PINE SEEDLING SURVIVAL AND GROWTH RELATED TO MOISTURE RETENTION OF EIGHT TEXAS FOREST SOILS

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Loblolly *(Pinus taeda L.)* and shortleaf *(Pinus echinata* Mill.) pines reach the extent of their western distribution in east Texas. Mature specimens of these pines occur sporadically among the oaks in the "tension zone" or "pine fringe," the transition zone between the pine type and the oak-hickory type. This indicates environmental conditions that are occasionally favorable for the natural establishment of pine (1) . Seed source availability, soil characteristics, hardwood competition, and water table variability are very likely some of the interrelated factors responsible for the occurrences of scattered pine.

Though precipitation in east Texas is adequate (normally 40 to 50 inches annually, decreasing toward the west) for maintaining forest trees, droughts due to poor water distribution are so common that pine seedlings, whether natural or planted, usually suffer heavy mortality in their first year (4). Similarities in the soils of the oakhickory type and those of the pine region of east Texas were noted by Bray (2) with recommendations for establishing pine plantations in the oakhickory type. However, the mortality risks for pine plantations in that region are greater than in the pine region.

This study was to determine the response of loblolly pine seedling growth and survival to moisture retention characteristics of various soils from the east Texas pine and oak-hickory belts. Seedling growth and mortality during a drought were of special concern.

Materials and Methods

This greenhouse experiment consisted of two parts. First, pine seedling growth in the various soils was measured during favorable soil moisture conditions. Second, the effects of soil moisture stress upon the seedlings was observed.

Forty loblolly pine seedlings (1-0) were potted in each of eight soils. Six of the soils were obtained from the east Texas pine region in Nacogdoches

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TABLE 1.—*Texture and organic matter content of 15-cm. surface soil samples.*

Soil type	Soil-texture class	Sand	Silt	Clay	Organic matter
		Percent	*Percent*	*Percent*	*Percent*
Ruston	Sandy clay	47	12	41	2
Swift	Sandy loam	55	36	9	2
Sacul	Sandy loam	61	29	10	2
Shubuta	Sandy loam	62	27	11	6
Eustis-A*	Loamy sand	76	19	5	1
Troup	Loamy sand	83	9	8	2
Troup-A	Sand	90	5	5	2
Eustis	Loamy sand	82	11	7	1

*Soil types marked —A are from Anderson County; the others are from Nacogdoches County.

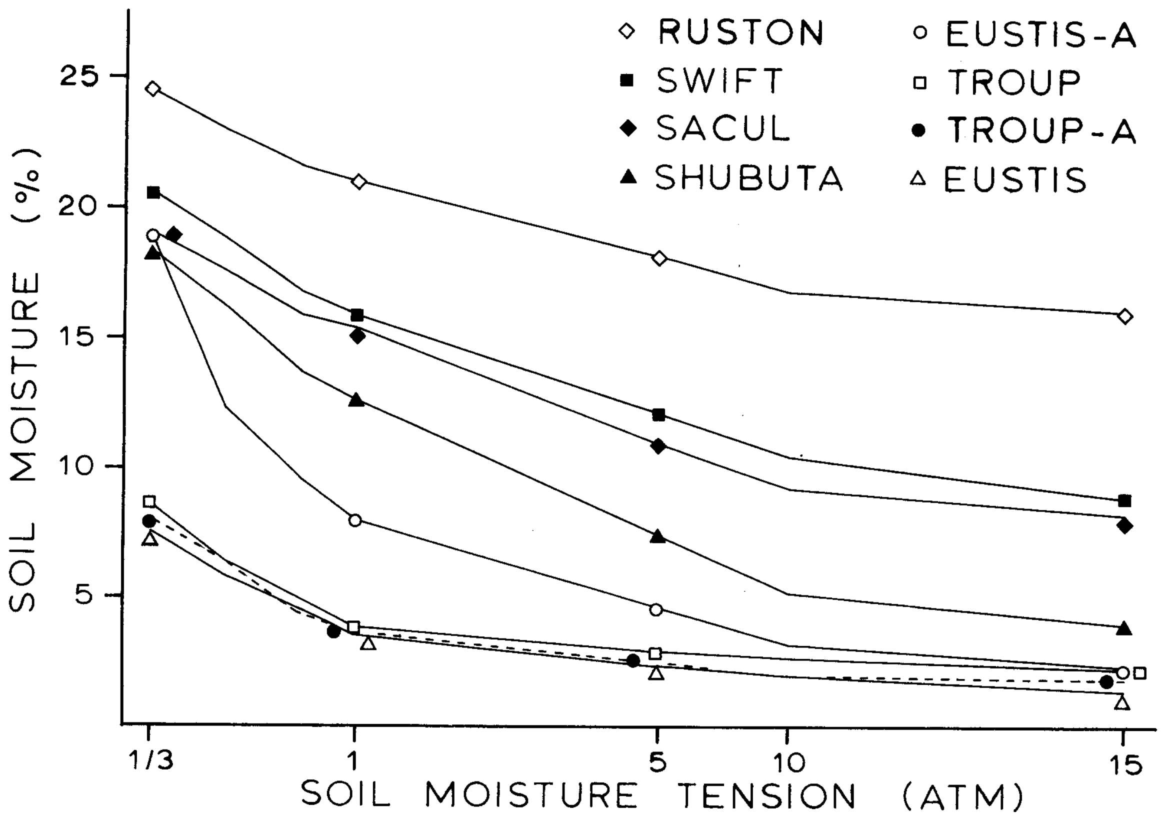

Figure 1.—Moisture retention values of the six test soils from Nacogdoches County and the two test soils from Anderson County (—A).

County (Eustis, Troup, Ruston-eroded phase, Sacul, Shubuta, and Swift series). Two others were taken from the oak-hickory belt in Anderson County (Eustis and Troup series, hereafter referred to as Eustis-A and Troup-A; those samples from Nacogdoches County will be referred to as Eustis-N and Troup-N). Surface samples (15-cm.) were obtained to approximate the root zone of newly planted seedlings. Analyses included determinations of texture (by hydrometer) and organic matter content (by ignition) (table 1) (7). Soil moisture constants at various tensions (1/3, 1/2, 3/4, 1, 5, 10, and 15 atmospheres) were determined by pressure membrane apparatus (fig. 1) on sieved samples.

Single seedlings were planted during the week of February 12, 1967, in 3.8-liter (1-gallon) metal containers coated with a rust inhibitor. The containers had no drainage holes. The seedlings were arranged in a randomized-block design with 10 blocks of 32 seedlings each and 4 replications of each soil type.

Initial seedling heights were recorded after planting, and height measurements were made periodically throughout the study. The two experiments encompassed both the first and second growth flush periods (March 1 to May 17, and May 17 to June 22, 1967).

At the beginning of each growth flush period, the pots were flooded and allowed to dry down to within 20 percent of field capacity (assumed at 1/3 atm.) by weight (3). The soil moisture contents were maintained within 20 percent of field capacity by periodic weighing and watering based on weight. It was hoped that soil moisture levels normal to field conditions and favorable to plant development would be maintained.

The first growth flush period was aimed at determining water use under nonstress conditions. Evaportranspiration was determined from the weights taken before and after watering. At the end of the first growth flush period, all seedlings were again measured for total height growth and reflooded to initiate the second experimental period.

During the second period, one-half of the seedlings were watered as before and water was withheld from the other seedlings. The seedlings subjected to soil moisture stress were randomly located throughout the blocks, and the different soils were equally represented under the two watering regimes.

Evapotranspiration and stem height growth measurements continued until June 22, 1967. Unwatered seedlings were observed until the last one died (July 15, 1967). The number of days after May 17, 1967, (date of dry-down initiation) required for these seedlings to die was recorded. Seedling death was determined visually with 65percent needle moisture content (ovendry weight) (5) at a check.

Results and Discussion

Seedling survival, growth, and evapotranspiration

in general showed a positive relationship to the moisture retention characteristics of the eight soils. The moisture retention curves appear to group according to the clay content of the sampled soils (fig. I and table 1) except for the Eustis-A soil. This, the sand fraction of soil, contained 84-percent fine and very fine sand, whereas the sand fraction of the Eustis-N soil contained only 39-percent sand in the fine and very fine sand class. The higher content of fine and very fine sand and the higher silt content may account for the high moisture retention at 1/3-atm. tension without affecting the moisture retention at 15-atm. tension.

With normal watering, seedlings grew somewhat more in height in sandy loams than in those soils with higher clay or higher sand content (table 2.) Likewise, water consumption in these soils was greater than in soils with higher clay or sand content. The Eustis-A soil with its large percent of fine and very fine sand also fell into this group. Total available water and soil aeration may have been related to these results.

While the performance of the seedlings in this study apppears to be roughly related to content of clay or sand, the soil moisture retention curves more accurately estimate the seedlings survival and height growth. For example, the Eustis and Troup soils from both Nacogdoches and Anderson Countries can be grouped on the basis of their textural analyses (table 1). However, the moisture retention curve of the Eustis-A soil is noticeably different from those of the Eustis-N and both Troup soils (fig. 1). Seedlings in this soil had a significantly higher rate of water consumption during both experimental periods and under moisture stress (table 2). During the second experimental period, significantly more height growth was observed in Eustis-A soil than in Eustis-N soil. The Eustis-A soil also yielded a significantly longer survival period under moisture stress than the Eustis-N soil. This may be an effect of the markedly different content of fine and very fine sand fraction in the two Eustis soils. The Eustis-A soil contained 84 percent of the total sand size in the fine and very fine sand fraction, whereas only 39 percent of the Eustis-N sand size was in this fraction.

Seedlings in soils with low moisture retention survived for significantly shorter periods than those in soils with high moisture retention (table 2).

TABLE 2.—*Average stem height growth and evapotranspiration for 1-year-old loblolly pine seedling with normal watering and under soil moisture stress. Average number of days until plant death is entered for seedlings having water withheld*

Soil type	First period		Second period				
	Normally watered		Normally watered		Water withheld		
	Height growth	E.T.[1]	Height growth	E.T.	Height growth	E.T.	Days until death
	Cm.	*Kg.*	*Cm.*	*Kg.*	*Cm.*	*Kg.*	
Ruston	11	1.70	3	1.98	1	0.86	42
Swift	13	1.94	4	2.14	1	0.70	38
Sacul	12	1.78	2	1.94	1	0.65	37
Shubuta	12	1.84	3	2.08	1	0.72	37
Eustis-A[2]	13	1.97	2	2.09	1	0.66	35
Troup	10	1.20	1	1.00	0	0.23	32
Troup-A	10	1.11	0	0.89	0	0.27	31
Eustis	11	1.13	0	0.87	0	0.25	30
D[3]	3	0.30	1	0.21	1	0.21	4

[1]Evapotranspiration. [2]Soil types marked—A are from Anderson County; the others are from Nacogdoches County. [3]Differences greater than or equal to *D* are significant at the 5-percent level.

Soils with high moisture retention values are likely to be better risks for pine planting than others with significantly lower moisture retention.

As in other similar tests, height growth was retarded during soil moisture stress, though the majority of the seedlings had completed their first growth flush when the moisture stress began (table 2). The second growth flush began for most of the seedlings during the second part of the experiment. Stransky and Wilson (6) found that growth was inhibited by soil moisture tensions not greater than 2 atm., growth stopped at 3.5 atm., and wilting occurred near 5 atm. The low-retention Eustis-N, Troup-N, and Troup-A soils showed no seedling growth under moisture stress.

Regression analyses of survival, and evapotranspiration during soil moisture stress on moisture percents of all the test soils at 1/3-atm. tension yielded correlation coefficients of +0.96**, and +0.99**, respectively; at 15 atm. correlation coefficients were +0.90**, and +0.75*, respectively. (One and two asterisks indicate significance at the 5-percent and 1-percent levels, respectively) . This indicates that 1/3-atm. or lower tension may provide a more accurate indicator of seedling survival and development than 15 atm.

Costly reforestation failures can be avoided in this or other areas of recurrent growing-season droughts through careful site selections. Although many soils of the east Texas pine type and the oak-hickory region are suitable for pine establishment, the moisture retention characteristics of these soils should be investigated to determine potential survival and development of 1-year-old seedlings and the extent of site preparation required prior to planting. Use of sieve analyses to determine fine and very fine sand content of the sand fraction are also encouraged in evaluating site suitability for reforestation.

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