Auburn University
Southern Forest
Nursery Management
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RESEARCH REPORT 03-08

INITIAL GROWTH OF LOBLOLLY PINE IN RESPONSE TO NURSERY STOCK AND OUTPLANTING SPACING

By
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INTRODUCTION

It is well known that seedbed density affects seedling performance. Seedlings grown at densities less than 20 ft^{-2} outperform seedlings grown at densities of 25 ft^{-2} (South 1993). In some cases, the height gain (at age 7 years) attributed to planting greater performing seedlings can be 1 to 3 feet for loblolly pine (*Pinus taeda* L.) (South and Rakestraw 2004).

From an economic point, there is a relationship between outplanting density and seedling quality. Morphologically improved seedlings grown at 16 ft^{-2} cost more to produce than seedlings grown at 25 ft^{-2}. For example, some nurseries charge 0.7 cents more for a seedling that is grown at a 16 ft^{-2}. However, the difference in cost will vary with nursery practices used. For example, sometimes a “culling crew” is used to cull seedlings lifted from high density beds but at low seedbed densities culling is sometimes not required. The retail price can also vary depending on if the nursery is producing seedlings primarily for internal use or for external sales (Caufield et al. 1987).

At current prices, the cost of seedlings grown at 25 ft^{-2} could be 4 cents each and those grown at 16 ft^{-2} may be 4.7 cents each. Assuming machine planting on 12 foot rows costs $50 per acre, then planting 606, 4-mm seedlings might cost $74.24 to plant while 303, 6-mm seedlings might cost $64.24. In this case, a landowner could reduce the cost of establishment by planting fewer higher quality seedlings. The question then becomes what are the results from reducing stocking when planting high-quality seedlings.

A number of studies have been conducted to determine the effect of seedling size on growth of loblolly pine (Wakeley 1969, Sluder 1979, South et. al.1985, Dierauf 1993, South et. al. 1995). All of these studies separated seedling sizes into seedling grades rather than growing seedlings at two different seedbed densities. This is the first published study that varies both nursery bed density and outplanting density. When valuable planting stock is used, the economic justification for planting more trees than needed is reduced (MacLaren 1993; South 1993).

MATERIALS AND METHODS

Seedlings were grown at the Buena Vista Nursery in Buena Vista, GA. Seed was obtained from a 1.5 generation Atlantic Coast seed orchard. Two bed densities (25 and 16 seedlings per square foot) were established in separate blocks in the nursery (i.e. density was not replicated). At time of lifting, 60 seedlings from each bed were sampled and measured for heights and diameters. Shoots and roots were oven-dried for 72 hours and roots were separated into laterals and taproots. The remaining seedlings were planted on a cutover site in Macon County, AL on January 11, 2001. Three planting spacings were used; 6 x 12 feet (605 trees per acre), 8 x 12 feet (454 trees per acre), and 12 x 12 feet (303 trees per acre). Site preparation consisted of shearing and raking in June 1999. In May of 2000, the area was aerially sprayed with 48 oz. of Chopper® herbicide and 1 qt. of Accord® per acre. A single bed was formed in July 2000. Seedlings were hand-planted on January 11, 2001.

A completely randomized factorial block design was established with planting stock (i.e. bed density) as one factor and initial planting density as the other factor. Four blocks were established for a total of 24 measurement plots. There were 96 trees per plot with 72 measurement trees.

A banded herbicide of 13 oz./acre of Oustar® was applied on May 1, 2001 and again on April 25, 2002. The soils are moderately well drained, clayey, with high montmorillonite content. Diameter at breast-height (DBH) and total tree height were measured in April of 2003. Individual tree volume was calculated using the formula: 0.0496+0.001962*(DBH*DBH)*height (VanDusen et al. 1981). It was assumed trees shorter than 4.5 feet have no basal area and no volume.

The NCSU Managed Pine Plantation Growth and Yield Simulator (Hafley and Buford 1985) was used to predict stand development to age 20 years (given stand stocking at age 2). Mature wood formation is assumed to begin 15 years after planting. Seedlings grown in low-density seedbeds were assumed to achieve a 6-month advance in stand development.

RESULTS

At lifting, seedlings from the low-density beds were larger than seedlings grown at 25 ft^{-2} (Table 1). All seedling variables at time-of-planting were significantly different (t-test; $\alpha = 0.01$). After two years in the field, morphologically improved seedlings were taller and larger in DBH than the regular seedlings (Tables 2, 3). As expected, larger seedlings at time-of-planting increased the number of trees taller than 4.5 feet at age 2. Morphologically improved seedlings (those grown at 16 seedlings per square foot) were about 0.5 feet taller on average than regular seedlings (Table 4).

The percentage of trees taller than 4.5 feet (DBH) was not affected by initial planting density (Table 5). However, as expected, the number of trees with a DBH was positively related to the number of surviving trees per acre.

The NCSU simulator indicates total volume at age 20 is related to tree spacing (Table 6). Regardless of spacing, the amount of basal area in juvenile wood was about 70%. In this example, doubling the number of seedlings planted (from 303 to 605) increased the merchantable volume by only 18%. However, this increase in total volume resulted in a 72% decrease in sawtimber volume. As a result, the higher stocking reduced overall stand value by 7 to 13%.

DISCUSSION

Recommendations regarding the "correct" number of loblolly pine seedlings are often based on traditional beliefs (South 2003). Rarely are such recommendations based on an economic analysis that involves planting morphologically improved seedlings (e.g. South et al. 2001; South 2003). As a result, landowners in the southern United States typically purchase 4-mm seedlings and outplant twice as many pines as landowners in New Zealand (in New Zealand, landowners often plant 320 seedlings per acre). In New Zealand, McLaren (1993) says that "High initial stockings [486-809 trees/ac] are expensive because of the cost of seedlings, planting, weed-control, etc., as well as the cost of thinning the surplus trees, if they are not to be extracted and sold."

The economic incentives for planting morphologically improved seedlings are greater when planting 303 trees per acre vs. 605 trees per acre (South 1993). In our example, a 6-month gain in stand development increased stand value by $151 per acre at a cost of only $2.13 per acre (Table 6). At a 6% interest rate, this amounts to a benefit cost ratio of 22 (i.e. $47.08/$2.13).

One factor that should not be overlooked is that it can be less expensive to plant morphologically improved seedlings at 303 trees per acre than to plant regular seedlings at either 454 or 605 trees per acre. This can result in a win-win situation by lowering establishment costs while increasing the volume in more valuable 11 to 13 inch logs (Figure 1).

This study can provide insights into the realized age-shift gain attributed to planting morphologically improved seedlings. It has been estimated that planting morphologically improved seedlings (with 6 mm RCD) can sometimes result in a 1-yr "age-shift" when compared to regular seedlings with 4 mm RCD (South 1993). The Macon County study clearly shows an age-shift in stand development has occurred. The percent of trees reaching a height of 4.5 feet was increased by planting morphologically improved seedlings instead of regular seedlings. The average height increase after two years in the field was 0.5 feet. Future data will be useful in determining if the age-shift is closer to 6 months or 12 months.

Table 1. Seedling morphological characteristics at time-of-planting for two nursery bed densities (16 and 25 seedlings per square foot): n = 60 per bed.

Bed	Height (cm)	RCD (mm)	Lateral root	Taproot	Shoot
			---dry weight per seedling (g)---		
16	32.1	6.34	0.59	0.55	5.11
25	27.6	4.55	0.27	0.39	3.25

Table 2. Probability of a greater F-statistic for second-year field survival (transformed), arithmetic mean second-year height (HT), quadratic mean diameter at breast height (QMD), square feet of basal area per acre (BA), cubic-foot volume per acre (VOL), number of trees per acre with a DBH (TPADBH), and percent of surviving trees taller than 4.5 feet (%DBH) of Pinus taeda L. seedlings.

Factor	d.f.	Survival	HT	QMD	BA	VOL	TPADBH	%DBH
Block	3	0.3756	0.0018	0.0049	0.0028	0.0023	0.0399	0.0256
Bed	1	0.4676	0.0003	0.0017	0.0004	0.0006	0.0045	0.0025
Field spacing	2	0.2581	0.1447	0.1439	0.0035	0.0001	0.0001	0.4562
Linear	(1)	0.3207	0.0699	0.0666	0.0010	0.0001	0.0001	0.2254
Lack of fit	(1)	0.1868	0.4874	0.4853	0.5902	0.6166	0.9962	0.8169
Bed*Spacing	2	0.4102	0.1353	0.3900	0.0504	0.1133	0.1300	0.1107
Error	15							

Table 3. Effect of bed (16 or 25 seedlings per square foot) and initial planting density on second-year survival, trees per acre (TPA), quadratic mean diameter (QMD), arithmetic mean height (HT), basal area per acre in square feet (BA), percent of surviving trees with a DBH, and number of trees per acre with a DBH (TPADBH).

Bed	Spacing	% Survival	TPA	QMD	HT	BA	VOL	% DBH	TPADBH
	303	98	298	0.81	5.5	0.83	91.1	77	234
16	454	97	440	0.81	5.6	1.38	133.6	83	378
	605	96	580	0.79	5.5	1.64	167.2	79	478
	303	98	296	0.75	5.3	0.75	80.0	76	229
25	454	94	426	0.72	4.8	0.81	101.2	62	283
	605	97	586	0.65	4.8	0.93	115.3	63	381

Table 4. Effect of bed sowing density (16 – 16 seeds per square foot or 25 – 25 seeds per square foot) on second-year survival, trees per acre (TPA), quadratic mean diameter (QMD), arithmetic mean height (HT), basal area per acre in square feet (BA), percent of surviving trees with a DBH, and number of trees per acre with a DBH (TPADBH).

Bed	% Survival	TPA	QMD	HT	BA	VOL	TPADBH	% DBH
16	97	439	0.80a	5.5a	1.28a	130.6a	363a	80a
25	96	436	0.71b	5.0b	0.83b	98.8b	298b	67b

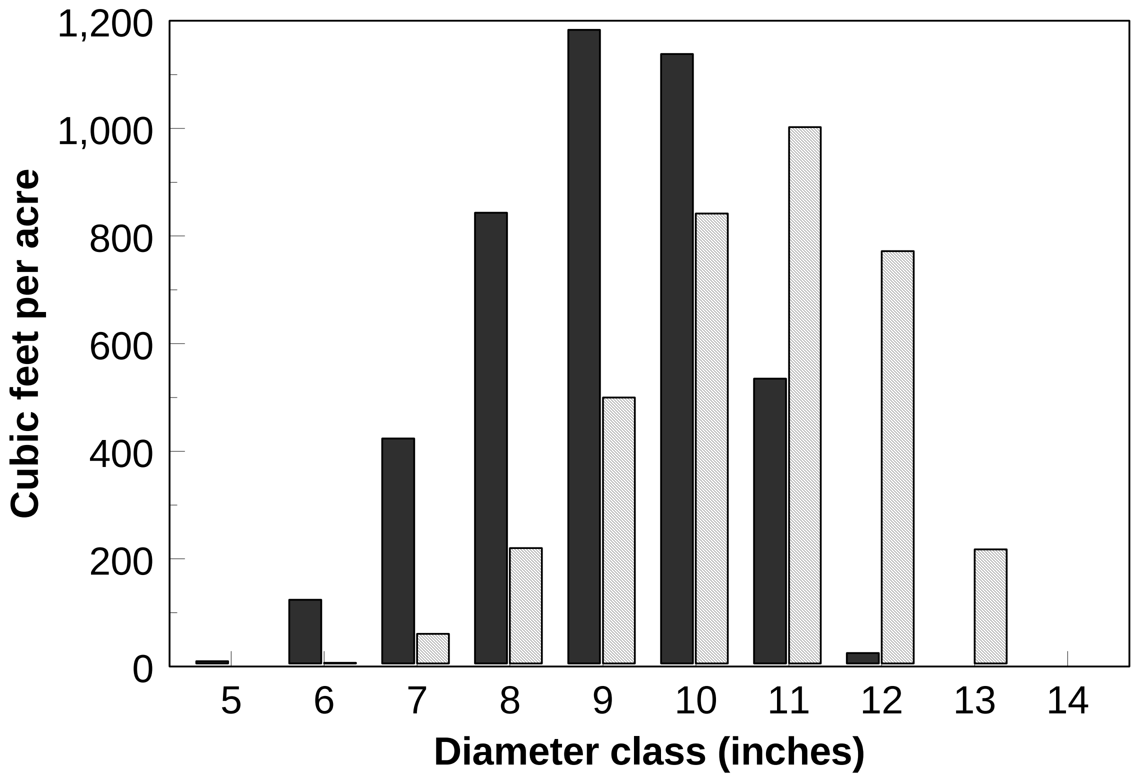
Table 5. Effect of initial planting density on second-year survival, trees per acre (TPA), quadratic mean diameter (QMD), arithmetic mean height (HT), basal area per acre in square feet (BA), percent of surviving trees with a DBH, and number of trees per acre with a DBH (TPADBH).

Spacing	% Survival	TPA	QMD	HT	BA	VOL	TPADBH	% DBH
303	98	297	0.78	5.4	0.79	85.5	232	76
454	95	432	0.77	5.2	1.10	117.4	331	73
605	96	583	0.72	5.2	1.28	141.3	429	71

Table 6. Simulated effects of planting density and seedling type on trees per acre (TPA); diameter at breast height (DBH); percent basal area (BA) in juvenile wood; pulpwood, chip-n-saw and sawtimber volumes (cubic feet per acre); stumpage value ($/acre) at age 20 years. Morphologically improved seedlings (MI) are assumed to increase stand development by 6 months more than regular seedlings. Stumpage values assumed to be $0.25, $0.90 and $1.25 per cubic foot for pulpwood, chip-n-saw, and sawtimber, respectively.

Planting Density	Seedling type	20-yr TPA	20-yr DBH	% BA in juvenile wood	Total volume	Pulpwood	Chip-n-saw	Sawtimber	Stumpage value	Seedling cost/acre
303	MI	270	10.25	70	3344	1752	425	1167	$2279	$14.25
303	Regular	272	10.1	69	3203	1717	454	1032	$2128	$12.12
454	Regular	380	9.2	70	3603	2162	864	587	$2052	$18.16
605	Regular	467	8.7	70	3787	2355	1149	283	$1977	$24.20

Figure 1: Simulated yield of 20-year-old loblolly pine from stands planted at 605 regular seedlings (4 mm diameter) per acre (black bars) and 303 morphologically improved seedlings (6 mm diameter) per acre (gray bars).



Acknowledgements:
We thank Tommy Hill and Humberto dosSantos for measuring the trees. Thanks are also extended to MeadWestvaco personnel for providing the site and the installing of treatments. This work was supported in part by the Auburn University Southern Forest Nursery Management Cooperative.

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