VARIATIONS IN FIBER LENGTH OF EASTERN COTTONWOOD

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Introduction

Variations in fiber length reflect at least some effects of growth factors on the morphology of wood. It has been almost universally found that the length of fibers increases, within certain limits, from the pith towards the bark -- that is, the fibers lengthen as the trees get older.[3, 4] There is no information, however, on variability of fiber length among gelatinous fibers and typical fibers in eastern cottonwood (Populus deltoides Bartr.). In a previous study of eastern cottonwood, larger numbers of the gelatinous fibers with peculiar inner layers of the secondary wall were found on the upper sides of leaning trees,

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[1] Associate professor of botany, Southern Illinois University, Carbondale. This study was made in cooperation with the Carbondale Research Center of the Central States Forest Experiment Station.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Spurr, Stephen, H., and Hyvärinen, Matti J. Wood Fiber Length as Related to Position in Tree and Growth. Bot. Rev. 20, 9:561-575. 1954.

[4] Gerry, Eloise. Fiber Measurement Studies, Length Variations: Where They Occur and Their Relation to the Strength and Uses of Wood. Science 41: 179. 1915.

particularly at breast height, than on the lateral or lower sides in the same annual rings. Those atypical fibers also tended to increase in abundance on the upper sides with increasing amounts of lean in the trees.

The research here reported was done with material from the same trees to determine whether fiber length varies with respect to: (a) amount of lean of bole at breast height (4-1/2 feet); (b) age, or the number of annual rings from pith in cross section; and (c) side of tree with respect to lean.

Materials and Methods

Complete disks about 2-1/2 inches thick were available from 4 vigorously growing trees from the Pottsville tract of the Shawnee National Forest.[5] The disks were taken at 4-1/2 feet above the ground. The amounts of lean for the 4 trees at this height (measured with a plumb bob device) were 1, 4, 8, and 12 degrees. The upper side of each leaning tree was marked on the bole before the tree was cut. The samples were taken along 6 radii 60 degrees apart, as shown in figure 1. The samples were cut at points 10 to 12, 19 to 20, and 24 to 25 annual rings from the pith. The total number of rings in the 4 disks varied from 24 to 28, and the disk diameters ranged from 16.2 to 20 inches.

Seventy-two wood specimens were used for the study. Three specimens were taken from each of 6 radii for a total or 18 specimens from each of the 4 trees. The specimens were selected to represent each side in relation to the cross-sectional area of each disk, and also for comparable growth rings from all four trees.

The specimens, each including 1 complete growth ring and measuring approximately 1 inch in tangential dimension and about 3/4 inch in longitudinal dimension, were boiled in distilled water until they sank. This took about 30 minutes. Each specimen was then split into equal

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[5] Kaeiser, Margaret, and Pillow, Maxon Y. Tension Wood in Eastern Cottonwood. Technical Paper 149, Central States Forest Experiment Station, November 1955.

parts about 3/4 inch long and the size of a match stick in cross section. These pieces were submerged in macerating fluid[6] and kept at 40° C. for about 2 days. The macerating fluid was then decanted and replaced by cold distilled water, and the mixture was gently agitated. After the fibers had settled, the water was decanted and replaced by fresh distilled water. This was repeated until the decanted distilled water failed to turn blue litmus paper red. The material was then ready for a light staining with crystal violet before use. Oversized slides and cover glasses were used so that all the fiber-length measurements for each specimen could be made from one sampling of the macerated wood. Measurements were made at random on 100 complete wood fibers[7] of each of the 72 specimens. The lengths were determined from projected camera lucida images calibrated in millimeters.

The variables to be considered were analyzed statistically.

Results and Discussion

The average length of the 100 fibers in each sample of these eastern cottonwood trees ranged from 0.90 to 1.20 millimeters, with an average for all the samples of 1.081 millimeters. The variations in average fiber length were associated with the number of the ring from the pith, which concurs with previous studies.[3] That is, the average fiber length in the samples increased successively with the number of the ring from the pith for samples from the upper, lower, and lateral sides of the trees, regardless of the amount of lean (table 1). A further trend toward greater fiber length was shown in trees that had greater amounts of lean, particularly those that leaned 8 or 12 degrees as compared to 1 or 4 degrees.

An analysis of the variance of the average fiber length of the samples showed a statistically high significance for the factors of age and amount of lean, but no significance was shown for the factor of side of the tree

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[6] Johansen, D. A. Plant Microtechnique. New York. 1940.

[7] Tippo, Oswald. A list of Diagnostic Characteristics for Descriptions of Dicotyledonous Woods. Trans. Ill. Acad. of Sci. 34, 2. Dec. 1941.

(upper, lower, or lateral) nor for the concomitant or interacting effects of those factors on fiber length. The lack of significant interaction for the important variables of age and lean implies that their effects are essentially independent of one another.

Only minor variations in average fiber length were found in the same annual rings within the trees, regardless of whether there were few gelatinous fibers scattered somewhat uniformly around annual rings in trees with small lean or those fibers were present in large numbers on the upper sides particularly of trees with the greater amounts of lean. The physiological conditions causing the formation of the atypical layer in the gelatinous fibers seemingly affect the anatomy of the fiber wall but have little effect on the morphological feature of fiber length within the same tree. That is, these data show that within certain annual rings average fiber length varied little, even with appreciable variation in the number of gelatinous fibers, but that certain trees, in this study those with the greater lean and many gelatinous fibers, tend to have longer fibers throughout each ring than other trees with lesser leans.

No attempt was made to assess possible effects of genetic factors on either the variations in fiber length or the occurrence of concentrations of gelatinous fibers. For example, it is speculative as to whether the trends toward greater abundance of the gelatinous fibers on the upper side of the bole and relatively longer fibers in all sectors of certain rings may have been due to genetic factors for those trees.

In summary, the variations in fiber length found in this study showed conformity with the general trend of increasing fiber length with increasing numbers of rings from the pith. The trees with the greater lean (8 and 12 degrees) had longer fibers throughout the rings of particular ages than those with lesser lean (1 and 4 degrees). The data are inadequate, however, to show whether the morphological feature of fiber length was affected by environmental factors, such as varying amounts of lean, or by genetic factors.

The small variations in fiber length among different segments of particular annual rings with widely varying relative numbers of gelatinous fibers seem to substantiate the concept that the peculiar inner layer of those fibers is a physiological response to certain internal conditions. That is, the length of gelatinous fibers is established before the formation of their peculiar inner layer begins.

Table 1. --Average fiber length in the same annual ring for the upper, lower, and lateral sides with respect to lean in eastern cottonwood trees at breast height

Amount of lean	Side of tree	Length of fibers from annual rings various distances from the pith			Average for lean class
		10-12 rings from pith	19-20 rings from pith	24-25 rings from pith	
Degrees		Mm.	Mm.	Mm.	
1	Upper	0.990	1.075	1.140	
	Lower	1.010	1.055	1.175	
	Lateral	.985	1.060	1.080	
	Average	[1] .995	1.063	1.132	[3] 1.063
4	Upper	.965	1.065	1.150	
	Lower	.955	1.070	1.115	
	Lateral	.975	1.095	1.135	
	Average	.965	1.077	1.133	1.058
8	Upper	1.015	1.100	1.150	
	Lower	.995	1.095	1.145	
	Lateral	1.020	1.100	1.150	
	Average	1.010	1.098	1.148	1.086
12	Upper	1.025	1.130	1.155	
	Lower	1.085	1.110	1.195	
	Lateral	1.040	1.130	1.185	
	Average	1.050	1.123	1.178	1.117
Average for age class ---		[2] 1.005	1.090	1.148	

[1] Least significant difference between age-lean classes ($t_{0.05}$) = 0.0321.

[2] Least significant difference between age classes ($t_{0.05}$) = 0.0160.

[3] Least significant difference between lean classes ($t_{0.05}$) = 0.0185.

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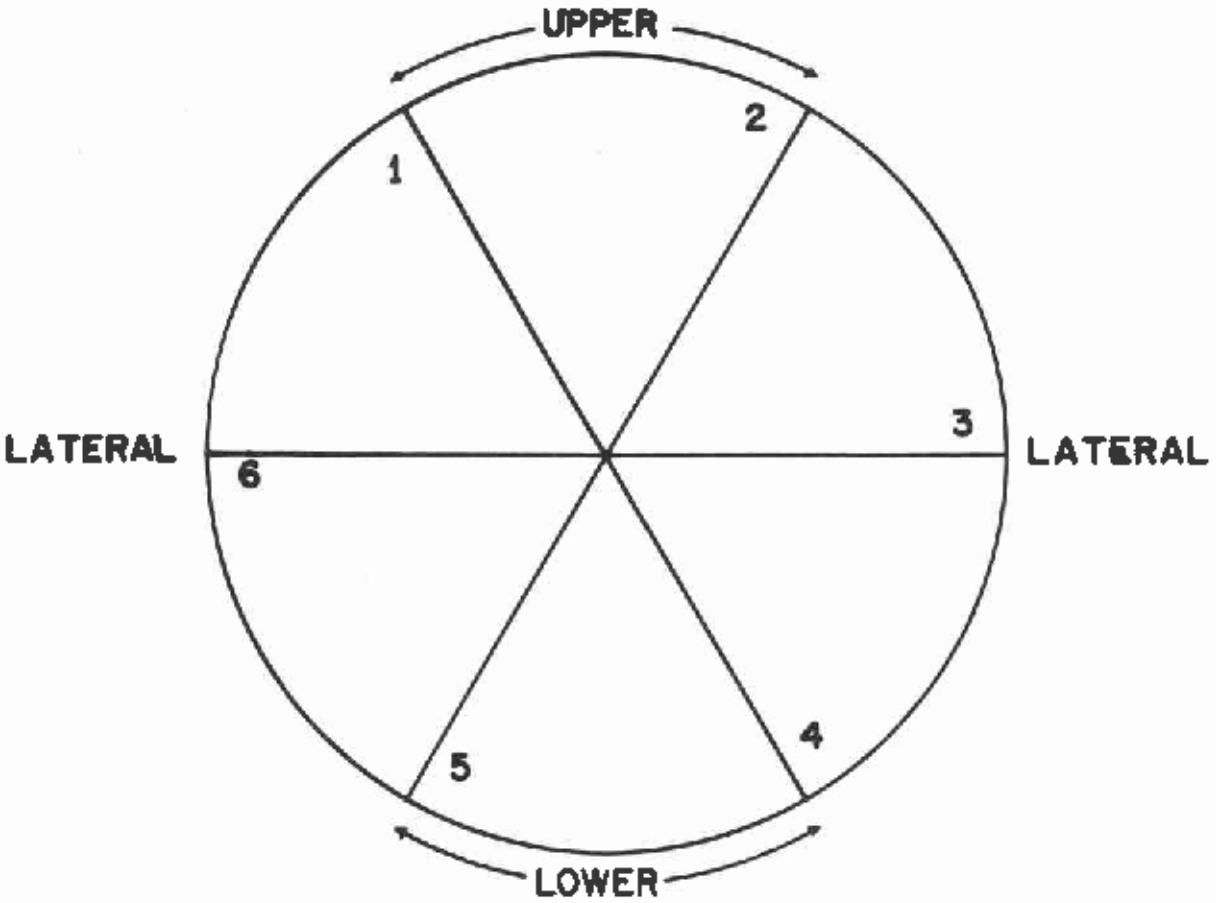

Figure 1. --Diagram of a disk from the trunk of a leaning tree to show the number of each radius in relation to the direction of lean.

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