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Effect of Nitrogen Fertilization Rate in the Seedbed on Growth of Loblolly Pine in the Field

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Varying rates of nitrogen were applied to loblolly pine (Pinus taeda L.) *seedbeds at 2 nurseries in Virginia. At the New Kent Nursery, the rates were 168, 336, and 504 kg/ha (150, 300, and 450 lb/a) of elemental nitrogen. Seedlings with root collar diameters averaging either 4.7 or 5.5* mm *from each nitrogen rate were planted in the field. At the Sussex Nursery, seedlings were fertilized with either 336 or 672 kg/ha (300 or 600 lb/a) of elemental nitrogen combined with either 13 or 25* mm *(0.5 or 1.0 in) of sawdust tilled in just before seeding. Due to a higher seedbed density, only seedlings with root collar diameters averaging 4* mm *were planted in the Sussex study. For both studies, nitrogen rate did not have a statistically significant effect on survival, height growth, or diameter growth after 7 years in the field.*
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In 1987, the Auburn University Southern Forest Nursery Management Cooperative established a loblolly pine *(Pin us taeda* L.) study at the New Kent Nursery to compare 3 levels of nitrogen at 2 seedbed densities. The target densities were 215 and 323 seedlings/m^2 (20 and 30 seedlings/ft^2), and the nitrogen rates were 168, 336, and 504 kg/ha (150, 300, and 450 lb/a) of elemental nitrogen (N). There were 4 seedbed replications of the 6 treatments using plots 15.2 m (50 ft) long. Seeds were sown using a vacuum seeder, but the seeder did not perform as expected for the higher density plots. In September, the average seedbed density for the lower density plots was 210 seedlings/m^2 (19.5 seedlings/ft2) but the higher density plots had been incorrectly sown and had only 191 seedlings/m^2 (17.8 seedlings/ft^2). Due to the small difference in stocking, the study was modified to compare 4.7- and 5.5-mm-diameter seedlings from the 3 nitrogen rates. We lifted samples from the 12 plots with the lowest stocking (191 seedlings/m^2) to ensure getting enough 5.5-mm seedlings.

In 1987, we installed additional loblolly pine monitoring plots at the Sussex Nursery. We compared 2 application rates of sawdust (13 and 25 mm, 0.5 and 1.0 in) tilled into the soil just before seeding, in combination with the operational N rate or double the operational N rate (Dierauf 1991). The operational N rate at the Sussex Nursery ranged from 302 to 336 kg/ha (270 to 300 lb/a). We lifted samples from 3 of the 4 treatments, from 3 seedbed replications scattered about the nursery. In addition to the moderate operational treatment, the 2 extremes in N status were lifted:

- Low N — operational N plus 25 mm (1 in) of sawdust
- Moderate N — operational N plus 13 mm (0.5 in) of sawdust
- High N — double operational N plus 13 mm (0.5 in) of sawdust.

Lifting and Measuring Seedlings

New Kent study. Seedling samples were lifted on January 25, 1988. Thirty-six samples — 3 samples, evenly spaced from within each of the 12 plots — were lifted, each 15 cm (0.5 ft) long and spanning the 60-cm-wide (2-ft-wide) seedbed, for a 0.186-m^2 (2-ft^2) sample size. Seedlings were measured on January 26 and 27, 1988. Seedlings from each sample were graded into the 2 diameter classes, and the shoot length of each seedling was measured. From the 3 samples from each plot, we proportionally selected twenty 4.7-mm and twenty 5.5-mm seedlings. Each field replication contained 2 rows of 20 seedlings, with the seedlings from each of the 4 seedbed replications kept separate in each of 4 field replications.

Sussex study. Seedling samples were lifted on February 3, 1988. Eighteen samples were lifted, each 15 cm long and spanning the seedbed. Two evenly spaced samples were lifted from each of the nine 3-m-long (10-ft-long) nursery plots. Seedlings were measured on February 10. The seedlings in each sample were separated into 0.8-mm-wide diameter classes, and their shoot lengths were measured. For 8 of the 9 plots, there were more 4-mm-diameter seedlings than any other diameter class. Consequently, we selected only 4-mm seedlings for planting in the field. From each of the 2 samples from each plot, we proportionately selected 15 seedlings for planting in the field (we did not have enough 4-mm seedlings from 1 of the 9 plots to plant 20-seedling rows). Seedlings from each of the 3 seedbed replications were kept separate in each of 3 field replications.

Seedbed Results

New Kent study. Average root collar diameters, shoot lengths, and seedbed densities at lifting are presented in table 1. Seedlings were not top-pruned during the growing season. The data suggested that the highest nitrogen rate produced the shortest seedlings, but the differences were not statistically significant. Producing shorter seedlings with extra N has been observed in other studies (Dierauf 1991). Nitrogen rate had little effect on root collar diameter.

Sussex study. Average root collar diameters, shoot lengths, and seedbed densities are presented in table 2. Seedlings were operationally top-pruned 3 times during the growing season. The low-N seedlings were the smallest. It was obvious during the growing season that this treatment was not providing enough N because the seedlings were chlorotic as well as small. Average bed densities were similar for the low-N and moderate-N plots, but bed density was considerably lower for the high-N plots, which would be expected to favor diameter growth. An analysis of covariance was performed to adjust average root collar diameters for differences in bed density. The effect of N status on diameter was statistically significant ($P = 0.033$).

Field Planting

Seedlings from both studies were planted on March 1, 1988. The New Kent seedlings were planted in 4 randomized blocks, each block containing a 20-seedling row of each of the 6 treatments (2 diameter classes X 3 nitrogen rates). The Sussex seedlings were planted in 3 randomized blocks, each block containing a 15-seedling row of each of the 9 treatments (3 nitrogen levels X 3 seedbed locations). New Kent and Sussex blocks were alternated in the field, so performance of the 2 seedling sources could be compared. Spacing was 2 × 2 m (6.6 X 6.6 ft) for both studies. Seedling heights were measured after 7 years in the field. Diameters at breast height (d.b.h.) were measured to the nearest 2.5 mm (0.1 in).

Table 1—*Average loblolly pine root collar diameter, shoot length, and seed bed density at lifting (1988), by rate of nitrogen application for all seedlings at the New Kent Nursery*

Nitrogen rate[a] (kg/ha)	(lb/a)	Diameter (mm)	(in)	Shoot length (cm)	(in)	Seedbed density (no./m²)	(no./ft²)
168	150	5.1	0.2019	24.9	9.8	198	18.4
336	300	5.2	0.2066	25.6	10.1	202	18.8
504	450	5.1	0.2013	22.6	8.9	200	18.6

[a]Nitrogen rate had no significant effect on root collar diameter or shoot length.

Field Results

New Kent study. Average survival decreased only 0.4% between age 1 and 7 (combining all 24 rows). At age 7, survival of 4.7-mm seedlings (89.6%) was slightly better than 5.5-mm seedlings (87.1%) (table 3). Seedlings receiving 504 kg/ha (450 lb/a) of N had the best survival (90.6%), followed by seedlings receiving 168 kg/ha (150 lb/a) of N (88.8%). In an analysis of variance, after first transforming to arc sine percent, these differences in survival were not statistically significant ($P = 0.259$ for diameter class and $P = 0.262$ for N rate).

Average height at age 7 was slightly greater for the 336- and 504-kg/ha (300- and 450-1b/a) N rates (6.34

Table *3-Average loblolly survival, height, and diameter at breast height (d.b.h.) at age 7 by seedling diameter class at lifting for 3 rates of nitrogen application in the New Kent study*[a]

Root collar diameter (mm)	(in)	Nitrogen rate (kg/ha)	(lb/a)	Survival (%)	Height (m)	(ft)	d.b.h. (cm)	(in)
4.7	0.1875	168	150	92.5	6.18	20.3	9.6	3.8
		336	300	85.0	6.34	20.8	10.2	4.0
		504	450	91.2	6.25	20.5	9.9	3.9
5.5	0.2188	168	150	85.0	6.15	20.2	9.6	3.8
		336	300	86.2	6.28	20.6	9.9	3.9
		504	450	90.0	6.43	21.1	10.2	4.0
Mean				88.3	6.27	20.6	9.9	3.9

[a]There were no significant differences between diameter classes or among rates of nitrogen application.

Table *2-Average loblolly pine root collar diameter, shoot length, and seedbed density at lifting (1988) and survival, height, and diameter at breast height (d.b.h.) at age 7, by nitrogen status for the Sussex Nursery study*

Nitrogen status[a]	Nitrogen rate (kg/ha)	(lb/a)	Sawdust rate (mm)	(in)	Diameter (mm)	(in)	Shoot length (cm)	(in)	Seedbed density (no./m²)	(no./ft²)	Survival (%)	Height (m)	(ft)	d.b.h. (cm)	(in)
Low	336	300	25	1.0	3.5	0.1366	20.8	8.19	418	38.8	88.9	5.88	19.3	9.14	3.6
Moderate	336	300	13	0.5	3.8	0.1497	22.0	8.67	410	38.1	88.9	5.79	19.0	8.64	3.4
High	672	600	13	0.5	4.1	0.1619	22.1	8.71	351	32.6	88.9	5.85	19.2	8.89	3.5

[a]The effect of nitrogen status on root collar diameter was significant ($P = 0.033$). There were no other significant effects of nitrogen.

and 6.25 m; 20.8 and 20.5 ft, respectively) than for the 168-kg/ha (150 lb/a) N rate (6.18 m; 20.3 ft) (table 3). The 5.5-mm seedlings were slightly taller (6.29 m; 20.6 ft) than 4.7-mm seedlings (6.26 m; 20.5 ft). However, in an analysis of variance, these differences in height were not statistically significant ($P = 0.328$ for N rate and $P = 0.782$ for initial diameter). There was no difference in average d.b.h. between 4.7- and 5.5-mm seedlings, and the slight differences in average d.b.h. among N rates were not statistically significant ($P = 0.346$) in an analysis of variance.

Sussex study. Average survival decreased 2% between age 1 and age 7 (combining all 27 rows). At age 7, survival was identical for all 3 nitrogen rates (table 2). The small differences among the 3 treatments in height and d.b.h. at age 7 were not statistically significant ($P = 0.464$ for height and $P = 0.336$ for d.b.h.). Although the seedbed density in the Sussex nursery was double that at New Kent, average height and d.b.h. at age 7 were only about 7% and 10% smaller, respectively, than seedlings from the New Kent Nursery.

Conclusions

There were no benefits demonstrated from applying more than 336 kg/ha (300 lb/a) of N to the sandy nursery soils at New Kent and Sussex. There were no gains in survival, height, or d.b.h., after 7 seasons in the field from applying heavier rates.

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Reference

Dierauf TA. 1991. A five-year study of different sawdust and nitrogen rates in a loblolly pine nursery. Charlottesville (VA): Virginia Department of Forestry. Occasional Report 94. 19 p.