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SURVIVAL AND GROWTH RESPONSE OF MESIC AND DRY-SITE SOURCES OF LOBLOLLY PINE SEEDLINGS TO CYCLIC SOIL MOISTURE DEFICIT [1]

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Abstract. A growth chamber study compared height, biomass, and mortality rate of 4 to 12 month-old loblolly pine (*Pinus taeda* L.) seedlings of mesic and dry-site seed sources to 7 cyclic soil moisture stress levels, averaging between -0.3 to -2.4 MPa. Soil moisture stress was monitored gravimetrically throughout each dry-down cycle until a predetermined soil moisture potential was reached; soil was then rewatered. Shoot height was measured at two-month interval, from 4 to 12 months after the emergence of the seedlings. The oven dry weight of the seedlings and their roots were used for biomass determination. Mortality was recorded every 2 months throughout the experiment.

Dry-site seedlings outgrew mesic seedlings in every soil moisture stress levels. Height growth declined with increasing moisture stress for both seed sources. The most abrupt reduction in height growth occurred between the nonstressed (-0.3 MPa) seedlings and those that grew under -0.6 MPa. Dry-site source produced more shoot biomass in all soil moisture stress levels.

Introduction

Water is one of the most important elements in plant growth and development. As described by Kramer and Kozlowski (1979), water is the solvent in which gases and salts are transported within the plant; it is a principal reagent in photosynthesis and it is necessary for maintaining turgidity of cells. Kramer (1983) mentioned that water deficits, in the long-run can reduce plant growth more than all other stresses combined. As soil moisture decreases, trees are subjected to prolonged internal water stresses which inhibit vital processes of growth. However, many plants seem to survive or grow well in regions where water is often inadequate. Such plants survive either because they avoid drought due to morphological or physiological modification which allows them to avoid or postpone desiccation or because these plants can tolerate some desiccation of their tissue.

Loblolly pine (*Pinus taeda* L.) ranges from south centeral Texas to Southern Delaware, a testimonial to its ability to adapt to widely differing environments. The isolated western-most limit of this natural range, Known as the "Lost Pines", receives 10-20 inches of rainfall a year less than the continuous range 200 miles to the east. Somehow, the "lost Pines" of semi-arid Bastrop, Caldwell, and Fayette counties, Texas survive on about one-half the rainfall of the main population (Wahlenberg 1960). It has also been shown that Lost Pines has several morphological and anatomical modifications which should tend to conserve moisture under droughty conditions (Knauf and Bilan, 1974; Knauf and Bilan, 1977). The physiological basis for such differences is poorly understood, however (Bongarten and Tesky 1986).

It is shown that Lost Pines seedlings have lower rate of transpiration and higher needle moisture potential under moisture stress conditions. signifying moisture conserving ability and tolerance features (Abdollahi, 1991). The search for a "drought-hardy" strain of loblolly pine is important because moisture stress imposed by drought, adverse sites, and competing vegetation largely determine the early performance of outplanted Southern pines (Ursic, 1961).

Experimental Methods

The experimental soil, a fine sandy loam, was collected from the surface 20 cm of a Psammentic Paleudult, in the Stephen F. Austin Experimental Forest. A Ceramic Pressure Plate Extractor was used to determine soil moisture retention. Soil moisture content was measured for pressure from 0.05 to 2.4 MPa. A curve was constructed to fit the obtained data (Figure 1). One hundred and sixty four-inch plastic pots were assembled for filling with the air dried

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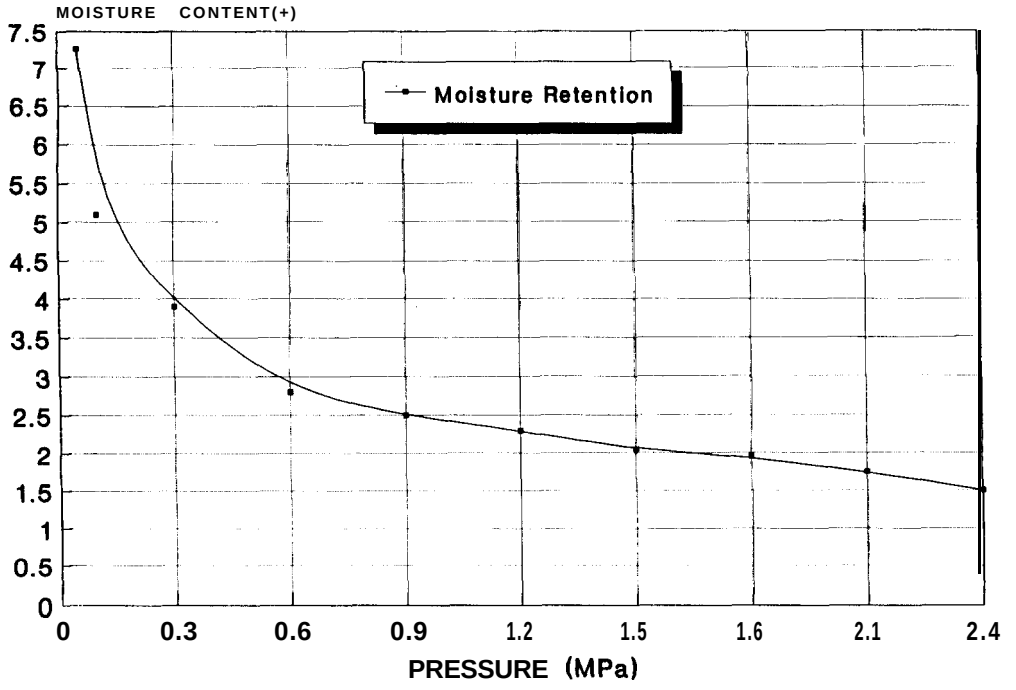

Figure 1. *Soil moisture retention curve for the experimental soil.*

experimental soil. Each pot was fitted with two 20 mesh, nylon screens to prevent soil from being lost through drainage; prewashed pea-size gravel was added to the pots until the combined weight of the pot, screen, and gravel reached 300 grams. An equal amount of oven dried soil was then added to bring the total weight of the pot, screen, gravel and soil to *720.0* grams.

Loblolly pine seeds from both East Texas (mesic) and Lost Pines (dry-site) seed sources were obtained from the Texas Forest Service. The seeds were stratified, and planted in the assembled pots. Each pot contained both seed sources. The experimental plants were grown for two months under favorable moisture conditions in a growth chamber. When the seedlings were two month old, each pot was randomly assigned to one of eight moisture regimes (3, 6, 9, 12, 15, 18, 21, 24 representing -0.3, -0.6, -0.9, -1.2, -1.5, -1.8, -2.1, -2.4 MPa). Throughout the study, soil moisture potential was estimated by weighing the pots each day and correlating soil moisture content with soil moisture potential. Watering weight was also adjusted for the increase in fresh weight of seedlings. All pots were subjected to cyclic moisture stress when plants were two month old. Each pot was weighed daily; and the number of drying cycles to which it had been subjected was recorded. When a pot reached the weight corresponding to its assigned moisture regime, it was watered with 150 milliliters of distilled water to bring the soil moisture to field capacity.

Shoot height was measured at two-month interval, from 4 to 12 months after the emergence of the seedlings. The oven dry weight of the seedlings and their roots were used for biomass determination. Mortality was recorded every 2 months throughout the experiment.

Results and Discussions

Height Growth

Cyclic soil moisture stresses of -0.6 to -2.4 MPa which were imposed on two month old seedlings of East Texas (mesic) and Lost Pines (dry-site) reduced subsequent height growth of both provenances. By the age of twelve months, height growth for both seed sources combined was reduced by 28% in -0.6 MPa regime and by 43% in -2.4 MPa regime (Table 1).

Although height growth declined with increasing moisture stress, the most abrupt reduction in height growth was found between the nonstressed seedlings (-0.3 MPa) and those growing under soil moisture stress of -0.6 MPa. The reduction in height growth between the control and -0.6 MPa constituted 28 %, while the additional reduction between -0.6 MPa and -2.4 MPa amounted only to 15%.

Table 1. *Results of t-test for the height growth (cm), shoot & root biomass of 12 month old loblolly pine seedlings grown in 8 soil moisture regimes for ten months.*

Moisture Regimes (MPa)	seed Source	Height Mean±S.E.	Biomass Shoot Mean±S.E.	Biomass Root Mean±S.E.
-0.3	ET	16.39f0.41	2.50k0.13	1.10±0.078
	LP	18.61±0.47***	2.89±0.12**	1.31±0.093*
-0.6	ET	11.70±0.40	1.70±0.14	0.60±0.056
	LP	13.62±0.33***	2.06±0.12*	0.84±0.031***
-0.9	ET	10.56 f0.48	1.45±0.08	0.78f0.167
	LP	11.74±0.40*	1.75±0.10**	0.86±0.056*
-1.2	ET	10.46 f0.54	1.60f0.16	0.59±0.096
	LP	10.58f0.57	1.78f0.12	0.91±0.123*
-1.5	ET	9.03 f0.38	1.28±0.09	0.58 ±0.300
	LP	11.58±0.41*	1.91±0.23**	0.82±0.073***
-1.8	ET	8.31 f0.43	1.31f0.10	0.52±0.036
	LP	9.92±0.50**	1.75±0.16**	0.71±0.045***
−2.1&-2.4	ET	8.82kO.23	1.17±0.12	0.39±0.031
	LP	11.15±0.14***	1.98±0.17***	0.67±0.063***

*: Significant at alpha .10 level; **: Significant at .05 ; ***: at .01 level. ET: East Texas seed souce (mesic); LP: Lost Pines seed source (dry-site).

Lost Pines (dry-site) outgrew East Texas (mesic) pines in every moisture regime and they exhibited a slightly lower rate in growth decline with an increase in moisture stress. The height growth reduction in -2.4 MPa moisture regime was 40% forlost pines as compared with 46% for East Texas seedlings.

Figure 2 demonstrates the trend in average height growth of loblolly pine seedlings from four to twelve month old regardless of the regimes. Average height growth of Lost Pines are higher than East Texas for all ages except four month old.

Biomass Accumulation

The results of t-test (Table 1) indicate significant' differences between the shoot biomass of seed sources at regime -0.3 MPa, -0.9 MPa, – 1.5 MPa, -1.8 MPa ($p \leq 0.05$); -0.6 MPa, -2.4 MPa ($p \leq 0.1$), and -2.1 MPa ($p \leq 0.01$). The Lost Pines seedlings had significantly greater shoot biomass than East Texas seedlings. The results (Table 1) also *revealed* significant differences between the seed sources at regimes -0.3 MPa, -0.9 MPa, – 1.2 MPa ($p \leq$ O.l), -0.6 MPa, -1.5 MPa, -1.8 MPa, and

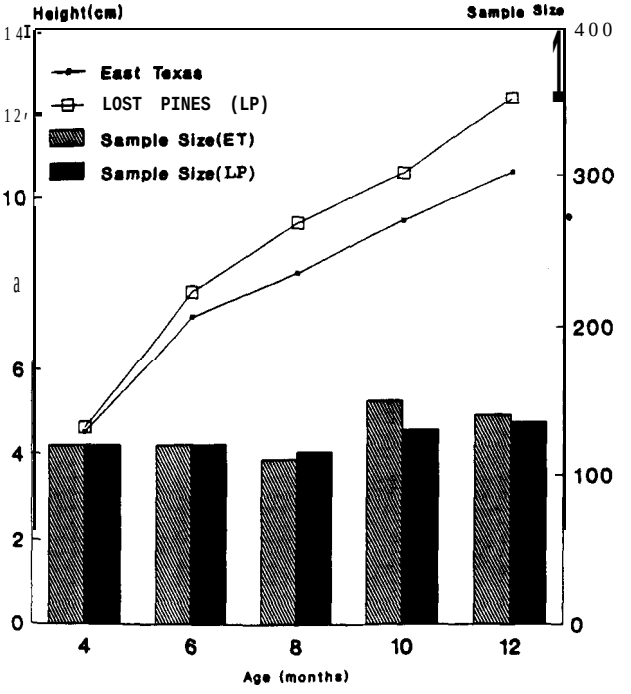

Figure 2. *Average height growth of loblollypine seedlings from 4 to 12 month old by seed source for combined soil moisture regimes.*

-2.4 MPa ($p \leq 0.01$). Roots of seedlings from Lost Pines had significantly higher biomass than that of East Texas seed source for all the regimes (eg. 19% at regime -0.3 MPa, 40% at regime -0.6 MPa, 16% at regime 0.9 MPa, 54% at regime – 1.2 MPa, 41% at regime -1.5 MPa, 36% at regime -1.8 MPa, and 71% at regimes -2.1 MPa & -2.4 MPa).

Seedling Mortality

Percent mortality for both seed sources during 12 months (Figure 3) increased as soil moisture stress increased, however, Lost Pines seedlings had a lower percentage mortality in all stress regimes. The highest mortality (5 1%) was exhibited by East Texas seed source under regime -2.4 MPa. The highest mortality exhibited by Lost Pines was 25.5% under stress level of – 1.8 MPa.

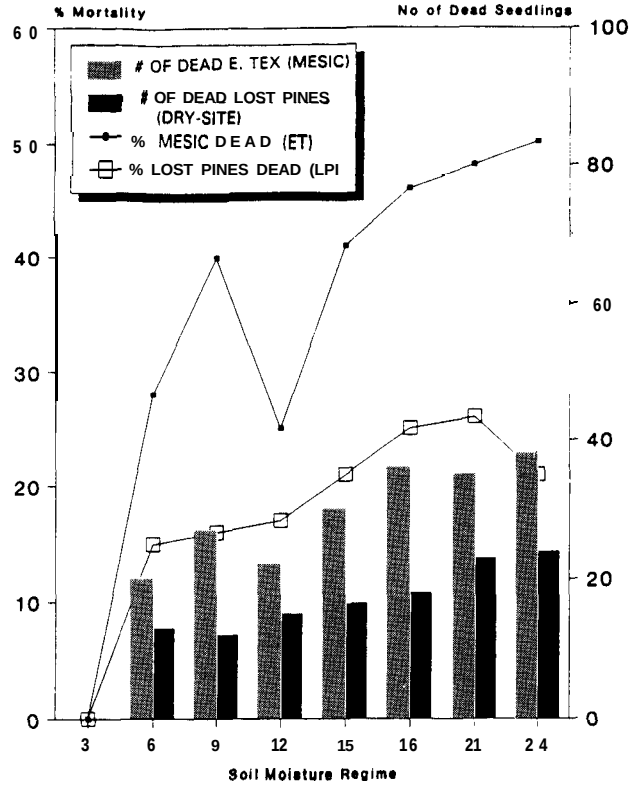

Figure 3. *Mortality of loblolly pine seedlings grown under 8 soil moisture regimes for twelve months.*

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