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Influence of Resin Duct Size and Number on Dleoresin Flow in the Southern Pines[1]

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SUMMARY

The number of radial resin ducts was significantly higher in slash pines than in loblolly, longleaf, or shortleaf. Average width of resin ducts was less in shortleaf than in the other three species. Flow rate of oleoresin was not correlated with size or number of resin ducts for any of the four species.

Additional keywords: *Pinus echinata, Pinus elliottii, Pinus palustris, Pinus taeda, Dendroctonus frontalis.*

INTRODUCTION

Oleoresin of conifers is a defense against attack by bark beetles. In some tree species, resistance to attack may be related to both chemical and physical properties of the oleoresin (Smith 1975). But in the southern pines resistance seems to be controlled by physical properties such as viscosity and rate, amount, and duration of flow (Hodges et al. 1977, 1979.).

For the southern pines, these variables for oleoresin flow differ greatly both among and within species (Hodges et al. 1977). Oleoresin flow is the most important variable for loblolly (*Pinus taeda* L.) and shortleaf (*Pinus echinata* Mill.) pines in distinguishing between trees that are resistant and those that are susceptible to southern pine beetle (Hodges et al. 1979). In slash pine (*Pinus elliottii* Engelm.), rate of oleoresin flow is strongly related to viscosity and to number and size of radial resin ducts (Schopmeyer et al. 1954), but this relationship has not been reported for the other southern pines. We wanted to discover the nature of the relationship between rate of oleoresin flow and the number and size of radial resin ducts in all the major southern pines. A strong correlation might permit forest managers to evaluate tree resistance to beetle attack by measuring resin duct size and number.

METHODS

Study trees were located on the Kisatchie National Forest in central Louisiana. The study area is within the natural range of longleaf, loblolly, and shortleaf pines, but slightly west of the natural range of slash pine. The slash pine trees we examined had been planted; trees of the other species originated from natural regeneration. We studied 17 loblolly, 14 longleaf, 19 slash, and 15 shortleaf trees.

Oleoresin viscosity, flow (rate, duration, and amount),

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Table 1. – *Comparison of radial resin duct size and number, viscosity and flow rate of **oleoresin** in the major southern **pines**[1]*

Species	Resin duct width: Horizontal	Vertical	Average	Number	Viscosity	Flow rate
	(μ)	(μ)	(μ)		(stokes)	(ml/hr)
Loblolly	52.6 (46.9–60.9)	56.5 (47.8-64.1)	54.6a	35.3a (26.0–46.5)	16.2a (8.3-72.2)	1.5a (0.2–2.9)
Longleaf	57.3 (47.6-67.2)	57.9 (48.6–64.3)	57.6a	32.6a (26.446.3)	55.7b (27.6-i 13.4)	I.Ib (0.3-2.9)
Shortleaf	46.7 (39.0-52.2)	51.4 (44.7-58.9)	49.0b	35.5a (26.547.7)	20.9a (9.4-38.8)	0.8c (0.1-2.2)
Slash	53.7 (47.3-59.7)	55.9 (51.4-64.4)	54.8a	43.9b (31.7-55.2)	241 .0c (63.5-547.6)	0.6c (0.3-2.2)

[1] Means followed by the same letter in a column are not significantly different at the 0.05 probability level (Duncan's Multiple Range Test).

and rate of crystallization were measured (Hodges et al. 1977). For observation and measurement of resin ducts, we removed two xylem samples from each tree. The samples, which measured 13×38 mm, were removed with a chisel from opposite sides of the tree. The samples contained xylem of the 3 most recent years' growth. They were immediately placed in formalin-acetic acid-alcohol-water (FAA) fixing and killing solution (Sass 1958).

We dehydrated xylem samples by standard methods using tertiary butyl alcohol (TBA) and then embedded them in Tissuemat (Sass 1958). Samples were cut in half, and tangential sections, 35-38μ thick,were cut on a rotary microtome. Most sections were taken from early wood. We made cuts parallel to tracheid orientation to insure good cross sections of radial resin ducts and to decrease friction on the microtome blade. Sections were stained with 2.0 percent safranin and counterstained with 0.5 percent fast green. Three or four slides of each sample were prepared. From these we chose the best sections for measurement of resin ducts.

A small piece of cardboard with a cutout area of either 1 .O cm^2 or 0.5 cm^2 was placed over the slide and secured with tape. All resin ducts within the cutout area were counted. Ten resin ducts/cm* were randomly selected for measurement of the horizontal and vertical axes. We used an ocular micrometer at a magnification of 100X. Two sets of measurements were made-one included the width of the enclosed epithelial cells and one did not.

A one-way analysis of variance was used to test for variation in number and size of resin ducts among species and among trees within a species. Duncan's Multiple Range Test (Steel and Torrie 1960), at 0.05, was used to test for differences among species.

RESULTS AND DISCUSSION

Radial resin ducts are located in fusiform rays with ray parenchyma cells above and below the resin ducts. Three or four epithelial cells, either triangular or rectangular, line each resin duct. These cells are easily distinguished from ray parenchyma, which are smaller and rounder. Radial resin ducts often lie next to longitudinal resin ducts, so the two resin canal systems may be interconnected and thus continuous.

In cross section, resin ducts are slightly elliptical with the vertical axis usually longer (table 1). But in all species a few resin ducts were wider on the horizontal axis. The elliptical shape is more pronounced for shortleaf and loblolly pine than for slash and longleaf. The resin ducts for trees in this study were less elliptical than those found in young slash pines (horizontal width of 5.49 and vertical width of 70.0μ) by Schopmeyer et al. (1954).

Average diameter of resin ducts (table 1) was significantly less in shortleaf than in loblolly, slash, and longleaf pines, which did not differ significantly. The number of resin ducts per cm^2 was significantly

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higher in slash pine than in the other three species.

For slash pine, Mergen et al. (1955) found a relationship between tree age (rings from pith) and number and size of resin ducts. Number of resin ducts decreased curvilinearly with age to age 20, and size decreased linearly with age at least to age 30. The average age for our trees, then, was 44 years for loblolly, 46 for longleaf, 59 for shortleaf, and 32 for slash. Slash pines were all about the same age, but the other three species varied widely. No trees were less than 20 years old and few were less than 30. Age and resin duct size or number did not correlate for any of the four species.

For longleaf, loblolly, and slash pines, number and size of resin ducts were not related. For shortleaf the correlation was low (r = 0.32) but significantly different from zero at the 0.05 level.

Rate of oleoresin flow was not correlated with size or number of resin ducts for any of the four species. This lack of correlation probably reflects dependence of resin flow rate on other characteristics such as oleoresin viscosity, volume of oleoresin in the system, rate of crystallization, and oleoresin exudation pressure. A negative relationship between flow rate and viscosity has been found for all species—the more viscous the oleoresin, the slower the rate of flow. (Hodges et al. 1977). Schopmeyer et al. (1954) showed that the product of three independent variables, the reciprocal of viscosity, and number and size of resin ducts, accounted for 63 percent of the variation in flow rate among young slash pines. But our study shows that differences in viscosity alone will account for 65 percent of the variation in slash pines, 56 percent for shortleaf, 50 percent for longleaf, and 36 percent for loblolly.

Previous work has shown that flow rate is highly correlated with total flow of oleoresin (r >.95) and that how well loblolly and shortleaf trees will resist attack can be predicted by flow measurements (Hodges et al. **1977, 1979).** We hoped that measurements of radial resin ducts could be used to predict oleoresin flow and thus resistance to beetle attack. Results of this study show that such a relationship does not exist.

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