Volume	0.02	0.17	0.34	-0.05
Ring Width Vs Ray Volume	0.05	0.29	0.0	0.08
Ring Width Vs Fiber Length	0.16	0.30	0.22	0.30
Fiber Length Vs Fiber Diameter	-0.20	-0.20	-0.11	-0.21
Fiber Length Vs Fiber Wall Thickness	0.42*	0.39	-0.22	-0.12

*Significant at the 0.05 probability level.
**Significant at the 0.01 probability level.

growing trees will not seriously alter specific gravity, or, as stated by Lee (1972), "improvement in growth rate and specific gravity can proceed simultaneously."

In sycamore, a species with a relatively large amount of ray tissue, specific gravity and the proportion of ray tissue are positively correlated (Table 3). Studies of other broad ray species (white oak, red oak, and beech) have shown that ray tissue is higher in specific gravity than total xylem tissue (Taylor 1969b). Hence, high specific gravity would be expected in wood with a high proportion of ray tissue. This relationship is important to tree breeders, for selection of high specific gravity phenotypes may result in an increase of ray tissue in select material. Increased ray content is undesirable for most present uses of wood. Therefore, tree breeders should evaluate the ray parenchyma content of breeding stock.

Specific gravity and fiber wall thickness are highly correlated in willow (Table 3, $\hat{Y} = 0.782 + 18.42\ X$). However, in sycamore, a species with fewer but much thicker-walled fibers, there is little relationship between these properties in the mature wood. Another difference is that long fibers of willow are thicker-walled than short fibers, but long fibers of sycamore tend to have thinner walls than short fibers.

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