PINE NURSERY STOCK

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Soils of southern pine nurseries are known to contain the beneficial mycorrhizal fungi. What has not been recognized, generally, is that a considerable portion of the seedlings may not become visibly infected with the fungi before they leave the nursery. A recent study in Louisiana showed that the presence of visible mycorrhizae on roots of seedlings of slash pine *(Pin us elliottii* Engelm.) may be as important as seedling grade in determining survival after outplanting. This suggests the value of insuring greater infection of nursery stock.

Procedure

The study was conducted from 1962 to 1964. Seedlings were obtained from one U.S. Forest Service nursery (The Stuart) and four Louisiana Forestry Commission nurseries in the first 2 years, and from three Commission nurseries in the third year.

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Four 20-foot sections of bed were selected in each nursery annually. A single section provided all classes of seedlings for one nursery replication in the field plantings. Within a nursery, the four bed segments were' similar in soil texture, drainage, and thickness of the A horizon, and usually had been managed similarly in the past.

A single lot of seed was used to sow all study beds each year. Seedling stands were thinned to a density of about 30 plants per square foot in May or June. These precautions were taken to eliminate seed origin and bed density as sources of variation in field survival. Otherwise, seedlings received normal nursery care, which varied by year and nursery.

The planting stock was classified by Wakeley's morphological grades (2), 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.-Other grade-3 seedlings that lacked any of these attributes.

Graded seedlings were further classed into plants with and without visible mycorrhizae. Mycorrhizal seedlings had a minimum of six mycorrhizal short roots scattered over the root system, or one heavily infected main lateral. Nonmycorrhizal seedlings usually lacked visible fungal growth, although individuals with one infected short root were accepted. Stock intermediate between these two classes-less than 1 percent of the total-was discarded, as were all injured and diseased seedlings.

Outplantings were made annually on deep sandy soils in northwest Louisiana and on sandy loams in the central part of the State. The former are so droughty that planting succeeds only in wet years. The latter are favorable for planting. The two sites will be termed *adverse* and *moderate.*

An annual installation consisted of four randomized blocks on each site. Each 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 following planting. Annual rainfall was mostly less than normal. Rainfall for the 3 years on the adverse site rang from 9 to 17 inches below the long-term 53-in average. The moderate site had deficits of 12 and 18 inches in 1962 and 1963, but received 4 inches more than the 58-inch normal in 1964.

Results

Morphological grade. - Morphological grade (outward appearance of vigor) significantly affected survival in all years on both sites (statistical evaluations were at the 0.05 level). On the moderate site (central sandy loam) , fall survival of grade 1 and 2 stock averaged 79 and 77 percent, respectively, and indicated little difference in the quality of these plants (table 1). Grade 3A seedlings, which possessed all characteristics of plantable stock except size, survived 64 percent. Only 39 percent of the small, immature, grade 3B seedlings lived.

First-year survival on the adverse site was extremely low, with only 12 percent of grade 1, 8 percent of grade 2, 4 percent of grade 3A, and 2 percent of grade 3B plants alive (fig. 1). But June survival on this site paralleled that on the moderate site in the fall: grades 1 and 2 averaged 66 percent survival, while grades 3A and 3B h 48 and 32 percent survival, respectively.

Mycorrhizae.-The presence of visible mycorrhizae had a significant and important beneficial effect on the survival of seedlings of all grades. This influence persisted throughout the growing season on the moderate site, but disappeared during the summer on the adverse site.

On the moderate site, grade 1 mycorrhizal stock had a year-end survival of 87 percent, or 16 percentage points above that of nonmycorrhizal plants. Similarly, mycorrhizal grades 2, 3A, and 3B survived 17, 20, and 29 percentage points better than nonmycorrhizal stock of the same morphological grades. Although the average survival of morphologically graded 3A stock was 64 percent, the mycorrhizal seedlings in this classification averaged 74 percent; thus they were equal or superior to larger nonmycorrhizal stock.

Spring survival trends on the adverse site (fig. 1) resembled those on the moderate site. Mycorrhizal plants survived 63 percent, or 20 percentage points higher than nonmycorrhizal stock. Mortality

TABLE 1.—*First-year survival of slash pine seedlings on the 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
	Pct.		*Pct.*		*Pct.*		*Pct.*	
Beauregard								
1962	94	82	95	69	92	56	71	24
1963	82	63	87	58	68	42	39	9
1964	73	50	80	49	38	29	27	10
Average	83	65	87	59	66	42	46	14
Columbia								
1962	98	76	88	67	88	57	80	30
1963	92	79	99	84	85	58	39	19
1964	88	74	97	69	89	58	78	39
Average	93	76	95	73	87	58	66	29
Oberlin								
1962	96	84	89	77	84	68	56	29
1963	87	58	83	47	67	38	15	8
1964	90	79	85	56	59	41	65	17
Average	91	74	86	60	70	49	45	18
Sibley								
1962	96	88	93	81	92	88	68	42
1963	78	57	83	59	59	56	46	30
Average	87	72	88	79	76	72	57	36
Stuart								
1962	96	93	95	88	89	82	79	48
1963	66	38	70	54	53	27	23	1
Average	81	66	82	71	71	54	51	24
5 nurseries	(All)		(All)		(All)		(All)	
Average	87	79 71	86	77 69	74	64 54	54	39 25

[1] M = mycorrhizal, N = nonmycorrhizal.

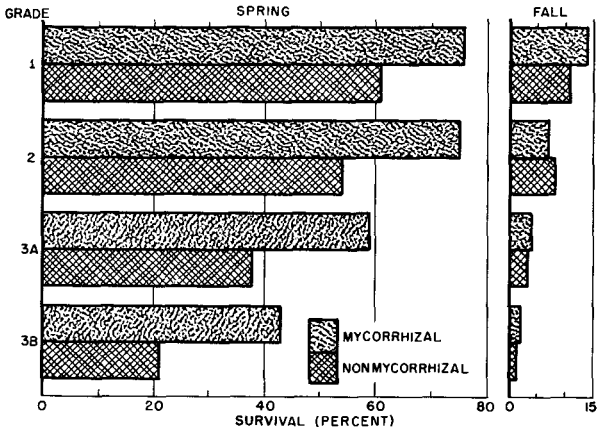

Figure 1.—Spring and fall survival of slash pine seedlings planted on the adverse site.

was heavy during the summer, however, and by fall no important differences existed between the two groups.

The percentage of seedlings with mycorrhizae varied by nursery, grade, and year (table 2). In 1963, for example, it decreased with grade, being 77 for grade 1, 73 for grade 2, 64 for grade 3A, and 51 for grade 3B. Moreover, the percentages ranged from 58 for the Columbia Nursery to 72 for the Stuart. In 1964 variation between grades was small, but the range between nurseries was as much as before.

Nursery.-Survival on the moderate site indicated significant differences in stock quality associated with nursery. There was considerable year to-year variation in the stock from some nurseries,

TABLE 2.—*Distribution of slash pine seedlings by grade and mycorrhizal class* [1]

Nursery and year	Grade 1		Grade 2		Grade 3A		Grade 3B	
	M [2]	N [2]	M	N	M	N	M	N
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Beauregard								
1963	14	5	33	10	19	6	4	6
1964	34	26	15	17	2	3	1	2
Columbia								
1963	12	4	19	12	16	13	11	11
1964	24	14	20	11	11	9	6	5
Oberlin								
1963	14	5	21	5	17	10	13	12
1964	30	18	25	10	7	4	2	4
Sibley								
1963	16	6	30	12	15	8	5	4
Stuart								
1963	25	4	29	11	16	9	3	3

[1] Seedlings not graded as either mycorrhizal or nonmycorrhizal are excluded, and thus the percents for a nursery-year may not total 100.

[2] M = mycorrhizal, N = nonmycorrhizal.

but stock from others, such as the Columbia Nursery, always survived well.

Field performance was not well correlated with size, color, or root development (other than mycorrhizae) of the stock. Plants from the Stuart Nursery illustrate this best. In 1962 the planting stock was small and pale and had few fibrous roots. Yet it survived well. The following year the seedlings were morphologically the best tested, but they had the poorest survival of all nursery-year combinations.

Because sample beds differed in the proportion of plants in each grade-mycorrhizal class, effective production could best be determined by measuring survival of bed-run stock. Essentially, this was done in 1964 by weighting survival on the moderate site by the quantity of each class and grade of stock produced in the sample beds. For that year, 61, 76, and 80 percent respectively of all seedlings from sample portions of the Beauregard, Oberlin, and Columbia Nurseries would have lived. Thus, marked differences in survival did exist between stock from the three nurseries planted on the moderate site.

On the adverse site, final survival did not differ by seedling source.

Discussion and Conclusions

The superior initial survival of mycorrhizal seedlings on both sites, and the first-year survival of mycorrhizal seedlings on the moderate site, agree well with results of Goss (1) and Wright (3) with ponderosa pine *(Pinus ponderosa* Laws.). Goss found that more mycorrhizal than nonmycorrhizal seedlings were able to survive moderate drought. In the present study, the severe conditions that preceded the June tally killed more nonmycorrhizal than mycorrhizal stock on both sites. Continued drought on the adverse site reduced the number of living plants until there was no difference in survival between the two groups. Wright's data also indicated that mycorrhizae influenced survival on a good site, but not on a poor one.

The survival difference in stock from one nursery to another and from year to year was very evident. Within nurseries, in the small areas sampled annually, both morphological grade and mycorrhizal class distinguished better from poorer stock. Between nurseries and annual replications these criteria were not reliable. Grade 3A stock from one nursery was in some instances superior to larger plants from another nursery, and in 1 year practically

no seedling grade-mycorrhizal combination from the sample beds of one nursery had acceptable survival.

Morphological grade continues to represent the most important combination of characteristics by which plants with high survival potential may be selected. But the fact that 3A mycorrhizal plants survived as well as nonmycQrrhizal grade 1 and 2 stock indicates that mycorrhizae and grade provide better criteria than grade alone.

The greatest opportunity for improving survival potential of slash pine seedlings appears to be through increasing the proportion of mycorrhizal stock. In the 1964 plantings of this study, about 40 percent of the seedlings in grades 1 through 3A lacked mycorrhizal short roots. Their survival on the moderate site would have been at least 20 percentage points higher if they had possessed them.

If this increase had been applicable to the total production of the three nurseries in that year, a gain of 1,600,000 effective seedlings would have been achieved.

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