

NURSERY-INFECTED SEEDLINGS DEVELOP FUSIFORM RUST CANKERS AFTER OUTPLANTING

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Nursery-infected seedlings that appear to be free of fusiform rust at planting may be the cause of unexplained mortality in young pine plantations. Such concealed infection, added to cull for rust in nurseries and natural infection in plantations, makes fusiform rust the most serious disease of pine seedlings in the South today.

Outbreaks of fusiform rust at nurseries in Louisiana and Mississippi during the past 2 years were responsible for a high percentage of cull, one nursery losing 35 percent of its slash pine production in 1957. This high incidence of infection in nurseries, which had followed recommended control practices, drew attention again to the rust problem. Investigating this outbreak led to the finding that many of the apparently disease-free seedlings shipped from the nurseries were infected with fusiform rust.

In September 1958, after excessive losses had been reported in an 80-acre slash pine plantation, an examination revealed that mortality was due primarily to fusiform rust infection, with cankers at or below the ground line, depending on the depth of planting. A very high percentage of the surviving seedlings had cankers at the ground line. The location of these cankers is considered to be positive evidence of nursery infection. Approximately 90 percent of the seedlings in this plantation were nursery-infected. A nearby planting of loblolly pine, from the same nursery, had 40 to 60 percent nursery-infected seedlings. Another plantation of 1957-58 slash pine from the same nursery, but lifted and graded about 1 month later, had 37.5 percent nursery-infected seedlings when examined 1 year after planting.

Samples of these seedlings were sectioned and examined microscopically.³ All examinations confirmed the presence of rust mycelium in seedlings with basal swellings.

The grading crew at the nursery was well trained, and spot checks showed that only a low percentage of seedlings with visible infections were being passed. It appears that much of the nursery infection was latent, that is, not sufficiently developed to be detectable by routine grading.

Further experience indicated that latent infection may also escape more exacting standards of grading. An experimental planting of loblolly pine, which had been carefully graded by an experienced regeneration specialist, was examined 10 months after planting. This plantation also had appreciable numbers of seedlings with ground-line galls. These seedlings had come from three nurseries in the same State. At nursery A, the beds in which the stock was produced had 55 percent of the seedlings visibly infected; at nursery B, 30 percent of the seedlings in the experimental beds had been culled because of visible rust galls. A precise tally for the experimental beds at nursery C was not available, but the nurserywide cull for rust had been under 5 percent.

When the origin of the planting stock is considered, the percentage of latent infection was approximately proportional to the percentage of cull at the nursery (table 1).

In a study aimed at evaluating nursery grading standards, three classes of slash pine seedlings were selected as disease-free at nursery D, in another State. The percentage of visible infection was quite high at this nursery. The seedling classes were as follows:

- (1) Seedlings examined and passed by nursery graders.
- (2) Seedlings re-examined by research personnel after being passed by nursery graders.
- (3) Seedlings having basal branches, but no visible signs of fusiform rust.

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³ Microscopic examinations by Dr. F. F. Jewell. Southern Institute of Forest Genetics, Gulfport, Miss.

Table 1.--Proportion of latent nursery infection and visible cull on 1957 loblolly pine by nursery sources

Source of seedlings	Fusiform rust developing after planting	Cull for rust at nursery
	<i>Percent</i>	<i>Percent</i>
Nursery A ¹	19.6	55
Nursery B.....	15.4	30
Nursery C.....	1.5	(²)

¹This nursery supplied seedlings for the 80-acre plantation discussed above.

²Low, but not known precisely.

Ten months after planting, all three classes of seedlings had ground-line galls (table 2). In addition, there were varying percentages of mortality in these classes, although no determination as to cause of early mortality had been made.

The higher percentage of infection on the regraded seedlings compared to routine nursery-graded seedlings is consistent with the latent nature of the infection. Normally, it would be expected that seedlings carefully examined by several people would have less infection than those subjected to a single rapid examination by nursery graders. However, in latent infection, there are no distinct signs to indicate which seedling should be culled, and it is a matter of chance whether an infected seedling is culled or not. If it is assumed that the mortality (table 2) was due primarily to latent fusiform rust, it appears that the amount of latent infection was the same whether the seedlings were graded once, or regraded.

Infection of seedlings with basal branches was substantially higher than that for either class of unbranched seedlings. Although Henry⁴ has reported that seedlings with basal branches, lifted and planted in 1937, did not develop cankers, visible infection in nurseries was quite low in 1937.⁵ In the present study, a high percentage of latent infection is postulated, and a considerable amount of infection may have been concealed by the branches.

Table 2.--Mortality and fusiform rust infection on slash pine, by grading class

Class	Rust	Mortality	Total
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Regular nursery grading.....	2.7	16.2	18.9
Regraded.....	7.0	12.0	19.0
Basal branches.....	29.5	8.0	37.5

It is probable that latent infection is the result of differences in rate of development of the galls on seedlings in the nursery. Some seedlings may develop a visible gall in 4 to 6 months after infection; on other seedlings galls may require 8 to 10 months to become visible. Sleeth⁶ believed that galls developed at a slower rate on unthrifty and undersized stock. The common experience of nurserymen finding more rust during lifting than their inventory showed may be the result of this variation in rate of gall development. It is highly probable that more latent infection is present in seedlings lifted in December than

4 Henry, Berch W. Basal branches no symptom of fusiform rust on slash pine seedlings. U.S. Forest Serv., Tree Planters' Notes 24, p. 16. 1956.

5 Siggers, Paul V. Weather and outbreaks of the fusiform rust of southern pines. Jour. Forestry 47: 802-806. 1949.

6 Sleeth, Bailey. Mortality of slash pine seedlings infected by Cronartium fusiforme. U.S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 35. 1940.

in those lifted 2 months later. The galls continue to develop during this time, and the infected seedlings are culled out. In at least three nurseries, the percentage of cull for fusiform rust at the end of the lifting season (February 1959) was 3 to 5 times that in December 1958.

It appears certain that culling out seedlings with obvious cankers at the nursery does not assure rust-free stock. Early in the lifting season, at least one-third of the infection may be latent, and the seedlings will not show the classical symptom of the disease—the pronounced swelling on the stem. Basal branching in itself apparently is not evidence of rust infection, but graders should scrutinize seedlings with such branching in heavy rust years. Further studies are needed to improve detection techniques during grading, and to determine if the proportion of latent infection is the same each year.

Latent infection of nursery stock is not a new phenomenon. Sleeth^{6,7} recognized this condition in 1940, and reported from 4 to 19 percent latent infection on uncantered seedlings planted in 1939. Wakeley⁸ also called attention to the fact that nursery-infected seedlings may fail to develop cankers by lifting time. Latent infection probably has been overlooked because the tendency toward deep planting usually conceals galls developing after outplanting, and on large plantings dead seedlings rarely are pulled up to determine the cause of mortality. Nurserymen and planters should be aware of latent infection, which may account for poor survival in severe rust years, even when rainfall is ample.

During normal years, latent infection probably is not serious. When visible nursery infection is about 2 to 3 percent of the crop, the concealed infection may be no more than 1/2 to 1 percent. In high-hazard years, when the visible cull in the nursery may be 50 percent or more, an additional latent infection of 20 to 25 percent of the total crop may be expected. This means that approximately 75 percent of the nursery production is worthless, and that the cost of producing 1,000 plantable seedlings has jumped from \$4 to about \$16. Considered in this light, a 100 percent increase in cost of fusiform rust control in the nursery is entirely justified.

As inspection during grading may not assure rust-free seedlings, the nurseryman should rely mainly on preventing infection in the seedbed. Current knowledge indicates that careful spraying with ferbam, ziram, or zineb will reduce infection to a tolerable level. Ferbam should be used at the rate of 2 pounds in 75 gallons of water per acre; a spreader-sticker should be included, and the solution applied at a pressure of at least 300 pounds per square inch through No. 2 nozzles⁹.

Timing and frequency are of the utmost importance. Spraying should begin as soon as the seed begins to germinate, and should be repeated at least twice a week until germination is complete. After that, the spray should be applied at 5- to 7-day intervals until mid-June. Spraying should be more frequent if rain washes off the fungicide, and additional sprays should be applied during critical periods: that is, whenever prolonged periods of high humidity coincide with temperatures between 60° and 80° F.¹⁰

This intensified program may result in 8 to 10 more sprayings than a conventional schedule of 12 to 15 sprays per season. The slight increase in cost, however, is likely to be offset by a reduction in the number of culled seedlings.

Unless better commercial rust-detection methods can be developed, it may not be advisable to ship seedlings from beds with more than 50 percent visible infection. Such a procedure would avoid the expense of lifting, grading, and shipping stock that will only be a burden to the planter.

CAUTION: In handling the chemicals listed, follow directions and heed precautions given by the manufacturer.

⁶Sleeth, Bailey. Mortality of slash pine seedlings infected by *Cronartium fusiforme*. U.S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 35. 1940.

⁷Sleeth, Bailey. Fusiform rust control in forest-tree nurseries. *Phytopath.* 33:33-44., illus. 1943.

⁸Wakeley, Philip C. Planting the southern pines. U.S. Dept. Agr., Agr. Monog. 18. 233 pp., illus. 1954.

⁹Foster, A. A., and Henry, Berch W. Nursery control of fusiform rust demands careful spraying. U.S. Forest Serv. Tree Planters' Notes 14, pp. 13-15. 1956.

¹⁰Verrall, A. F. Fusiform rust of southern pines. U.S. Dept. Agr. Forest Pest Leaflet 26. 4 pp., illus. 1958.