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The Response of Bareroot Loblolly Pine Seedlings to the Amount and Timing of Nitrogen Fertilization in the Nursery

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THE RESPONSE OF BAREROOT LOBLOLLY PINE SEEDLINGS TO THE AMOUNT AND TIMING OF NITROGEN FERTILIZATION IN THE NURSERY

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Abstract—A nursery study was conducted to observe the effects of altering the amount of nitrogen fertilizer at each application on bareroot loblolly pine (*Pinus taeda* L.) seedling morphology, survival and growth. The treatments were an equal amount of fertilizer applied each time, an increasing amount each time, and a schedule characterized by low amounts, high amounts, and low amounts. Six applications of ammonium nitrate (32.5 percent N) were applied between June and August 2000, and for all treatments, a total of 169 kg N per ha was applied. In addition, for each growing season treatment, the seedlings were treated either in October or November with a one-time application of 56 kg N per ha or 113 kg N per ha as ammonium nitrate. The seedlings were lifted in January 2001, for morphology measurements and field planting. The seedlings treated with an increasing amount of N during the growing season had greater foliage, stem and root weights. Seedlings treated with 113 kg N per ha in October had the largest root collar diameters. First-year survival exceeded 90 percent for all treatments. First-year height growth was greatest for the seedlings that received 113 kg N per ha in October in the nursery.

INTRODUCTION

Wakeley's (1954) morphological grades for loblolly pine continue to serve as useful guidance for growing the optimum southern pine seedling. However, bareroot loblolly pine seedling production philosophy appears to have changed from one of achieving few seedlings smaller than Grade 3 at lifting (less than 3.2 mm root-collar diameter) to one of achieving a high proportion of seedlings greater than Grade 1 at lifting (greater than 4.8 mm root-collar diameter). Boyer and South (1988) 15 years ago reported that 50 percent of the southern pine nurseries sampled produced fewer than 5 percent Grade 1 seedlings. Recently, South (2000) defined morphologically improved loblolly pine seedlings to be those grown at low seedbed densities in the nursery with half the population having a root-collar diameter (RCD) at lifting greater than 5 mm and none less than 3 mm, a more fibrous root system, but not taller than seedlings with a RCD of 3.9 mm. Lowering seedbed density is an effective means of increasing the proportion of seedlings with RCD greater than 5 mm (Caulfield and others 1987). Results from experiments also indicate manipulating nitrogen (N) fertilization timing and amounts in combination with seedbed density can influence seedling morphological characteristics (Brissette and Carlson 1987, Kormanik and others 1998, Switzer and Nelson 1963).

A study was conducted to observe the morphology and field response of bareroot loblolly pine seedlings treated in the nursery with different amounts of N applied at each application while still maintaining the total amount applied during the growing season. In addition to the growing season treatments, the seedlings were treated with two different amounts of N applied in October or November.

METHODS

The study was conducted at the Temple-Inland Clyde-Thompson Forest Tree Nursery located near Jasper, TX. On May 5, 2000, seed from one, half-sibling family were sown in the nursery bed at a rate to achieve a density of 269 seedlings per m^2. The seedlings were raised using the cultural practices typical for the nursery, except for the growing season N and fall N treatments. Four nursery beds were used in the study. Each nursery bed represented a replication of the growing season N and fall N treatments.

The growing season N treatments consisted of applying a total of 169 kg N per ha over six applications using one of three different protocols. The N source was ammonium nitrate (AN). The first protocol, referred to as "Operational", involved applying 28.2 kg N per ha at each application for the six applications. The "Increasing" treatment consisted of two applications at 9.4 kg N per ha, two applications at 18.8 kg N per ha, one application at 37.6 kg N per ha, and one at 75.1 kg N per ha. The "Low-Hi-Low" treatment consisted of 9.4, 18.8, 75.1, 37.6, 18.8, and 9.4 kg N per ha. The first of the six N applications was on June 1, and the last application was on August 9.

The growing season N whole plots were divided into five subplots representing the five fall N treatments. One subplot received no fall N application. In October, two subplots were treated with 56 or 113 kg N per ha as AN. In November, the two remaining subplots were treated with 56 or 113 kg N per ha as AN.

The seedlings were lifted in January 2001, placed in polyethylene-lined storage bags, and transported to Stephen F. Austin State University. The seedlings were placed in cold storage (4 °C) for about 1 week until planted. Twenty-five seedlings were randomly selected from each nursery replication and treatment combination for field planting. The seedlings were hand-planted near Etoile, TX on February 2, 2001. The soil at the planting site is a Woodtell very fine sandy-loam (Fine, montmorillontic, thermic Vertic Hapludalfs). Site preparation prior to planting included chopping, subsoiling, and bedding. An aerial application of

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an imazapyr, triclopyr, and glyphosate solution was applied in September 2000, to control woody and herbaceous plants. The site was fertilized with diammonium phosphate at a rate of 280 kg N per ha in November 2000. In March 2001, about 6 weeks after planting, the site was treated with an aerial application of hexazinone to control herbaceous plants.

The dependent variables measured after lifting the seedlings in the nursery were seedling height, RCD, stem oven-dry weight, root oven-dry weight, and needle oven-dry weight. Percent foliar N concentration was determined prior to the fall N treatments and at lifting. Percent survival, total height, height growth and ground-line diameter were measured after the first growing season following planting.

The growing season N and fall N treatments were applied using a randomized complete block split-plot experimental design with four replications. The main effects were the growing season N and fall N treatments in the nursery. The whole plots were the growing season N treatments, and the subplots were the fall N treatments. The experimental design of the field planting was the same as the nursery design. Analysis of variance was conducted to test for statistical differences between the growing season N treatments, the fall N treatments, and their interactions for the dependent variables measured. Statistical differences are discussed at the 5 percent Type I error rate. Results from the data analysis indicated that the interaction between growing season N treatments and fall N treatments were not statistically significant. As a result, only main effect means will be presented in the results.

RESULTS

The differences in mean percent foliar N between the growing season N treatments or the fall N treatments were not statistically significant for the August 2000, or January 2001, sampling dates (table 1). When measured in August 2000, about 2 weeks after the last fertilizer application, the foliage of seedlings receiving the "Increasing" growing season N treatment seemed to have higher N concentrations when compared to the other growing season treatments ($P > F = 0.0552$). However, when measured in January, they had the lowest N concentrations. The foliage of seedlings treated with a fall N application appeared to have had slightly higher N concentrations than the seedlings treated with no fall N application.

Table 1—Percent foliar N concentration of bareroot loblolly pine seedlings used in the nursery nitrogen nutrition study

N treatment	August 16, 2000[a]	January 30, 2001[b]
Growing season[c]		
Operational	2.01	1.54
Increasing	2.18	1.46
Low-Hi-Low	1.82	1.54
(P > F)	0.0552	0.4487
Fall		
None		1.44
October-56 kg N/ha		1.59
October-113 kg N/ha		1.51
November-56 kg N/ha		1.53
November-113 kg N/ha		1.49
(P > F)		0.6638

[a] Means determined two weeks after final growing season N application.

[b] Means determined on seedlings lifted from the nursery.

[c] Operational = 28.2 kg N per ha at each application for six applications. Increasing = 9.4, 9.4, 18.8, 18.8, 37.6, and 75.1 kg N per ha. Low-Hi-Low = 9.4, 18.8, 75.1, 37.6, 18.8, and 9.4 kg N per ha.

Table 2—Mean morphology, at time of lifting, of bareroot loblolly pine seedlings used in the nursery N nutrition study

N treatment	Height	Root-collar diameter	Weights		
			Stem	Foliar	Root
	cm	*mm*	*g*		
Growing season[a]					
Operational	31.4	6.2	2.2	3.0	1.3
Increasing	32.6	6.3	2.6	3.4	1.8
Low-Hi-Low	32.2	6.1	2.9	2.9	1.4
(P > F)	0.7329	0.6107	0.0098	0.0018	0.0003
Fall					
None	31.6	6.1	2.3	3.1	1.4
Oct-56 kg N/ha	33.1	6.2	2.5	3.1	1.5
Oct-113 kg N/ha	31.6	6.6	2.5	3.3	1.7
Nov-56 kg N/ha	32.8	6.2	2.3	3.1	1.4
Nov-113 kg N/ha	31.3	5.3	2.2	2.9	1.4
(P > F)	0.3314	0.0123	0.3891	0.0878	0.0595

The seedlings were lifted from the nursery in January 2001.

[a] Operational = 28.2 kg N per ha at each application for six applications. Increasing = 9.4, 9.4, 18.8, 18.8, 37.6, and 75.1 kg N per ha. Low-Hi-Low = 9.4, 18.8, 75.1, 37.6, 18.8, and 9.4 kg N per ha.

Mean seedling height and RCD, at the time of lifting, were similar regardless of growing season N treatments (table 2). The differences measured in seedling biomass between the growing season N treatments were statistically significant. The seedlings treated with the "Increasing" treatment had heavier stem, foliar, and root oven-dry weights. The root-collar diameter differences observed at lifting between the fall N treatments were statistically significant. The seedlings treated in October with 113 kg N per ha had the greatest mean RCD. The differences for mean height and seedling biomass observed between the fall N treatments were not statistically significant. Although not statistically significant, it may be worthy to note that the seedlings treated with the 113 kg N per ha in October seemed to have the heaviest root systems ($P > F = 0.0595$).

First-year survival after planting exceeded 90 percent for all treatments (table 3). First-year total height, height growth and ground-line diameter were not statistically different between growing season N treatments. The differences observed in first-year height growth between fall N treatments were statistically significant. The seedlings treated with 113 kg N per ha in October exhibited the greatest first-year height growth.

CONCLUSIONS

The loblolly pine seedlings treated in the nursery during the growing season with an increasing amount of N had the greatest biomass at the time of lifting. Kormanik and others (1994) tested an N fertilization schedule for loblolly pine seedlings similar to the "Increasing" treatment. Their regimen produced seedlings with good shoot to root ratios and a high number of first-order lateral roots. The seedlings treated in the nursery with 113 kg N per ha in October had the greatest RCD at lifting and the best first-year height growth. Sung and others (1997) and Irwin and others (1998) also have reported positive results for southern pine seedlings treated in the fall with a N fertilizer. The field planting will be measured for several more years in order to observe whether the nursery treatments will have a lasting effect on seedling growth. The study has been repeated for a second year at the same nursery, and a similar N fertilizer study has been done at another nursery that uses a different form and schedule of fertilization.

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Table 3—First-year mean percent survival and growth of bareroot loblolly pine seedlings used in the nursery N nutrition study

Nursery N treatment	Survival	Total height	Height growth	Ground-line diameter
	percent	- - - - - - - *cm* - - - - - - -		*mm*
Growing season				
Operational	94.4	59.7	35.8	14.3
Increasing	94.0	61.1	37.8	15.4
Low-Hi-Low	92.9	60.5	39.3	10.2
(P > F)	0.7887	0.7714	0.6182	0.1568
Fall				
None	94.0	60.5	37.4	14.8
Oct-56 kg N/ha	92.6	58.2	34.4	14.6
Oct-113 kg N/ha	94.3	63.4	41.5	16.1
Nov-56 kg N/ha	93.3	59.5	36.3	14.1
Nov-113 kg N/ha	94.7	60.6	38.4	15.2
(P > F)	0.7479	0.5430	0.0083	0.1178

The seedlings were hand-planted in February 2001 and measured on September 21 and 22, 2001.
Operational = 28.2 kg N per ha at each application for six applications; Increasing = 9.4, 9.4, 18.8, 18.8, 37.6, and 75.1 kg N per ha; Low-Hi-Low = 9.4, 18.8, 75.1, 37.6, 18.8, and 9.4 kg N per ha.

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