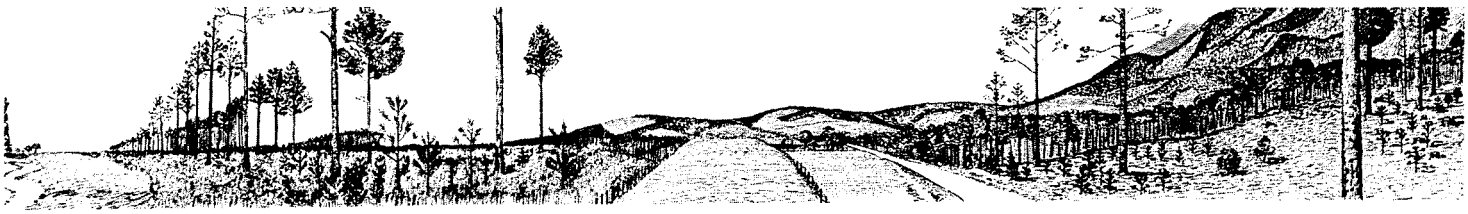

USDA Forest Service Research Note SE-155 March 1971

HERITABILITY AND SEASONAL CHANGES IN VISCOSITY OF SLASH PINE OLEORESIN

Abstract.--Oleoresin viscosity was measured in slash pine (Pinus elliottii var. elliottii) trees of known genetic origin over a 1-year period. A strong broad-sense heritability of this trait was found. Seasonal variation followed a definite pattern, with the highest viscosities occurring in early spring and a gradual decline occurring in late spring and summer. This decline began earlier at the 1-foot sampling level than at the 6- or 11-foot levels. Aspect from which samples were taken did not affect viscosity.

Ever since researchers began the study of oleoresin exudation of slash pine (Pinus elliottii var. elliottii) in response to wounding, they have searched for oleoresin characteristics related to the yield potential of individual trees. Investigations showed that the thickness or viscosity of oleoresin differed from tree to tree. A method for collecting a small oleoresin sample and measuring its viscosity was developed. Using this technique, Schopmeyer et al.[1] found that viscosity of slash pine oleoresin affected the flow rate during the first 24 hours after wounding. More viscous oleoresin flowed more slowly. Further measurement by Mergen et al.[2] showed that viscosity of oleoresin in individual slash pine trees was highest at the start of the growing season and then declined rapidly. These workers also found the viscosity trait in slash pine to be strongly heritable from both parents. In addition, a relationship between viscosity and yield was found. This relationship, however, was established only for microface yields over a 4-week period. The relation between oleoresin viscosity and fullface, full-season yields has not yet been measured, nor have the changes in oleoresin composition which cause the changes in viscosity been determined.

The study reported here was designed to measure the degree of heritability of the viscosity trait within clones (broad-sense heritability), to record the seasonal fluctuations in viscosity over an entire year, and to determine if viscosity varies with position of sampling on the trunk.

GENERAL METHODS

Study trees.--Fourteen ortets and five ramets from each ortet were sampled over an 11-month period in 1968-69. Both ortets and ramets were in plantings on the Olustee Experimental Forest in Baker County, Florida. Each ortet was a slash pine tree grown from a seed obtained through controlled pollination. These ortets were in their 23rd growing season from seed during the sampling year and averaged 11.2 inches d.b.h. at the beginning of 1968.

[1] Schopmeyer, C. S., Mergen, F., and Evans, T. C. Applicability of Poiseuille's law to exudation of oleoresin from wounds on slash pine. Plant Physiol. 29: 82-87. 1954.

[2] Mergen, F., Hoekstra, P. E., and Echols, R. M. Genetic control of oleoresin yield and viscosity in slash pine. Forest Sci. 1: 19-30. 1955.

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The ramets grew from air layers taken from the ortets over a 3-year period. They were in either their ninth, 10th, or 11th growing season from outplanting during the sampling year. At the start of this study, they ranged from 6.9 to 10.1 inches d.b.h., averaging 8.6 inches.

Spacing in both ortet and ramet plantings was 20 by 20 feet. This wide spacing, plus regular weeding, produced large crowns. Portions of the ramet planting had been fertilized and irrigated, but an earlier study failed to detect any effect of these cultural treatments on oleoresin viscosity of slash pine.[3]

Viscosity measurements.--Viscosity can be defined as the resistance to change of form that all fluids possess. It is usually expressed in dyne-seconds per square centimeter, or poises. The ratio of viscosity to density is termed kinematic viscosity. The unit of kinematic viscosity, which is expressed in centimeter-gram-seconds, is called the stoke after Sir George G. Stokes. Stokes' Law states that the force required to move a sphere through a given viscous fluid at a low uniform velocity is directly proportional to the velocity and radius of the sphere. Higher numerical stokes denote a higher (thicker) viscosity.

One way to measure the viscosity of a fluid such as pine oleoresin is to measure the time it takes an air bubble to rise through the fluid for a fixed distance at a given temperature. This bubble-time method[4] measures kinematic viscosity in stokes. The method has been adopted for measuring viscosity of small samples of slash pine oleoresin[5] and was used to make the viscosity measurements reported here.

BROAD-SENSE HERITABILITY OF OLEORESIN VISCOSITY

Although ramets and their ortets share the same genetic origin, differences still exist within a clone because of each individual's unique physiological response to its own microenvironment.[6] The first part of this study was designed to estimate broad-sense heritability of the viscosity trait in slash pine irrespective of environment.

Methods.--Oleoresin samples were taken from the ortet and five ramets in each of 14 clones on April 15, June 10, and August 5, 1968. The samples were taken at random azimuths in a band 3 inches below d.b.h. (Sampling at this height avoids wounding the tree at the point where future d.b.h. measurements will be made.)

The viscosity measurements from these samples were used to calculate the correlation coefficients (which are estimates of broad-sense heritability) between an ortet and the average of five of its ramets. The intraclass correlation coefficients were also computed.

Results.--The correlation coefficients are shown in table 1. These coefficients are high, indicating a strong broad-sense heritability of the viscosity trait in slash pine.

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[3] Lane, John M. Effect of intensive cultural treatments on gum production in slash pine. 1967. (Unpublished final report of Study NS-112-G on file at the Naval Stores and Timber Production Laboratory, Southeastern Forest Experiment Station, USDA Forest Service, Olustee, Florida.)

[4] ASTM Committee D-1 on Paint, Varnish, Lacquer and Related Products. Standard method of test for viscosity of transparent liquids by bubble time method (Standard D 1545-63). ASTM Standards [Amer. Soc. Testing & Mater.], Part 20 (Paints, varnishes, lacquers, and related products); material specifications and tests; naval stores; industrial aromatics and hydrocarbons, pp. 700-702. 1965.

[5] McReynolds, R. D., and Lane, J. M. Adapting the bubble-time method for measuring viscosity of slash pine oleoresin. Southeast. Forest Exp. Sta., USDA Forest Serv. Res. Note SE-147, 6 pp. 1971.

[6] Libby, W. J., and Jund, E. Variance associated with cloning. Heredity 17(4): 533-540. 1962.

Table 1.--Correlation coefficients of viscosity of slash pine oleoresin

Sampling date	Ramet-Ortet correlation	Intraclass correlation[1]
April 15	.67*	.32**
June 10	.72**	.63**
August 5	.56*	.69**

[1]Correlation among ramets.
*Significant at 5-percent level.
**Significant at 1-percent level.

SEASONAL CHANGES IN VISCOSITY

The second part of the study was designed to measure seasonal changes in oleoresin viscosity of slash pine.

Methods.--Samples were taken at 14- and 28-day intervals. Sampling began on March 20, 1968, and ended on January 21, 1969. The period during which samples were taken every 14 days lasted from March 20 to June 10. A rapid decline in viscosity was expected during this period. On each date, samples were taken from five ramets in each of eight clones. One of 15 evenly spaced azimuths (again in a band 3 inches below d.b.h.) was chosen at random on each sampling date, and the samples were taken at that aspect. The full complement of 40 samples was obtained from April through August, the most productive portion of the commercial gum season. Samples could not be obtained from every tree in the fall and winter.

Results.--The seasonal changes found in viscosity are plotted in figure 1. There was a gradual decline in viscosity from early May until September rather than the rapid decline expected in spring. Viscosities fluctuated at relatively low

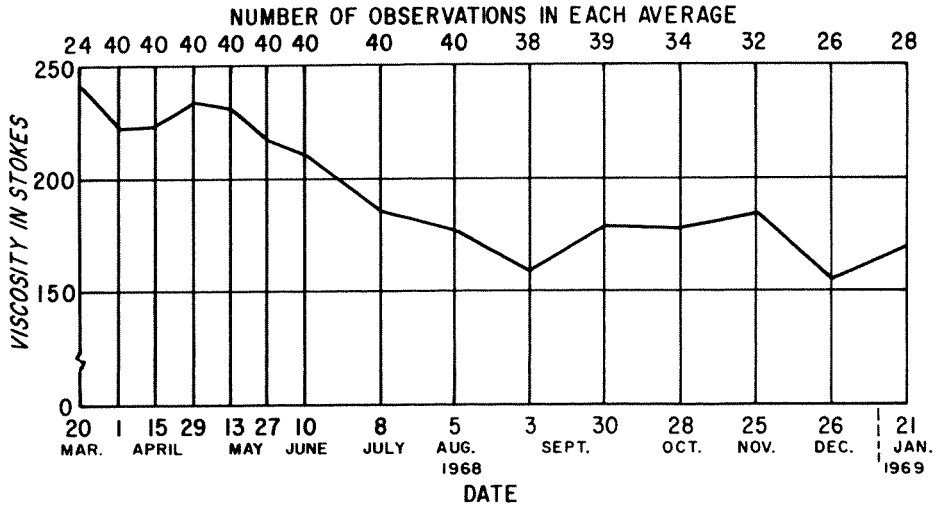

Figure 1.--Average viscosities of slash pines on 15 dates over an 11-month period.

levels during fall and winter. It appears that the oleoresin viscosity of slash pine is highest in the early spring and gradually declines during late spring and summer. The overall decrease is on the order of 30 percent.

VARIATION IN VISCOSITY WITH SAMPLING POSITION

The third part of the study dealt with variation in oleoresin viscosity of slash pine as a result of sampling position on the trunk.

Methods.--The effect of sampling position on viscosity was determined by taking samples from six different ramets, each of a different clone, on April 18, June 13, and August 8, 1968. On each date, oleoresin was collected from 12 positions on each ramet, i.e., at the four cardinal points at trunk levels of 1 foot, 6 feet, and 11 feet above ground. (The June and August samples were taken to the left and right of the April samples.)

Results.--The aspect from which samples were taken did not significantly affect the oleoresin viscosity of slash pine. A significant interaction existed between date of sampling and level of sampling. This interaction existed because the seasonal decline in viscosity began earlier at the 1-foot level than at the 6-foot or 11-foot level, as shown in table 2.

Table 2.--Average viscosity of slash pine oleoresin at different levels on the trunk[1]

Date of sampling	Sampling levels		
	1 foot	6 feet	11 feet
	- - - -Viscosity in stokes - - - -		
April 18	231	196	203
June 13	204	217	213
August 8	148	178	160

[1] Each viscosity is the average of 24 samples.

CONCLUSIONS

Viscosity traits of slash pine trees or clones can be validly compared by collecting oleoresin samples at about the same trunk height on the same day. Replication can be achieved by sampling at several random azimuths around the trunk.

Robert D. McReynolds, Associate Silviculturist
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