Oleoresin Yields for Slash Pines from Seven Seed Sources

BY
J. P. BARRETT
G. W. BENGTSON

Abstract. Tests were made of the oleoresin-yielding potential of *Pinus eliottii elliotii* from a number of geographic sources planted in Louisiana 200 miles west of the natural range of the species. Seed sources ranging from South Carolina to Florida and westward to Louisiana did not differ in oleoresin yield under microchipping, nor in viscosity and and exudation pressure of the resin. Individual trees, by contrast, varied greatly, their productivity being correlated with diameter, length of live crown, ratio of crown length to total height of tree, and viscosity of resin.

Do SLASH PINES (*Pinus elliottii* var. *elliottii*) Engelm. of various geographic sources differ in ability to yield oleoresin? The question is of importance, for this species furnishes about 80 percent of the annual U. S. supply of crude resin. Until recently most slash pine worked for oleoresin was in natural stands or in plantations of wildling stock of local origin. Today, plantations of nonlocal origin are furnishing an increasing amount of the total production.

Methods

The study reported here was in a 24-year-old plantation that contained trees from 7 geographic seed sources. The sources (Fig. 1) represent the natural east-west range of slash pine well, but cover only part of the north-south range in Georgia and Florida. Seed for each source had been collected from at least 10 trees and sown in the Stuart Nursery, in central Louisiana. At age 1 year the trees were planted near Alexandria, 25 miles to the southwest of the nursery. Seedlings for each source were planted in three 0.4-acre plots arranged in a randomized block design. Spacing was about 6.5 by 6.5 feet.

The planting site was open grassland, the original longleaf pine forest having been logged off some years before. The soil is a Bowie fine sandy loam, with fairly good surface and internal drainage. Topography is very gently rolling. As Figure 1 suggests, the site is about 200 miles west of the natural range of slash pine.

The plantation had been measured at age 22 years by Derr and Dell (1960), who found that the merchantable portion (trees larger than 3.6 inches dbh) averaged 539 trees per acre. These trees had a mean dbh of 6.4 inches and an outside-bark volume of 2,542 cubic feet per acre. Fourteen percent of all trees had their trunks cankered by the southern fusiform rust (*Cronartium fusiforme* Hedgc. & Hunt ex Cumm.). Dominants and codominants averaged 54 feet in height; site index for slash pine was estimated to be 85 feet at age 50 years. Seed source had not significantly affected any of these characteristics.

For the study of resin yield, 15 trees from each plot—i.e., 45 from each seed

The data are from a Ph.D. thesis submitted by the senior author to Duke University. Barrett, a member of the Southern Forest Expt. Stat., Forest Service, U.S. Dept. Agric., when the research was done, is now on the faculty of the Univ. of New Hampshire. Bengtson is a member of the Southeastern Forest Expt. Stat., Forest Service, U.S. Dept. Agric. Manuscript received Oct. 9, 1963.

Reprinted from FOREST SCIENCE, Volume 10, Number 2, June, 1964

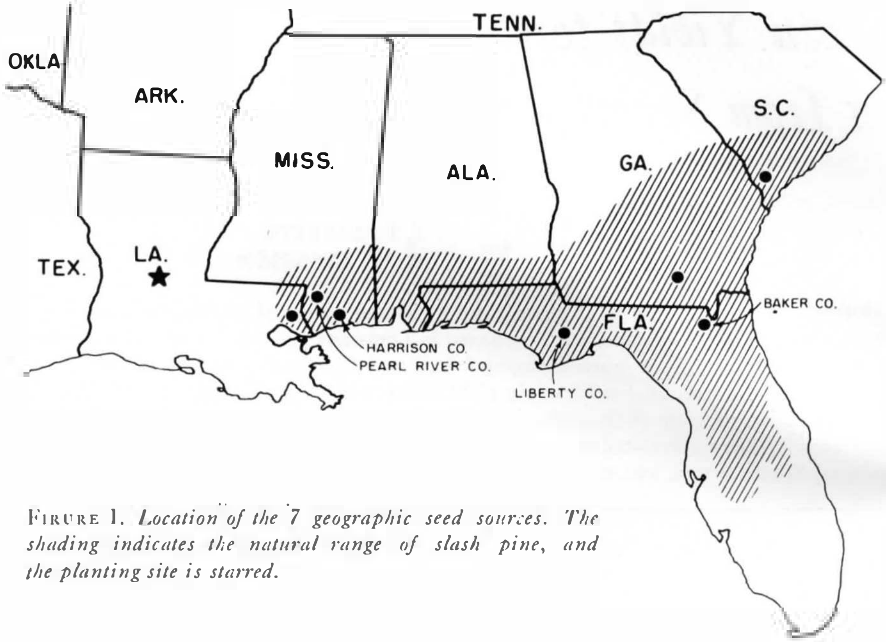

FIGURE 1. *Location of the 7 geographic seed sources. The shading indicates the natural range of slash pine, and the planting site is starred.*

source—were randomly selected from among those that had one-third or more of their length in live crown, were at least 6.6 inches in dbh, and were free of trunk cankers. They ranged from 6.6 to 11.9 inches in diameter and from 46 to 69 feet in height, and had 15 to 32 feet of live crown. Because most were too small for commercial naval stores production, yields were determined by the microchipping technique of Ostrom and True (1946). By this technique a square inch of bark and cambium was removed from the bole about 10 inches above the ground with a metal punch, the exposed wood sprayed with 50-percent H_2SO_4, and the resulting oleoresin collected in a can. Oleoresin collected and scraped from the face was weighed every two weeks, and then a new chip was made directly above the previous one. Figure 2 shows a face as it appeared near the end of the chipping season.

Chipping began on April 20, 1961, and yields were measured every two weeks, or a total of 14 times, between that date and November 2.

The method for measuring viscosity was that described by Schopmeyer *et al.* (1954) and Mergen *et al.* (1955). Oleoresin was obtained by attaching a small glass tube to a shallow auger hole in the tree

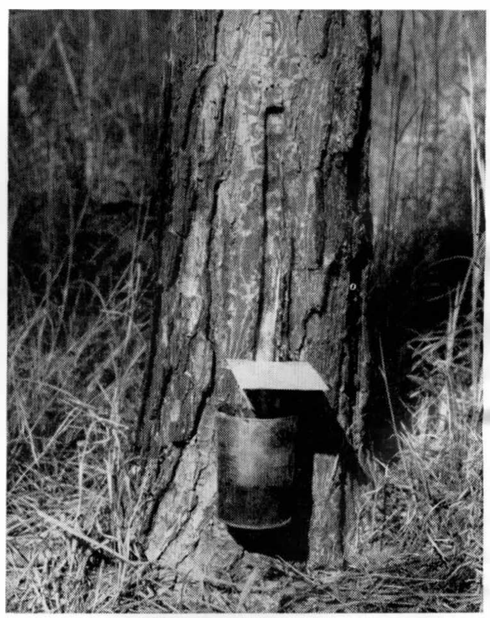

FIGURE 2. *Microchipped face near the end of the season.*

trunk. Samples were taken in conjunction with pressure determinations made from May 22 to 26 and from July 17 to 21. Viscosity was measured in Stokes, by the bubble-rise method.

Exudation pressure was measured from May 22 to 26 and again from July 17 to 21. During these periods pressures were read daily on about 100 sample trees divided equally among the 21 plots. Manometers used to measure pressure consisted of capillary glass tubes with one end sealed and the other joined to a 16-gauge hypodermic needle inserted 2 cm into the xylem (Bourdeau and Schopmeyer 1958). A single manometer was inserted on the west side of the bole of each tree, and pressure was estimated in atmospheres by determining the ratio of the initial air volume in the manometer to the final air volume.

Before the final installation of manometers, a preliminary test was made to determine whether microchipping and stem aspect result in differences in exudation pressure. Manometers were attached on the east, south, west, and north stem aspects of 20 trees, 10 chipped at the base on the east aspect and 10 not chipped. Exudation and vapor pressure were read at 6:30 AM, 10:30 AM, 1:30 PM, 6:00 PM, and 12:00 PM on April 22 and 23, when soil moisture was near field capacity. Vapor pressure readings were converted to gradients by subtracting the vapor

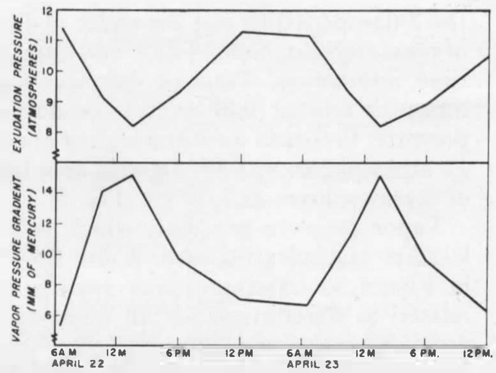

FIGURE 3. *Variation in exudation pressure and vapor-pressure gradient over a 2-day period.*

pressure of the air from the vapor pressure inside the pine foliage. The pressure in the leaf tissue was assumed to be at the saturation point.

When readings for the 2 days were averaged, mean exudation pressure was 10.6 atmospheres for unchipped trees and 7.3 atmospheres on the east aspect of chipped trees. The difference was statistically significant at the 0.05 level. However, when 2-day averages from the four aspects of chipped and unchipped trees were included in an overall analysis neither chipping, stem aspect, nor their combinations resulted in significant differences in exudation pressure.

Data from the four stem aspects of chipped and unchipped trees were averaged for each time of measurement over

Table 1. Average per-tree values of four indicators of oleoresin-yielding potential, by source of seed.

Seed source		Oleoresin yield	Exudation pressure	Viscosity	Ratio of pressure to viscosity
State	County				
		Grams	*Atmos.*	*Stokes*	
Florida	Baker	712	12.5	149	0.084
Florida	Liberty	774	12.2	145	.084
Georgia	Clinch	771	12.1	143	.084
South Carolina	Jasper	712	12.2	118	.103
Mississippi	Harrison	751	11.2	154	.073
Mississippi	Pearl River	728	12.1	154	.078
Louisiana	St. Tammany	712	11.7	124	.094
Average		737	12.0	141	.086

the 2-day period to test the effect of date of measurement, time of day, and date × time interaction. Time of day was significantly related (0.01 level) to exudation pressure. Pressures were at a high of about 11 atmospheres at 6:00 AM and at a low of 8 atmospheres at 1:30 PM (Fig. 3).

Vapor pressure gradient, which is related to transpiration rate, is also shown in Figure 3. Exudation was apparently related to water stress within trees; exudation pressure was high when the vapor pressure gradient was low. But as the gradient increased, transpiration increased, internal water stress developed in the trees, and exudation pressure decreased. Vapor pressure gradient accounted for 83 percent of the variation in exudation pressure.

In general, the diurnal variations were comparable to those found by Bourdeau and Schopmeyer (1958) and Vité (1961). Thus, techniques of measuring exudation pressure were considered satisfactory. In the seed source test, manometers were never installed directly above a chipped face, and readings were made between 5:00 and 6:00 AM, when exudation pressure was at a maximum.

Results

Total oleoresin yields. Average yield per tree for the 28-week period ranged from 712 to 774 grams (Table 1). Analysis of variance indicated no significant differences among the sources. Moreover, yields were not significantly affected by source of seed when variations due to diameter and live-crown ratio were eliminated by a multiple covariance analysis.

Seasonal variation in yield. Seasonal variation in microchipping yield was similar for the seven seed sources. For all sources, there was a significant variation which was characterized by the equation:

$$Y = 38.7 - 3.23T + 1.540T^2 - 0.0933T^3$$

where:

Y = average oleoresin yield, per biweekly microchip, of the 315 trees

T = time expressed as the number of biweekly periods elapsing after initiation of chipping.

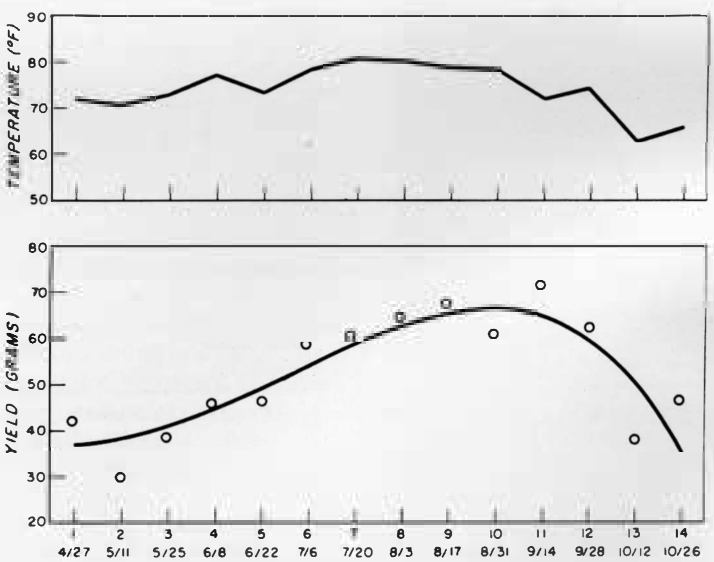

FIGURE 4. *Seasonal trends in mean daily temperature and average oleoresin yield per tree in 1961. Dates are mid-points of the 14 two-week periods. Each point is the actual average yield per chip of the 315 trees.*

The relationship of yield and time is graphed in Figure 4. Yields increased from about 38 grams in May to 67 grams in August and then dropped to approximately 38 grams in October. The trends followed fluctuations in mean daily temperature reasonably well, with the sharp drop in October corresponding with a marked decrease in temperature.

The seasonal variation in yield as indicated by microchipping in this plantation agrees reasonably well with those described by Harper and Wyman (1936) for slash pine in Florida. Microchipping yields are comparable to those of Mergen *et al.* (1955).

Relation of seed source to pressure and viscosity. Average exudation pressures ranged from 10.9 to 12.7 atmospheres in May and from 11.4 to 12.3 in July.

Viscosity averaged 141 Stokes (Table 1). It ranged by sources from 124 to 161 stokes in May and from 113 to 152 Stokes in July.

Pressure-to-viscosity ratios ranged from 0.068 to 0.107 for the seven sources and two dates. For these ratios, as well as for exudation pressure and viscosity, the variations among sources, dates, and source-date interactions proved nonsignificant under variance analysis.

Regression analyses of individual tree yields. Regression analyses were used to relate microchipping yield per chip to dbh, live-crown length, live-crown ratio, exudation pressure, viscosity, and pressure-to-viscosity ratios of the 315 trees. The block and seed-source effects were eliminated by a technique described by Snedecor (1956).

The best relationship, in which dbh (D, in inches) and viscosity (V, in Stokes) accounted for 20 percent of the variation in average yield per chip, is expressed by the following equation (Fig. 5):

$$\text{Yield} = 18.4 + 6.41D - 0.12V \quad (1)$$

Dbh, live-crown length, live-crown ratio, and viscosity also were related to yield at the 0.01 level:

$$\text{Yield} = 3.0 + 6.15D \quad (2)$$

$$\text{Yield} = 27.4 + 1.15 \text{ (live-crown length in feet)} \quad (3)$$

$$\text{Yield} = 24.0 + 0.74 \text{ (live-crown ratio in percent)} \quad (4)$$

$$\text{Yield} = 69.8 - 0.12V \quad (5)$$

Eq. 2 accounted for 7 percent of the variation in yield, and Eq. 3 and 4 each explained 3 percent. The significant relationship between dbh and yield from a face of fixed width was about as indicated by Squillace and Bengtson (1961). Schopmeyer and Larson (1955) reported that a relationship of dbh and live-crown ratio accounted for 64 percent of the variation in gum yield of slash pine. In their study, however, face widths were set equal to dbh and thus yields would be expected to show a closer relation to dbh than where face width was held constant. Also, because their study was in a stand of lesser density than the Alexandria plantation, variation in crown volume was probably greater.

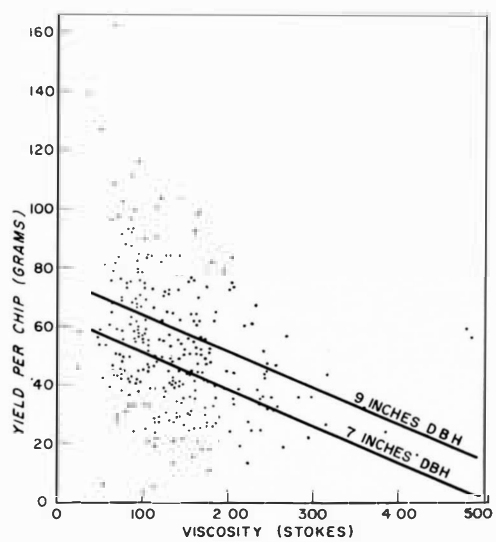

FIGURE 5. *Relationship of microchipping yield per tree to viscosity and tree diameter.*

Eq. 5 accounted for 12 percent of the variation in yield, a result similar to that of Mergen *et al.* (1955).

The pressure-to-viscosity ratio was significantly related to yield, but viscosity alone accounted for 12 percent of the variation and the ratio for only 10 percent. The lack of correlation between exudation pressure and yield is in contrast to the results of Bourdeau and Schopmeyer (1958).

Discussion

The study suggests that the quantity of gum produced by slash pine stands grown from seed originating in the lower Coastal Plain from South Carolina to Florida and westward into Louisiana is not likely to show any effects of the seed's origin. It also indicates that the superior oleoresin-producing strains currently being developed by the U. S. Forest Service at Lake City, Florida, through breeding of Florida and Georgia slash pine probably will not lose their relative superiority when planted at the western extremes of the species' range.

At the same time, the study does not rule out all possibility of geographic variation in oleoresin yield of slash pine. Conceivably, the sources tested in central Louisiana would react differently in other environments. A more important qualification to the present test probably is that the north-south range of the species was sampled less adequately than the east-west range. Trees from localities in the northern and southern extremes may show geographic differences in oleoresin yields —as they have done in growth (Squillace and Kraus 1959, Switzer 1959).

Literature Cited

BOURDEAU, P. F., and C. S. SCHOPMEYER. 1958. Oleoresin exudation pressure in slash pine: its measurement, heritability, and relation to oleoresin yield. *In* Physiology of Forest Trees, K. V. Thimann, ed. Ronald Press, New York. pp. 313–319.

DERR, H. J., and T. R. DELL. 1960. Where should we get slash pine seed for Louisiana? Forests and People 10(2):30–31.

HARPER, V. L., and L. WYMAN. 1936. Variations in naval stores yields associated with weather and specific days between chippings. U.S. Dept. Agric. Tech. Bull. 510. 35 pp.

MERGEN, F., P. E. HOEKSTRA, and R. M. ECHOLS. 1955. Genetic control of oleoresin yield and viscosity in slash pine. For. Sci. 1:19–30.

OSTROM, C. E., and R. P. TRUE. 1946. A "test-tube" method for experiments in gum flow. AT-FA J. 9(2):10.

SCHOPMEYER, C. S., and P. R. LARSON. 1955. Effects of diameter, crown ratio, and growth rate on gum yields of slash and longleaf pine. J. For. 53:822–826.

————, F. MERGEN, and T. C. EVANS. 1954. Applicability of Poiseuille's law to exudation of oleoresin from wounds on slash pine. Plant Physiol. 29:82–87.

SNEDECOR, G. W. 1956. Statistical methods. 5th ed. Iowa State College Press, Ames. 534 pp.

SQUILLACE, A. E., and G. W. BENGTSON. 1961. Inheritance of gum yield and other characteristics of slash pine. Proc. Sixth South. Forest Tree Improvement Conf. pp. 85–96.

————, and J. F. KRAUS. 1959. Early results of a seed source study of slash pine in Georgia and Florida. Proc. Fifth South. Forest Tree Improvement Conf. pp. 21–34.

SWITZER, G. L. 1959. The influence of geographic seed source on the performance of slash pine on the Northeast Mississippi Experimental Forest. Miss. Agric. Expt. Sta. Inform. Sheet 652. 2 pp.

VITÉ, J. P. 1961. The influence of water supply on oleoresin exudation pressure and resistance to bark beetle attack in *Pinus ponderosa*. Contrib. Boyce Thompson Inst. 21(2):37–66.