HEREDITARY VARIATIONS IN SLASH PINE TRACHEIDS

by

L. W. R. Jackson and James T. Greene
Professor of Silviculture and Research
Assistant, respectively, University of Georgia
Athens, Georgia

Variation in tracheid length in conifers and fibers in hardwoods has been a subject of investigation throughout the world for over 80 years. Interest in tracheid dimensions was started by Sanio, who in 1372, reported that the variation in tracheid length of Scotch pine (Pinus sylvestris) was closely related to the position in the stem. Briefly, the laws set forth by Sanio were as follows: (1) tracheids increase in size from the pith in an outward direction until a constant size is attained, and (2) the size increases from the base of the stem to a maximum at a certain height and then decreases to the top.

Since Sanio's pioneer work, a large number of investigators, particularly in the United States, Canada, Australia and Japan, have made contributions to our knowledge of tracheid dimensions in forest trees. Most of the investigations fall into the following categories; (1) continuation of the work on the relation of tracheid length to position in the stem, (2) variations within stem tissues such as springwood and summerwood, (3) tracheid length in branches and roots, and (4) effect of growth rate on tracheid length. In 1954, Spurr (7) published a fairly comprehensive review of the literature on wood fiber studies.

Most of the investigators were in agreement that at any given height in the stem the tracheids are shortest near the pith. On any give radius, the length increases rapidly with an increase in the number of rings from the pith to the first maximum. From the point of this first maximum outward, there is considerable variance in the results obtained by the various investi gators. The length maxima may remain fairly constant as found by Sanio, or the length may tend to increase slightly, or show a tendency to fluctuate.

Most of the investigators found that the shortest tracheids occur in the lower levels of the stem. In any given annual increment, the length increases to a peak at a certain height and then it decreases toward the top of the crown.

There is general agreement that the tracheids in the branches are shorter than those in the stem. Most of the investigators concluded that tracheids in the summerwood are slightly longer than those in the springwood. Gerry (4) however found that the tracheids in the springwood of longleaf pine (Pinus paluetraic aDouglas fir (Pseudotsuga taxifolia) were in general, longer than those in the summerwood. It should be stated at this point that as far as could be ascertained from published results, the conclusions drawn by the early investigators were not confirmed by statistical methods.

Only a limited number of investigations have been made of tracheids of southern pine species. Gerry (4) in 1916 found that the tracheid length of longleaf pine increased rapidly from the pith outward through the first 20 rings but then it fluctuated widely beyond that point. Bailey and Shepard (6) in 1914 reported also that the tracheid length in longleaf pine increased rapidly outward from the center to a peak but then it fluctuated widely in the outer rings instead of remaining constant. In 1934, Berkeley (2) stated that rate of growth had an influence on the tracheid length of certain southern pine species. In a recent study, Bethel (1) found that the variation in tracheid length in the stem of loblolly pine agreed with the first two laws laid down by Sanio. Echols (3) reported in 1955 that he had found evidence of rigid control of tracheid length in slash pine (Pinus <u>elliottii</u> Open pollination had an equalizing effect which resulted in progeny with average tracheid length. He concluded from the results of this investigation that the breeding of slash pine for long fibers should be feasible. Of particular interest too was the fact that ring width was not related to tracheid length. In 1955, Zobel and Rhodes (8) reported on a study of the relationship of wood specific gravity in loblolly pine to growth and environmental factors. These data also lead to the inference that the genetic factor may be of importance. They concluded that such factors as age, rate of growth and site characteristics accounted for only a small part of the specific gravity variation observed. The foregoing resume of research on tracheid dimensions in coniferous species has offered strong evidence that variations in length may be genetically controlled.

On the basis of this inference a project under the S-23 Regional Research Program was set up to determine the reliability of certain anatomical and cytological features of the southern pine species as criteria for the selection of breeding stock. Slash pine was selected for the first phase of the work because of the availability of parents and their open-and cross-pollinated progeny. All the parent progeny material used in the study has been propagated by Mr. James Greene at the Ida Cason Callaway Foundation, Hamilton, Georgia. Trees used for natural variation in tracheid length within the stem were taken from plantings on the University Forestry School forests, located in the vicinity of Athens, Georgia. The entire investigation, thus far, has been concerned with an evaluation of the tracheid length of parents and progeny as a tool for the selection of breeding stock.

Several problems in technique and sampling methods were encountered when the project was started that had to be solved before definite progress could be made. In the first place, a method of tracheid measurement had to be developed that was not only rapid and accurate but would also minimize the eye fatigue of the operator. The wood samples were macerated by means of Jeffery's (5).cbromic-nitric acid solution. After maceration, the tracheid suspension was prepared in a solution of 4 per cent formaldehyde. Temporary dry uncovered mounts of the tracheids were prepared by coating microscope slides with a very thin smear of Haupt's (5) adhesive. Then about 2 or 3 drops of the suspension were immediately spread over the surface of the slide. The slides were dried on a warming table at 40° C. A microprojector called the Rayoscope* with a mechanical stage proved in practice to be the most ideal for the length measurements. A 15 X wide field ocular in combination with a 3.5X objective will give a 100X projection of the tracheids which can be measured directly with a millimeter rule to an accuracy of 0.01 mm. This procedure practically eliminates the error caused by including any fibers with broken tips.

Another major problem was how best to collect wood samples for the tests without causing too much damage to the selected parents and their progeny. For this reason, one of the main objectives has been done to determine whether the first ring tracheids of branches could be used for comparative purposes.

Trachied length of the springwood and summerwood was taken in the first, fifth, tenth and nineteenth ring from the center of single discs from each of two trees. There was no significance difference in the length of spring wood and summerwood tracheids in either of the discs. From this point on in the investigation, only springwood tracheids were used.

Variation with height and age was obtained by measuring tracheids in the first, fifth and tenth rings of 9 discs taken at equally spaced levels from 4 to 40 feet from single tree. Tracheid length in the first ring was fairly constand at all heights, varying from only 1.86 to 1.96 mm. In the other rings, the length increased from the base to a certain height and then decreased to ward the top. These data lead to the decision to use the first ring tracheids of stems and branches for comparative purposes.

Tracheid length of the outermost ring was measured at 9 equally spaced levels from 4 to 51 feet in single tree. Length increased from the base to a maximum of 4.97 mm. at the 26 foot level and then decreased to 1.70 mm. in the 1-year-old shoot at 51 feet. These data indicated that it is better to take the tracheid measurements from the outside to 'the center.

A single disc was taken at 4 1/2 feet from a 45- and a 60-year-old tree. Tracheid measurements were made at 5-ring intervals from the center to the out side. Length increased rapidly from the center to the first peak of 4.18 mm in the fortieth ring and then remained fairly constant to the outermost ring.

In two 9-year-old trees, the first ring tracheids of the branches were significantly shorter than those in the stem at all the height levels sample.

The first ring tracheids in the 1955 branches were significantly shorter than those in the stem of the 3 loblolly pine and 5 slash pine parents that were used in this study. These data showed that the first ring tracheids of branches can be used for comparative purposes.

A determination was made be the average branch tracheid length of 7 slash pine parents and 10 one-year-old open-pollinated progeny from each of the parents. Tracheid length of the progeny was significantly shorted than that of the parents in 6 of the 7 combinations. An analysis of these data showed that the parents with relatively long tracheids produced progeny that had longer tracheids than the progeny from parents with short tracheids. Of the possible

*/ Manufactured by Rayoscope, 358 N, Sandusky St., Delaware, Ohio.

21 comparisons of parents and progeny, the parents with longer tracheids produced progeny with longer tracheids in 14 or 67 percent of the combinations. For one of the parents which had the longest tracheids, the progeny had longer tracheids than 5 of the 6 possible progeny comparisons. The same results were obtained for 2 of the 3 loblolly pine combinations that were included in the study. Thus, it appears that open-pollination tends to equalize the tracheids of the trees in the forest.

In the controlled pollination study, branch tracheid measurements were taken on 10 one-year-old progeny from each of 7 parental combinations. The crosses were as follows: (1) 1 slash X slash (2) 2 loblolly X loblolly, and (3) 4 slash X loblolly. In 6 of the 7 combinations, the tracheid length of the progeny was intermediate to that of the parents but much closer in the female parent than to the male parent. In the other combination, the progeny was close to the male parent. These data showed that tracheid length of the progeny from 83 percent of the combinations was influenced more by the female parent than the male parent. In conclusion, the results obtained, thus far, indicate that the genetic factor does have a controlling influence on tracheid length in slash pine. Therefore it appears that breeding pines for long or short tracheids should be feasible.

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