Konkurrenten. Silvae Genetica 15, 1–11 (1966). — STERN, K.: Die Bedeutung der Konkurrenz in Pflanzenbeständen für die Pflanzenzüchtung. Arbeitsgemeinschaft für Biometrie in der Pflanzenzüchtung. Rundschreiben 1. 3–7, 1968. — STERN, K.: Vollständige Varianzen und Kovarianzen in Pflanzenbeständen. IV. Phänotypische Korrelationen zwischen Wachstumsleistungen in verschiedenen Altersstufen. Theor. and Appl. Gen. 38, 66–73 (1968). — STERN, K.: Überlegungen zur optimalen Teilstückgröße in Feldversuchen mit Waldbäumen. Act. For. Fenn., Vol. 3, No. 4, 248–260 (1968).

Dendrological and Anatomical Characteristics of a Dwarf Variety of Sweetgum

By KLAUS STEINBECK, MICHAEL A. TARAS, and PAUL P. KORMANIK[1])

(Received for publication July 8, 1968)

A multi-stemmed, symmetrical dwarf sweetgum *(Liquidambar styraciflua L.)* growing in Oconee County Georgia, U.S.A. was reported by KORMANIK *et al.* (1966). Two specimens of this dwarf exist in one locality. One is growing on the terrace of an abandoned cotton field which now supports a stand of volunteer loblolly pine interspersed with normally growing sweetgum. That bush is about 11 feet tall *(Figure* 1) and about 25 years old. The second specimen *(Figure 2),* about 9 feet tall, was apparently propagated by a tenant farmer about 20 years ago and planted in the open near a house. Both are bushy and symmetrical.

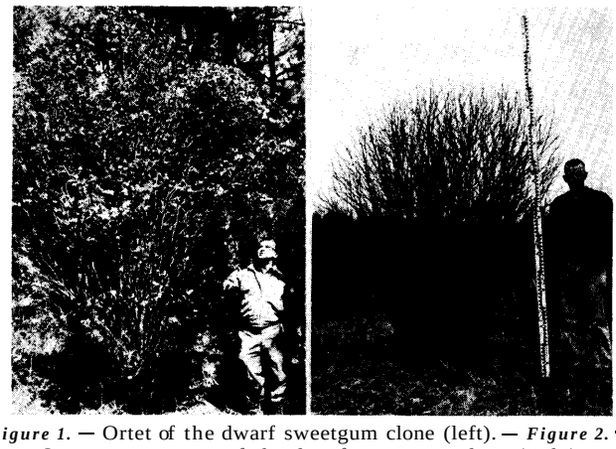

Figure 1. — Ortet of the dwarf sweetgum clone (left). — ***Figure 2.*** — Open-grown ramet of the dwarf sweetgum clone (right).

Similar dwarfs are growing at the Forest Nursery Company near McMinnville, Tennessee. Its president reports that he observed four or five of them in nursery beds of normal sweetgum seedlings. Therefore this dwarf form does not seem to be as unique as had been assumed. Because we have been unable to distinguish among any of these dwarfs in the field, the nomenclature published by the Forest Nursery Company naming the dwarf L. *styraciflua* c. v. 'Gum Ball' (ARNOLDIA, 1969) will be followed in this paper.

Several of the dwarfs have been propagated vegetafively from root and stem cuttings. All propagules retained the bushy habit of the ortet *(Fig.* 3).

Scion material from the dwarf has been successfully grafted onto rootstock of normal sweetgum seedlings. These grafts are in their fourth growing season. They have retained their deliquescent habit after grafting *(Figure* 4) and seem to inhibit the buds of the rootstock.

[1]) Assistant Professor, School of Forest Resources, University of Georgia. Athens, Ga., Principal Wood Scientist and Silviculturist, respectively, U.S.D.A., Forest Service, S.E. Forest Experiment Station, Athens, Ga. The senior author was employed by the Forest Service in Athens when research was performed.

Figure 3. — Three-year-old ramet produced by a root cutting.

Dendrological Characteristics

The two outstanding characteristics of this dwarf sweetgum are its symmetrical deliquescent growth and the absence of flower production. According to observations of BROWN *et al.* (1967), *L. styraciflua* L. pcssesses weak apical dominance but exhibits strong apical control, a combination which results in an excurrent habit of growth. The dwarf,

Figure 4. — Three-year-old graft of dwarf sweetgum on normal stock.

however, exhibits strong apical dominance and weak apical control and consequently is deliquescent.

The older branches characteristically exhibit the spur or short shoot habit of growth *(Figure 5)*. In other species which commonly develop short shoots — ginkgo, beech, pear and apple — this type of growth is restricted mainly to second or higher order lateral branches. In 'Gum Ball', however, the primary branches and first order laterals can also exhibit the short shoot habit. We have found that the terminal of dwarf shoots can produce long shoots, and vice versa. Occasionally, individual branches elongate 4 to 6 inches during a growing season and higher orders of laterals are initiated. The combination of slow growth and initiation of higher order laterals produces a dense, symmetrical crown.

Figure 5. — On the left: Typical branch of the open-grown ramet of fig. 2. — On the right: All branch tips characteristically elongate but little each year.

Fertilized and irrigated sprouts from root cuttings may grow 8 to 12 inches in each of the first 2 or 3 years, but the internodes are conspicuously shorter than those of normal sweetgum branches. Strong apical dominance, a characteristic of the ortet, is not as pronounced in these young, vigorous propagules and their axillary buds break. However, shoots developing from these buds remain short.

Morphological characteristics of the leaves, buds, and twigs of 'Gum Ball' are almost identical to those of *Liquidambar styraciflua* L. The leaves are alternate, simple, stipulate, and vary from 2 to 7 inches in diameter. They exhibit the characteristic lobing variations common to *L. styraciflua* L.; i. e. leaves with three, five, or seven lobes can be found on any individual tree *(Figure 6)*.

The twigs are slender to moderately stout, yellowish brown to brown, with fine pubescence on 1- and 2-year-old twigs. This pubescence becomes more prominent as the twigs turn brown and it is more conspicuous on slow-growing twigs. The terminal bud is ovate to conical. Only inconspicuous axillary buds are present where the typical short shoot type of elongation has occurred. However, axillary and collateral accessory buds are conspicuous on twigs or branches where some internodal elongation has taken place.

Figure 6. — Leaf lobing variations of the 'Gum Ball' dwarf sweetgum.

Anatomical Characteristics

Description of the anatomical features of dwarf sweetgum is based on observations made of tissue from pith to bark at 1 foot above the ground. The stem examined had a diameter of 2.33 inches at this level, and a ring count of 24.

Gross features. — Pith is continuous, brown, and irregular in shape appearing with scalloped outer edges. A small amount of dark brown to chocolate brown heartwood was observed surrounding the pith. Sapwood is white to light buff. The wood is without characteristic odor or taste. It has a fine texture, is straight grained, and of medium density (specific gravity based on oven-dry weight and green volume averages 0.395 — range is from 0.330 to 0.436). Growth rings are not readily discernible with the naked eye or lens. Pores are small, not visible to the naked eye, uniform in size within a growth ring, and uniformly distributed throughout growth rings (diffuse porous). Pores are numerous, solitary, and frequently crowded *(Figure 7)*. Parenchyma are not visible. Rays are not visible to the naked eye, but appear as numerous, fine white lines under the lens. Vertical gum canals were not observed with lens but were found under microscopic examination. These were of the traumatic type.

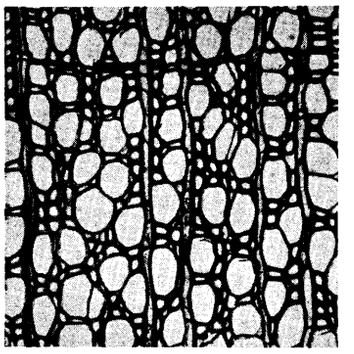

Figure 7. — Cross section shows solitary pores uniformly distributed within growth ring (mag. 80×).

Microstructure. — Pith is heterogeneous, being made of two types of parenchymatous cells. The central portion of the pith is comprised of isodiometric cells which occasionally contain large druse crystals; the outer margin of the pith next to the protoxylem area is made up of square cells arranged in discrete longitudinal files. Occasional gum ducts with epithelial cells are found in the outer margin of the pith in areas next to the protoxylem.

Primary tracheary elements have helically thickened secondary walls. Vessels vary in size and number from pith to bark. In the ring nearest the pith, vessels number 370 per square mm.; in the vicinity of the bark, the number of vessels per square mm. decreases to 85. Vessel diameter increases from pith to bark, averaging about 36 microns in the ring nearest the pith and 71 microns in the periphery of the stem. Vessel member length averages 0.85 mm. near the pith and 1.00 mm. in the older, mature wood. Vessel perforation plates are exclusively scalariform with many bars (12—25 per plate) *(Figure 8)*. Spiral thickenings are present only in tapering ends of vessel elements. Intervessel pitting is orbicular to oval to scalariform. Parenchyma are metatracheal-diffuse, and sparse. Fiber tracheids have numerous, conspicuous bordered pits 6—10 microns

Figure 8. — Left: Radial section, scalariform perforation plates — large bordered pits in fiber tracheids, and heterogeneous type rays with upright and procumbent cells (mag. 110×). — *Figure 9.* — Right: Tangential section, uniseriate and biseriate heterogeneous type rays — fiber tracheids with large bordered pits (mag. 110×).

in diameter on both radial and tangential surfaces (Figures 8 and 9). Gelatinous fiber tracheids were also observed in several rings. Fiber tracheid length averages 1.07 mm. near the pith and 1.34 mm. in the outer part of the stem.

Rays *(Figure 9)* are unstoried, predominately 1- and 2-seriate (3-seriate rare), heterogeneous type I (KRIBS, 1950) with both upright and procumbent cells. Uniseriate rays are 1 to 17 cells high. Biseriate rays have uniseriate tips as long or longer than the multiseriate portion of the ray; tips are 3 to 15 cells long. Ray-vessel pitting is coarse, half bordered, orbicular to oval to scalariform; coarse pitting is most abundant at crossings of the upright type cells and vessels. Gum canals when present occur in single tangential rows with angled orifices as observed from cross section; average diameter is 44 microns, range is 27 to 65 microns.

Summary

Liquidambar styraciflua L. c. v. 'Gum Ball' exhibits strong apical dominance which, combined with its short shoot habit of growth, results in a bushy, symmetrical form. Other dendrological and wood anatomy features are practically identical to those of the common growth form of the species. Except for differences in the relative size of various elements, there appear to be no anatomical differences of consequence. At 25 years of age it has not produced flower buds. Of the known specimens of 'Gum Ball', several apparently developed from seed. With their symmetrical growth habit and attractive, deep-purple fall coloration these dwarfs are of horticultural interest.

Literature Cited

ANON., Plant Registrations Arnoldia 29 (1): 4 (1969). — BROWN, CLAUD L., MCALPINE, ROBERT G., and KORMANIK, PAUL P.: Apical dominance and form in woody plants: a reappraisal. Amer. J. Bot. 54: 153—162 (1967). — KORMANIK, PAUL P., STEINBECK, KLAUS, and BROWN, CLAUD L.: A new variety of sweetgum. U.S. Forest Serv. Southeast. Forest Exp. Sta. Res. Note SE-55, 2 pp. (1967). — KRIBS, DAVID A.: Commercial foreign woods on the American market. Ann Arbor: Edwards Brother, Inc., 157 pp. (1950).

Inherent Variation in South Mississippi Sweetgum

By JAMES R. WILCOX[1])

(Received for publication July 17, 1968)

Because of its broad utility and wide distribution, sweetgum *(Liquidambar styraciflua* L.) is one of the most important hardwoods in the Southern United States. Recent interest in planting the species has prompted research in genetic improvement. This paper reports data from a half-sib progeny planting in south Mississippi. The research indicates that much of the observed variation in growth and form of juvenile sweetgum is under strong enough genetic control to make possible considerable improvement through mass selection.

Methods

Forty sweetgum trees were selected in south Mississippi on the basis of phenotypic variability expressed on a range of sites. Seeds were collected from two to five trees in each of 12 stands and sown by family groups in the nursery of the Harrison Experimental Forest during the spring of 1962. In February 1963, the 1—0 seedlings were lifted and outplanted in a randomized block design with five replications at each of two locations about 200 miles apart: the Harrison Experimental Forest near Gulfport (30° 35' N latitude, 89° 5' W longitude), and the Delta Experimental Forest near Greenville (33° 25' N latitude, 90° 55' W longitude), Mississippi. The Harrison soil is a fine sandy loam, strongly acid, with low natural fertility. The Delta soil has a high clay content and is poorly drained, but has good productive potential.

At each location four trees per family were planted in row plots at a 12-foot (3.66 m) spacing. Rows were 10.4 feet (3.17 m) apart. Since trees were offset 6 feet (1.83 m) within adjacent rows, there was a 12-foot (3.66 m) space between all adjacent trees. Both plantations were cultivated regu-

[1]) When the study was made, the author was Research Geneticist, U. S. Department of Agriculture, Forest Service, Gulfport, Mississippi. He is now Research Geneticist, Crops Research Division, Agricultural Research Service, Purdue University, Lafayette, Indiana.