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SURVIVAL AND FIRST-YEAR GROWTH OF HARDWOODS PLANTED IN SATURATED SOILS

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SOUTHERN FOREST EXPERIMENT STATION

Up to 16 weeks of soil saturation from the time of planting did not significantly affect survival, date of bud-break, or initiation of height growth of sycamore, sweetgum, and Nuttall oak seedlings. But when soil temperatures were rapidly increasing in mid-April, saturation for more than 10 to 12 weeks did severely reduce height, root, and stem-diameter growth. Saturation was more detrimental in Commerce silt loam than in Sharkey clay.

This note describes a pot study to determine the response of sycamore (*Platanus occidentalis* L.), sweetgum (*Liquidambar styraciflua* L.), and Nuttall oak (*Quercus nuttallii* Palmer) to planting in saturated soils. Commerce silt loam and Sharkey clay were selected for the study because they are typical alluvial soils of the Mississippi River batture and the slackwater clay area, respectively.

Most hardwoods withstand flooding in the dormant season, but few tolerate it during the growing season. Although many hardwood planting sites in the South are saturated during the planting season, most previous studies have dealt with seedlings that were flooded after establishment in well-drained soil.

PROCEDURE AND METHODS

Two 18- by 40-foot reservoirs, 15 inches deep, were dug and lined with thick polyethylene to make them watertight. After the reservoirs were filled with water to a 10-inch depth, 324 10-inch clay pots filled with Sharkey clay and a like number filled with Commerce silt loam were placed in the reservoirs.

One-year-old sycamore, sweetgum, and Nuttall oak seedlings were lifted from the Southern Hardwoods Laboratory nursery in early February 1962. Roots were pruned to 6 inches and were washed free of all soil and organic matter. Root dry weights for all seedlings were estimated from root volumes as measured by water displacement. Relations between root volume and root weight were computed from 100 samples of each species.

[1] Stationed at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Miss., in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group. The work was done as partial requirement for the Doctor of Forestry degree at Duke University. The author thanks Dr. P. J. Kramer for advice before and during the research.

On February 9, 1962, 54 seedlings of each species were planted in individual pots of each soil in each reservoir. These seedlings were divided into nine treatment groups of six seedlings each. Original heights and stem diameters at the soil surface were recorded. One group, the check, was taken from the water immediately, and every 2 weeks for 16 weeks an additional group was removed. After pots were removed from a reservoir they were allowed to drain, then placed in the open where they received rain, plus artificial watering when needed.

Date of bud-break, date of height-growth initiation, and weekly height growth were noted. Final measurements of survival, height, and stem diameter were made on August 4, 9 weeks after the last seedlings had been drained. The root systems of all live seedlings were washed free of soil, and their dry weights were obtained after drying at 65° C. in a forced-air oven for 24 hours. Since the species studied sprout readily, a seedling was considered dead only if the roots as well as the top appeared to be dead.

Soil temperatures 3 inches below the surface were taken weekly with 22 mercury-bulb soil thermometers randomly distributed among all treatments. These measurements were intended to detect radical changes in soil temperature during the study rather than furnish detailed temperature records.

For observation of new root growth, 16 additional pots, each with three seedlings, were established with each soil for each species on February 13. Forty-eight pots contained Sharkey clay, and forty-eight contained Commerce silt loam. Half of the pots were placed in a reservoir, and half were not. A pot of each species in each soil was first removed from the reservoir and the check area on February 23. Roots were washed free of soil, and the total length of white, unsuberized rootlets was measured. This procedure was repeated every 2 weeks when a group of pots in the main study was drained.

Relative leaf moisture stress was measured on selected seedlings at various times by the relative turgidity method (7). Ten leaf disks, 0.7 cm. in diameter, were taken from each seedling, weighed to the nearest 0.1 mg., and floated in distilled water in petri dishes for 4 hours under 100 foot-candles of light. The disks were then blotted dry between eight sheets of Whatman No. 1 filter paper pressed together with a 2,500 g. weight, reweighed, and dried for 24 hours at 65° C. in an oven. Relative moisture stress was expressed as water deficit (WD):

$$WD = \frac{\text{Turgid weight—fresh weight}}{\text{Turgid weight—oven-dry weight}} \times 100$$

RESULTS

Bud-break and initiation of height growth.—Sweetgum buds broke an average of 16 days after planting; sycamore, 26 days; and Nuttall oak, 75 days. The first terminal growth appeared an average of 46 days after bud-break for sweetgum, 36 days for sycamore, and 14 days for Nuttall oak. Neither bud-break nor initiation of height growth were influenced by soil or saturation treatment.

Survival.—Survivals averaged 89.8 percent for sycamore, 94.0 for sweetgum, and 95.4 for Nuttall oak; they were not influenced by saturation.

Seedling growth.—Long saturation significantly decreased terminal, stem diameter, and root growth (fig. 1). In general, saturation for 10 weeks was required for large decreases in growth. A rapid rise in temperature (from 60° to 80° F.) of the saturated soils also occurred about 10 weeks after planting. A few weeks of saturation after planting seemed beneficial to growth.

Several differences between species were noted. Sycamore, for instance, made the best overall growth, but prolonged saturation curtailed its terminal growth more severely than that of other species. Nuttall oak did poorly in Commerce silt loam, especially in terms of root growth. There was no significant species effect in stem-diameter growth.

Seedlings that spent long periods in saturated soil had few lateral branches. Their foliage was small and often chlorotic.

Initiation of root growth.—In well-drained pots, new root growth started approximately 4 to 6 weeks after planting, and all three species had 20 to 40 cm. of white, unsuberized rootlets per seedling by mid-April. In saturated soil only sycamore roots grew appreciably. After 10 to 12 weeks, seedlings averaged about 25 cm. of growing root tips in saturated Sharkey clay and 12 cm. per seedling in saturated Com-

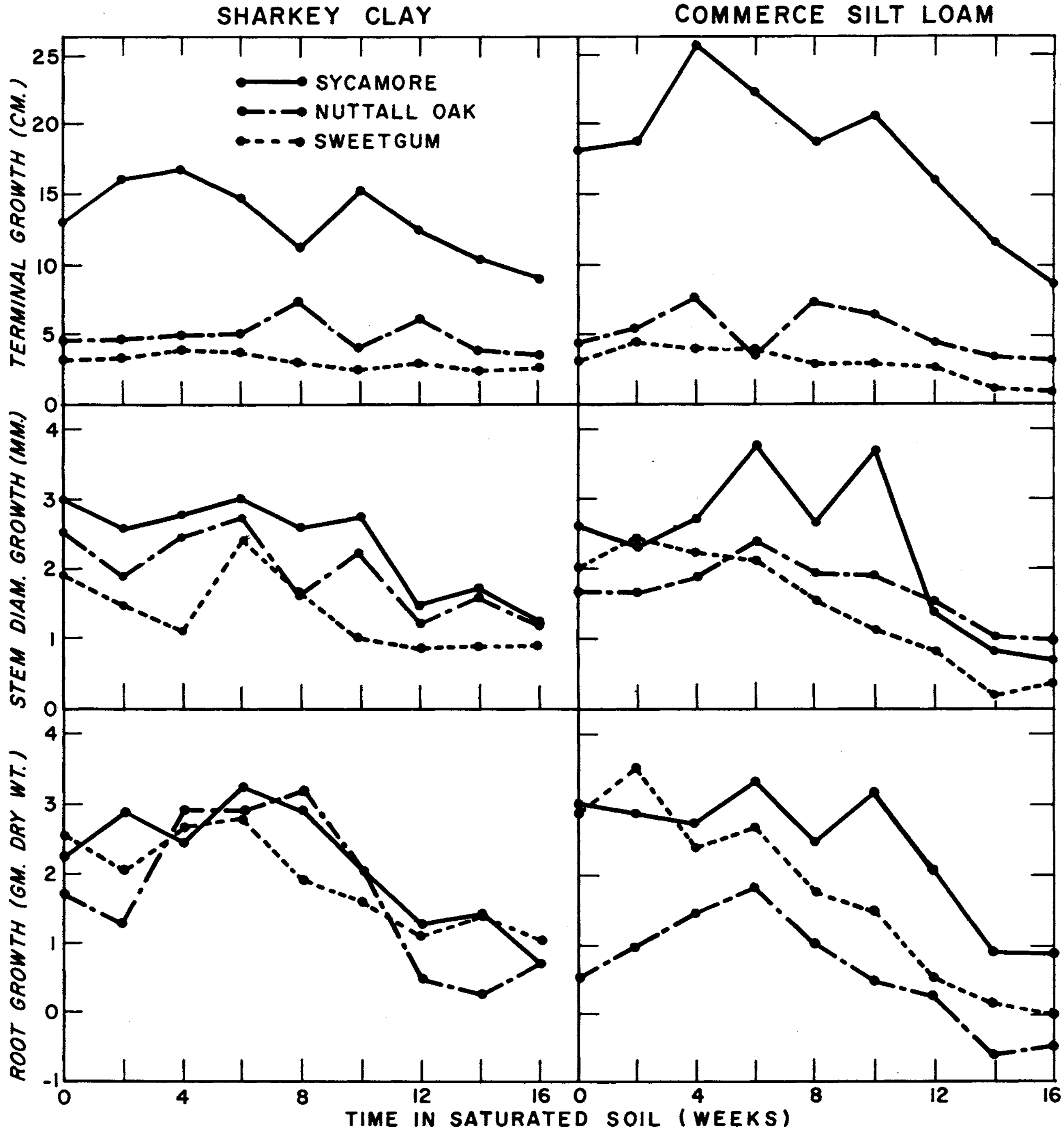

Figure 1.—*Growth responses to soil saturation, by species.*

merce silt loam. Sweetgum and Nuttall oak never had more than 10 cm. of growing root tips per seedling in Sharkey clay, nor more than 3 cm. in Commerce silt loam.

Relative leaf moisture stress. — Leaf WD measurements on May 17 and June 16 showed that soil saturation was detrimental to the water balance of most seedlings, especially those on Commerce silt loam. On May 17 all seedlings had slightly higher leaf WD values in saturated than in drained soils, except sycamore in Sharkey clay and Nuttall oak in Commerce silt loam. On June 16, 2 weeks after drainage, seedlings grown in saturated Sharkey clay for 16 weeks had leaf moisture stresses similar to those of check seedlings, but seedlings grown in saturated Commerce silt loam had consistently higher WD values than their checks (table 1).

Table 1.—*Leaf water deficits (WD) of seedlings in percent (sampling time was 11:00 a.m. to noon)*

SPECIES	SHARKEY CLAY		COMMERCE SILT LOAM	
	DRAINED	SATURATED	DRAINED	SATURATED
		May 17, 1962		
Sycamore	12.8	11.8	12.2	14.6
Sweetgum	11.6	13.2	11.4	16.1
Nuttall oak	16.0	22.5	24.1	20.7
		June 16, 1962		
Sycamore	12.9	[1]13.7	10.2	[1]16.1
Sweetgum	12.4	[1]12.2	13.0	[1]16.1
Nuttall oak	18.7	[1]18.7	17.2	[1]19.5

[1]Measurements taken 2 weeks after drainage.

DISCUSSION

All three species have been described as rather tolerant of flooding (*3, 4, 5, 6*). The present data do not conflict with previous evaluations if survival alone is considered, but they do show that extended periods of soil saturation from the time of planting can reduce shoot and root growth considerably. The "critical period" of soil saturation in this study was 10 to 12 weeks, but soil temperature probably strongly influences its length.

The apparent benefit to growth of several weeks of soil saturation (fig. 1) may not be real. Supplemental irrigation from overhead sprinklers following drainage may not have been sufficient to allow maximum growth, and may have reduced growth by compacting the soil.

Although drought effects were not measured directly, decline in root growth in saturated soil and increases in leaf moisture stress after saturation indicate that a drought immediately after drainage may be very damaging to seedlings planted in saturated soil. This kind of damage has been observed on larger trees (*1, 2*).

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