Seedling Production Trends and Fusiform Rust Control Practices at Southern Nurseries, 1981–1991

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ABSTRACT. *Southern pine seedling production and fusiform rust control practices within the Auburn University Southern Forest Nursery Management Cooperative were summarized from annual questionnaires since 1981 and projected for the South. Production peaked at approximately 1.6 billion seedlings in 1987 and 1988 and declined about 31% to 1.1 billion seedlings in 1991. The systemic fungicide triadimefon (Bayleton®) replaced contact fungicides for control of fusiform rust during this period. Before triadimefon, the average percentage of rust-infected seedlings for southern nurseries was estimated at 2.5% (Rowan 1977); after triadimefon the average rust incidence has been only 0.2%. Sowing and harvest dates have not changed since 1981 and loblolly* (Pinus taeda) *and slash pines* (P. elliotii) *continue to account for 75% and 20% of southern seedling production, respectively. Reducing the rust infection percentage from 2.5% to 0.2% decreases by approximately 30 million the number of infected seedlings annually. South. J. Appl. For. 17(4):207–211.*

Fusiform rust, caused by *Cronartium quercuum* (Berk.) Miyabi ex Shirai f. sp. *fusiforme* Burdsall and Snow, is the most important disease of loblolly (*Pinus taeda* L.) and slash (*P. elliottii* Engelm.) pine seedlings throughout most of the southeastern United States. Most southern nurseries must protect seedlings from shortly after germination (early May) until the end of inoculum production (late June), or the percentage of diseased seedlings will be unacceptable (Kelley and Runion 1991). Protecting seedlings with fungicides is a cost-effective approach; alternative methods have been insufficient to meet the demand for disease-free seedlings. Although infection can be avoided either by sowing late or by locating nurseries away from areas where the disease is endemic (Czabator 1971), neither of these alternatives is entirely satisfactory. Delayed sowing results in fewer seedlings becoming established because of increasing temperatures (Boyer and South 1988), and transportation costs prohibit returning seedlings from off-site nurseries for planting.

The percentage of seedlings that become infected in a given nursery varies among years (Figure 1) as a function of weather conditions, but the average probability for a particular nursery or a given area over time is reasonably predictable. Rust infection percentages among 8- to 12-yr-old loblolly pine plantations were recorded and mapped by Phelps (1977). The rust percentages in these plantations were found to be correlated with the abundance of certain oak species (Squillace 1976, Squillace and Wilhite 1977). In general, the percentage infection declined with increasing distance away from central Georgia and Alabama such that the northern isobar for 10% infection was near the northern borders of Louisiana, Mississippi, Alabama, Georgia, and South Carolina, extending north through the western piedmont of North Carolina to Virginia (Phelps 1977). The rust-control practices of nurseries within the Auburn University Southern Forest Nursery Management Cooperative (AUSFNMC) are, on average, much less intensive in areas north of this 10% isobar. To accommodate analyses of nursery-control practices to these

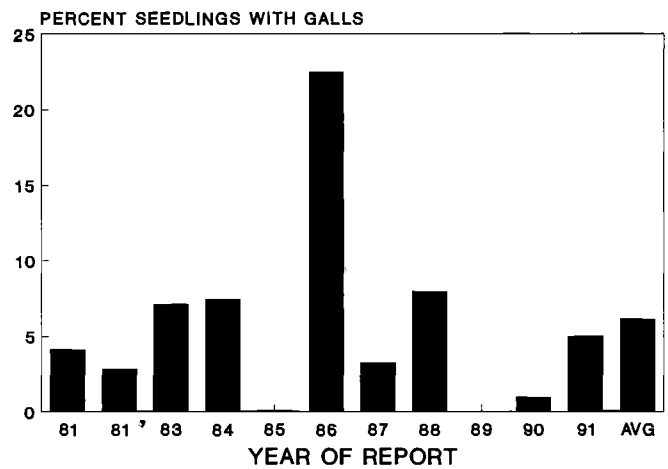

Figure 1. Annual percentages of fusiform rust-infected slash and loblolly seedlings in nontreated (control) nursery plots.

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differences, records were separated based on nursery location into those for a southern region (Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas) and those for a northern region (Arkansas, North Carolina, Tennessee, and Virginia). Production values and estimates in this report are restricted to states covered by the AUSFNMC. AUSFNMC member nurseries produce about 80% of the forest tree seedlings in this region.

The AUSFNMC has solicited information on fusiform rust control practices, their effectiveness, and other aspects of nursery culture and seedling production annually from its members since 1981. Approximately 55 nurseries representing federal, state, and private industry ownership have been members of the cooperative since 1981, and an average of 31.5 of these nurseries supplied data each year.

Seedling Production in Southern Forest Tree Nurseries

Seedling production estimates for AUSFNMC nurseries for 1981 and 1990 allow comparison to that for the entire regional industry. In 1981, The American Association of Nurserymen, in cooperation with the USDA Forest Service, published a nationwide directory of forest tree nurseries (Anonymous 1981). The production reported in that directory, and that reported and projected for the AUSFNMC in 1981, are presented in Figure 2. The 63 nurseries (54 of which were AUSFNMC member nurseries) listed in the 1981 directory produced an average of approximately 19 million seedlings per nursery, a total of almost 1.2 billion seedlings. AUSFNMC survey forms received that year reported production of 639 million seedlings, an average of 21.3 million per reporting nursery. Projected for all 54 AUSFNMC nurseries, estimated production was 1.15 billion seedlings. The USDA Forest Service estimated seedling production for the same states in 1990 to be 1.35 billion (Anonymous 1991). At that time, projections from the 40 AUSFNMC survey forms returned indicated that seedling production in the Cooperative was approximately 1.11 billion, or 82% of regional production. The production reported by the USDA Forest Service for 1990 is compared to that for the AUSFNMC in Figure 3.

Based on reported seedling production and the distribution of reporting AUSFNMC nurseries (Figures 2 and 3), the authors conclude that representative trends can be projected both for the cooperative and for the region. Slightly more than 80% of all seedlings produced during this period were grown by nurseries within the Cooperative. Production trends of AUSFNMC nurseries over the decade ending in 1991 are presented in Figure 4. It is evident that production during this period declined from approximately 1.6 billion seedlings in 1987 and 1988 to 1.1 billion in 1991, a decrease of about 31%. Based on AUSFNMC records, the estimated decrease in production for the whole region was from 2 billion to 1.4 billion seedlings over the same period. The decrease in production is due partly to reduced demand for Conservation Reserve Program (CRP) seedlings and partly to corrections in overproduction within the nursery systems.

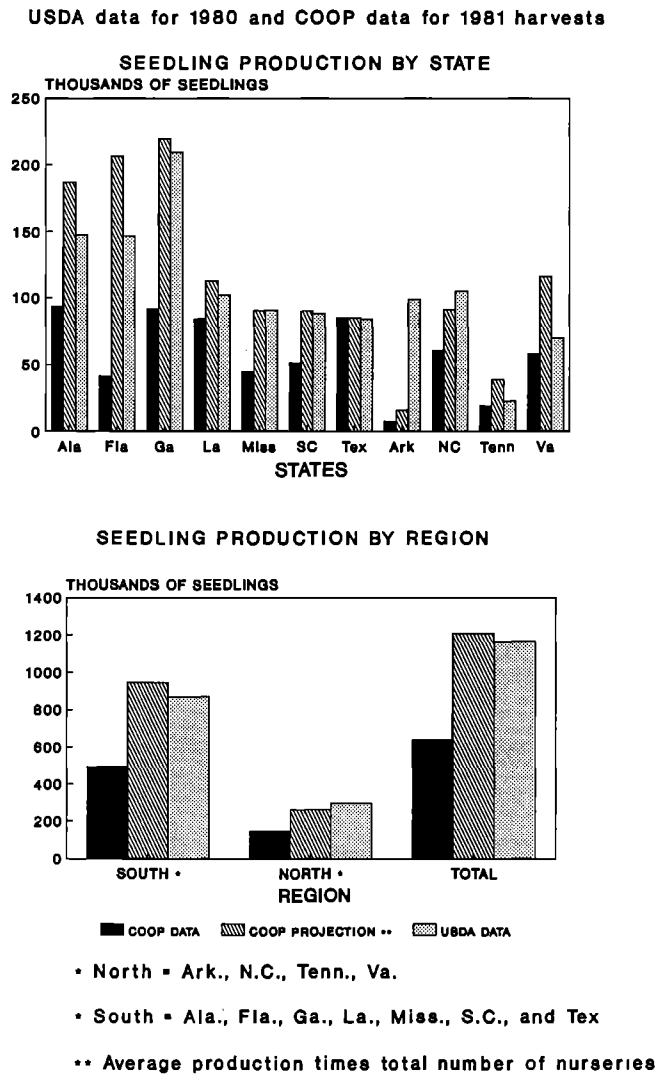

Figure 2. Nursery production of forest tree seedlings for 1980 and 1981 by state and region for all southern nurseries (USDA data for 1980 harvest) and for members of the AUSFNMC (Coop data for 1981 harvest).

There were no conspicuous changes in percentages of the various species of southern pines produced in southern tree nurseries over the last decade (Figure 5). Loblolly and slash pine production remained relatively constant at about 75% and 20%, respectively, of total production. However, there does seem to be a growing interest in the silvicultural and nursery management aspects of longleaf pine (*Pinus palustris* Mill.). Reported longleaf production was 77% greater for the last 5 yr compared to the preceding five (2.86% for 1987–1991 and 1.61% for 1982–1986), however longleaf seedling production remains a small fraction of total production.

Rust Control in Southern Forest Tree Nurseries

Control of fusiform rust in southern pine nurseries has been standard practice since 1941 (Czabator 1971). Until the effectiveness of the systemic fungicide triadimefon (Bayleton®) was discovered in the late 1970s (Snow et al.

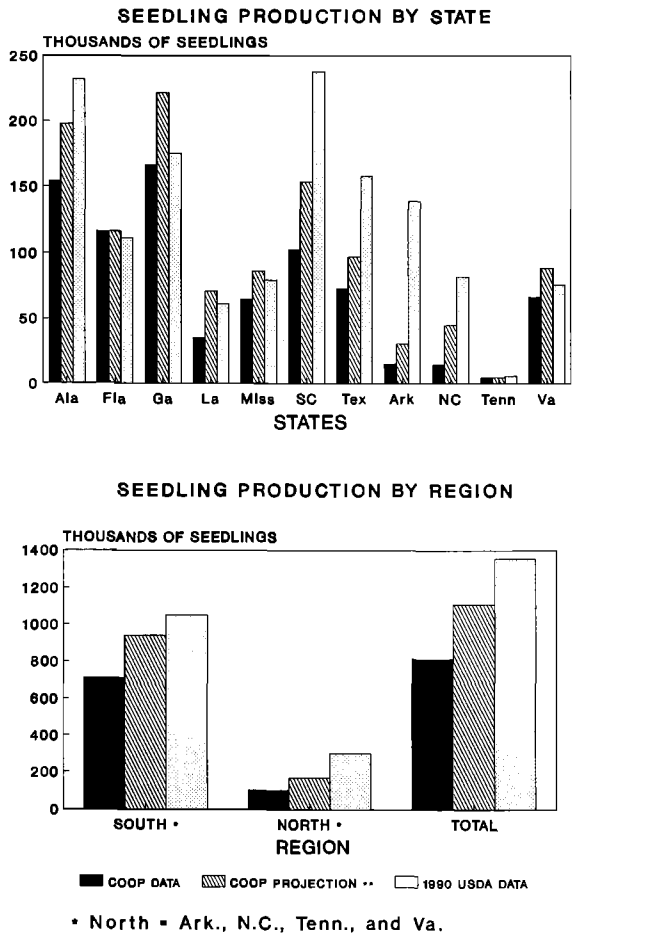

Figure 3. Nursery production of forest tree seedlings for 1990 by state and region for all southern nurseries (USDA data) and for members of the AUSFNMC.

1979), the standard control consisted of protective sprays of either Bordeaux® mixture or Fermate® (Kelley and Runion 1991). To provide reasonable protection, the nonsystemic fungicides required application at least twice a week from seed-crack to early July. Even this was inadequate when conditions were especially favorable for rust infection. Rust infection in regularly sprayed nurseries averaged 2.5% over the long term (Rowan, 1977), and when conditions were favorable, infections were sometimes as high as 60% (Czabator 1971). The efficacy of triadimefon for rust control was established in 1979 (Snow et al. 1979), and an effective rust control spray program was in use by 1982 (Kelley and Runion 1991). The foliar spray program, coupled with the development of triadimefon seed treatments (Mexal and Snow 1978, Kelley 1985), constitute the current recommendations for fusiform rust control in nurseries. There have been reports of triadimefon suppressing mycorrhizae under certain situations (Kelley 1982, Marx 1987). However, the benefits of it far outweigh these reported liabilities.

Triadimefon had been adopted by virtually all nurseries in the southern region of the AUSFNMC (Figure 6) within 3 yr of the original publication of its efficacy. Since 1983, rust

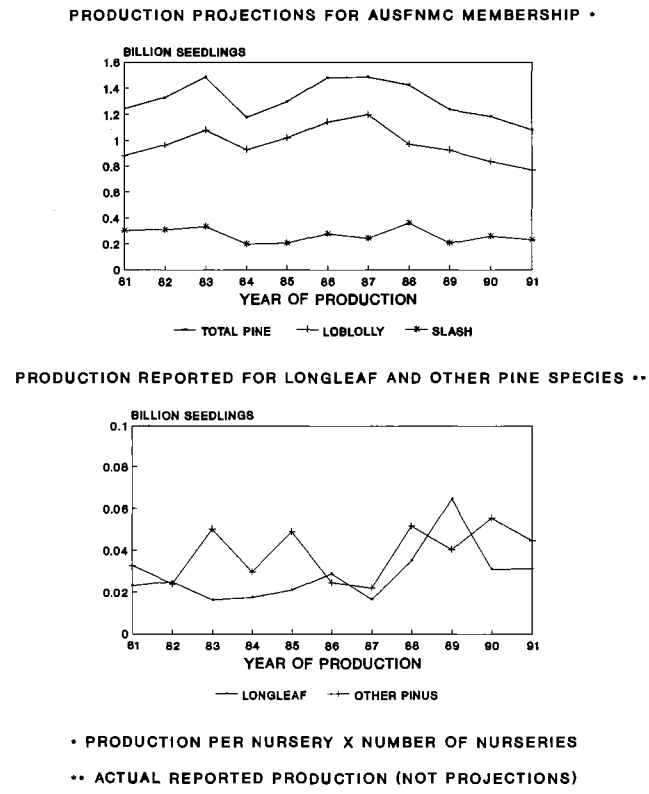

Figure 4. Numbers of loblolly, slash, longleaf, and other pine seedlings produced annually from 1981 to 1990 in southern forest nurseries.

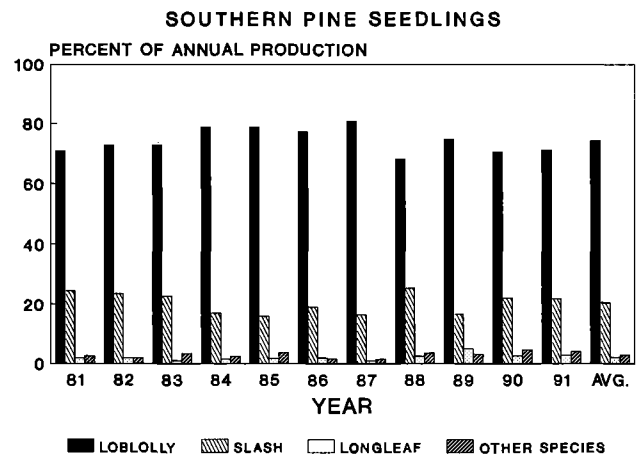

Figure 5. Percentages of loblolly, slash, longleaf, and other pine seedlings produced annually from 1982 to 1990 in southern forest nurseries.

incidence in these nurseries has averaged less than 0.2% annually (Figure 7). Seed treatments have been used by most of these nurseries since 1986, and the reported rust incidence since then has decreased to an average of less than 0.1%. A savings of 34.5 million seedlings per year is realized by reducing rust incidence from 2.5% (Rowan 1977) to 0.2% on an average annual production of approximately 1.5 billion seedlings. At an average value of $29.40/1000, this reduced rust incidence results in a monetary savings of $1,014,300 per year.

The amplitude of year-to-year fluctuations in rust incidence also has decreased since triadimefon became widely used, and, nurserywide, rust incidence has not been reported

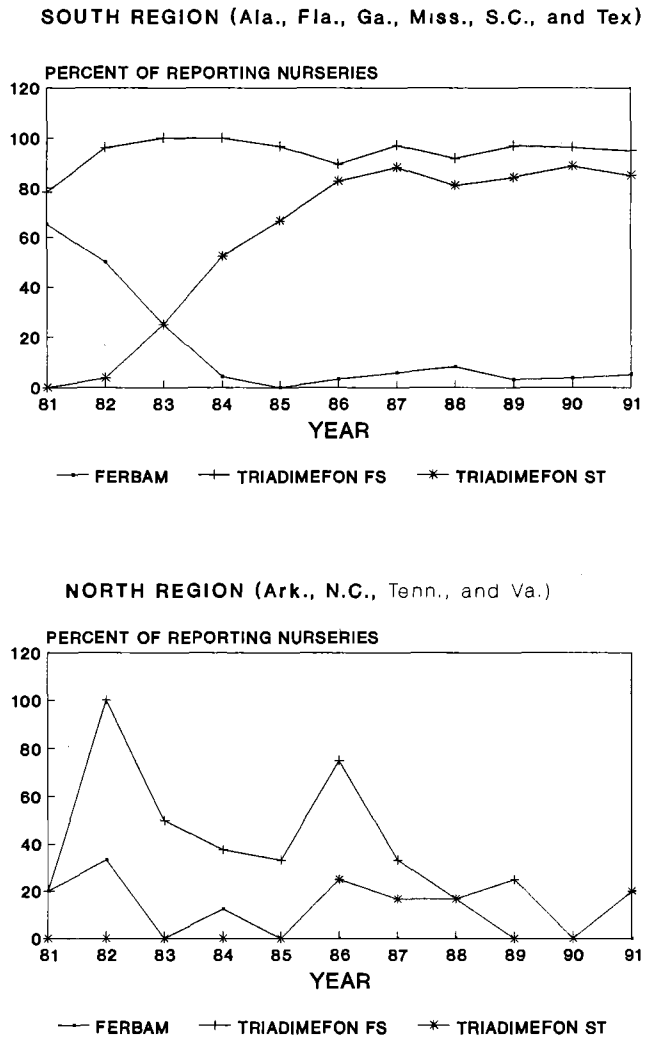

Figure 6. Percentages of nurseries by region using Fermate® or triadimefon (FS = foliar spray, ST = seed treatment) for control of fusiform rust.

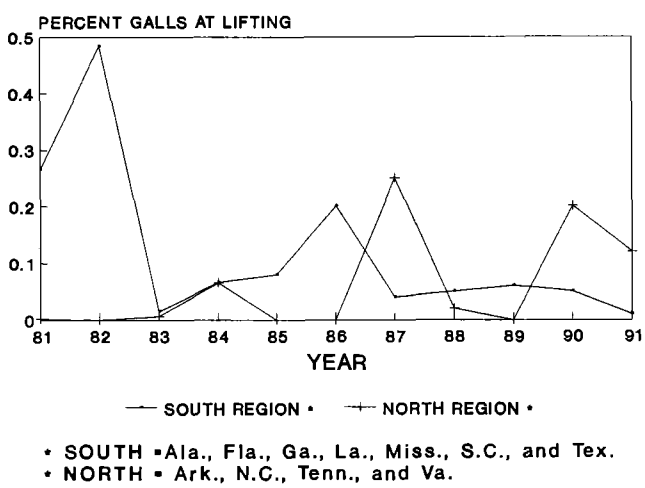

Figure 7. Annual percentages of fusiform rust-infected loblolly and slash pine seedlings in nursery beds receiving chemical treatments for rust control.

to exceed 2 5%. Other savings attributable to triadimefon include fewer fungicide applications, reducing the costs to cull infected seedlings, and reduction of shipping of infected seedlings.

Across the southern region, timing of cultural practices has varied little since 1981. On average, sowing extended from April 14 to April 26, with a standard deviation (SD) of only 2 days between annual averages for either date. The mean date for the first foliar spray for rust control is May 5 (SD = 3.5 days). Since May 5 is only 15 days from the median day of the sowing period, the timing of this application is earlier than necessary and is probably a holdover from the days before seed treatments and systemic fungicides were available. Because Bayleton® seed treatments provide at least 26 days of protection from sowing (Kelley and Runion, 1991), the first foliar application should be about 10 days later than the current average. The mean date for the final foliar spray for rust control is June 17.

For the nurseries in the northern region of the AUSFNMC, sowing occurs about a week later than for the southern region, beginning about April 21 and ending May 2 (SD = 5 days) Use of fungicides for rust control in this area has declined over the survey period (Figure 6). Analyses of nonsprayed control plots indicate that at most northern area nurseries, rust hazard is insufficient to warrant control. In the absence of control measures, rust incidence in the northern region is occasionally greater than that in the southern region (Figure 7). However, rust incidence for the region as a whole is low enough to justify avoiding fungicidal control measures. Such a decision can be shown to be cost effective, and it preserves the tenets of integrated pest management.

Comments from recent rust incidence questionnaires indicate that nursery personnel believe that rust control has been achieved and suggest that a sense of complacency has set in This complacency is evidenced by the lack of data submitted from nonsprayed control plots and from surveys made especially to determine percentage infection among lifted seedlings. Rust incidence data from nonsprayed control plots have been reported annually from no more than three southern region nurseries during any of the last 5 yr. This decrease in data makes it more difficult to either recognize fluctuations in rust incidence or to assess whether such changes are due to control efficiency or to weather conditions. The literature on the ability of plant pathogens in general and rusts in particular to adapt to changing conditions makes it clear that "ultimate solutions" to disease problems do not occur.

Investigations of problems encountered in producing billions of pine seedlings in southern nurseries, developing technologies to overcome these problems, and the expedient dissemination of the knowledge required to implement these technologies comprise one of the great successes of modern nursery management. The rapid adoption of significant improvements in rust control strategy outlined in this paper is one example of the efficiency of our information system and the attitude of personnel in the nursery industry.

The current level of rust control leaves little room for improvement as far as reducing further the percentage of rust infections. However, current rust control practices could be

improved in two ways with respect to integrated control. First, in some cases the amount of triadimefon applied could be reduced. The 10% to 15% of nurseries in high hazard states which do not use triadimefon seed treatments are encouraged to do so. Seed treatments require less product per acre, but are as effective as foliar sprays. Further, the first foliar spray should be delayed to take full advantage of the 26-day protection provided by seed treatments. In some years and locations, this would eliminate one spray from the schedule. Second, because the cornerstone of integrated pest management is accurate information on incidence and damage, the reduction both in numbers of control plots and in the assessment of control efficiency among seedling production beds should be viewed with alarm. Since all pest control practices are being subjected to increased scrutiny it is imperative that sound data justify all uses. The current challenges to a number of widely used practices can be expected to continue in the future.

Conclusions

Southern pine seedling production since 1981 peaked at around 2 billion seedlings during 1987–1988. Production in 1991 amounted to around 1.1 billion seedlings, a decrease of about 31%. The decrease in production is partly due to a reduced demand for Conservation Reserve Program (CRP) seedlings and partly due to corrections in overproduction within nursery systems. Loblolly and slash pines have remained relatively constant over the last decade at 75% and 20%, respectively, of total production. Longleaf production increased from 1.61% during the period 1982–1986 to 2.86% during 1987–1991.

The systemic fungicide triadimefon (Bayleton®) replaced Fermate® as the fungicide of choice for controlling fusiform rust. Since 1986, most nurseries have also used a triadimefon seed treatment as a component of their rust control strategy. The combination of triadimefon applied as a seed treatment plus foliar sprays has resulted in an average of less than 0.1% rust across the region; an average of 2.5% rust incidences existed when Fermate® was being used.

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