GEORGIA SYCAMORE SEED SOURCES IN MISSISSIPPI PLANTINGS: SITE ADAPTABILITY A KEY FACTOR

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Abstract.--When seedlings from five sources along the Chattahoochee and Apalachicola Rivers were planted on a moderately good river-bottom site in southern Mississippi, those from Coastal Plain sources leafed out earlier in spring and grew more rapidly than those from more northerly sources in the Piedmont and mountains. It was therefore inferred that sycamore foliation date is under strong genetic control. Third-year heights differed significantly among seed sources and among families within sources, but the component of variance for sources was almost three times the size of the component for families within sources. On a poor site nearby, a genetically identical plantation was established with rooted cuttings from tops of the seedlings. Thirty-three families were common to both plantations. Family performance was not significantly correlated in the two plantations. The discrepancy may have been due to interactions between family and environment or between family and propagation method.

Sycamore (Platanus occidentalis L.) has silvical characteristics--including rapid growth, abundant seeding, and relative intolerance--which lend themselves to large-scale plantation management. It is not surprising, then, that forest geneticists have undertaken to determine the extent to which vigor components in native sycamore are heritable. Since sycamore has a broad geographic range in the eastern half of the United States (USDA Forest Service 1965), seed source adaptability to varying climatic and site regimes is a matter of immediate importance.

Fogg (1966) observed that trees from six widely separated sources varied in their response to a planting site near Baton Rouge, Louisiana. We report the performance, at two planting locations in Mississippi, of five seed sources from a short transect through Georgia and Florida.

METHODS

Seeds from ten randomly selected trees were collected in each of five stands along the Chattahoochee and Apalachicola Rivers. The two

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streams follow essentially a north-south course from the mountains of north Georgia to the Gulf of Mexico. The seed sources were 60 to 100 miles apart:

Seed source	Physiographic province	Elevation
		-Feet-
White County, Ga.	Blue Ridge Mountains	1400 - 1600
Douglas County, Ga.	Piedmont	700 - 800
Stewart County, Ga.	Upper Coastal Plain	150 - 200
Seminole County, Ga.	Upper Coastal Plain	50 - 100
Liberty County, Fla.	Lower Coastal Plain	< 50

Results of stratification and germination tests were reported by Webb and Farmer (1968).

Seeds were sown in an experimental nursery at Gulfport, Mississippi. The first planting was established during January 1967; the site was near Picayune, Mississippi, on land of the St. Regis Paper Company. The seedlings were top-pruned before being lifted, and the tops were subsequently rooted in the nursery and planted out at Gulfport in 1968. The planting design at both locations was a randomized block in which the families were restricted to and randomized within the parent seed source; sources were randomized within the replication. Four-tree row plots were employed in both plantings, with five replications at Picayune and four at Gulfport. The plantations were genetically identical to the extent that each family at Gulfport had 16 of the 20 genotypes planted at Picayune. Spacing between trees was 10 by 10 feet.

Forty families were represented at Picayune and 33 at Gulfport. White County was represented by five families at Picayune and four at Gulfport, Douglas County by eight and five families, and Seminole by seven and four families. Stewart and Liberty Counties each had 10 families in both plantations.

Sites.--The soil at the Picayune site is a rich, alluvial sandy slit underlain by gravel lenses. It is subject to moderately frequent spring overflows from the Pearl River. The Gulfport soil is a typically well-drained infertile Coastal Plain sand (Ruston series).

The two sites are 30 miles apart along a more or less east-west axis. There are no essential climatic differences. In August 1969, both plantings withstood hurricane-force winds that left some trees leaning permanently.

Measurements.--Survival, root-collar diameter, and total height were measured in the Picayune planting at the end of the first growing season. The following spring the dates of foliation were recorded twice weekly until the entire planting had leafed out. Foliation data were expressed as days since March 31, when the first observations were made. Both plantings were remeasured at the end of their third year in the field.

RESULTS

Survival.--At Picayune, survival was 97 percent after one year and 93.6 percent after three years. A Bartlett's test, following arc sine transformations of plot survival (Mosteller and Youtz 1961), showed that survival variances were not homogeneous. (All differences noted in this article are significant at the 0.05 level.) The mean square for families within sources was extremely low for the Seminole and Liberty sources, yet these two sources differed considerably, Seminole averaging 83.5 percent and Liberty 97.0 percent. From a practical standpoint, however, survival differences are trivial, and are unlikely to influence stand development.

Root-collar diameter and d.b.h. measurements at Picayune.--Separate analyses of variance of root-collar diameter by source and families within source disclosed no differences among sources; differences between families were significant only in the Seminole source. After three years, there were no differences among sources in d.b.h., but differences between families occurred in the Douglas and Stewart sources. Mean variances were homogeneous. Though source differences in d.b.h. were not significant, there was a noticable trend for diameter to increase from northern to southern sources:

Source	Mean d.b.h.
	-Inches-
White	2.6
Douglas	2.4
Stewart	2.8
Seminole	2.8
Liberty	3.0

Moreover, the source component of variation (0.0261) was about 1.5 times as large as the within-source component (0.0172).

Height in the Picayune planting.--When variances in first-year heights at Picayune were analyzed separately by source and families within source, differences among families were judged significant only within the Seminole and Stewart sources. Of the 10 tallest trees at age 1, six were from Liberty County, the most southern source. The average height of these 10 trees was 9.1 feet, almost twice the plantation average of 4.9 feet.

By the end of the third growing season significant source differences had appeared (table 1): Differences among families within sources also persisted, but the component for the sources was almost three times as large as the component for families within source. By Bartlett's test, mean variances were homogeneous.

Table 1.--Analysis of variance of third-year height and d.b.h. at Picayune, Mississippi

Source of variation	D.F.	Height	D.b.h.
		M.S.	M.S.
Blocks	4	36.3718	2.6613*
Sources	4	60.4171*	1.7688
Error I	16	13.2360	.6513
Families/sources	35	3.8091*	.2156*
Error II	140	1.7516	.1298
Source component, δ_s^2		1.1424	.0261
Families/source component, δ_{fs}^2		.4115	.0172

Significant at the 0.05 level.

Mean plantation height after 3 years was 14.9 feet, and the 10 tallest trees averaged 22.7 feet. Eight of these 10 trees were from Liberty County.

Third-year height at Gulfport. The objective of the Gulfport planting was to determine the performance of genetically identical plantations on sites obviously differing in quality.

If heredity were the sole influence on height growth, a regression of the mean heights of the 33 families at Gulfport on the same 33 families at Picayune should have yielded a 45° line with a regression coefficient approximating 1.0. The actual coefficient for raw family means at both locations was 0.1591.

The simplest model for analysis over locations is: $X = Tr. + L + R_L + F + FL + e$. Here u is the population mean over both locations, R_L is replication within locations, F is family effect, FL is family x location interaction, and e is pooled residuals. In this simple model F subsumes source effects, and FL subsumes source x location effects.

In a combined analysis over both plantations, sources and families within sources differed significantly. The Picayune plantation was the cause of most of the differences, but there was also a significant interaction involving families within sources and locations.

Date of foliation at Picayune.--At Picayune, foliation date differed significantly between sources and among families within sources. When dates are plotted over the distances separating the sources, a clinal pattern emerges (fig. 1). If date of foliation at Picayune is plotted over date of last killing frost at the source (data from U. S. Department of Agriculture 1941), a clinal pattern is also obtained (fig. 2). Kaszkurewicz and Fogg (1967) analyzed growth initiation (defined as bud break) in sycamore from 39 locations throughout the species' range in the United States. They found it to be highly correlated with latitude, photoperiod, mean air temperature in the month of bud break, and last killing frost up to 33° N. latitude (the northernmost source in the present study, White County, is at 34° 30' N. latitude). They postulated that photoperiod and temperature and other factors, including genetic adaptation, were interrelated and conditioned the plant's response to the environment.

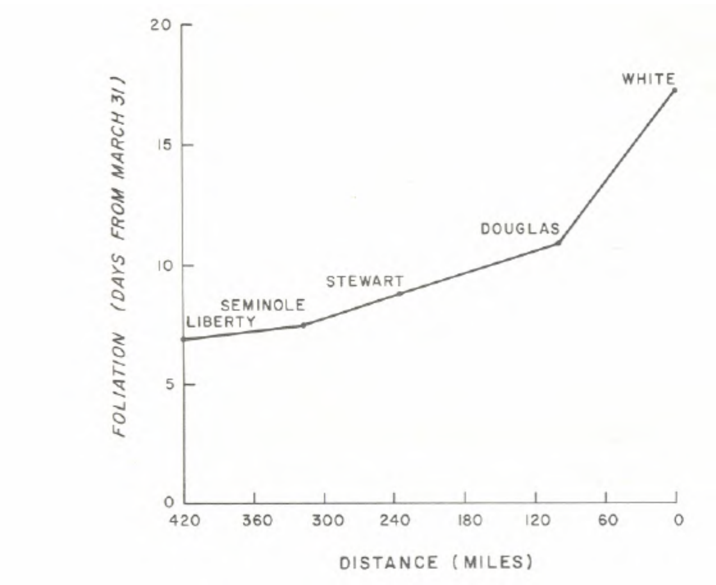

Figure 1.--Date of sycamore foliation in Mississippi as related to seed source distances from origin of the Chattahoochee River.

In the present study we do not have foliation information from the source locations, but it is striking that at Picayune the relation between foliation date and distances between sources in Georgia, and dates of last killing frosts at source locations, are precisely as would be predicted from Kaszkurewicz and Fogg's (1967) analysis of sycamore phenological data. Consequently we infer that date of foliation in this short transect along the Chattahoochee and Apalachicola Rivers is under strong genetic control.

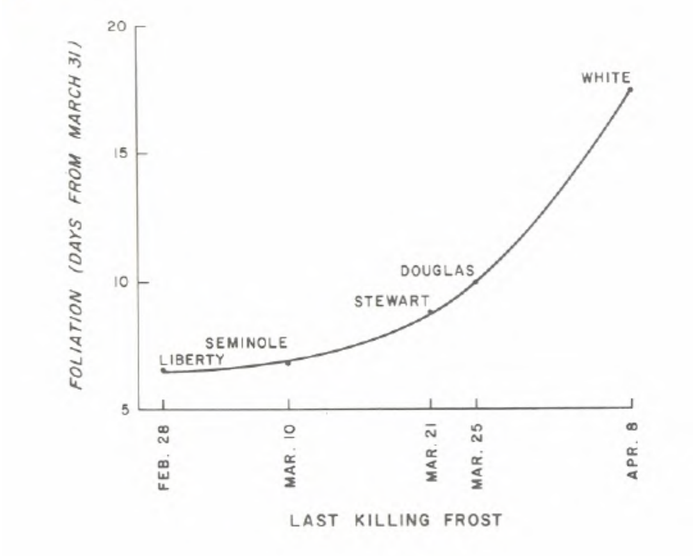

Figure 2.--Foliation dates in relation to last killing frost at the seed sources.

In correlation analysis including all 40 families, with source disregarded, third-year height was negatively correlated with foliation date. Families foliating early were taller than families foliating late. Relationships within sources were inconsistent.

DISCUSSION

Two important features of the investigation bear on the development of research and breeding programs in sycamore. We have provided circumstantial evidence that date of foliation is under strong genetic control. Moreover, the sources which leafed out earliest at Picayune (Liberty and Seminole at the southern end of the transect) also had the greatest d.b.h. and total height at age 3. However, foliation dates and family heights varied within sources, and there seemed to be no relation within a source between foliation date and third-year height and diameter. Since there were at most 10 families per source, the evidence for lack of such a growth relation is not very convincing. Still, it is a matter deserving research, on the possibility that foliation date can be used as a guide for phenotypic selection.

The second important feature of the investigation was the comparison of third-year heights in two plantings differing in site and propagation method. The location effect, unconfounded by genetic differences between plantings, was 3.9 feet in favor of Picayune. This is a large difference for 3-year-old plantings, and it can be attributed mainly to the soils at the two sites. According to a subjective classification (Briscoe 1969, table on p. 8), the Picayune site would rate as moderately good and the Gulfport site as poor.

The rather drastic changing of family performance from one plantation to the next may be due to one or both of two factors: (1) a true genotype x environment interaction, (2) a family x propagation-method interaction. Webb (1970) reported a significant family x planting site interaction in sycamore, and Steinbeck (1970) found significant interactions of clones with nutrient levels. Data presented by Schmitt and Webb (1970) show similar family x location interactions in sweetgum. But the possibility remains that differences in rooting ability among clones may also occur among half-sib families of rooted cuttings; if so, they would contribute to an interaction between family and propagation method. With the present study design, it is not possible to determine which is the more accurate explanation.

Finally, analyses of the Picayune planting showed that source effects were increasing for diameter growth and, by age 3, were already significant for height. Moreover, source components of variation were larger than family components for both diameter and height at age 3. These results are in accord with unpublished data we have for sweetgum in the Mississippi Valley.

A comprehensive interpretation is that genetic improvement in sycamore vigor will be achieved only when knowledge of site adaptability is increased (survival does not appear to be a factor (Briscoe 1969; McAlpine 1963)).

This conclusion may seem obvious, but the answers to the questions, "What constitutes site adaptability in terms of genes, growth, and the environmental factors which affect them?" and "How do we predict adaptability?" are not at all obvious at the present time.

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