Principles of Fungicide Usage in Container Tree Seedling Nurseries

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Fungicides are commonly used to control a wide range of diseases in container nurseries that produce conifer seedlings. These chemicals should be used only in conjunction with other practices of disease control. Proper use of chemical fungicides including types and amounts and timing of applications are discussed. Tree Planters' Notes 39(2):22-25; 1988.

Several pathogenic fungi cause greater amounts of disease in greenhouses than in bareroot nurseries because greenhouse conditions are so conducive to fungal growth, sporulation, and development. The artificial growing media often used in container operations either lack or have reduced populations of natural biological control organisms such as other fungi and certain bacteria and actinomycetes (*4*).

The conducive environmental conditions and lack of natural biological controls have usually resulted in widespread use of and dependency on chemical fungicides to reduce disease losses (*5*). Unfortunately, many growers use chemical fungicides rather indiscriminately whether or not a disease is present. Such actions are costly and often detrimental because of effects on nontarget organisms and increased possibility of development of resistance to fungicides by pathogenic fungi (*7*).

The Importance of Proper Diagnosis

Fungicides should generally not be used routinely in the absence of disease (*14, 15*). A possible exception is to control expected and recurring diseases such as damping-off during seed germination and seedling establishment. In such cases, fungicides are often applied shortly after sowing. However, fungicides should not be applied after the period of damping-off susceptibility (when young seedling stems have lignified) unless a specific disease has been identified.

A very important aspect of proper fungicide usage is diagnosis and identification of pathogens responsible for disease symptoms. Many of the newer fungicides are specific for particular species or genera of fungi rather than being appropriate against widely varying groups of fungi (*1, 5, 8*). For example, chemicals such as Aliette, carbanolate (Banol), and metalaxyl (Subdue) are only effective in controlling water mold fungi (*6, 16*). Water molds are a group of fungi (oomycetes) that include important plant pathogens such as *Pythium* and *Phythophthora*. These fungi differ chemically, morphologically, and evolutionarily from most other fungi. Use of fungicides specifically designed for water mold fungi to control other fungal pathogens will be largely ineffective. Such a practice may also be detrimental because it can a) eliminate resident populations of nonpathogenic water mold fungi, some of which may be competitors of pathogens (for example, saprophytic *Pythium* spp. compete against pathogenic *Pythium* spp.) and b) place unnecessary selection pressure on resident populations of water molds so that resistant individuals may proliferate in environments of high fungicide concentrations.

In another example, the selective fungicide PCNB (pentachloronitrobenzene) is very effective in controlling damping-off caused by *Rhizoctonia* but has no efficacy against other common damping-off fungi such as *Pythium* and *Fusarium* (*16*). In addition, some fungicides formulated to be effective against several different groups of fungi, such as carbanolate, have other problems, such as poor solubility in water, resulting in inadequate coverage of plant tissues (*16*).

Proper Timing of Application and Dosage of Fungicides

Many commonly used fungicides are protectants (*15*); those few that have therapeutic

value are somewhat systemic and their ability to kill pathogenic fungi within host tissue is limited (*8*). Many fungicides inhibit spore germination or suppress sporulation of pathogenic fungi. Therefore, they should be applied when and where they can be most effective.

Growers should also remember that seedlings at different stages of development show variable susceptibilities to infection and only apply fungicides when host tissues are likely to become infected. For example, to control blight caused by *Botrytis cinerea* Pers. ex Fr., fungicides should be applied only after the seedling canopy closes and basal needles have become senescent, since these needles are the major site of infection by this pathogen (*10*). Applying fungicides directed at *Botrytis* before this stage of host development is wasteful and may even be detrimental because of potential fungicide resistance developing in the pathogen (*7*).

Preliminary evidence indicates that infection by *Botrytis* spores only occurs for a short time and most subsequent spread of the pathogen within greenhouses is vegetative (Sutherland, personal communication). Therefore, fungicides should be applied only during this short period of susceptibility. Research is currently underway to identify this period of susceptibility so that chemical control can be more effective.

Another disease in which proper fungicide timing and dosage are critical is post-emergence damping-off. Seedlings are susceptible to this disease for only a short period of time after emergence. After stem tissues begin to lignify, seedlings are generally no longer susceptible to infection (*17*). Fungicides should only be applied if a damping-off problem is anticipated, such as with seedlots showing chronically poor vigor or problems of poor germination, and with highly contaminated seed. It is also important that fungicides not be applied past the period of host susceptibility to damping-off.

Application methods. Fungicides should be applied only to the portion of seedlings where the pathogen is active (*5, 14*). Foliage pathogens may be fairly easy to control with fungicides because the chemicals can be delivered to the site of infection with little difficulty. However, for root pathogens, it is much harder to get the fungicide to the site of pathogen activity (*13*). For example, attempts to control *Fusarium* root disease by drenching with fungicides have usually been ineffective (*11, 12*). This may be because of inadequate fungicide concentrations at the site of pathogen activity in the roots of container seedlings.

Application rates. Fungicides should be applied at the lowest possible dosages that will effectively control the disease (*15*). Pesticide label rates have been developed to adequately control the target pest if applied properly. Excessive applications of fungicides are often detrimental because they often place selection pressures on pathogens to develop resistance (*7*). Because of their rapid reproduction rates and abundant propagule production, fungi can readily mutate to become resistant to fungicides.

New genetic strains of fungi often proliferate in an environment of high pesticide concentrations (*7, 10*). This behavior is especially common in response to some of the newer chemicals, which are more specific in their mode of action; one or two small mutations may be sufficient for an organism to develop resistance to these chemicals (*8*). Excessive fungicide applications can also kill beneficial organisms that may help keep pathogen populations in check. If fungicide concentrations continue at high levels, biological balances are disrupted and usually cannot be restored until these chemicals are no longer used.

Effects of Fungicide Use on Beneficial Microorganisms

The primary goal of fungicide usage should not necessarily be to kill organisms, but rather to

reestablish a "biological balance" by reducing populations of pathogens and/or promoting proliferation of beneficial competitors (*3, 4*). For example, if a container-growing medium is fumigated with a general biocide such as methyl bromide or completely sterilized at high temperatures (autoclaved or microwaved), all organisms are killed (*3*). A "biological vacuum" is thus established, and the first organisms reinvading the medium often proliferate in the absence of competition. If the primary reinvading organism is a pathogen, such as *Fusarium* introduced on seed, much more disease will likely result than if the medium had never been treated.

In contrast, a process developed at the University of California (*2*) uses aerated steam to treat growing media to selectively kill pathogens. Steam treatment raises the temperature of a medium to approximately 50 °C, which is sufficient to kill most pathogens (including those that form resting structures such as chlamydospores and sclerotia) but does not harm certain spore-forming bacteria (primarily *Bacillus* spp. and some actinomycetes) that are important competitors and antagonists of pathogenic fungi. This steam-treated medium therefore, becomes "pathogen suppressive"; that is, if a pathogen is introduced into it, the organism cannot proliferate because of the competitive and antagonistic qualities of the current residents.

Another example of non-chemical disease control is maintaining or enhancing pathogen suppressiveness of a growing medium by amending it with composted tree bark (*9*). Such amendments enhance proliferation of certain bacteria and fungi by altering the chemical composition of the medium. In sterilized media, pathogens are usually suppressed at the expense of competitors and antagonists. However, if a biological balance or suppressive state is present, introducing chemical fungicides into the system will usually alter this balance, often to the advantage of pathogens.

Conclusions and Recommendations

The following guidelines can help growers in the proper use of fungicides to control diseases of containerized seedlings:

1. The proper fungicide should be used to control the proper pathogen; therefore, accurate diagnosis of the problem is essential.
2. Fungicides should be applied at the lowest possible dosage that will achieve disease control; application rates should never exceed label rates.
3. Use only fungicides that are registered for specific diseases on specific hosts.
4. Fungicides should be applied at the proper time and to the proper part of the seedling to control specific pathogens.
5. Fungicides should be used prudently and only when necessary to control diseases.
6. Fungicides should be used *only* when other practices of disease control are inadequate. These other practices include sanitation before and during the crop cycle and controlling the growing environment to render pathogens ineffective or hosts less susceptible to infection.

Fungicides may not adequately control a disease for the following reasons:

1. The disease may not be caused by a pathogenic fungus, but may be due to abiotic factors, insect damage, or other causes.
2. Resident pathogen populations may have acquired resistance to chemicals used.
3. There may be too much pathogen inoculum present. Consider problems of sanitation, seed contamination, and pathogen reservoirs such as weeds in and near greenhouses.
4. The fungicide used is effective, but does not reach the

site of infection by the pathogen.

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