SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-56

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

RESPONSES OF 1-YEAR-OLD COTTONWOOD TO INCREASING SOIL MOISTURE TENSION

F. T. Bonner [1]

SOUTHERN FOREST EXPERIMENT STATION

Cottonwood cuttings potted in sandy loam and clay soils showed a sensitive control of water loss as soil moisture tensions increased. Transpiration rates began decreasing at leaf water deficits of 2.5 percent in sandy loam and 4.5 percent in clay. There were no significant differences in rates per unit of leaf area or shoot dry weight between plants grown in the two soils. Terminal growth ceased when leaf water deficits reached 4 percent in sandy loam and 5 percent in clay.

Although cottonwood *(Populus deltoides* Bartr.) seems to require a relatively large amount of water for good growth, little is known about its basic water relations. This note describes a pot study to determine the effects of increasing soil moisture tension on shoot growth, transpiration, and leaf moisture stress in 1-year-old cottonwood grown in two soils of different textures.

[1] This work was done 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.

MATERIALS AND METHODS

In early January 1965, 100 cuttings 6 inches long from the "Rosedale 8" clone were taken from the Southern Hardwoods Laboratory nursery and stored at 38° F. In early April, each cutting was planted in a 6-inch clay pot; half were potted in sandy loam, half in clay. Each pot contained 1,850 g. of well-mixed soil, the moisture content of which was determined to allow for later estimates of soil moisture tension by weight.

The cuttings were placed in a covered lath house and watered daily. All plants were pruned to a single shoot when they sprouted. In late May, they were randomly placed in a controlled environment chamber and exposed to the following 24-hour regime: 12 hours light with 2,000 foot-candles at 90° F. and 60 to 70 percent relative humidity, and 12 hours darkness at 60° F. and 90 to 100 percent relative humidity. Each pot was enclosed in a polyethylene bag tied to prevent any moisture loss except by transpiration.

After a week of adjustment to chamber environment, terminal growth and transpiration were measured three times per week at the start of the light cycle. Transpiration was determined by loss of pot weight. At each weighing, distilled water was added to bring the soil to approximately 1/3 bar of moisture tension. Soil moisture retention curves developed with standard procedures (fig. 1) were used to relate moisture content by weight to moisture tension.

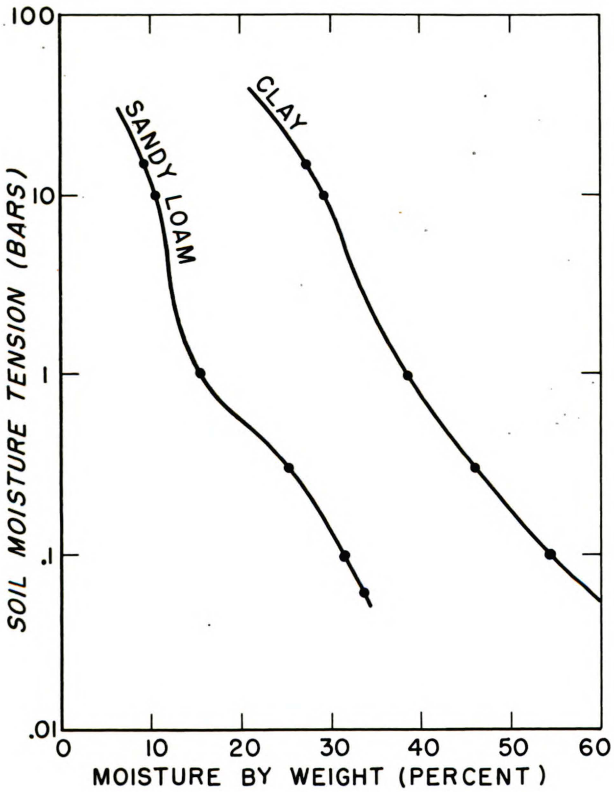

Figure 1.—*Relations of moisture tension to moisture content of the soils.*

After 3 weeks, the soil in all pots was adjusted to 1/3 bar of moisture tension during the dark cycle, and watering was discontinued. At the start of the following light cycle, five cuttings from each soil were randomly selected for measurement of: (1) transpiration, (2) terminal growth, (3) leaf water deficit, (4) leaf area, (5) shoot dry weight, (6) root dry weight, and (7) soil moisture content. The heights of all live shoots were recorded daily.

Similar measurements were made on five cuttings from each soil after 1, 2, 3, 4, and 7 days without water. In addition, five cuttings grown in clay were analyzed 10 days after watering ceased. The last cuttings were measured when they appeared to be almost dead.

Leaf water deficit was determined by a modification of Weatherley's method [2] on 10 disks, 0.8 cm. in diameter, which were cut from each of the two fully developed leaves nearest the terminal. The disks were weighed, floated in distilled water for 4 hours in 100 foot-candles of light, blotted dry between eight pieces of Whatman No. 1 filter paper under a 2,500 g. weight, and reweighed. Water deficit in percent (WD) was calculated from the formula:

$$WD = \frac{\text{Turgid weight} - \text{original weight}}{\text{Turgid weight} - \text{ovendry weight}} \times 100$$

Leaf areas were estimated from dot-grid counts of leaf outlines traced on paper. Plant dry weights were taken after drying for 24 hours at 65° C. Transpiration rate was calculated per $dm.^2$ of leaf area and per g. of shoot weight.

Gravimetric soil moisture data taken from two samples per pot were converted to soil moisture tension values with figure 1.

RESULTS

Because of differences in nutrient content as well as moisture characteristics of the two soils, cuttings grown in clay had larger shoots and roots, and more and larger leaves than cuttings grown in sandy loam (table 1). Under increasing soil moisture tension, terminal growth stopped abruptly when leaf water deficits reached about 5 percent in clay and 4 per-

[2] Weatherley, P. E. Studies in the water relations of the cotton plant. I. The field measurement of water deficits in leaves. New Phytol. 49: 81-97. 1950.

Table 1.—*Growth of cottonwood cuttings in controlled environment (Each value is the mean for 30 plants)*

Measurement	Unit	In clay	In sandy loam
Shoot height	cm.	61.3	33.6
Shoot dry weight	gm.	10.46	5.42
Root dry weight	gm.	2.17	.74
Total leaf area per cutting	$dm.^2$	8.97	4.22
Leaves per cutting	No.	19.8	14.9
Mean area per leaf	$dm.^2$	.45	.28

cent in sandy loam (fig. 2). The spurts of growth 7 days after watering ceased were the result of a malfunction in the growth chamber which sent the temperature up to 118° F. for several hours about 30 hours prior to height measurement.

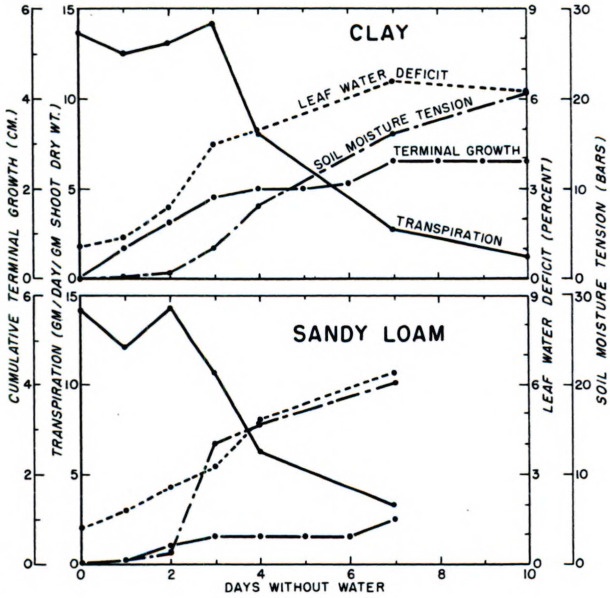

Figure 2.—*Responses of cottonwood cuttings to moisture deficiency.*

Transpiration was generally steady through the first 2 days without water for plants in sandy loam and 3 days without water for plants in clay (fig. 2). Soil moisture tensions during this period reached 2.2 bars in sandy loam and 3.5 bars in clay. Transpiration decreased with further increases in soil moisture tension. The larger plants in the clay transpired at almost double the rate of the plants in the sandy loam, but when transpiration was expressed on a leaf area or shoot weight basis, the rates did not differ significantly by soil type (table 2).

When transpiration rates began declining, leaf water deficits in the plants were 4.5 percent in clay and 2.5 percent in sandy loam. Plants were still transpiring when the last measurements were taken. Leaf water deficits averaged 6.3 percent, and soil moisture tension averaged 20 bars at this time.

Table 2.—*Transpiration rates of cottonwood cuttings expressed by two methods*

Soil	Sampling time (No. days without water)						Soil mean
	0	1	2	3	4	7	
	Gm./day/gm. shoot dry weight						
Sandy loam	14.3	12.2	14.5	10.7	6.3	3.5	10.2
Clay	13.6	12.5	13.1	14.2	8.2	2.8	10.7
	Gm./day/dm.² leaf area						
Sandy loam	16.3	14.9	17.5	14.5	9.0	4.9	12.8
Clay	14.0	14.7	15.5	15.1	10.1	3.5	12.4

As soil moisture tension increased, the bottom leaves on all plants became chlorotic, and small necrotic spots appeared on them. Finally, they abscised. The young leaves showed a definite advantage over older ones in the competition for moisture within the plant. Pronounced wilting was rarely observed.

DISCUSSION

The cessation of terminal growth at leaf water deficits of 4 to 5 percent in cottonwood indicates a sensitive control of water loss in response to moisture stress. In comparison, values were 6.9 percent for sycamore, 6.4 for sweetgum, and 8.9 for Nuttall oak in clay, and slightly less in silt loam.[3] Put in more general terms, cottonwood uses large amounts of soil moisture, but apparently reduces its needs at relatively low levels of moisture tension.

[3] Bonner, F. T. Reaction to soil moisture deficiency by seedlings of three hardwood species. Forest Sci. (submitted)