MYCORRHIZAE INCREASE FIELD SURVIVAL OF PLANTED LOBLOLLY PINE

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In a recent TREE PLANTERS' NOTES, we reported that mycorrhizae may be as important as seedling grade to survival of outplanted slash pine *(Pinus elliottii* Engelm.) (1). Tests reported in the present note show that loblolly pine *(P. taeda L.)* survival is also increased by the presence of visible mycorrhizae. While their exact value is difficult to assess, mycorrhizae appear to be important enough to loblolly survival for nurserymen to seek ways to encourage high, uniform mycorrhizal development.

Methods

In 1964 and 1965, 1-0 loblolly seedlings from each of the Louisiana Forestry Commission's active nurseries were outplanted to determine the effects of nursery origin, seedling grade, and mycorrhiza on field survival. Three nurseries were sampled in the first and two in the second year.

At each nursery, samples for an annual field test were lifted from four, 20-foot sections of bed. Within each nursery, the sections were similar in soil properties and in past management. A single section of bed provided all categories of seedlings for a nursery replication in the outplantings.

All seedlings were grown from one lot of seed to eliminate variation due to source. Dense stands were thinned to about 30 plants per square foot in June, but light stocking could not be corrected. Consequently, final density averaged 20 to 22 seedlings per square foot at the Columbia Nursery and 28 to 29 seedlings per square foot in the other nurseries. Seedlings received normal care except for thinning.

The planting stock was classified by Wakeley's morphological grades (5), except that grade 3 was subdivided into:

Grade 3A.-Seedlings 3/32 to 4/32 inch in root collar diameter that had stiff woody stems and fascicled needles.
Grade 3B.-Grade 3 seedlings that lacked any of these attributes.

Graded seedlings were further classed as mycorrhizal or nonmycorrhizal, and the numbers in each grade and class were recorded. The effect of visible mycorrhizae was observed on each grade of seedling from each nursery. The influence on overall performance of a nursery's stock was also determined.

Mycorrhizal seedlings had a minimum of six infected short roots scattered over the root system, one heavily infected main lateral. Nonmycorrhizal seedlings usually lacked visible fungal growth, although individuals with one infected short root were accepted in the class. Stock intermediate between the two classes was discarded, as were all injured or diseased seedlings.

The stock was lifted in late January or early February and outplanted within 2 weeks. Seedlings were planted on deep sandy soil in northwestern Louisiana and on sandy loam soil in the central part of the State. The deep sands are so droughty that newly planted seedlings survive only in wet years. The sandy loams are favorable for pine planting. The two sites were termed adverse and moderate.

Four randomized blocks were planted on each site each year. A block contained one 25-tree row, or plot, of each grade and mycorrhizal class from each nursery.

Survival was measured in June and in the fall of the year of planting.

In 1964, rainfall was about average on the moderate site and below average on the adverse site. Both areas received abundant rainfall during the 1965 growing season.

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Results and Discussion

In 1964, 37 percent more mycorrhizal than nonmycorrhizal seedlings survived on the moderate site. Differences in first year survival by planting grade were as follows: 1-18, 2-12, 3A-21, and 3B-42 percentage points (table 1). Similar differences were present in June, an indication that the inferiority of nonmyocorrhizal seedlings is overcome quickly by those individuals that survive the first spring. Beauregard and Oberlin seedlings of every grade benefited from mycorrhizae. Only large (grade 1) and small (grade 3B) plants from Columbia Nursery benefited.

Few plants lived through the 1964 growing season on the adverse site. There, only spring survival indicated differences in the relative vigor of the seedlings. It showed that mycorrhizal seedlings were superior to nonmycorrhizal seedlings in every grade from all nurseries. The improvement in survival averaged 30 percent (table 2). Moreover, grade 3A mycorrhizal seedlings had 8- to 30-percent

points higher survival than grades 1 and 2 nonmycorrhizal plants from the same nursery.

It is not clear why mycorrhizae increased survival of all grades of seedlings from all nurseries on the adverse site but did not improve survival of grade 2 and 3A seedlings from Columbia on the moderate site. Perhaps the low bed density at Columbia increased vigor of medium-sized seedlings so that they benefited from mycorrhizal roots only under severe conditions. Other studies have shown that field survival is increased by lowering nursery bed density. (3).

The favorable rainfall during the 1965 growing season resulted in good survival on both sites. Differences in performance of mycorrhizal and nonmycorrhizal seedlings were statistically significant at the 0.05 level, but they were not of practical magnitude. Nevertheless, they strengthen the conclusion that mycorrhizae enhance field survival of loblolly nursery stock.

The probable advantage of altering nursery practices in 1964 to produce only mycorrhizal seedlings varied by nursery. At Oberlin, about 40 percent of the seedlings in grades 1, 2, and 3A were nonmycorrhizal (table 3). Overall survival of this nursery's stock would probably have been at least 13 percentage points higher had all seedlings been mycorrhizal. In the same year, complete infection of Beauregard and Columbia seedlings planted on the moderate site would have increased survival by only 3 and 1 percent, respectively. The variation by nursery is caused by differences in proportion of stock that was infected as well as the difference in survival between infected and uninfected seedlings.

TABLE 1.—*First-year survival of loblolly pine seedlings on a moderate site, by grade, nursery, year of planting, and mycorrhizal class*

Nursery and year	Grade 1		Grade 2		Grade 3A		Grade 3B	
	M [1]	N [1]	M	N	M	N	M	N
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Beauregard								
1964	93	79	98	91	92	78	54	32
1965	99	95	98	93	94	79	84	47
Average	96	83	98	92	93	78	69	40
Columbia								
1964	100	91	98	98	92	89	72	11
1965	99	100	98	99	99	94	96	82
Average	99	96	98	98	96	92	84	46
Oberlin								
1964	94	65	100	71	87	41	46	3

[1] M = mycorrhizal, N = nonmycorrhizal.

TABLE 2.—*Spring and fall survival of loblolly pine on an adverse site, by grade, nursery, year of planting, and mycorrhizal class*

Nursery and year	Season	Grade 1		Grade 2		Grade 3A		Grade 3B	
		M [1]	N [1]	M	N	M	N	M	N
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Beauregard									
1964	Spring	72	38	65	38	65	20	27	7
	Fall	2	3	2	1	2	0	0	0
1965	Spring	100	100	100	98	100	96	93	63
	Fall	100	99	99	96	98	95	91	45
Columbia									
1964	Spring	84	48	87	61	69	39	37	10
	Fall	6	1	4	6	3	0	0	0
1965	Spring	100	—	100	100	100	93	95	93
	Fall	100	—	100	98	98	93	79	87
Oberlin									
1964	Spring	53	24	78	43	54	23	12	0
	Fall	1	3	2	1	0	3	0	0

[1] M = mycorrhizal, N = nonmycorrhizal.

TABLE 3.—*Production of loblolly seedling, by grade and mycorrhizal class*

Nursery and year	Grade 1		Grade 2		Grade 3A		Grade 3B	
	M[1]	N[1]	M	N	M	N	M	N
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Beauregard								
1964	16	4	34	14	17	10	2	3
1965	19	7	29	14	13	9	5	4
Average	18	5	31	14	15	10	4	3
Columbia								
1964	27	10	24	13	13	9	2	2
1965	5	1	26	7	24	15	13	9
Average	16	6	25	10	18	13	7	5
Oberlin								
1964	21	13	27	17	10	10	1	1

[1] M = mycorrhizal, N = nonmycorrhizal.

In some nurseries, 3A seedlings are usually discarded. They were included in the present appraisal because mycorrhizal seedlings of this size were good planting risks. Survival of such seedling ranged from 87 to 99 percent on the moderate site. Grade 3A stock comprised 20 to 27 percent of the total production of the three nurseries in 1964, and accounted for about one-third and one-half of the potential gain from complete mycorrhizal infection.

What nurserymen can do to ensure mycorrhizal development is uncertain, but published studies have suggested some possibilities. Inoculum apparently is present in southern nursery soils, even in the first year after fumigation with methyl bromide (4). Hacskaylo and Snow (2) showed that mycorrhizal roots are most abundant on loblolly pine seedlings grown in full sunlight if the nutrient supply is sufficient for adequate but not lush root

growth. These authors concluded that fast-growing roots are less apt to be infected than slow-growing ones. They noted, however, that extremely low nutrient levels limited growth of both fungi and roots. Thus, seedlings should probably be grown at a uniform spacing in low-density beds that are fertilized at moderate rates.

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