Tracheid Dimensions in Rootwood Of Southern Pine

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ABSTRACT. In samples from 20 trees aged 12 to 89 years, rootwood tracheids were one-third longer and one-third larger in diameter and had walls 18 percent thinner and lumens almost two-thirds larger than stemwood tracheids measured at stump height. Tracheids from horizontal roots were longer and had thicker walls than those from roots of other orientations; length, cell diameter, and lumen diameter increased along the root. In vertical roots cell and lumen diameters increased with distance along the root while wall thickness decreased; in oblique roots cell and lumen diameters decreased while length and wall thickness increased. Along the taproot all dimensions increased to a maximum and then decreased.

WHEN A SOUTHERN PINE TREE is harvested, loggers leave behind a stump and roots containing about 25 percent as much wood as is found in the so-called merchantable stem. Retrieval of this material would therefore extend the forest resource considerably. Since the chief use is likely to be by the fiber industry, a study was made to determine tracheid dimensions in the portion of the root system that could readily be removed in logging. A secondary objective was to observe changes in tracheid dimensions along the roots and between roots of varying orientation. The tracheid dimensions considered were length, diameter, lumen diameter, and wall thickness.

Procedure

Twenty southern pine stumps were selected from a number uprooted during highway construction in central Louisiana. While many small roots had broken off in the ground, the greatest part of the woody volume was present. It is likely that any practical stump-extraction system would recover a similar portion of the root system. The trees ranged from 12 to 89 years in age. Stump heights were 18 to 24 inches.

A sample consisting of two opposed 20-degree wedges, 1 inch thick, was removed from a disk cut from the top of each stump. The two wedges were chipped and combined, and then a subsample was macerated. Two hundred tracheids were measured from each stump for comparison with rootwood tracheids. Lengths were measured at a magnification of 40X with an ampliscope and transverse dimensions at 360X under a microscope equipped with a micrometer eyepiece.

From each root system ten 1-inch-long disks were taken at various distances from the stump, at all root orientations between horizontal and vertical, and from roots of various sizes. After the 10 disks had been chipped, combined, and macerated, 200 tracheids were measured as described for the stumpwood. The root system

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was considered to start at the point of attachment of the major laterals.

Within one root system, trends were observed along the taproot and other roots of three orientations: horizontal, oblique, and vertical. Two roots of each orientation (except tap) were sampled and results combined. Five equally spaced 1-inch-long disks were removed from each of the 28-inch-long horizontal roots; 4 disks were removed from each of the 15-inch-long vertical roots; 5 were removed from each of the 13-inch oblique roots; and 9 from the 25-inch-long taproot. The disk from each location was macerated and 200 tracheids measured. These roots were on a stump 8.1 inches in diameter and with 17 growth rings.

Table 1. — MEAN TRACHEID DIMENSIONS IN ROOT AND STUMPWOOD OF 20 SOUTHERN PINES.

Dimension	Stumpwood		Rootwood	
Length (mm)	2.97	0.64	3.99	0.89
Cell diameter (μm)	38.76	9.39	52.48	12.21
Lumen diameter (μm)	25.66	11.06	41.69	13.08
Wall thickness (μm)	6.55	2.15	5.40	1.67

Results

Dimensions of tracheids from stumps and roots are summarized in Table 1. The root and stem samples from each stump were paired for statistical analysis. For all dimensions measured — i.e., tracheid length, cell diameter, wall thickness, and lumen diameter — there was a significant difference (0.01 level) between stump and rootwood. Rootwood tracheids were one-third longer, averaging 3.99 mm as compared to 2.97 mm for stumpwood tracheids.

In transverse dimensions root tracheids were larger in diameter and had thinner walls and larger lumens than stem tracheids from the same stump. Cell diameter averaged one-third greater (52.48 μm) in rootwood than in stumpwood (38.76 μm). Average thickness of cell walls was 5.40 μm in roots and 6.55 μm in stumps. Lumen diameters averaged 41.69 μm in roots and 25.66 μm in stumps.

Linear regression analyses indicated that none of the means for root dimensions changed with tree age. At stump height, however, both average wall thickness ($r^2 = 0.42$) and tracheid length ($r^2 = 0.53$) increased with age. Changes

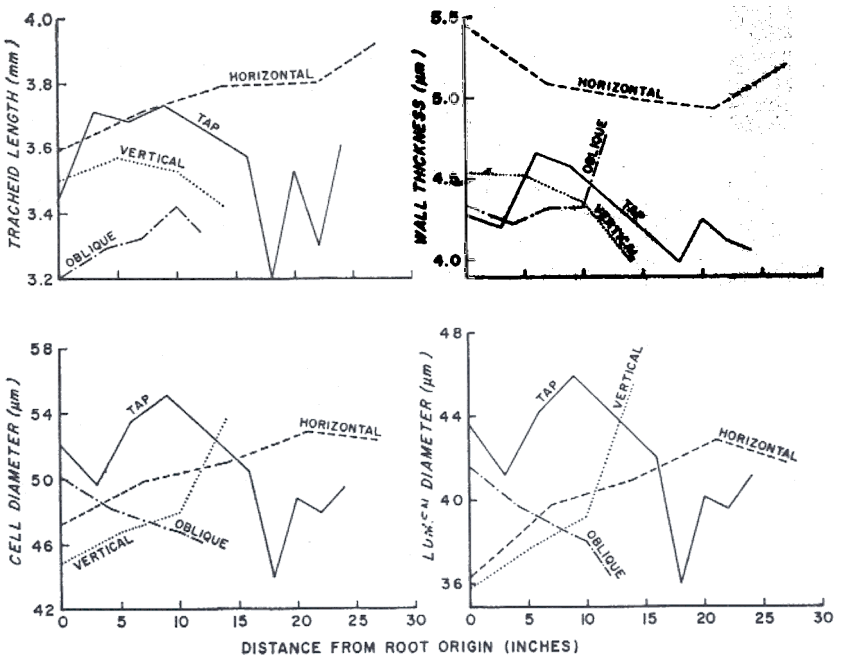

Figure 1. — Tracheid dimensions along roots of a single southern pine tree. Measurements were taken from one taproot, two horizontal roots, two obliques, and two verticals off laterals. Data are averages of 200 measurements on the taproot and 400 measurements on other roots.

in stump, fiber dimensions were not accompanied by corresponding changes in root fiber dimensions. The stumps were not selected for broad ranges in dimensions, however, and another sample might produce significant relationships.

Since the samples representing roots of various orientations were all from one tree, no statistical analysis was attempted. Tracheids tended to be longest in horizontal roots and shortest in oblique (Fig. 1). Length increased slightly along horizontal and oblique roots, but remained relatively constant in vertical roots. In the taproot, length increased to a maximum and then decreased irregularly.

Cell diameter increased along the horizontal and vertical roots and decreased in the oblique roots. In the taproot, cell diameter increased to a maximum and then decreased.

Tracheids in the horizontal roots had thicker walls than tracheids in roots of the other three orientations. Taproot cell-wall thickness increased to a maximum and then decreased. Tracheids in the vertical roots decreased in wall thickness with increasing distance along the root. Wall thickness in oblique roots increased along the length.

Lumen diameter in the taproot followed the trend of the other dimensions by increasing to a maximum and then decreasing. It increased along horizontal and vertical roots while decreasing in oblique. The curves for lumen diameter are very similar to those for cell diameter, since changes in wall thickness are small in comparison.

All cellular dimensions in the taproot reached their maximum at 6 to 9 inches below attachment point of major laterals and then decreased in the parts more distant from the stump.

There are no previously published data for tracheid dimensions of southern pine roots. For conifers in general, Fayle's[1] monograph indicates that tracheids in rootwood tend to be as long as or longer than those in the stem. Cell length and diameter tend to increase along a growth layer in horizontal roots, while wall thickness decreases with distance from the stem. Cell diameter and length tend to be smaller and the wall thicker in vertical and oblique roots than in horizontal roots; as distance from the stem increases, tracheid dimensions appear to alter less in oblique and vertical roots than in horizontal roots. Tracheid dimensions of southern pine rootstock tended to follow the trends reported by Fayle, except that tracheids of horizontal roots were thicker-walled than those of the other orientations; changes in dimensions along oblique and vertical roots were similar in magnitude to those of horizontal roots, but more erratic.

[1]Fayle, D. C. F. 1968. Radial growth in tree roots. Fac. For., Univ. Toronto Tech. Rep. 9:183.