Auburn University Southern Forest Nursery Management Cooperative

RESEARCH REPORT 99-10

FALL SOWING, SEEDBED DENSITY AND EXTRA NITROGEN AFFECT MORPHOLOGY OF LOBLOLLY PINE SEEDLINGS

by
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INTRODUCTION

Several studies with pines have shown that an increase in outplanting survival and growth can be achieved by planting seedlings with large root-collar diameters (South *et al.* 1993, Zwolinski *et al.* 1996, South and Mitchell 1999). However, little is known about the potential size that can be achieved by 1+0 pine seedlings in the nursery. Therefore, the objective of this research was to determine how much increase in seedling size can be obtained by applying practices such as fall sowing, extra nitrogen fertilization, and low seedbed densities.

METHODS

Study 1

Loblolly pine seed were sown at the MacMillan Bloedel Nursery near Camden, Alabama in November 1992. During the following winter, birds and frost destroyed about 50% of the young seedlings. In March 1993, a study was established by reducing the bed density in experimental plots to 32, 65, and 129 seedlings/m^2. In April 1993, a second density experiment was established in this area by sowing the same seed stock next to the fall-sown experiment. On June 30, 1993, the seedlings were thinned to 32, 65, 129, and 258 seedlings/m^2. Both experiments were laid out as a randomized complete block (RCB) with six replications.

The experimental beds were irrigated, fertilized and protected with pesticides according to standard procedures except there was no root-pruning or undercutting. Seedlings were lifted in January/February 1994. Morphological attributes of the seedlings (height [HT], root collar diameter hand lifted in early February. Morphological attributes of the seedlings (height [HT], root collar diameter [RCD], root and shoot dry mass) were determined on 25 seedlings per plot. A root-growth potential (RGP) study was conducted using an additional six seedlings from each plot. After the removal of white root tips, the seedlings were placed in aquariums with roots submerged in aerated water. After 28 days, the number of new roots longer than 5 mm was counted on each seedling. Thirty seedlings from each plot were planted in two field experiments established with the same design as the nursery experiments (RCB with six replications). Where possible, the seedlings were planted with dibble bar. For the larger seedlings, however, planting pits were made with mechanical auger. Post-planting survival and early growth of the seedlings were assessed one year after planting.

Study 2

Two experiments were established to study morphological and performance attributes of loblolly pine grown at two fertilizer regimes and four bed densities. One study was established in Union Camp Nursery near Union Springs (Alabama) in April/May 1994, and one in the MacMillan Bloedel Nursery. All the experiments involved testing seedlings at densities 32, 65, 129, 258 seedlings/m^2. The fertilizer treatment included operational rates (172 kg N/ha at Union Springs and 63 kg N/ha at MacMillan Bloedel) and double the operational rate of nitrogen. Seed were sown by hand at a spacing needed to obtain desired bed densities. Seedlings were undercut at both locations but were laterally root-pruned only at the Union Camp Nursery. All experiments were treated in the same way as commercial beds. The design of these experiments was a split plot with fertilizer (2 treatments) the main plots and bed density (4 treatments) the subplots.

Twenty-five seedlings were lifted by hand from each plot in January 1995 and were assessed for height, root-collar diameter, and shoot and root mass. RGP tests (5 seedlings/plot) were performed on MacMillan Bloedel seedlings in the same manner as the previous study. Analyses of variance were used to test for treatment effects. When treatments were significant, Tukey's HSD test was used to separate means.

RESULTS AND DISCUSSION

Study 1

As expected, there was a substantial increase in seedling size by sowing in the fall (Table 1). The overall increase in HT, RCD, root and shoot mass of the fall sown beds was 45%, 57%, 245% and 182%, respectively. On an area basis, total biomass production was increased by growing seedlings at high density and fall-sowing (Figure 1). Fall sowing at low densities produced seedlings with 9 to 11 mm RCD while spring sowing produced 5 to 8 mm RCD seedlings. Although the fall-sown seedbed had densities less than 150/m^2, density still affected RCD and root biomass. The lowest bed density produced seedlings with larger roots and larger diameters. These larger seedlings also produced more new roots in the RGP study. However, field survival from fall-sown beds was about 30% less than spring-sown seedlings (when comparing seedlings of the same bed density). Likely, most of the fine roots of the larger seedlings were lost during lifting because root growth was not restricted by either undercutting or root pruning. In addition, the fall-sown seedlings were operationally lifted with a machine. In one nursery in Florida, machine lifted seedlings on a fine-textured soil had 20% to 34% less survival than hand-lifted seedlings (Barnard et al. 1981). This might help explain why the difference in survival was great between the fall- and spring-sown beds.

Table 1. Morphological characteristics of loblolly pine seedlings at the MacMillan Bloedel nursery grown at various seedbed densities after sowing in the fall or spring. Means followed by the same letter within a sowing season are not significantly different at the .05 level of probability.

Sowing season	Density (trees/m²)	Height (cm)	RCD (mm)	Dry mass (g) roots	Dry mass (g) shoots	Root growth potential trees (%)	Root growth potential roots/tree	Field survival (%)
fall	35	37.6 a	11.4 a	13.9 a	19.4 a	83 a	20 a	48 a
	69	39.4 a	10.6 ab	10.6 ab	17.9 a	60 a	10 b	46 a
	129	40.8 a	9.5 b	7.5 b	15.1 a	63 a	15 ab	49 a
spring	35	29.1 a	8.1 a	4.9 a	8.7 a	100 a	50 a	72 a
	69	26.3 a	6.6 b	2.4 b	5.9 b	94 a	32 a	82 a
	129	26.1 a	5.4 c	2.0 b	4.1 bc	97 a	35 a	80 a
	258	26.6 a	4.9 c	1.4 b	3.5 c	97 a	26 a	89 a

As expected, seedbed density resulted in morphological differences for spring-sown seedlings. RCD, root mass and shoot mass of seedlings from the lowest bed density (32 trees/m²) were larger by 65%, 250% and 149% compared to the same characteristics of seedlings grown at the standard density of 258 seedlings/m². The 65 and 129 seedlings/m² densities yielded intermediate values. However, field survival was not related to seedbed density. Although the largest seedlings performed best in the RGP tests their field performance was worst (Table 1). Seedlings grown at 258/m² survived best (89%)

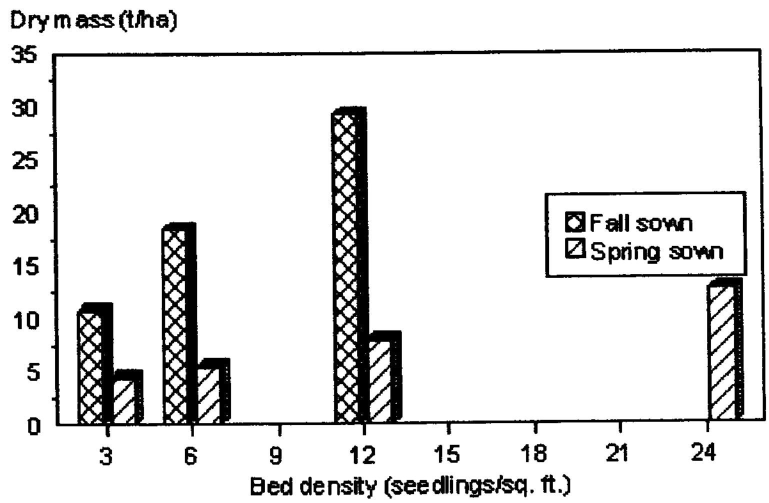

Figure 1 Biomass production of seeldings by sowing season and bed density.

In general, the range of sizes of planting stock (in terms of seedling diameter at root collar) declined with increasing bed density (Figure 2). Also, spring-sown beds yielded more uniform stock than fall-sown beds. However, the variation in size of seedlings from fall-sown beds was likely increased by bird and frost damage during winter. It took longer for the damaged seedlings to recover once growth conditions improved in the spring. Therefore, distribution of seedling sizes from the fall-sown beds may not be representative in this study.

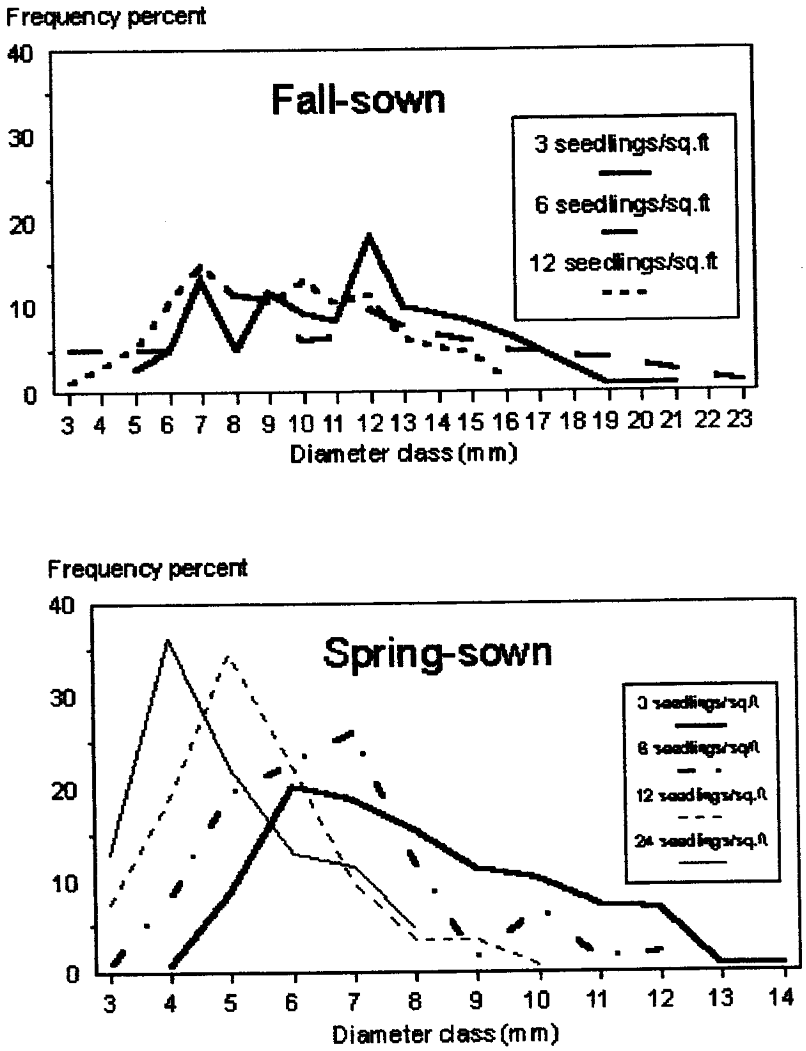

Figure 2 Frequency distribution of seedling root collar dimeter class for various bed densities of fall- and spring-sown seedbeds.

Study 2

Sowing of the experiments was slightly delayed due to moist weather during the spring of 1994. Growing conditions were good throughout the year and no unexpected damage occurred to the seedlings. There was, however, some water and wind erosion of the organic mulch in parts of some beds, especially where widely spaced seedlings did not provide sufficient shelter. This could result in poorer growth conditions for widely spaced seedlings and produced some differences between replications.

Since seedlings at both nurseries were top-pruned, no significant differences in height were found (Table 2). As expected, bed density resulted in large differences in seedling morphology. Substantially thicker and heavier seedlings were produced at lower bed densities. When grown at 35 seedlings/m^2, seedling were 61% thicker and 140% heavier seedlings than standard seedlings (258 seedlings/m^2) at MacMillan Bloedel. The same comparison for the Union Camp showed low-density bed seedlings thicker and heavier by 55% and 107%, respectively. Despite differences between the two nurseries in soils and production technology, the magnitude of change resulted from the experimental treatments were similar for both locations (Figure 3).

Table 2. Morphological and performance attributes of loblolly pine seedlings grown at various densities and nitrogen treatment in the MacMillan Bloedel and Union Camp nurseries. Means within a set followed by the same letter are not significantly different at the 0.05 level of probability.

	Nitrogen rate (kg/ha)	Density (trees/m^2)	Height (cm)	RCD (mm)	Dry mass (g) roots	Dry mass (g) shoots	RGP roots/tree
MacMillan Bloedel	63	-	29	6.6 a	3.0	7.1 a	24 a
	126	-	27	5.9 b	2.7	5.8 b	19 b
	-	35	28	7.7 a	4.2 a	9.5 a	24
	-	69	29	6.8 b	2.9 b	7.0 b	18
	-	129	28	5.7 c	2.4 c	5.4 bc	21
	-	258	28	4.8 d	1.8 d	3.9 c	21
	63	35	29	8.1	4.5	10.7	28
		69	30	7.1	3.1	7.7	21
		129	29	6.2	2.5	5.9	24
		258	28	4.9	1.9	4.1	21
	126	35	27	7.4	3.9	8.4	20
		69	28	6.4	2.8	6.4	15
		129	27	5.3	2.3	4.9	18
		258	27	4.6	1.8	3.7	21

Table 2. Continued

	Nitrogen rate (kg/ha)	Density (trees/m^2)	Height (cm)	RCD (mm)	Dry mass (g) roots	shoots
Union Camp	172	-	24	6.4 a	3.6	7.0 a
	344	-	23	6.0 b	3.5	6.3 b
	-	35	23	7.6 a	5.7 a	9.4 a
	-	69	24	6.2 b	3.2 b	6.7 b
	-	129	24	6.0 c	2.8 c	5.3 bc
	-	258	24	4.9 d	2.4 d	4.9 c
	172	35	23	8.0	5.9	11.3
		69	34	6.7	3.3	6.6
		129	25	5.9	2.7	5.2
		258	24	4.9	2.0	4.0
	344	35	22	7.3	5.4	7.6
		69	23	5.8	3.2	6.9
		129	23	6.0	3.0	5.3
		258	24	4.8	2.6	5.4

The frequency distribution by diameter class showed a relatively uniform planting stock produced with easily defined modes (or peaks) for bed densities of 65, 129 and 258 seedlings/m^2 (Figure 4). At the lowest bed density (32 seedlings/m^2), the distribution was spread out and the mode was not as distinct. Overall, the spring-sown seedlings exhibited good uniformity irrespective of bed density.

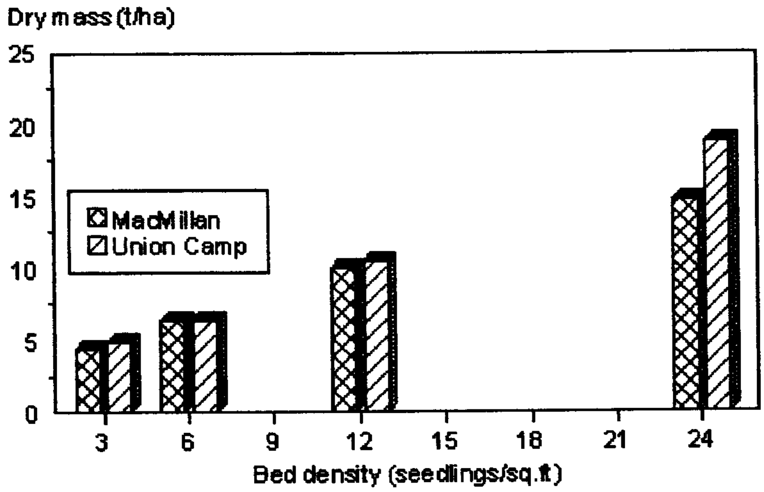

Figure 3 Biomass production of seedlings by nursery and bed density.

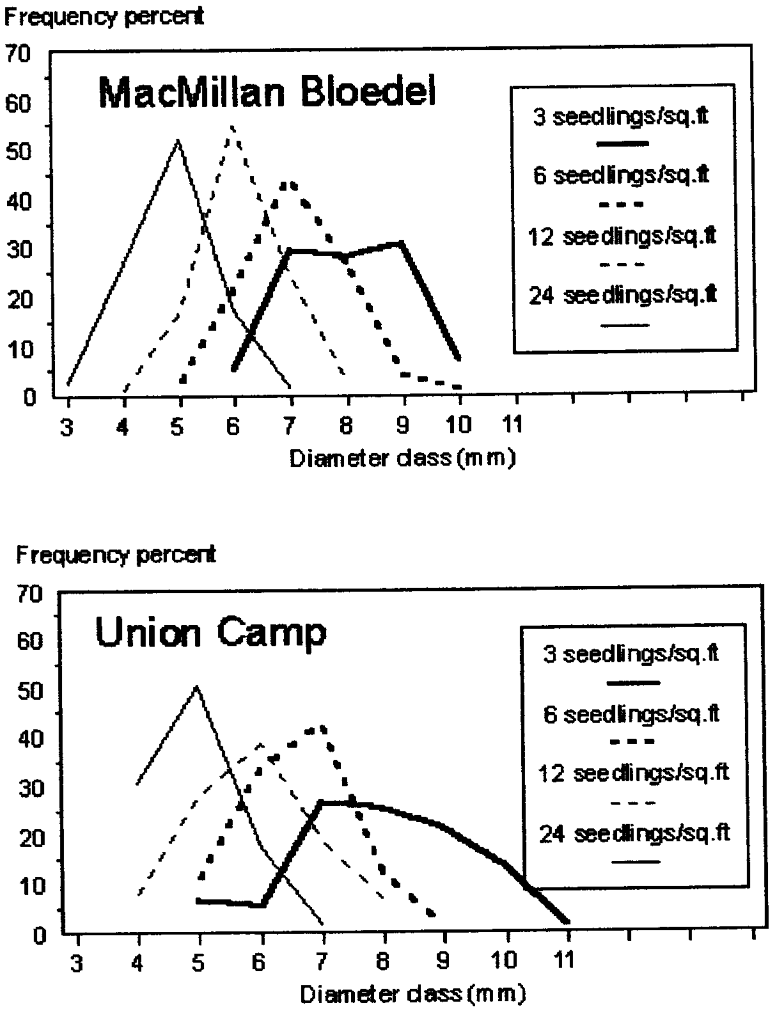

Figure 4 Frequency distribution of seedlings by root-collaar diameter class for seedlings receiving the normal rate of nitrogen application.

For loblolly pine, a growing season rate of 126 kg/ha is not a high rate of nitrogen fertilization. In fact, most nurseries fertilize at rates of 170 to 300 kg/ha during the growing season. However, in this study, this rate of fertilizer caused a significant decrease in RCD, RGP and shoot mass at the MacMillan Bloedel Nursery (Tables 2).. Since the extra fertilization was applied as a "double dose", the resulting salt effect was likely too great (at both nurseries). In hindsight, the extra fertilization should have been accomplished by increasing the frequency of applications (as opposed to increasing the amount applied per application). Future fertilization studies should be designed to avoid harm to seedlings by applying too much fertilizer in a single application. Small, but frequent doses of nitrogen will benefit seedling growth more than a few high-dose, applications.

MANAGEMENT IMPLICATIONS

Nursery culture of large seedlings (average RCD = 10 mm) can be a difficult undertaking and will involve the development of new techniques from sowing to method of lifting. These data indicate that fall sowing may lead to significant losses of seedlings during the winter, yet typical April sowing does not allow enough time for seedlings to develop into really large sizes, regardless of spacing. March sowing may have to be considered.

Fertilization to accelerate development in the nursery must be done carefully so as not to "burn" seedlings which achieves the opposite of the desired goal.

Lifting extra large seedlings may reduce seedling quality if the root system is not properly cared for. In fact, these larger seedlings may be proportionally more sensitive to fine root loss than smaller more "normal" seedlings. Although no conclusions can be drawn from this study, large-diameter seedlings might be injured (more so than usuall) when lifted using 8-row belt-lifters.

Growing seedlings at wider spacings appears to be the least complicated method for increasing seedling size.

References

Barnard, E.L., C.A. Hollis, and W.L. Pritchett. 1981. A comparative evaluation of seelding quality in commercial forest nurseries in Florida. Pp. 34-41. *In:* Proc. 1980 Southern Nursery Conference, Lake Barkeley, KY. USFS State and Private Forestry.

South, D.B. and R.J. Mitchell. 1999. Determining the "optimum" slash pine seedling size for use with four levels of vegetation management on a flatwoods site in Georgia, U.S.A. Can. J.For. Res. 29:1039-1046.

South, D.B., R.J. Mitchell, B.R. Zutter, J.M. Balneaves, B.L. Barber, D.G. Nelson, and J.B. Zwolinski. 1993. Integration of nursery practices and vegetation management: economic and biological potential for improving regeneration. Can. J. For. Res. 23:2083-2092.

Zwolinski, J.B, South, D.B., Cunningham, L, and Christie, S. 1996. Weed control and large bare-root stock improve early growth of Pinus radiata in South Africa. N.Z. J. For. Sci. 26:163-172.