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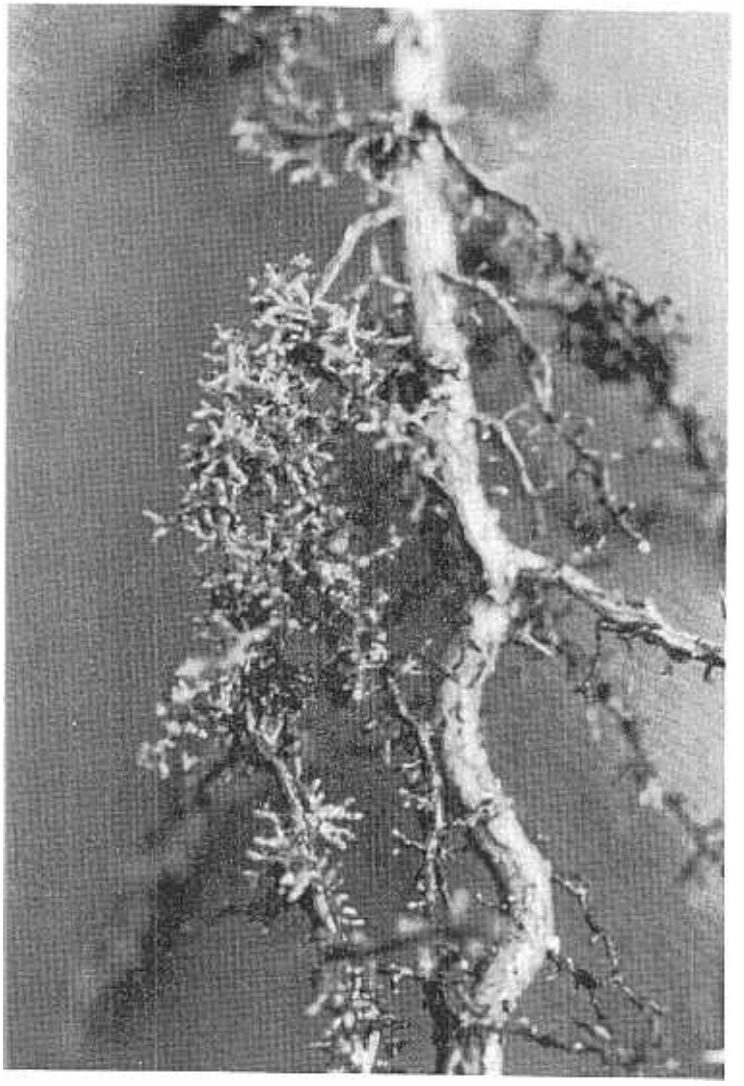

Virginia
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The Effect of Mycorrhizae on Survival and Growth of Loblolly Pine Seedlings

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INTRODUCTION

In the summer and early fall of 1987, we were concerned by what seemed to be a low level of mycorrhizal infection at both our New Kent and Sussex nurseries. Practically all the loblolly seedlings had at least some forked roots, but many of these forked roots did not have the other attributes which we associated with mycorrhizae, and we wondered if they might be non-functional mycorrhizae. Our idea of a functional mycorrhizae was a forked, somewhat-swollen, short-root that was lighter in color than non-mycorrhizal roots (Figure 1). Often, if the root systems were lifted carefully, the mantle of hyphae could also be seen. Ed Cordell[1] spent two days with us in December 1987 looking at seedlings at both New Kent and Sussex. Ed reinforced our ideas about what were functional and non-functional mycorrhizae. He also told us that from observations in different parts of the South he felt that mycorrhizal infection was down in 1987 and seemed to occur later in the season. He also said that production of mycorrhizal fruiting bodies was less than normal in 1987 and was also delayed, wherever he had been.

We decided to install a study to try to find out how serious the consequences might be for seedlings that had no mycorrhizae, or only "non-functional" mycorrhizae (forked roots that were not lighter-colored and swollen).

Procedure

Our initial plan was to lift seedling samples from a number of different nursery locations, at both Sussex and New Kent, and separate three classes of seedlings from each sample: no mycorrhizae (or only non-functional mycorrhizae), a small number of mycorrhizae (perhaps 10 to 20 percent of the short roots infected) and moderate to heavy mycorrhizae (greater than one-third of the short roots infected). We hoped we would be able to get at least 60 seedlings (enough for three 20-seedling rows in the field) of each of these classes from all nursery locations.

On January 4, 1988, we carefully hand-lifted large samples of seedlings from a number of different locations at each nursery. On January 6 and 7 we went through the samples, one at a time, (after dipping the roots in water to wash off soil) looking quickly at every seedling and placing them in three piles: no mycorrhizae (or only non-functional), light infection, and moderate to heavy infection. If it looked like we would have 60 seedlings of at least two, and hopefully all three, of these classes, we went through them all again, this time looking at each seedling much more carefully and

[1] A pathologist with the U. S. Forest Service stationed at Asheville, North Carolina.

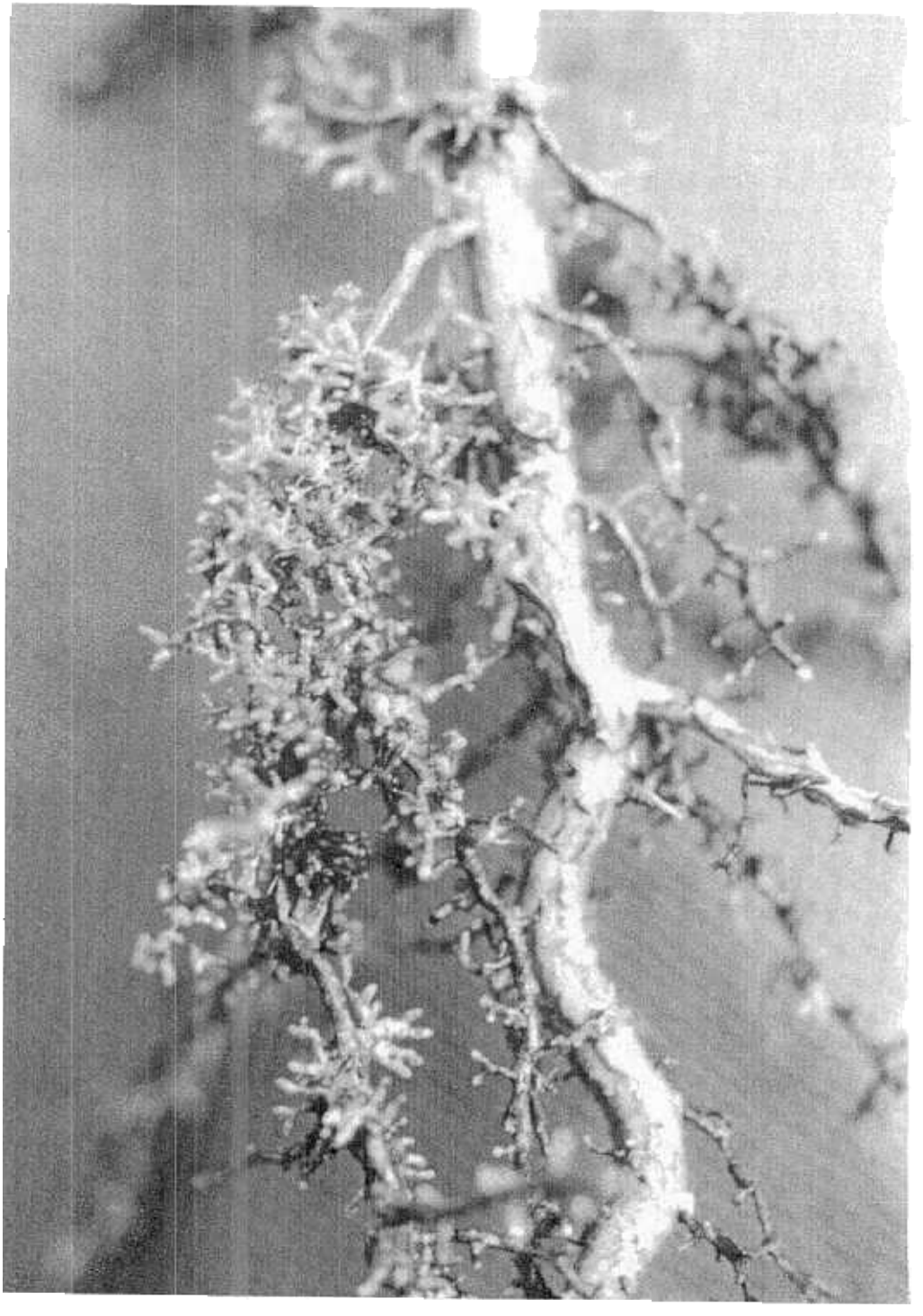

Figure 1. A seedling with many swollen, light-colored mycorrhizae.

shifting borderline seedlings back and forth until we had 60 seedlings in each class. We ended up selecting seedlings from three different locations at each nursery, and from two of these six locations we were only able to obtain two different classes of mycorrhizal infection.

After the seedlings were selected, we measured the 60 seedlings to be planted in the field for root collar diameter and top length. We discarded seedlings less than 7/64 inch root collar diameter. Non-mycorrhizal seedlings tended to be slightly larger than mycorrhizal seedlings. Some of the seedlings we discarded, because they were less than 7/64 inch in root collar diameter, were heavily mycorrhizal. From one nursery location we threw away large numbers of "too-small" seedlings that were as heavily mycorrhizal as any we saw in all our observations. Table 1 includes average root collar diameter, average top length, and range of infection of individual seedlings within the samples. Percent infection was our estimate of the percent of short roots infected by functional mycorrhizae. The estimates were not based on actual counts of short roots.

After measurement, the seedlings were placed in cold storage after dipping the roots in a kaolin clay slurry. They were left there for two weeks, and then planted on January 21. They were planted on a typical upland site on the Appomattox-Buckingham State Forest in the central Piedmont of Virginia.

Results

Among the 16 samples from the 6 different nursery locations, there was a general tendency for survival and height growth to improve with increasing amounts of mycorrhizal infection. There were exceptions, however. For the seedlings from West Hughes V-1, seedlings with no mycorrhizae survived slightly better than seedlings with light mycorrhizal infection (96.7 vs. 93.3 at age 3). Also, for seedlings from West 3, OO-5, seedlings with light mycorrhizal infection survived slightly better than seedlings with heavy infection (98.3 vs. 96.7 at age 3). Table 1 includes average survival at age 1 and 3 and average height at age 3 for each of the samples.

In Table 2 we have combined samples by mycorrhizal infection class. There is danger in doing this, because there are other seedling differences between sample locations than just percent infection by mycorrhizae. The overall trends, however, are easier to see in Table 2 than in Table 1.[2]

[2]Analyses of variance were performed on the 16 samples (treatments) as arranged in Table 2. Survival percents were first transformed to arc sine percent. The effect of mycorrhizal infection on survival was significant (probability of a larger F=.039) but the effect on 3-year height was not (probability of a larger F=.073).

Table 1. **Average root collar diameter and top length, and range in estimated percent of short-roots that were mycorrhizal, for the 60 seedlings from each sample that were planted in the field. Also, average survival at ages 1 and 3 and average height at age 3.**

Nursery Location	Mycorrhizal Infection	Root Collar Diameter (32nd inch)	Top Length (inches)	Survival Age 1	Survival Age 3	Height (feet) Age 3
West Hughes, V-1	Light (5 to 50%)	4.48	7.82	95.0	93.3	5.4
West Hughes, V-1	None	4.35	8.03	98.3	96.7	4.8
West 3, OO-5	Heavy (40 to 70%)	5.08	6.17	96.7	96.7	6.1
West 3, OO-5	Light (5 to 20%)	5.27	6.33	98.3	98.3	6.1
West 3, OO-5	None	5.35	6.65	65.0	65.0	5.2
Far West 1, J-1	Heavy (35 to 65%)	4.90	6.92	100	100	5.8
Far West 1, J-1	Light (5 to 20%)	4.87	6.85	96.7	93.3	5.2
Far West 1, J-1	None	4.98	6.87	90.0	88.3	4.9
East Hughes, E-5	Light (20 to 40%)	4.38	8.72	96.7	95.0	5.6
East Hughes, E-5	Very Light (3 to 10%)	4.60	8.88	91.7	91.7	5.2
East Hughes, E-5	None	4.62	9.05	88.3	88.3	4.9
East Hughes, C-8	Medium (15 to 40%)	5.00	7.73	100	98.3	5.7
East Hughes, C-8	Light (2 to 10%)	4.92	7.92	96.7	96.7	5.0
West 3, DD-9	Medium (20 to 50%)	4.57	5.25	100	100	5.6
West 3, DD-9	Very Light (2 to 15%)	4.78	5.85	91.7	91.7	5.7
West 3, DD-9	None	5.00	6.33	85.0	85.0	5.5

Table 2. **Average survival and height at age 3, combining samples by mycorrhizal infection classes.**

Infection Class	Number of Samples	Range in infection among seedlings	Survival	Height
Heavy	2	35-70	98.3	5.9
Medium	2	15-50	99.2	5.7
Light	5	2-50	95.3	5.4
Very light	2	2-15	91.7	5.4
None	5		84.7	5.1
	16			

1988 STUDY

A smaller study was done in 1988, when mycorrhizal infection again seemed to be below normal. Seedlings from four different locations at our New Kent Nursery were examined and separated into mycorrhizal classes as in 1987. A higher proportion of seedlings had at least some mycorrhizae than in 1987, and it was more difficult to get a separation into different infection classes. The same procedure was followed as in 1987, except that root-collar diameters and top lengths were not measured and the range of infection within each planted sample was not estimated.

The four samples were lifted and the seedlings separated on February 6 and 9 and March 6. We obtained three mycorrhizal infection classes from one sample and two classes from each of two samples, but one of the four samples did not have enough variation in infection to get even two infection classes.

The seedlings were planted on March 22 on a typical upland site on the Appomattox-Buckingham State Forest in the central Piedmont of Virginia.

Results

Table 3 includes average survival at age 1 and 3 and average height at age 3 for each of the seven samples. Mycorrhizal infection improved survival for only one of the three nursery locations (West 1, Y), and improved 3-year height for only one of the three locations (West 3, NN).

Table 3. Average survival at ages 1 and 3 and average height at age 3.

Nursery Location	Mycorrhizal Infection	Survival		Height (feet)
		Age 1	Age 3	Age 3
West 3, NN	light	91.7	91.7	4.9
West 3, NN	none	96.7	95.0	4.6
Far West 1, H	medium	93.3	93.3	4.8
Far West 1, H	light	98.3	98.3	5.0
Far West 1, H	very light	98.3	98.3	5.5
West 1, Y	medium	98.3	98.3	4.5
West 1, Y	light	93.3	91.7	4.7

Discussion

If our assessment of mycorrhizal infection was reasonably accurate, mycorrhizal infection provided a modest but significant improvement in survival in 1987 but not in 1988. We are not completely satisfied that we were accurately differentiating between mycorrhizal and non-mycorrhizal roots. There may have been functional mycorrhizae that we were not recognizing, for example among the dark-colored, non-swollen, forked roots.