34. Fusarium Root and Stem Diseases

Robert L. James

Hosts

Fusarium diseases are caused by several *Fusarium* species, especially *F. oxysporum, F. proliferatum, F. solani*, and several species within the "*roseum*" complex, including *F. acuminatum, F. avenaceum, F. sambucinum, F. sporotrichioides*, and *F. equiseti*. Recent evidence indicates that some highly virulent strains previously identified as *F. oxysporum*, should be classified as *F. commune*. Although all conifer and many hardwood species may be affected, Douglas-fir, pines, larch, and true firs are most susceptible to Fusarium diseases. Spruce is often damaged less and species of cedar and cypress are relatively resistant to Fusarium diseases.

Distribution

Fusarium diseases are common throughout North America and in many temperate and tropical parts of the world. They especially have been a problem in Western Canada, and the North Central, Southern, and Western United States.

Damage

Fusarium species cause seedling root decay, stem cankers (including hypocotyl rot), seed decay, and wilt of some plant species within nurseries. Infected seedlings are often killed or have reduced growth and vigor. This pattern often results in increased numbers of culls and reduced survival after outplanting. Mortality is more common during the first growing season on bareroot stock and toward the end of the growth cycle on container seedlings. Losses can vary greatly depending on nursery management practices, seedling species, seedlot, geographic area, soil type, and environmental factors.

Diagnosis

Fusarium species cause a variety of disease symptoms within nurseries. Root disease usually results in primary and secondary root decay. Affected root systems often look black and lack actively growing root tips. The epidermis and cortex can often be easily stripped away from decayed roots. Aboveground root disease symptoms include: yellowing of foliage; needle tip and twig dieback; and foliar, branch, and stem necrosis (figs. 34.1, 34.2, and 34.3). Some *Fusarium* species also cause stem cankers either just above the groundline or higher on the main stem. Cankered seedlings often display aboveground symptoms similar to those of root-diseased seedlings. Fusarium sporulation can often be found on necrotic stem cankers or on seed coats and appear as orange to yellow pustules called sporodochia (fig. 34.4). *F. oxysporum* can also cause wilt of some nursery seedlings, resulting in foliage chlorosis and necrosis, and seedling tip and lateral branch bending. Root necrosis is not associated with wilt-causing *Fusarium*.

Analysis by a specialist is needed to identify *Fusarium* species. In a laboratory, *Fusarium* can be isolated from infected tissues or from soil using selective agar media and the different species identified by the unique fungal colony and reproductive morphology characteristics. In

Figure 34.1—*Severe mortality in bareroot seedlings due to Fusarium root disease.* Photo by Robert L. James, USDA Forest Service.

Figure 34.2—*True fir seedlings killed by Fusarium root disease. Note the random distribution of mortality.* Photo by Robert L. James, USDA Forest Service.

Figure 34.3—*Containerized conifer seedlings with typical symptoms of Fusarium root disease.* Photo by Robert L. James, USDA Forest Service.

Figure 34.4—*Orange pustules of sporulating* Fusarium *species on an infected seed.* Photo by Robert L. James, USDA Forest Service.

culture, the mycelium is extensive or appressed (pionnotal). Different *Fusarium* species produce different pigments in culture. For example, *F. oxysporum* and *F. proliferatum* usually produce dense white aerial mycelium and violet pigments best seen through the bottom of culture plates (fig. 34.5). Species in the "*roseum*" complex may produce carmine red to yellow mycelium and different intensities of carmine pigmentation (fig. 34.6). Four main spore types can be produced. Macrocondia are multicelled, slightly curved, and typically canoe-shaped (fig. 34.7). Microconidia usually have one or two cells, are ovoid or oblong, and borne in masses or in chains. Macroconidia and microconidia are formed within phialides on condiophores. Chlamydospores comprise the major resting structures of many *Fusarium* species. These chlamydospores have thick cell walls and form within plant substrates or macroconidia (fig. 34.8). A few *Fusarium* species, such as *F. oxysporum*, also produce long-lived resting structures called sclerotia. These sclerotia may remain viable within plant tissues or soil for many years. Light is required for some spore types to be produced.

Biology

Fusarium species have very wide host ranges, including many agricultural and natural plants and weeds. Host-specific strains of some pathogenic species occur, however. *Fusarium* strains can either be pathogenic (capable of causing plant disease symptoms) or saprophytic (not causing symptoms). Pathogenic and nonpathogenic strains are genetically distinct, but often appear morphologically identical. *Fusarium* species readily colonize nursery soil and organic matter and can remain dormant as chlamydospores and sclerotia in the absence of susceptible host plants. Diseased seedling roots from previous crops and organic amendments are major inoculum sources in bareroot nurseries. Reused containers and contaminated debris within greenhouse interiors are important inoculum sources

Figure 34.5—*Violet pigment produced by* Fusarium oxysporum *and* F. proliferatum *in culture.* Photo by Robert L. James, USDA Forest Service.

Figure 34.6—*Carmine pigment typical of species in the* Fusarium "roseum" *complex in culture.* Photo by Robert L. James, USDA Forest Service.

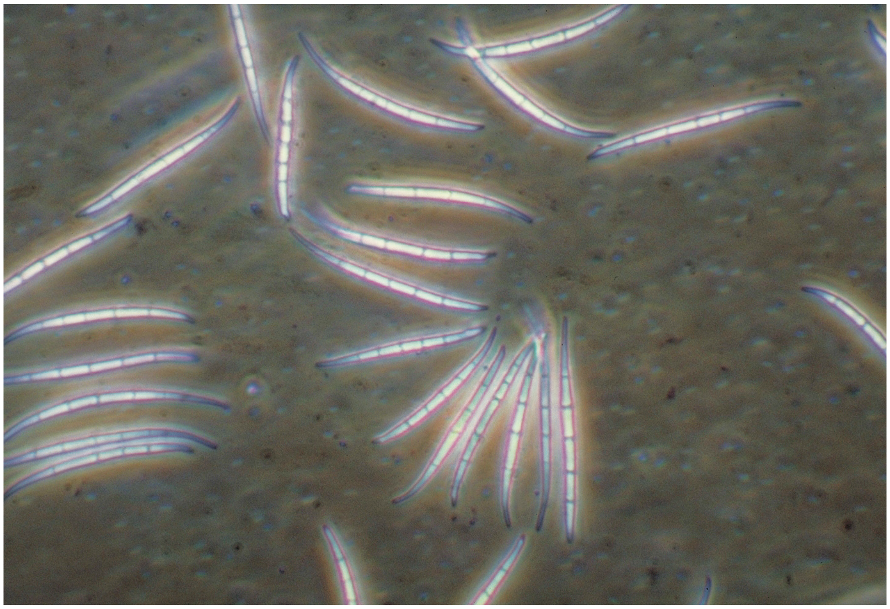

Figure 34.7—*Multicelled, canoe-shaped macroconidia typical of* Fusarium *species. Details of shape and number of cells are among the characteristics used to identify species.* Photo by Robert L. James, USDA Forest Service.

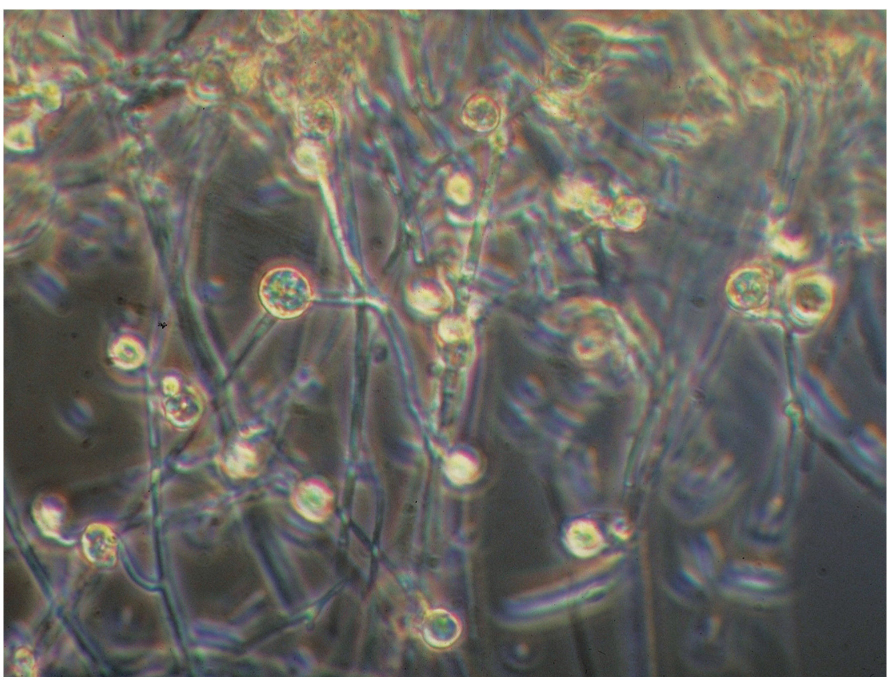

Figure 34.8—*Thick-walled chlamydospores can survive unfavorable conditions.* Photo by Robert L. James, USDA Forest Service.

in container operations. Many different plant seeds may be contaminated with *Fusarium* and may provide an important pathogen introduction source for nurseries. Chlamydospores germinate when root exudates of susceptible host plants are present and soil or greenhouse temperatures are warm. During warm, moist conditions, *Fusarium* grows on root surfaces, penetrates the epidermis, and spreads throughout root cortical tissues. Pathogenic strains penetrate host vascular systems, initiating disease symptoms. Some *Fusarium* species also produce toxins that aid host plant colonization and disease expression. Secondary disease spread can occur from aboveground inoculum (primarily macro-conidia within sporodochia), especially on container stock within greenhouses. After the infected plants die and the fungus uses all available plant substrate nutrients, resting structures form and the cycle is repeated. Although some *Fusarium* species periodically form perfect (sexual) states, these spores are usually not as important in disease epidemiology as the more common asexual spores (macroconidia, microconidia, and chlamydospores).

Control

Prevention

The most effective way to reduce losses from Fusarium diseases is prevention, primarily by reducing pathogen inoculum levels within seedling growing environments. Prevention methods include treating seeds before sowing, adequately cleaning reused containers, cleaning greenhouse interiors between seedling crops, using pathogen-free growing media for container seedling production, and periodic diseased seedling removal during crop production cycles. Any seedling culls should not be added to soil for organic matter or stored near seed or transplant beds.

Cultural

Cover crops that control soil erosion and increase soil organic matter usually increase *Fusarium* populations after incorporation into the soil. The cover crop incorporated into the soil provides organic matter that stimulates pathogen population buildup. Leguminous cover crops are especially conducive to *Fusarium* level buildup. Fallowing fields for at least 1 year before sowing seeds helps reduce soilborne *Fusarium* populations. Some composts have potential to reduce *Fusarium* inoculum and subsequent seedling diseases. Avoiding seedling stress is important in reducing disease severity. It is important to maintain proper irrigation and balanced fertilization to avoid excess nitrogen levels.

Chemical

Preplant soil fumigation is the most common way to reduce *Fusarium* populations and subsequent disease in bareroot operations. Efficacy of particular fumigants varies among nurseries and is probably primarily related to soil characteristics including texture, density, and biological properties. Solarization (covering nursery soils with clear polyethylene tarps) is fairly effective in reducing *Fusarium* populations in some areas, but has limited efficacy on more northern sites. Commercial biological control agents (primarily antagonistic fungi, actinomycetes and bacteria) are available to help control Fusarium diseases. Their efficacy varies; most tests have resulted in disappointing disease control probably because biological control agents were not derived specifically from forest nurseries. Chemical fungicide application as a soil drench is usually ineffective after diseased seedling symptoms become evident, unless it is applied to reduce secondary disease spread from stem-colonizing pathogens, particularly within greenhouses.

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