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Effects of sower type and seedbed density on bareroot seedling morphology and early field performance of an East Texas family of loblolly pine

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THE EFFECTS OF SOWER AND BED DENSITY ON BAREROOT LOBLOLLY PINE SEEDLING MORPHOLOGY AND EARLY HEIGHT GROWTH

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Abstract—Precision sowing is commonly used at forest tree nurseries in order to improve the growing space uniformity of seedlings in the beds. Temple-Inland Forest Products Corporation recently purchased a vacuum sower and requested a study be conducted comparing their new sower with a drill sower on the morphological characteristics of loblolly pine (*Pinus taeda* L.) at lifting. The study was conducted in 2000 and repeated in 2001. The seed were sown using the two sower types to achieve four densities of 161, 215, 269, and 323 seedlings/m². Two half-sibling families were tested in 2000, and one half-sibling family was tested in 2001. For both studies, the experimental design was a randomized complete block with four replications. Cultural practices used to grow the seedlings were typical for the nursery. The seedlings were hand-lifted mid-winter for measurements of stem height, root-collar diameter, and oven-dry biomass. For the 2001 study, seedlings were hand-planted 1 week after lifting in a clearcut near Etoile, TX. The mean morphology of the seedlings was similar when comparing the two sowers. When averaged for all densities, more seedlings with small root-collar diameters (≤ 3 mm) were sampled in the 2000 study from the drill sower plots than from the vacuum sower plots. For the 2001 study, slightly more seedlings with small diameters were sampled from the vacuum sower plots. At typical operational densities of 215 and 269 seedlings/m², the use of the vacuum sower resulted in more seedlings at lifting, fewer small-diameter seedlings, and more large-diameter seedlings (≥ 5 mm). As seedbed density was reduced, mean seedling root-collar diameter and oven-dry biomass increased. Seedlings grown in the nursery at 161 seedlings/m² were taller after the first and second growing season following planting.

INTRODUCTION

Numerous studies have been conducted investigating the effects of bareroot southern pine seedling grade on field performance. South (2000) provides a review of many of these studies. In most cases, the authors report planting larger-diameter seedlings can result in better height and diameter growth. Precision sowing is just one nursery culture practice that should increase the proportion of seedlings at lifting with larger root-collar diameters. Precision sowing results in uniform seed placement giving each developing seedling an equal amount of growing space. Drill sowers cannot achieve the same level of uniform seed placement as precision sowers (Boyer and others 1985, May 1985). However, complaints regarding the use of precision sowers include a slower operating speed and more time spent on maintenance when compared to drill sowers. Temple-Inland Forest Products Corporation purchased a vacuum precision sower in 2000. This provided an opportunity to compare the vacuum sower with a drill sower at different seedling densities on morphology at lifting, field survival, and growth of loblolly pine (*Pinus taeda* L.).

METHODS

For the 2000 study, two one-half sibling families of loblolly pine (Family LSG-008 and Family S4PT6-98M) were sown on May 5, 2000, in seed beds prepared at the Temple-Inland Clyde-Thompson Nursery, Jasper, TX. The seeds were sown using a drill sower or a vacuum sower to achieve four seedling densities of 161, 215, 269, and 323/m². The study was conducted as a randomized complete block, 2 x 2 x 4 factorial experiment with four replications. Four beds in the middle of a section were used in the study with each bed being a replication of all family, sower and density combinations. The beds were in their second year of seedling production. The beds were covered in bark mulch following sowing. Cultural practices such as mineral nutrition, irrigation, weed control, and undercutting applied to the seedlings were typical for the nursery during the 2000 growing season. In February, 2001, about 4 lineal-bed-feet of seedlings were hand-lifted from each plot. The interior six drills of seedlings were sampled. The two outside drills were not sampled. The seedling roots were dipped in water, and then the seedlings were placed in kraft storage bags, sealed, and transported to a cold storage room at the Arthur Temple College of Forestry and Agriculture Building, Stephen F. Austin State University (SFASU). Fifty seedlings were randomly sampled from each bag for morphology measurements. These measurements included height, root-collar diameter, number of first-order lateral roots, and root and shoot oven-dry weights. Statistical analysis was conducted and differences in morphology between families, sowers, and densities are discussed at the $\alpha = 0.05$ probability level.

The 2001 study was conducted in a manner similar to the 2000 study. The factors tested were the same sower types and densities. Only one loblolly pine family was tested (LSG-008-98M). The seeds were sown on April 11, 2001. The study was conducted as a randomized complete block, 2 x 4 factorial experiment with four replications. Four beds in the middle of a section were used with each bed serving as a replication of all sower and seedling density combinations. The beds were in their first year of seedling production following a cover crop. Nursery cultural practices applied to the seedlings were typical for the 2001 growing season. Seedlings were hand-lifted from each plot in early January, 2002, roots dipped in water, seedlings placed in kraft bags, transported to SFASU, and placed into cold storage. Within a week following lifting, 20 seedlings were randomly selected from each kraft bag, placed in a plastic bag, and transported to a field site for planting. Fifty seedlings from each kraft bag were randomly sampled for morphology measurements.

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The field planting for the 2001 study was conducted at a location near Etoile, Nacogdoches County, TX. The soil at the site is a Woodtell very fine sandy loam (fine, montmorillonitic, thermic Vertic Hapludalfs). Site preparation following harvest included chopping and burning. A mixture of imazaypr, triclopyr, and glyphosate was applied in fall, 2001. The seedlings were hand-planted using planting bars in January, 2002. Twenty-seedling row plots were established with each row in a replication representing a sower and density combination. An herbaceous weed control application of hexazinone and sulfometuron methyl was applied in spring, 2002. Height measurements were taken at the end of each growing season for 3 years after planting. Survival exceeded 90 percent for all treatment combinations, so no statistical analysis was performed on survival data. Statistical analysis was conducted and differences between sowers and among densities for seedling morphology and height growth in the field are discussed at the $\alpha = 0.05$ probability level. Since for both studies the interactions between the sower and density treatments were not statistically significant, the interaction means will not be presented.

RESULTS AND DISCUSSION

In August, 2000, and July, 2001, seedling counts were conducted in each plot in order to observe if the actual seedling densities were similar to the desired target densities (table 1). In the 2000 study, the vacuum sower plots averaged between 22 and 33 seedlings/m^2 more than desired in the lower density plots but averaged at the target densities in the higher density plots. In the drill sower plots, the target densities were achieved at the lower densities but averaged about 22 seedlings/m^2 lower than desired in the higher density plots. In the 2001 study, seedling densities in the higher density plots for both sowers averaged about 32 to 54 seedlings /m^2 less than the desired target density. When comparing sowers, the seedling densities in the vacuum sower plots were consistently about 22 seedlings/m^2 higher, regardless of the target density, for each study. A potential advantage of vacuum, or precision, sowing is an improvement in seed efficiency. South (1987) defines the seed efficiency value as the quotient of the number of plantable seedlings produced divided by the number of pure live seed sown. The additional 22 seedlings/m^2 for the vacuum sower would indicate greater seed efficiency when compared to the drill sower but only if the additional seedlings are plantable.

A plantable seedling has a root-collar diameter ≥ 3 mm. Seedlings with root collar diameters < 3 mm are considered unacceptable, or cull, and should not be planted. The use of vacuum or precision sowers increased in the 1980s because of the desire for more uniform growing space for each seedling developing in a nursery bed (Barnett 1989). This results in a more uniform seedling crop with a lower number of culls. Boyer and others (1985) reported that a vacuum sower provided more precise seed placement and lower cull percentage when compared to a drill sower. When comparing sowers, the mean morphological characteristics of seedlings sampled in both studies were similar (tables 2 and 3). However, when grouped into 1 mm diameter classes, a greater number of seedlings with small root-collar diameters (≤ 3 mm) were sampled in the plots sown with the drill sower in 2000 (fig. 1). When averaged across all densities, about 11 percent of the seedlings sampled from the drill sower plots had small

Table 1—Mean loblolly pine seedling density for the sower/seedbed density studies conducted at the Clyde Thompson Nursery, Temple-Inland Forest Products Corporation, Jasper, TX (N = 8)

Sower	Target density	Actual density	Number of seedlings > 3 mm RCD
		m^2	
2000 study[a]			
Vacuum	161	194	185
Drill	161	172	158
Vacuum	215	237	217
Drill	215	215	190
Vacuum	269	269	260
Drill	269	247	213
Vacuum	323	323	281
Drill	323	301	270
2001 study[b]			
Vacuum	161	172	168
Drill	161	151	150
Vacuum	215	215	208
Drill	215	194	176
Vacuum	269	237	223
Drill	269	226	208
Vacuum	323	290	241
Drill	323	269	258

[a] 2000 study: families LSG-008-98M and S4PT6-98M.
[b] 2001 study: family LSG-008-98M.

Table 2—Mean morphology of 1-0 bareroot loblolly pine seedling for the 2000 sower-density study conducted at the Temple-Inland Clyde Thompson Nursery. Fifty seedlings were sampled from each replication, sower, family, and density combination: 3,200 seedlings sampled. Interactions between sower, family, and density were not statistically significant

Treatment	Height	Diameter	First-order lateral roots	Root oven-dry weight	Shoot oven-dry weight
	cm	*mm*	*no.*	- - - - - - - - - *g*	- - - - - - - - -
Sower					
Vacuum	23	5.20	10	1.39	3.98
Drill	22	5.02	10	1.38	3.68
(P > F)	0.5273	0.1287	0.1676	0.8188	0.1577
Family					
LSG-008	24	5.02	10	1.31	3.81
S4PT6	21	5.61	10	1.46	3.83
(P > F)	0.0028	0.0296	0.8178	0.0206	0.9423
Density (m^2)					
161	22	5.48	11	1.72	4.28
215	23	5.18	10	1.37	4.01
269	22	4.97	10	1.30	3.50
323	24	4.82	9	1.14	3.50
(P > F)	0.5196	0.0010	0.0026	<0.0001	0.0298

Table 3—Mean morphology of 1-0 bareroot loblolly pine seedlings from the 2001 sower/ density study conducted at the Temple-Inland Clyde Thompson Nursery. Fifty seedlings were sampled from each replication, sower, and density combination: 1,600 seedlings sampled. Temple Family = LSG-008. Interactions between sower and density were not statistically significant

Treatment	Height	Diameter	First-order lateral roots	Root oven-dry weight	Stem oven-dry weight	Needle oven-dry weight
	cm	*mm*	*no.*	- - - - - - - - - - - -	- *g* -	- - - - - - - - - - - -
Sower						
Vacuum	29.3	4.51	10.0	0.76	1.47	2.12
Drill	29.9	4.59	10.6	0.83	1.58	2.25
(P>F)	0.1483	0.2862	0.1183	0.1832	0.0251	0.1548
Density (m^2)						
161	29.8	4.92	11.6	0.96	1.77	2.62
215	29.4	4.55	10.2	0.76	1.50	2.15
269	29.8	4.50	9.6	0.82	1.51	2.14
323	29.4	4.24	9.8	0.64	1.33	1.83
(P > F)	0.5665	< 0.0001	0.1642	0.0003	0.0001	< 0.0001

diameters compared to 7 percent for the vacuum sower plots. However, the overall number of seedlings with small diameters in the vacuum sower plots was slightly higher for the 2001 study. The drill sower plots had more seedlings with small diameters in the 2000 study at densities of 161 (8 versus 5 percent), 215 (12 versus 8 percent), and 269 (14 versus 3 percent) seedlings/m^2, and a lower number of seedlings at 323 seedlings/m^2 (10 versus 13 percent). In the 2001 study, the number of seedlings with small diameters was lower for the vacuum sower at 215 (3 versus 10 percent) and 269 (6 versus 8 percent) seedlings/m^2, but higher at densities of 161 (2 versus 0.5 percent) and 323 (17 versus 4 percent) seedlings/m^2. The much greater number of seedlings sampled with small root-collar diameters at the highest density may explain the overall higher number of seedlings with small diameters sampled from the vacuum sower plots in the 2001 study. Because more seedlings/m^2 were counted in the vacuum sower plots at each density, the actual number of seedlings/m^2 with root-collar diameters > 3 mm was higher for the vacuum sower plots, except for the highest density of the 2001 study

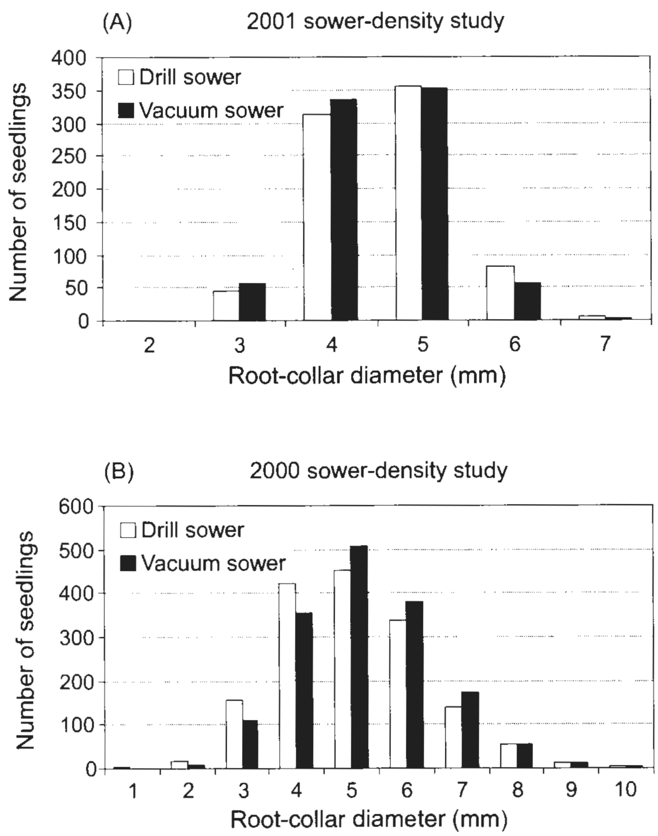

Figure 1—Averaged across all seedling densities, the loblolly pine seedling distribution by root-collar diameter for the 2001 (A) and 2000 (B) sower density studies conducted at the Temple-Inland Clyde-Thompson Nursery, Jasper, TX.

(table 1). While seedlings with root-collar diameters of 3 mm are plantable, cultural practices that can increase the number of seedlings with larger root-collar diameters would be desirable. After reviewing several studies, South (2000) reported that for each 1 mm increase in seedling root-collar diameter, the average gain in volume after 15 to 20 years may be 13 m^3/ha. Plot volumes after 4 years were greater when loblolly pine seedlings 8.5 mm in root-collar diameter were planted compared to plots planted with seedling having a diameter of 5 mm (South and others 2001).

Morphologically improved bareroot loblolly pine seedlings are defined by South (2000) as being grown at low densities (< 215 seedlings/m^2) with at least half the seedling population having a root-collar diameter > 5 mm and none < 3 mm. When averaged across all the densities, more than half the seedlings sampled in each study were ≥ 5 mm in diameter (large-diameter seedlings). Seventy-one percent of seedlings sampled for the 2000 study from the vacuum sower plots were ≥ 5 mm at the root collar compared to 62 percent of the seedlings sampled from the drill sower plots. A greater number of large-diameter seedlings were observed from the vacuum sower plots at 161, 215, and 269 seedlings/m^2. At the highest density, the amount of large-diameter seedlings observed was equal. Overall, slightly fewer seedlings with ≥ 5 mm diameters were found in the vacuum sower plots for the 2001 study. At 215 and 269 seedlings/m^2, a greater number of larger-diameter seedlings were observed from the vacuum sower plots. However, more large-diameter seedlings were observed from the drill sower plots at the lowest and highest density.

As seedling densities were reduced in the beds, the mean root-collar diameter and oven-dry weights of the lifted seedlings increased (tables 2 and 3). For the 2001 study, seedlings grown in the nursery at 161 seedlings/m^2 were significantly taller 2 years after planting than the seedlings grown at the higher densities (table 4). Rowan (1986) reported that loblolly pine seedlings grown at 108 or 161 seedlings/m^2 were significantly taller up to 5 years after planting when compared to seedlings grown in the nursery at higher densities.

Table 4—Mean field height of loblolly pine from the 2001 sower/density study conducted at the Temple-Inland Clyde Thompson Nursery. Twenty 1-0 bareroot seedlings were planted in rows for each replication, sower, and density combination: 640 seedlings planted, Temple Family = LSG-008. Seedlings planted near Etoile, TX. Interactions between sower and density were not statistically significant

Treatment	Initial	First-year	Second-year	Third-year
	height in cm			
Sower				
Vacuum	17	45	113	241
Drill	18	46	117	244
(P>F)	0.5669	0.7670	0.3501	0.6809
Density (m^2)				
161	19	50	126	252
215	18	45	111	236
269	17	42	111	244
323	16	45	112	238
(P>F)	0.3404	0.0125	0.0207	0.3157

SUMMARY

For densities of 215 and 269 seedlings/m^2, using the vacuum sower appears to improve seed efficiency when considering the combined results of the production of more seedlings, a fewer number of small-diameter seedlings, and a greater number of large-diameter seedlings. Only at the highest density did the drill sower appear to outperform the vacuum sower with regards to the proportion of small-diameter and large-diameter seedlings. Seedlings grown at 161 seedlings/m^2 in the nursery were statistically taller 2 years after planting and continued to be taller after 3 years.

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LITERATURE CITED

Barnett, J.P. 1989. Seed cultural practices, and seedling uniformity. Forestry Supplement. 62: 95-105.

Boyer, J.N.; South, D.B.; Muller, C.A.; Vanderveer, H. 1985. A comparison of nursery sowers. Tree Planters' Notes. 36(3): 20-24.

May, J.T. 1985. Chapter 6: sowing and mulching. In: Southern pine nursery handbook. Atlanta, GA: United States Department of Agriculture, Forest Service, Southern Region: 6-1 to 6-17.

South, D.B. 1987. Economic aspects of nursery seed efficiency. Southern Journal of Applied Forestry. 11(2): 106-110.

Rowan, S.J. 1986. Seedbed density affects performance of slash and loblolly pine in Georgia. In: South, D.B., ed. Proceedings of the international symposium on nursery management practices for the southern pines. Auburn University, AL: Alabama Agricultural Experiment Station: 126-135.

South, D.B. 2000. Planting morphologically improved pine seedlings to increase survival and growth. Forest and Wildlife Research Series no. 1. Auburn University, AL: Alabama Agricultural Experiment Station. 12 p.

South, D.B.; Rakestraw, J.L.; Lowerts, G.A. 2001. Early gains from planting large-diameter seedlings and intensive management are additive for loblolly pine. New Forests. 22: 97-110.