Sixth-Year Results from a Yellow-Poplar Provenance Test

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Yellow-poplar (Liriodendron tulipifera L.), one of the South's most widely planted hardwoods, is the subject of intensive research in management and genetic improvement. The association of genetic variation with geographical source is important to both breeding and cultural efforts. Some reported data on racial variation in yellow-poplar fall within a pattern now generally predictable for wide-ranging woody species: Frost damage to material planted in the Midwest is greater in stock from southern than from nothern sources (Funk 1958) and frost damage limits major northward movement of planting stock. This relationship hinges upon genetic variation in photoperiodic response (Vaartaja 1964).

In an Ohio study of racial variation in first-year growth, plants from southern sources were among the largest (Limstrom and Finn 1956). Lotti (1955) observed that 3-year-old Coastal Plain yellow-poplar was taller than yellow-poplar from western North Carolina when both were planted in a small unreplicated test near Charleston, South Carolina. On the other hand, in two replicates of 16 sources (Mississippi to Michigan) planted in western North Carolina, Sluder (1960) found no statistically significant racial differences in 5-year height. Variation in dates of bud-break and growth cessation followed expected patterns, however, with trees from northern sources beginning growth later and ending it earlier than those from southern provenances.

In our study, juvenile growth of yellow-poplar from Coastal Plain and Cumberland Plateau sources has been observed in four plantings near seed origins.

METHODS

Material

In the fall of 1959, seed was collected from four sources:

(1) 10 trees on the University of the South Forest, Sewanee, Tennessee (lat. 35°30', elevation 1,500-1,800 ft.)

(2) 9 trees on the Tanahatchie Experimental Forest, Oxford, Mississippi (lat. 34°30', elevation 200-400 ft.)

(3) 20 trees on the Flat Top Experimental Forest, Birmingham, Alabama (lat. 33°30', elevation 400-600 ft.)

(4) 20 trees on the Homochitto National Forest, Gloster, Mississippi (lat. 31°30', elevation 100-200 ft.)

Trees hadaverage to good form and growth and represented several stands in each of the general collection areas.

Bulked seed from each source was shipped to Stoneville, Mississippi, where it was stratified from late November until late March 1960. Seed from the four provenances was then shipped to cooperators who grew seedlings for their respective plantings. Seedlings for two plantings near Sewanee, Tennessee, were grown at the TVA nursery, Clinton, Tennessee. Material for plantings near Birmingham, Alabama, and Vicksburg, Mississippi, was grown near planting sites.

Planting Sites

At Sewanee, seedlings from the four provenances were planted on a plateau and a cove site on the University of the South Forest. The plateau-top site (elevation 1,850 ft.) lies on a 4-percent east slope and is characterized by a uniform Hartsells fine sandy loam; depth to bedrock is 36 to 48 inches. The cove installation (elevation 1,540 to 1,620 ft.) is on a northwest-facing site with any overall slope of 40 percent; plots are on benches with slopes of 5 to 15 percent. The soil is a Jefferson bouldery colluvium derived primarily from sandstone. Depth to bedrock is extremely variable but averages 20 feet or more. Site preparation on both of these areas consisted of chemically killing all hardwood trees and brush.

the test is replicated near Birmingham in small upland hollows (elevation 490-560 ft.) on the Flat Top Experimental Forest. Soils on the plots are Montevallo or Muskingum silt looms ranging from 2 to 4 feet in depth; slopes are moderate. The planting areas were cleared of a mixed stand of pine and hardwoods, and hardwood stumps were treated with silvicide to prevent sprouting.

The planting at Vicksburg is in a gently sloping

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field (elevation 200 ft.) adjacent to a moderate-sized intermittent creek. The soil is deep Adler silt loam. The site was disced in preparation for planting.

Climatic conditions in three planting areas are tabulated below. No data are available for the Sewanee cove area.

Planting localities	Mean number frost-free days	Temperatures, °F January average	Temperatures, °F July average	Annual rainfall, inches
Sewanee (Plateau)	201	39	75	56
Birmingham	241	46	80	54
Vicksburg	252	50	81	49

Design find Establishment

Seedlings (1-0)were bar-planted during the winter of **T961** in randomized block designs with four replications at all four locations. Each plot contained 121 seedlings at 5- by 5-foot spacing. Blocks were planted contiguously on the Sewanee plateau and Vicksburg sites. On the Sewanee cove and Birmingham sites, uneven topography necessitated separating blocks by distances of up to Y2 mile.

Maintenance and Observations

Weeds in the Vicksburg planting were mowed four times during the first growing season and twice during the second. Competitive growth at the other three sites was not cut. Height and survival after 3 and 6 years' growth were recorded for a central square of 49 trees in each plot. In 1966, foliation dates of 5 trees per plot were observed at Vicksburg and of 2 trees per plot in both Sewanee installations. Foliation of four trees per plot was observed in 1967 at Vicksburg and in the Sewanee plateau planting. Foliation date was defined as the first date on which one or more leaves were completely out of buds, and was recorded as number of days after February 28.

Analysis of variance in all characters took the form of a split-plot design with planting locations as major plots and provenance as subplots. Plot means were the units of analysis.

RESULTS

Survival

Mean 3-year survival of seed I i n g s from provenances represented in the four plantings varied from 75 to 97 percent (Table 1). Survival was lowest (77 percent) at Birmingham and highest (96 percent) on the Sewanee plateau site. In the Sewanee cove planting, trees from the Sewanee source survived less well than those from the Oxford source (.05 level of significance); source differences were nonsignificant at other locations. Increase in mortality between 3 and 6 years was 3.6 percent points on the Sewanee cove site and less than 1 percent in the other plantings. No evidence of cold damage to stems has been observed in any of the plantings, although apices of Gloster seedlings grown at Clinton, Tennessee, were killed by frost in the nursery. Late spring frosts have occasionally caused slight leaf damage in Sewanee plantings.

Table 1. Survival at 3 years of yellow-poplar from four provenances growing at four locations

Provenance	Vicksburg	Sewanee cove	Sewanee plateau	Birmingham
	Percent			
Sewanee, Tenn	87	83	93	82
Oxford, Miss.	93	95	97	75
Birmingham, Ala.	87	90	96	78
Gloster, Miss.	91	91	96	75
Mean	90	90	96	77

Growth

Mean 6-year heights for the Vicksburg and Sewanee cove p I an t i n g s were both 21 feet, and heights at Birmingham and Sewanee plateau locations were approximately one-half that (Table 2). Three-year heights followed a similar pattern. These differences in growth on the two groups of sites (Vicksburg and Sewanee cove; Birmingham and Sewanee plateau) were statistically significant (.05 level) for 3- and 6-year heights and the 3- to 6-year height increment.

Source means based on combined data from all four plantings were practically identical. However, comparison of means within locations revealed the following significant differences (.05 level) in 6-year heights:

Gloster > Birmingham at Vicksburg

Oxford > Sewanee at Sewanee cove

Birmingham >Oxford at Sewanee plateau

Trends leading to these differences were apparent at 3 years, but no significant differences were found in analyses of 3-year heights and 3- to 6-year height increments.

Coefficients of within-plot variation in 6-year height were uniformly low in the Vicksburg planting (0.1^7), but averaged 0.23 on the Sewanee cove site, 0.27 on the Sewanee plateau, and 0.28 at Birmingham. The lower coefficients of variation in the Vicksburg plots are probably related to plots being in a cleared, disced. field. All coefficients of

variation in the test are lower than those reported by Sluder (1960) for a planting in western North Carol ina.

followed a pattern which has been previously observed in yellow-poplar (Sluder 1960) and other species (Kriebel and Wang 1962; Perry and Wang

Table 2. Juvenile height (feet) of yellow-poplar from four provenances growing at four locations

Provenance	Vicksburg		Sewanee cove		Sewanee plateau		Birmingham		Test mean	
	3 yr.	6 yr.	3 yr.	6 yr.	3 yr.	6 yr.	3 yr.	6 yr.	3 yr.	6 yr.
Sewonee, Tenn.	9	21	6	19	4	10	4	9	6	15
Oxford, Miss.	10	21	8	23	4	9	4	9	6	16
Birmingham, Ala.	8	18	7	22	6	13	5	12	6	16
Gloster, Miss.	10	22	7	21	5	12	4	10	7	16
Mean	9	21	7	21	5	11	4	10		

Foliation

The sequence of foliation was the same in all observed plantings (Table 3): trees from Gloster broke dormancy first, followed by those from Birmingham, Oxford, and Sewanee. In 1966 the Sewanee cove planting foliated a few days before the more elevated Sewanee plateau p I ant i n g, and both Sewanee installations flushed earlier than the Mississippi one. This unexpected difference between the Mississippi and Tennessee foliation time is probably due to an unusually cold late March in central Mississippi. In 1967 the Vicksburg planting foliated about 4 days earlier than the one on the Sewanee plateau.

DISCUSSION

The juvenile performance of trees from all provenances has been good at all four locations. It is especially notable that the Gloster material has survived on the Cumberland P I a tea u, and that Sewanee trees have grown well in central Mississippi. Apparently, yellow-poplar's adaptive response to climatic variation over the test region is not great enough to penalize movement either north or south within the region.

Most of the observed variation in growth is related to site and follows a pattern which can be easily predicted, given a rudimentary knowledge of yellow-poplar site relations. All sources performed best on deep, moist, well-drained cove or creek-bottom soils. Growth has been remarkably similar on sites of generally equal quality (i.e., Sewanee plateau and Birmingham) despite major differences in their geographical location. In short, variation in growth to date seems to be re I a ted mostly to edaphic factors.

Variation in foliation dates, on the other hand, 1960): trees from southern sources foliate earlier, given the same environment, than those from more northern areas. This reaction is probably related to genetic differences in dormancy among populations sampled in this study.

Table 3. Mean number of days from February 28 to foliation date of yellow-poplar from four provenances growing at three locations. Means not connected by the same line are significantly different (.05 percent level).

Provenance	Vicksburg		Sewanee plateau		Sewanee cove
	1966	1967	1966	1967	1966
Sewanee, Tenn.	43	35	35	38	35
Oxford, Miss.	43	32	35	36	32
Birmingham, Ala.	41	32	33	34	25
Gloster, Miss.	33	27	26	34	21

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