FUSIFORM RUST AND ITS CONTROL IN SOUTHERN FOREST TREE NURSERIES

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Abstract.--Fusiform rust is the most important disease of slash and loblolly pine seedlings in southern forest tree nurseries. Caused by Cronartium quercuum f. sp. fusiforme, fusiform rust was controlled for many years with the contact carbamate fungicide Fermate. Current control in forest nurseries is accomplished with the systemic fungicide triadimefon (Bayleton 50 WP) applied as a seed treatment and as foliar sprays.

The Pathogen and Its Life Cycle

Under proper environmental conditions fusiform rust can be the most devastating disease of slash and loblolly pine seedlings in southern nurseries. This disease is caused by Cronartium quercuum (Berk.) Miyabe ex Shirai f. sp. fusiforme Burdsall and Snow, a fungus with five spore stages that requires two hosts to complete its life cycle. The uredial, telial, and basidial stages occur on members of the red oak group; the pycnial and aecial stages occur on loblolly and slash pines and occasionally on longleaf pine (Czabator, 1971).

Aeciospores (spore stage II) are produced in galls on infected pines in February and March each year. These spores are wind disseminated and are capable of infecting only oaks. Within two weeks after infection, orange spots are evident on the lower leaf surfaces. These spots contain urediospores (spore stage III) that are capable of infecting other oaks or other leaves on the same tree. This is the only repeating spore stage in the life cycle.

Shortly after the uredial stage has been completed, telial columns (spore stage IV) emerge from the same leaf spots that produced urediospores. The telial columns are comprised of many thick-walled cells (teliospores), each of which can germinate in place and produce four basidiospores (spore stage 0).

The thick-walled teliospores can remain dormant until conditions are favorable for release of basidiospores. Basidiospore release usually occurs at night and other times when the relative humidity is high; spores are carried by air currents to the pine host.

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Pines are susceptible to fusiform rust infection from the time the radicle emerges from the seed coat until the tree dies. Young, succulent needles and meristematic tissues serve as infection courts. After infection, the fungus slowly develops internally. Except for a small purple spot at the point of infection, there are no obvious symptoms until the rust gall begins to develop four to seven months later. The gall results from hypertrophy and hyperplasia.

The pycnial stage on an infected pine (spore stage I) usually occurs during the second autumn following spring infection, although occasionally it occurs during the first autumn. Pycniospores are believed to serve as a means for the fungus to reach the dikaryon stage.

In the spring following the occurrence of the pycnial stage, and in subsequent springs thereafter as long as the rust gall remains active, aeciospores are produced and the cycle repeats itself.

Early Control Measures

Bordeaux mixture, maneb, zineb, and Fermate were used in early years in forest nurseries to control fusiform rust (Czabator, 1971). Fermate and the other dithiocarbamate fungicides were preferred over Bordeaux mixture because they were not corrosive to equipment. Fermate was the fungicide of choice for nearly forty years and was effective when applied properly. Recommendations were to apply two to three lb (ai) (2.24 to 3.36 kg/ha) of Fermate per acre per application as foliar sprays two or three times a week and after rains. The spray program began at the inception of seed germination and continued until risk of infection was over (usually around the first week of July). As many as 50 sprays were applied in some years when a nursery was sown early and/or rainy periods were frequent. Nursery personnel often were forced to spray when conditions were too wet, resulting in mud splashing of seedlings, soil compaction, and considerable expense of labor and equipment. In spite of the best intentions, various circumstances during the rust infection season often resulted in a portion of the seedling crop becoming infected. For example, extended rainy periods could have allowed new, unprotected tissue to develop before spray equipment could operate in the nursery; a rain (or irrigation) could have washed the fungicide off the foliage, leaving the seedlings unprotected; or faulty spray equipment could have resulted in poor or irregular coverage. During a 17-year period, an average of 2.5% of the pine seedlings produced in Georgia and North Florida nurseries were infected, even though the nurseries were sprayed with Fermate.

Evaluation of Systemic Fungicides for Rust Control

Although Sleeth (1943) tested two systemic chemicals against fusiform rust in 1943, it wasn't until the 1970's that systemic fungicides effective against fusiform rust were identified (Hare, 1973; Hare and Snow, 1976; Kelley, 1977; Kelley, 1978; Mexal and Snow, 1978; Snow et al., 1979; Rowan, 1979).

The first systemic fungicide that consistently demonstrated potential as a control for fusiform rust was benodanil (2-iodobenzanalide; BASF Wyandotte Corp.). Although effective when applied as a foliar spray or preplant soil incorporated, benodanil required relatively high rates (Kelley, 1978). For reasons of economics, benodanil was never developed for use in the United States.

Just as benodanil was being shelved, Mobay Chemical Corp. released for experimental purposes the systemic fungicide triadimefon (Bayleton 50 WP). This compound proved to be remarkably effective against fusiform rust (Mexal and Snow, 1978; Snow, 1978). Results from coordinated tests conducted at several locations within the Southeastern United States strengthened the case for obtaining a label for Bayleton on pine seedlings (Snow et al., 1979). Other tests conducted with Bayleton during this period (Kelley, 1979; Kelley, 1980; Rowan and Kelley, 1980; Rowan, 1981; Rowan, 1982) further refined rates and spray schedules for use in forest nurseries. In 1982, Bayleton was issued 24(c) labels by most of the Southeastern states; since that time an EPA label has been issued permitting foliar sprays with Bayleton on pine seedlings.

In addition to being effective as a foliar spray, Bayleton also is effective against fusiform rust when applied as a seed treatment. First reported in 1978 (Mexal and Snow), the Bayleton seed soak procedure has been labeled [24(c)] in most Southeastern states. The seed soak procedure provides protection from fusiform rust for approximately 30 days after sowing (Kelley, 1985); thus, delaying application of the first foliar spray and providing protection for the young seedlings during the critical emergence period.

Recently, a simplified seed treatment procedure has been developed that is equally as effective as the seed soak (Kelley, 1985). The new method involves direct treating of wetted pine seed with Bayleton 50 WP at a rate of 1.0 oz/25 lb of seed (2.5 g Bayleton 50 WP/12 g of seed); other compounds such as a bird repellent can be added concomitantly.

Current Control Recommendations

Current recommendations for control of fusiform rust in forest tree nurseries are to use Bayleton as both a seed treatment and as foliar sprays. These recommendations are based on results of tests conducted annually by several researchers since 1978 in both greenhouses and nurseries. They reflect the most effective and economical means of controlling the disease in forest nurseries while simultaneously having minimal effects on mycorrhizal fungi and other non-target organisms.

The seed treatment may be applied as either a seed soak (see A below) or as a seed dressing (see B below). Seed treatment alone will provide complete protection for approximately four weeks after sowing (Kelley, 1985).

A. Seed Soak

- Use Bayleton (triadimefon) seed soak treatment at a dosage rate of 1 oz (28.35 g) of Bayleton 50 WP per 5 gallons (18.9 liters) of water.

- Soak loblolly or slash pine seed in the above solution for 24 hours at room temperature, stirring occasionally.

- Additional seed treatments (e.g., Arasan or Anthraquinone) may be applied following the Bayleton seed soak and partial drying.

- Treated seed may be held under refrigeration for up to 26 days after soaking without affecting efficacy of Bayleton.

B. Seed Dressing

- Use Bayleton (triadimefon) at a dosage rate of 1 oz (28.35 g) of Bayleton 50 WP per 25 lb (11.34 kg) of seed.

- Apply the Bayleton powder to wetted (water or latex solution) pine seed in a tumbler apparatus and tumble for 10 minutes.

- Additional seed treatments (e.g. Arasan or Anthraquinone) may be applied following the Bayleton treatment.

- Treated seed may be held under refrigeration for up to 26 days after treatment without affecting efficacy of Bayleton.

Since application of a foliar spray eradicates rust infections up to 7 days old and provides protection from new infection for about 21 days after spraying, it is not necessary to apply the first foliar spray until about 14 days after emergence begins. The seed treatment provides protection during the critical germination period when the risk of infection is highest. The second and subsequent foliar sprays should be applied at intervals of 14-21 days after the first spray. A fourth spray should be applied only in nurseries that sow seed early enough that the third spray is applied before June 7. A foliar spray applied between June 7 and 10 provides adequate protection until the end of the spore flight period. Each nurseryman should determine the number of sprays for his nursery based on the sowing date and a June 7-10 spray termination date. Foliar sprays (up to 4) should be equally spaced (14-21 day intervals) beginning 26 days after sowing and terminating on June 7-10.

Foliar sprays should be applied with a suitable rig calibrated to deliver 280 or more liters per hectare. Spray nozzles should be either hollow cone or fan jet, depending on wind speed and spray drift; the latter type should be used only when drift is a problem and the foliar spray cannot be delayed. Sprays should be applied at a rate of 280 grams (ai) of triadimefon per hectare (560 grams Bayleton 50 WP), and each hectare-volume of spray should contain 290 ml of Agri-dex oil-surfactant blend.

Non-Target Effects of Bayleton

Bayleton is fungitoxic to fungi such as Pisolithus tinctorius and Thelephora terrestris that form ectomycorrhizae on roots of slash and loblolly pines (Kelley, 1982). In addition, Bayleton may be phytotoxic to slash and loblolly pine seedlings when applied at dosages above recommended rates (Snow et al., 1979). Furthermore, nurserymen who inoculate their nursery beds with vegetative inoculum of a mycorrhizal symbiont at sowing time are advised not to use Bayleton to control fusiform rust (Cordell and Marx, 1984), since the inoculum may be killed.

Effects of Bayleton on naturally occurring mycorrhizal fungi in nursery beds are transient and are not considered to be worthy of concern. Field tests conducted at two nurseries showed that three applications of 12 oz ai/acre (0.84 kg ai/ha) were necessary to cause a significant decrease in percentage of mycorrhizal roots (Kelley, unpublished data). More importantly, seedlings from

these plots and from plots that received three applications of 24 oz ai/acre (1.68 kg ai/ha) survived and grew as well as seedlings from control plots in outplanting trials (Rowan and Kelley, In Press). Thus, concerns about non-target effects of Bayleton in forest tree nurseries appear to be unwarranted except in the case of nurseries where vegetative inoculum of an ectomycorrhizal fungus is used.

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