Physiographic Seed Source Variation in Tupelo Gums Grown in Various Water Regimes

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Abstract.--- One-year-old swamp tupelo and water tupelo seedlings were grown for one growing season in six artificially imposed water regimes with replications in two consecutive years. Height growth, leaf dry weight, total dry weight, stem form A (in flood zone), and stem form B (above flood zone) were measured. Results showed that height growth and dry weight varied significantly between some seed sources for each species. Both height growth and dry weight were lower in intermittent and continuous flooded treatments than under continuous surface saturated treatments. With the exception of one seed source from each species, dry weight production was less in the intermittent flooding than continuous flooding treatment. Stem form (butt swell) appeared to be related more to the presence of flooding than to seed source.

Physiographic characteristics of different types of swamps may impose rigid limitations on seed selection for tupelo regeneration. Swamps that differ in such characteristics as soil origin, water origin, degree of flooding, and type of flooding frequently occur in a relatively small locale in the coastal plain. Consequently, the possibility of seed source variation in tupelo gums is greatly increased in local areas. First year germination and height growth of tupelo seedlings vary significantly between various physiographic seed sources when grown in the nursery bed environment.

This paper reports on a test of variation in growth and morphology of swamp tupelo, **Nyssa sylvatica** var. **biflora** (Walt.) Sarg.; and water tupelo, **N. aquatica L.**, from different physiographic seed sources when grown in various water regimes.

METHODS

The study was carried out in the hydro-edaphytron at the Santee Experimental Forest, Berkeley County, S.C. This facility was designed primarily for study of wetland problems, consequently control of water and soil is its main and most flexible asset. The structure consists of six growing compartments (6 x 6 x 6 feet) and their flood tanks, which abut each compartment on the **north** and south sides and allow for water flow from left to right (fig. 1). We can control water flow and level at any depth in the soil by perforated holes in the walls adjacent to flood tanks. Water can be moved over the soil and through the soil

FIGURE 1. An end view of five of the growing comportments of the hydro-edaphytron just prior to planting seedlings in 1965. Flood tanks abut each compartment on the left and right side.

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both horizontally and vertically by controlling the side drain and central drain in each compartment. Water is circulated through the system by either of two pumps. A large pump (2400 gal./min. capacity) is used for rapid water flow and a smaller pump (250 gal./min. capacity) for slow flow rates. Water is obtained from a deep well and is stored in a large central storage tank. The same water is recirculated through the treatments to lessen salt accumulation in the soil.

Species were randomly positioned to either the east or west side of each compartment (fig. 2). For each species, two 1-year-old seedlings from three physiographic seed sources were randomly placed in each row and column of a 6 x 6 Latin square. Each compartment had two Latin squares and each seedling had a 6 x 12 inch growing space.

Selection of seed source was based on preliminary analysis of nursery observations. The seed sources were:

WATER TUPELO

(RR) Red River Source
- (1) Santee River
- (2) Pee Dee River

(BR) Black River Source
- (1) Edisto River
- (2) Black River

(NA) Non-Alluvial Swamp Source
- (1) Little Wambaw Swamp
- (2) Watson Hill Swamp

SWAMP TUPELO

(BR) Black River Source
- (1) Edisto River
- (2) Black River

(NA) Non-Alluvial Swamp Source
- (1) Ravenwood
- (2) Little Wambaw

(P) Pond Source
- (1) Jacksonboro-Cottageville
- (2) Strawberry Rd.

Treatments were designed so that we could compare differences in plant response under continuously flooded, intermittently flooded, and continuously surface-saturated treatments of both stagnant and moving water.

Treatments

I. Surface saturated continuously
- A. Moving water
- B. Stagnant water

II. Surface saturated 2 weeks, flooded 8 inches deep, one week, cyclic
- A. Moving water
- B. Stagnant water

II!. Flooded continuously, 8 inches deep
- A. Moving water
- B. Stagnant water

The treatments were started in late April 1964 on the first replication and in early March 1965 on the second replication. They were both stopped in October of the respective years, and seedlings were harvested for measurements.

FIGURE 2. Swamp tupelo (left) and water tupelo (right) seedlings in continuously flooded treatment in September 1965 Water was lowered to surface to illustrate seedling position and facilitate photograph ing.

The soil used was Lynchburg loamy fine sand, premixed and uniformly placed to a depth of 5 feet in each soil tank.

Height growth was measured periodically throughout the growing season for both years. In 1965, we estimated dry weight gain by correlations between fresh weight and oven dry weight at planting and harvesting time. Correlations varied from r= 0.96 to r= 0.99. Leaves were collected each each year in early October and oven dry weight was measured. At harvest time, stem diameter was measured to the nearest 1/100 inch by calipers at 1/4, 6, and 9 inches above the ground line. Diameter at 1/4 inch was divided into diameter at 6 inches to give stem form in flood zone (stem form A), and diameter at 1/4 inch was divided into diameter at 9 inches to give stem form above flood zone (stem form B).

ANALYSIS

Each year's data and the combined two years' data were analyzed separately for each species by the Latin Square Analysis of Variance. Means for within seed source, between seed source, and seed source-treatment interaction were tested for significance by Duncan's Multiple Range Test.

The dependent variables tested for each species were initial height, height growth for season, leaf dry weight, total dry weight (less leaves), stem form A and stem form B.

RESULTS AND DISCUSSION

There were only a few significant within-and between-seed source variations when summed across treatment; however, there were numerous seed source-treatment interactions.

Water Tupelo

Height of seedlings immediately after planting showed significant within-and between-seed source variation. Seed source NA was significantly taller than seed source RR and BR, and seed sources BR and NA had significant within-source variation.

The dependent variables of height growth, leaf dry weight, increase in total dry weight, stem form A, and stem form B showed no consistent within-or between-seed source variation when summed across treatments.

The major interactions for water tupelo occurred in moving-water treatments. Growth was consistently better in continuous surface-saturated treatments for all seed sources and decreased with flooding; however, seed source NA did relatively better in dry weight production under intermittent flooding than did seed sources BR and RR. This trend was observed in leaf dry weight (combined analysis) and 1965 total dry weight (less leaves), but was essentially reversed in height growth (fig. 3). The reversal in height growth and dry weight response appears to be related to differences in diameter of seedlings for the different seed sources. Stem diameter at 1/4, 6, and 9 inches above ground (1965) responded the same for seed sources as total dry weight (fig. 3); that is, stem diameter at each position was larger for seed source NA in the intermittent treatment than for seed sources BR and RR.

Swamp tupelo

In 1965, seed source BR for swamp tupelo was lost due to insufficient seed. This reduced the sensitivity of our overall analysis by about one-

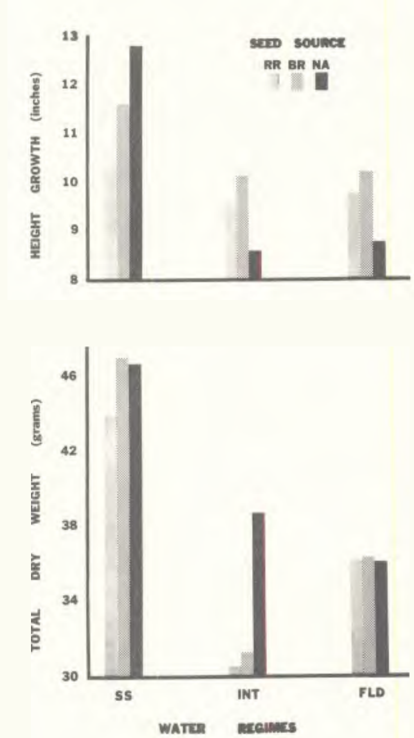

FIGURE 3. Interactions of the three water tupelo seed sources in height growth and 196 5 total dry weight (less leaves) with three moving-water treatment regimes: surface saturated (SS), intermittent flooding (Int.), and flooded continuously (Fld.).

half. Initial height of seedlings immediately after planting showed no seed source variation in the combined analysis and the separate 1965 analysis. In 1964, seed source NA was significantly taller than seed sources BR and P.

Height growth (combined analysis) of seed source NA was influenced more by the intermittent flooding treatment than seed source P (fig. 4). Leaf dry weight (combined analysis) showed no significant interactions with treatments, but increase in total dry weight (less leaves) in 1965 did show a significant interaction. Figure 4 also illustrates the reversed effect of intermittent flooding under stagnant conditions on height growth. The beneficial influence of the intermittent treatment under stagnant conditions can probably be attributed to flushing of toxic compounds from the soil and possibly to improved aeration.

Stem form showed only one instance of seed source variation in the combined analysis. Seed source NA had essentially the same stem form A in moving surface-saturated and intermittently flooded treatments us contrasted to a near linear increase in stem form A for seed source P (fig. 4). Stem form A reflects butt swell, which is so characteristic of tupelo gums. Implications are that degree of butt swell is related more to presence of water, either stagnant or moving, than to seed source.

and water tupelo seedlings do exhibit physiographic seed source variation under artificially imposed water regimes. How well these data apply to natural conditions is a moot question. We recommend that selections of seed for tupelo gum regeneration be made within physiographic swamp sites and not between such sites.

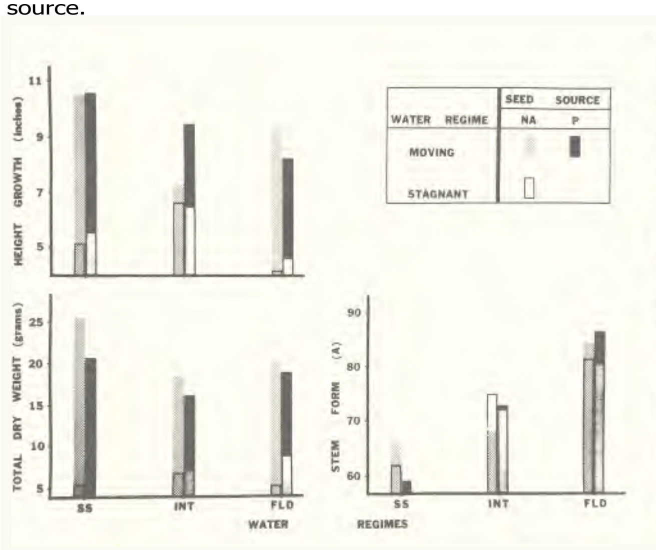

FIGURE 4. Height growth, total dry weight and stem form A for swamp tupelo under moving and stagnant water regimes.

FIGURE 5. Lenticel and water-root development on the flooded portion of a swamp tupelo stem that was flooded continuously by moving water for one growing season.

Increase in degree of flooding generally caused a negative effect in growth responses, but intermittent flooding was more detrimental than continuous flooding. Exceptions were seed source NA for water tupelo and seed source P for swamp tupelo-- growth of these seed sources decreased nearly linearly with degree of flooding.

Why would intermittent flooding be more detrimental to growth than continuous flooding? One explanation may be found in the adaptative qualities of these species to wetland sites. Both species develop prolific lenticels and water roots under continuous flooding (fig. 5) as contrasted to intermittent flooding (fig. 6). Gas exchange through lenticels is probably beneficial to root respiration under prolonged flooding. The role of water roots is not clear. Intermittent flooding treatments probably cause initiation of water roots and lenticel proliferation during the flooded period, and these new succulent organs were probably damaged by desiccation during the non-flooded period. This suggests that there may be a difference in development and tolerance of the adaptative qualities between seed sources.

Our observations indicate that swamp tupelo

FIGU RE 6. Lenticel development on a swamp tupelo stem that was intermittently flooded with moving water for one growing season.