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Geographic Variation in Disease Susceptibility of American Sycamore

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ABSTRACT. Leaf scorch, top dieback, and lethal bole cankers were found in two progeny tests of sycamore in Mississippi. Both tests indicated that southern seed sources are more disease resistant than northern seed sources and that some progenies within seed source have even greater resistance. Although eight organisms associated with one or more of the disease symptoms were identified, determination of the primary organism causing lethal cankers will require further research.

American sycamore (*Platanus occidentalis* L.) has generally had few lethal disease problems. Anthracnose, caused by *Gnomonia veneta* (Sacc. and Speg.) Kleb., has been reported (Waterman 1924, Himelick 1961, Neely and Himelick 1963), as have canker diseases (Mook 1940, Walter 1946, Thompson 1951, McAlpine 1961, Filer 1969) and top dieback (Thompson 1951, Filer 1969), but losses have been minor. In recent years, however, a potentially serious disease of sycamore involving leaf scorch, dead branches, top dieback, long, narrow lethal cankers extending from the dieback area to the base of the tree, orange discoloration of the inner bark, water sprout formation on the lower trunk, and death of the tree after one to ten years, has occurred in Illinois and adjacent states and has been attributed to attacks by various organisms on environmentally stressed trees (Ricketts 1975). In the South, where extensive plantations of sycamore have now been established, a 1973 survey of 26 sycamore plantations in Tennessee, Mississippi, Louisiana, and Alabama revealed trees with symptoms of leaf scorch, top dieback, and lethal bole cankers in four bottomland plantations (Filer *et al.* 1975).

We are reporting variation in the incidence of an array of disease symptoms in two progeny tests in Mississippi. Both tests involve open-pollinated progeny of random trees from natural stands of sycamore. The symptoms appeared to be identical to those in the Midwest described by Ricketts (1975). However, disease development was much more rapid.

PROGENY TESTS

One progeny test was at Huntington Point, north of Greenville, Mississippi (33°20'N latitude). It consisted of 100 families from five stands located along the Mississippi River from New Madrid, Missouri, to Vidalia, Louisiana, a range from 180 miles north to 140 miles south of the planting site. Open-pollinated seed was collected from random trees in each stand, and seedlings were grown in the nursery.

One-year-old seedlings were outplanted in 1969 at 10 × 10 foot spacing. The 100 families were arranged in a repeated triple lattice design (Cochran and Cox 1957) with six replications and six trees per plot. The site was Commerce loam, newly cleared of mixed riverfront hardwoods. It proved excellent for sycamore since average height was 36 feet at age 5 (Ferguson *et al.* in press).

All trees appeared normal at age 3. Top dieback and lethal bole cankers were first noted at age 4 and increased during the fifth season. In addition, leaves became scorched on many trees, particularly those in families having at least some top dieback. The leaf curl symptoms initially consisted of marginal necrosis which progressed inward until the entire leaf became infected and appeared scorched. Most infected leaves remained on the tree until frost. The leaf scorch appeared to be related to top dieback. The top dieback symptom consisted of necrotic twigs and branches in the upper portion of the crown. All symptoms progressed downward toward the bole. The lethal canker occurred on the main bole and proceeded downward. The cankers were 1/2 to 4 inches in width, but extended 1 to 36 feet in length. Death occurred when the cankers reached the root collar. Apparently the disease runs its course in one to two years.

On September 1, 1973, near the end of the fifth growing season, each of the 3,600 trees was examined for leaf scorch and top dieback. Lethal bole cankers were often difficult to see without scraping the bark and were not recorded. Leaf scorch in the upper half of the crown was recorded to the nearest 10 percent of the leaves. Dieback was scored from 0 through 4 based upon the proportion of the main stem that was dead: 0 = no dieback, 4 = dead. Since dieback prevented the expression of scorch, the percentage of trees per plot with either scorch or dieback was computed.

The second progeny test was at Picayune, Mississippi (30°30′N latitude). It consisted of 40 families from five stands along the Chattahoochee River from northern Georgia to northern Florida. This sampling area extended from 300 miles north to 25 miles south and was 280 miles east of the planting site. The stands were chosen so as to be spaced as evenly as practical over this area. Open-pollinated seed was collected from random trees in each stand, and seedlings were grown in the nursery. One-year-old seedlings were outplanted in 1967 at 10 × 10 foot spacing. Families were arranged in a compact family block design (Panse and Sukhatme 1955) with five replications and four trees per plot. The site was newly cleared alluvial sandy silt underlaid with gravel. It was an above average site for sycamore as evidenced by 14.8 foot mean height at age 3 (Schmitt and Webb 1971).

Inspection of the plantation near the end of the fifth season revealed no evidence of dieback or cankers. But two years later, early in November 1973, the plantation was found to contain many dead and cankered trees. Dieback was recorded to the nearest 10 percent of the tree height for each of the 800 trees. Dead trees were scored as having 100 percent dieback. Since most leaves had fallen, scorched leaves were not recorded.

Dieback data from Picayune and percent of trees having scorch or dieback at Huntington Point were transformed to arcsin $\sqrt{\text{percent}}$ of plot means and subjected to analysis of variance. The triple lattice restriction on randomization at Huntington Point was ignored. Separate analyses were performed for each group of families from a single stand (stand-progeny) and then pooled over stands within testing location in order to determine the relative amounts of variability among and within stands (Table 1).

TABLE 1. Analysis of variance for amount of top dieback and percentage of trees with scorch or top dieback in sycamore progeny tests at Picayune and Huntington Point, Mississippi.

Source of variation	df	Expected mean squares[1]
Blocks	$(b-1)$	$\sigma_{e_1}^2 + ft\sigma_b^2$
Stands	$(t-1)$	$\sigma_{e_1}^2 + b\sigma_{f(t)}^2 + bf\,\frac{\sum\tau^2}{t-1}$
Blocks × stands	$(b-1)(t-1)$	$\sigma_{e_1}^2$
Families within stands	$\sum_{i=1}^{t}(f_i-1)$	$\sigma_{e_2}^2 + b\sigma_{f(t)}^2$
Blocks × families within stands	$(b-1)\sum_{i=1}^{t}(f_i-1)$	$\sigma_{e_2}^2$

[1] *The harmonic mean of the number of families in each stand is represented by f.*

Thirty isolations were made to represent each sample of healthy and diseased leaf, twig, and trunk tissue collected from trees in each plantation. Tissues were placed on potato-dextrose agar in petri plates and stored at 25°C for seven days. Aseptic fungal isolates were obtained from hyphal tips and cultured on potato-dextrose agar for identification and for inoculation of seedlings.

Each of several fungus isolates was used to inoculate two or more one-year-old potted seed-

TABLE 2. Leaf scorch, dieback, and mortality in a five-year-old sycamore progeny test at Huntington Point, Mississippi (N. Lat 33°20′)

			Trees with scorch or top dieback		Scorch percentage		Top dieback score		Percent of dead trees	
Seed source	N Latitude	Families/ stand	Stand mean	Family range	Stand mean	Family range	Stand mean	Family range	Stand mean	Family range
New Madrid, MO	36°25′	10	88.0	73.7–97.2	20.6	12.0–26.8	1.33	0.59–2.25	21.3	2.8–38.8
Catfish Point, MS	33°40′	16	26.6[1]	11.0–50.0	3.0	0.8–6.3	0.36	0.00–0.78	3.3	0.0–11.8
Greenville, MS	33°20′	24	21.2[1]	2.8–49.0	2.5	0.0–8.5	0.17	0.00–0.61	1.8	0.0–8.5
Newellton, LA	32°05′	25	5.1	0.0–19.5	0.7	0.0–4.2	0.08	0.00–1.17	0.3	0.2–2.8
Vidalia, LA	31°25′	25	1.1	0.0–3.3	0.1	0.0–0.3	0.01	0.00–0.06	0.0	0.0–0.0

[1] *Differences among families within source significant at 0.05 level of probability.*

lings by spraying mycelial suspensions on leaves and twigs, and by cutting through the bark and placing agar-mycelium inoculum behind the bark flap (Filer 1969). Bark-flaps were closed with masking tape, and the seedlings were kept in a mist chamber for 48 hours, then transferred to a greenhouse. Inoculation results were recorded 30 days later.

RESULTS AND DISCUSSION

At Picayune, 91 percent of the trees had top dieback, but at Huntington Point only 28 percent of the trees had scorch or top dieback. In both plantings, trees of southern origin were significantly healthier than trees of northern origin (Tables 2 and 3). In addition, variation among families was significant within two of the stand-progenies at Picayune for percent top dieback and in two at Huntington Point for percent of trees having scorch or top dieback. Variations among families was least in the essentially disease-free southern stand-progenies from Newellton and Vidalia and in the heavily infected northern stand-progenies from White and Douglas Counties. At Huntington Point, where scorch top dieback and mortality from lethal cankers were separately scored, the north-south trend among stands was similar for each character (Table 2).

Data from the three southernmost stand-progenies at Picayune were pooled, as were those from the four southernmost stand-progenies at Huntington Point, to determine the relative amount of variability among and within these stand-progenies. Analysis showed that even among the southern progenies the stand effect was significant, but the families-within-stand effect was larger. The ratio of stand to families-within-stand variance was 1 to 2 at Picayune and 1 to 1.1 at Huntington Point. Therefore, considerable additional improvement in disease resistance should be attainable from selection among progenies from the best southern stands. Additional disease development in these plantations may further improve the opportunity to identify the most highly disease-resistant trees for use as parents in a breeding program.

Figure 1. Portion of a lethal bole canker nearly 4 in. wide and 10 ft. long extending to ground line. Tree died after canker reached root collar.

TABLE 3. Top dieback in a seven-year-old sycamore progeny test at Picayune, Mississippi (N Lat 30°30′)

Seed source	N Latitude	Families/ stand	Top dieback percent of main stem: Stand mean	Top dieback percent of main stem: Family range
White County, GA	34°45′	5	96.5	91.2–100.0
Douglas County, GA	33°45′	8	94.8	90.0–99.5
Stewart County, GA	32°00′	10	45.8[1]	21.4–64.8
Seminole County, GA	31°00′	7	27.0	6.6–41.5
Liberty County, GA	30°30′	10	33.5[1]	18.0–51.5

[1] *Differences among families within source significant at 0.05 level of probability.*

Although the north-south trend in disease incidence among stands was clear, the causes for the differences were not. The authors noted no obvious north-south trend in disease incidence in natural stands from New Madrid, Missouri, to Vidalia, Lousiana, in 1973. The greater growth rate and earlier foliation of southern sources (Schmitt and Webb 1971, Ferguson *et al.* in press) may have contributed to their reduced disease incidence.

TABLE 4. Fungi isolated from diseased sycamore at Huntington Point and Picayune, Mississippi in 1973.

Organism	Plant parts			Geographic location	
	Leaves	Twigs	Trunk	Huntington Point	Picayune
Botryodiplodia theobromae Pat.		x	x	x	x
Dothiorella gregaria Gross & Dug.		x	x	x	
Phomopsis scabra (Sacc.) Trav.		x		x	
Ceratocystis fimbriata Ellis & Halst.			x	x	x
Gloeosporium platani Edg.	x	x		x	x
Gloeosporium nervisequum (Fcl.) Sacc.	x			x	
Phyllosticta platani Sacc. & Speg.	x			x	x
Hypoxylon tinctor (Berk.) Cke.			x		x

From the 30 isolates of each leaf, twig or trunk sample, eight fungi were isolated and associated with disease symptoms (Table 4). *Gloeosporium platani* Edg. and *G. nervisequum* (Fckl.) Sacc. were isolated from trees showing leaf scorch or twig canker symptoms in the Huntington Point plantation. The former appears to be the primary foliar pathogen. Seedlings sprayed with mycelial suspensions of *G. platani* developed leaf scorch, top dieback, and twig cankers; those sprayed with *G. nervisequum* showed only leaf scorch.

The primary organism causing lethal bole cankers (Figure 1) has not been established, but *Ceratocystis fimbriata* Ellis and Halst. and *Botryodiplodia theobromae* Pat. are prime prospects. When seedlings were inoculated with either of these organisms by the bark-flap technique, cankers developed on stems within 30 days. Since both organisms can cause cankers, more testing is needed to determine the primary pathogen causing mortality and the relationship of the other organisms to the development of lethal bole cankers.

The destructiveness of lethal cankers demonstrated in these two plantings, especially at Picayune, may limit conventional long-rotation plantation management of sycamore. Lethal cankers were not observed on trees less than four years old (Filer *et al.* 1975). Therefore, the concept of growing sycamore on a four- to five-year rotation followed by whole tree harvesting (McAlpine *et al.* 1966) may be a way to avoid losses from disease. Any scheme aimed at increasing genetic resistance to this disease should take advantage of the geographic effect. The northern parts of the present study area (southern Missouri and the mountains of Georgia) are poor seed sources for areas farther south. Use of seed from approximately 125 miles south of the planting site would appear to be a way to avoid these disease problems.

Literature Cited

COCHRAN, W. G., and G. M. COX. 1957. Experimental designs. 2nd ed. John Wiley and Sons, New York. 611 p.

FERGUSON, R. B., S. B. LAND, JR., and D. T. COOPER. [*In press*] Inheritance of growth and crown characters in American sycamore. Silvae Genet.

FILER, T. H., JR. 1969. Sycamore canker caused by *Botryodiplodia theobromae*. Phytopathology 59: 76–78.

———., D. T. COOPER, R. J. COLLINS, and R. WOLFE. 1975. Survey of sycamore plantations for canker, leaf scorch, and dieback. Plant Dis. Rep. 59: 152–153.

HIMELICK, E. B. 1961. Sycamore anthracnose. Pages 136–144 in Proc. 37th Nat. Shade Tree Conf.

MCALPINE, R. G. 1961. *Hypoxylon tinctor* associated with a canker in American sycamore trees in Georgia. Plant Dis. Rep. 45: 196–198.

———., C. L. BROWN, A. M. HERRICK, and H. F. RUARK. 1966. "Silage" sycamore. For Farm. 26(1): 6–7, 16.

MOOK, P. V. 1940. Three new locations for the sycamore (planetree) disease. Plant Dis. Rep. 24: 205–206.

NEELY, D., and E. B. HIMELICK. 1963. Temperature and sycamore anthacnose severity. Plant Dis. Rep 47: 171–175.

PANSE, V. G., and P. V. SUKHATME. 1955. Statistical methods for agricultural works. Indian Counc. Agric. Res., New Delhi. 361 p.

RICKETTS, S. T. 1975. Sycamore decline in southwestern Illinois. MS thesis. University of Illinois, Urbana-Champaign, Ill. 56 p.

SCHMITT, D. M., and C. D. WEBB. 1971. Georgia sycamore seed sources in Mississippi plantings: site adaptability a key factor. Pp. 113–119 in Proc. 11th Conf. on South. For. Tree Improv. Atlanta, GA. 284 p.

THOMPSON, G. E. 1951. Die-back of sycamore. Plant Dis. Rep. 35: 29–30.

WALTER, J. M. 1946. Canker stain of Planetrees. U.S.D.A. Circ. #742, p. 12.

WATERMAN, A. M. 1924. Sycamore blight. Plant Dis. Rep. 3: 40–42.

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