EARLY DEVELOPMENT OF OPEN-POLLINATED SWEETGUM PROGENIES

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Abstract.--Data on 6-year-old sweetgum progenies planted on two sites in Mississippi indicate moderate heritabilities for height and diameter. Relatively large family-location interactions for height and diameter suggest that most sweetgum selections should be planted within limited zones. Since number of branches on the lower bole was not under strong genetic control, selection to minimize number of branches would be ineffective.

Additional keywords: Liquidambar styraciflua, heritability, genetic variability.

Because sweetgum (Liquidambar styraciflua L.) is a prime candidate for intensive hardwood management in the South, tests to determine its genetic variability are underway. This paper summarizes measurements made in two such tests 6 years after planting. The data supplement Wilcox's (1970) report on survival, growth, phenology, and crown development through the end of the third growing season.

MATERIALS AND METHODS

In 1962 we planted sweetgum seedlings from 40 parent trees representing a wide range of phenotypes and sites in south Mississippi. Two plantations were established with 1-0 seedlings. The planting sites were about 200 miles apart; one was on the Harrison Experimental Forest (HEF) near Gulfport, Mississippi (31°N); and the other, on the Delta Experimental Forest (DEF) near Greenville, Mississippi (33°N). The HEF plantation is on a sandy, well-drained loam; and the DEF planting is on a fertile, poorly-drained clay.

Trees were spaced 12 feet apart in a randomized complete-block design with five blocks at each site. Each plot contained a four-tree row from a single family.

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During the 1968-69 dormant season, 6 years after planting, we collected the following data from all surviving trees: total height to the nearest 0.1 foot, d.b.h. to the nearest 0.1 inch, number of live and dead branches between 3 and 4.5 feet, and base diameter to the nearest 0.1 inch of the largest branch in this segment of the bole. Mortality was 7 percent in the HEF and 17 percent in the DEF. Dead trees were well distributed among plots, and results probably were not influenced by the pattern of mortality.

Heights, tree diameters, branch diameters, and numbers of branches were examined by analysis of variance using plot means. Within-plot variances were estimated from individual-tree data on one-fifth of the plots; and heritabilities were estimated from these values. We first analyzed the data separately for each planting. When significant (0.05 level) differences were found for a trait in both plantations, we performed combined analyses for that trait. Components and standard errors were estimated with techniques described by Becker (1967). Independence of family and percentage of living branches were tested by chi-square (Steel and Torrie 1960). Relationships between means of different traits in the same plantation and the same traits in the two plantations were examined using Spearman's coefficient of rank correlation (Steel and Torrie 1960).

Table 1.--Growth and branch characteristics of a sweetgum progeny test on two sites

Characteristic	Site	
	Harrison Exp. Forest	Delta Exp. Forest
Sixth-year height (feet)		
Mean	17.1	11.6
Range family means	14.3 - 19.5	10.2 - 12.9
Sixth-year diameter (inches)		
Mean	2.2	1.4
Range family means	1.56 - 2.55	1.1 - 1.6
Number of branches 3 to 4½ feet		
Mean	7.5	9.1
Range family means	6.3 - 8.6	7.8 - 10.7
Percent branches living 3 to 41/2 feet		
Mean	78	93
Range family means	46 - 98	85 - 100
Diameter largest branch 3 to 4½ feet (inches)		
Mean	.38	.46
Range family means	.33 - .44	.39 - .57

Table 2.--Variance components and heritability estimates for characteristics showing significant differences at age 6

Characteristic and Plantation	Component				
	family (σ_f^2)	experimental error (σ_{rf}^2)	within plot (σ_w^2)	location x family (σ_{fl}^2)	h^2 [a]
Total height					
DEF	.043	.294	.736	----	.16 ± .13
HEF	.282	.199	3.503	----	.28 ± .11
combined	.069	.108	2.586	.110	.10 ± .08
Diameter					
DEF	.0027	.0090	.0297	----	.26 ± .14
HEF	.0069	.0119	.0757	----	.29 ± .13
combined	.0028	.0090	.0584	.0023	.15 ± .10
No. branches					
HEF	.032	.001	1.343	----	.09 ± .07

[a]
$$h^2 = \frac{4\,\sigma_f^2}{\sigma_f^2 + \sigma_{rf}^2 + \sigma_w^2} \quad \text{(individual plantations)}$$

$$h^2 = \frac{4\,\sigma_f^2}{\sigma_f^2 + \sigma_{rf}^2 + \sigma_{fl}^2 + \sigma_w^2} \quad \text{(combined plantations)}$$

RESULTS AND DISCUSSION

Differences among families for sixth-year height and diameter were significant in both plantations (table 1), and the family component of total variation was substantial (table 2). Heritabilities for height were larger in the HEF plantation than in the DEF (.28 vs .16), but heritabilities for diameter were essentially equal in the two plantings (.29 HEF vs .26 DEF). Genetic control of these two characteristics is strong enough in both plantations to make selection effective. As expected, the two traits are strongly correlated; rank correlations of height and diameter means were .80 in the HEF planting and .82 in the DEF. Because of this close relationship between height and diameter, volume increases should be easy to obtain.

Differences in growth between the two plantations were substantial, reflecting the effects of site and location (table 1). Height growth was faster in the HEF during the first two growing seasons but was essentially the same in both plantations in the third year. Thereafter, the HEF's height growth again exceeded the DEF's. By the sixth year, mean height in the HEF plantation was 5.5 feet greater and mean diameter 0.8 inches larger than in the DEF.

The combined analyses for sixth-year height and diameter showed significant family-location variance components. The ratio of the interaction component to the family component indicates the relative importance of the former. The ratios for available height and diameter were:

Years after planting	Ratio of family-location to family for Height	Diameter
1	.45	--
2	.32	--
3	.69	--
6	1.59	.82

The relative magnitude of the family-location interaction appears to be increasing over time for height. This trend is paralleled by a reduction over time in Spearman's rank correlation coefficients for mean family heights in the two plantations. These coefficients were significant (0.05 level) every year, but the value decreased from .54 in year 1 to .35 in year 6. Even more striking is the complete lack of correlation between family mean growth in the two plantations after the third year ($r_s = -.01$). These data suggest that future heights of families in the two plantations may be completely unrelated. Values needed to examine trends in diameters are not available, but sixth-year interaction components were large relative to family variation.

Squillace (1970) suggests that interactions between genotypes and environments are common when trees are grown on widely separated sites. In this experiment the small number of sites prevented determination of patterns or trends, and no biological explanation for the interaction can be offered. However, the existence of strong family-location interactions, regardless of their origin, has implication for improvement work. The reduced heritability estimates obtained by combining data from the two sites suggests a potential loss in effectiveness of selection if materials are used over a wide geographic area. The sweetgum breeder should plant improved material in bioclimatic areas similar to those supporting the original selections.

The average DEF tree had more branches, larger branches, and a higher percentage of living branches than the typical HEF tree. On the other hand, genetic control of branch characteristics seemed slight. Branch size did not vary significantly among families in either plantation. Number and proportion of living branches were also unrelated to family in the DEF planting.

In the HEF, family influenced number of branches somewhat, but the heritability estimate was only .09 ± .07 (table 2). The proportion of living branches was also significantly related to family in the REF planting, where trees were taller and more branch mortality had occurred. Family means for this trait ranged from 46 to 98 percent, and there was a significant positive correlation between family means for branch mortality and for height (r = .32). Since height affects branch mortality, any conclusions regarding the genetic control of the latter characteristic are tenuous.

In brief, the relatively small variation among families in the HEF and the lack of variation among families in the DEF do not suggest strong genetic control of branch characteristics or indicate that selection to influence such characteristics would be particularly effective.

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