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Loblolly Pine Seedling Morphology and Production at 53 Southern Forest Nurseries

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*Seedling morphology of loblolly pines (*Pinus taeda *L.) was surveyed at 53 southern nurseries. Selected cultural and soil data are also given. A range of conditions were sampled at each nursery. Morphology varied widely among samples. Seedbed density and sowing date influenced seedling size.* Tree Planters' Notes 39(3):13-16; 1988.

Loblolly pine (*Pinus taeda* L.) is the most commonly planted tree in this country, with well over a billion seedlings produced each year. Loblolly pine seedling morphology can vary considerably, depending upon genotype, cultural practices, soil conditions, and numerous other environmental factors. As an example, Burns and Brendemuehl (2) found that seedling morphological grade varied considerably among three Florida State forest nurseries. Most importantly, seedling morphology can affect survival and growth upon outplanting (7, 9). Morphological measurements of seedlings have been reported in many research studies, but there is little information available on the morphology of loblolly pine seedlings produced operationally at forest nurseries across the South.

This paper reports the results of a survey of loblolly pine seedling production throughout the South. The objectives of this survey were to determine:

1. the range and distribution of loblolly pine seedling morphology produced at southern forest nurseries; and
2. any significant correlations of certain soil factors or cultural practices with seedling production and morphology.

Materials and Methods

During the second and third weeks in December 1982, four separate crews visited a total of 53 forest tree nurseries in 13 Southern States (fig. 1). Most of these nurseries were on the Coastal Plain. Three different sites within each nursery were chosen in order to examine a range of conditions. (In several nurseries, fewer than three samples were taken.) Each sample

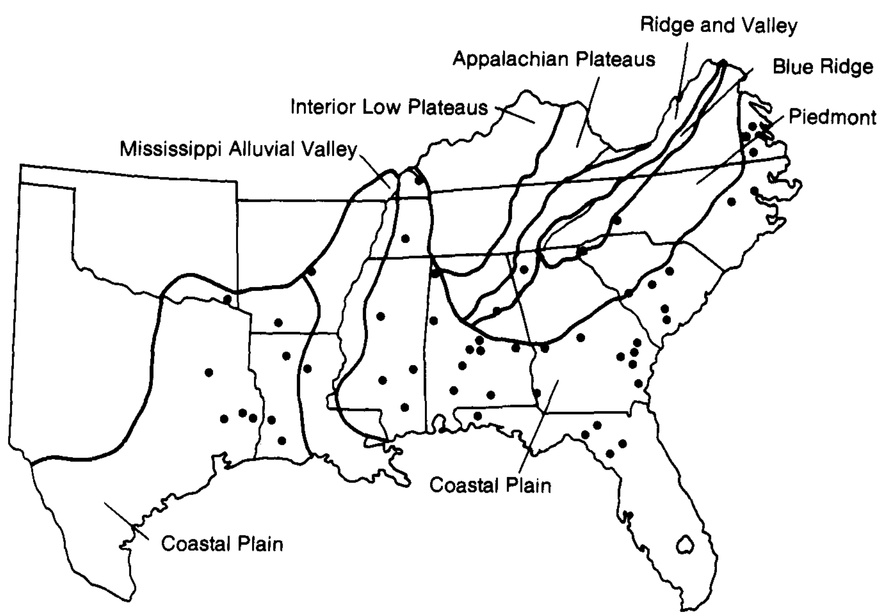

Figure 1—*Locations of sampled nurseries.*

Table 1—*Cumulative percentile distributions for 153 nursery samples in the Southern United States*

Seedling variable	Minimum value	Values for percentile 10th	25th	50th	75th	90th	Maximum value
Median sample height (cm)	7.0	15.3	19.0	21.0	25.0	28.0	31.0
Median sample diameter (mm)	1.1	2.5	2.8	3.3	3.7	4.0	4.5
Height/diameter (mm/mm)	38.1	51.4	60.9	70.0	79.5	87.5	113.6
Percent in quality grade[a]							
Grade 1	0.0	0.0	0.8	4.3	10.2	16.9	32.4
Grade 2	0.0	18.8	30.1	46.2	60.9	69.5	81.7
Lg. cull	5.4	15.3	24.0	35.7	49.2	61.4	82.7
Sm. cull	0.0	1.7	3.2	7.2	15.4	23.8	91.7
Weight (g DW/sample)							
Shoot	9.1	109.8	154.3	198.0	247.5	319.3	457.0
Root	1.9	35.4	45.0	54.5	68.0	101.0	157.1
Total	11.0	147.8	201.8	255.4	317.5	406.3	576.2
Shoot wt./root wt.	1.5	2.5	2.8	3.4	4.2	4.9	6.0
Total sample (g/g)							
Grade 1	0.8	2.1	2.5	3.1	3.9	5.0	6.8
Grade 2	1.4	2.4	2.9	3.4	4.1	4.9	6.0
Lg. cull	1.1	2.5	3.0	3.7	4.7	5.5	7.7
Sm. cull	0.3	1.8	2.8	4.1	5.7	7.9	31.0
Quality index[b]	0.03	0.12	0.15	0.21	0.27	0.34	0.52
Basal area (cm²/sample)	0.4	5.7	8.0	10.7	13.4	16.1	21.1
Density (no./sample)	36	77	98	122	140	168	234
Sowing date (mo./day)	3/26	4/5	4/8	4/19	5/1	5/6	6/7

[a]Grade 1 = ≥ 4.8 mm diameter, grade 2 = 3.2–4.7 mm, large culls = 2.0–3.1 mm, small culls = < 2.0 mm.
[b]Quality index equals the average seedling weight in grams (shoot plus root) divided by the sum of the shoot–root ratio and 0.1 of the height–diameter ratio.

Table 2—*Cumulative percentile distributions for average seedling weights*

Seedling variable	Minimum value	Values for percentile 10th	25th	50th	75th	90th	Maximum value
Weight (g DW/seedling)							
All							
Shoot	0.25	1.03	1.33	1.67	2.16	2.56	3.37
Root	0.05	0.30	0.37	0.50	0.59	0.78	1.29
Total	0.31	1.41	1.67	2.14	2.74	3.35	4.17
Grade 1							
Shoot	0.70	2.48	3.23	4.10	4.80	5.81	9.90
Root	0.30	0.70	1.00	1.25	1.53	1.90	4.02
Total	1.20	3.40	4.43	5.40	6.24	7.47	13.80
Grade 2							
Shoot	1.17	1.63	1.85	2.19	2.51	2.77	3.33
Root	0.31	0.48	0.52	0.61	0.73	0.89	1.55
Total	1.62	2.16	2.47	2.88	3.16	3.56	4.28
Lg. cull							
Shoot	0.35	0.73	0.88	1.09	1.32	1.53	2.02
Root	0.09	0.19	0.23	0.28	0.37	0.47	0.79
Total	0.44	0.97	1.14	1.37	1.68	1.97	2.42
Sm. cull							
Shoot	0.05	0.21	0.30	0.43	0.52	0.70	1.20
Root	0.01	0.04	0.07	0.10	0.16	0.20	0.90
Total	0.09	0.27	0.40	0.53	0.69	0.86	1.60

Table 3—*Cumulative percentile distributions for selected soil variables*

Soil variable	Minimum value	Values for percentile					Maximum value
		10th	25th	50th	75th	90th	
≥ 75% Sand (60 samples)							
Organic matter (%)	0.5	0.6	0.8	1.2	1.5	2.2	2.5
CEC (meq/100 g)	1.0	1.2	1.5	1.9	2.3	2.7	3.4
pH	4.5	5.0	5.2	5.4	6.0	6.1	6.4
Bulk density (g/cm³)	1.2	1.3	1.3	1.4	1.5	1.6	1.6
50–75% Sand (68 samples)							
Organic matter (%)	0.8	1.2	1.3	1.6	2.1	2.6	3.2
CEC (meq/100 g)	1.3	1.9	2.5	3.0	3.5	3.8	4.6
pH	4.8	5.1	5.3	5.5	6.0	6.4	6.9
Bulk density (g/cm³)	1.0	1.2	1.3	1.4	1.5	1.6	1.7
<50% Sand (25 samples)							
Organic matter (%)	1.1	1.3	1.4	1.7	2.0	2.5	2.8
CEC (meq/100 g)	2.4	3.3	4.5	5.3	6.2	7.0	7.8
pH	5.0	5.1	5.5	5.8	6.4	7.1	7.2
Bulk density (g/cm³)	1.0	1.2	1.2	1.3	1.4	1.5	1.7

consisted of the seedlings lifted from 1 linear foot of seedbed.

Seedlings were lifted by hand, and each sample was labeled *good, poor*, or *average* according to the nursery manager. At each seedling sample location, soil from the surface 15 cm was collected for determination of sand content, pH, cation exchange capacity (CEC), and organic matter and nutrient content. Soil bulk density and infiltration rate were also measured at these locations. For each sample, density (seedlings per linear foot of seedbed) and sowing date were recorded. Soil samples were analyzed by A&L Laboratories, Memphis TN.

Stem height and root collar diameter were measured on individual air-dried seedlings. Seedlings were separated into four grades (based on root collar diameter) and ovendried at 70 °C. Seedlings from each grade were combined for measurement of total shoot and root weights.

Calculations were then made of height-diameter ratio (5), shoot-root ratio, average seedling weight (shoot, root, and total), total sample biomass, percentage of the sample in each seedling grade (as measured by diameter), and a "quality index." The quality index is equal to the average seedling dry weight (shoot plus root) divided by the sum of the shoot-root ratio and 0.1 of the height-diameter ratio (3).

Distributions of the seedling variables are shown as percentiles (tables 1, 2, and 3). The value given for a particular percentile is higher than the values for that percentage of the samples. For instance, in the first entry in table 1, 25% of the samples had a median height below 19 cm. Correlation coefficients were calculated between seedling data and soil and cultural data to determine which factors influence seedling production most strongly.

Results and Discussion

Seedling production and morphology among the 53 nurseries varied considerably (table 1). Most nurseries were producing very few grade 1 trees. For example, 50% of the samples contained 4.3% grade 1 seedlings or less. Table 2 shows that, even within grades, morphology (seedling weight) can vary widely.

For instance, average root weight for grade 1 trees ranged from 0.3 to 4 g. As seedling grade decreased (from grade 1 to cull), shoot-root ratio tended to increase (table 1). This illustrates that grade 1 seedlings are larger by weight and direct more of their energy into root development than grade 2 or cull seedlings.

Correlations between soil variables and seedling morphology were generally poor, with correlation coefficients less than 0.27. Seedling size decreased slightly with higher levels of potassium, calcium, and manganese. It may be that these results are confounded with other factors. Bulk density was the only other soil factor that was correlated with seedling variables; high bulk densities were associated with poorer seedlings.

Of the samples taken from nurseries with at least 50% sand, 25% had a bulk density of greater than 1.5 g/cm^3. Distributions for bulk density, CEC, organic matter, and pH are given in table 3. For a more complete description of the distributions of soil nutrient levels in southern forest nurseries, see South and Davey (6). Likewise, the reader is referred to Boyer and South (1) for distributions of loblolly pine seedling nutrient levels.

The highest correlations were between seedbed density and total sample biomass (r = 0.54), basal area (r = 0.55), and height-diameter ratio (r = 0.49). Correlations between seedbed density or sowing date and most morphological measures were highly significant. When these correlations were examined, it was found that lower seedbed density and earlier sowing date resulted in larger and heavier seedlings with a higher quality index. Dry weight and shoot-root ratio of loblolly pine seedlings have been shown to be related to seedbed density, with weight decreasing and shoot-root ratio increasing with increasing density (4). Burns and Brendemuehl (2) found that seedling size decreased with increasing density, with the proportion of large high-grade seedlings reduced and the proportion of small cull seedlings increased at greater seedbed densities.

Van den Driessche (8) reported that not only do seedling dry weight and stem diameter decrease as seedbed density increases, but the tree percent, or number of seedlings obtained from a given amount of seed, also decreases as density increases. He also stressed the importance of sowing as early as possible in the spring. A week or two gained in the spring has a disproportionately large effect on seedling morphology at the end of the season because of the exponential nature of seedling growth.

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