INTEGRATED CONTROL PROCEDURES FOR NURSERY PEST MANAGEMENT

Charles E. Cordell [1/]

ABSTRACT

Accelerated emphasis on field forestation in the United States is placing increased emphasis on nursery seedling production with corresponding increases in nursery construction, seedling species, and nursery sites. These conditions combine to promote a wider variety and higher intensity of nursery pest problems. An integrated control approach, consisting of a concerted harmonious combination of preventive, cultural, biological, and chemical procedures, represents the most effective and efficient means of nursery pest management.

INTRODUCTION

The present accelerated emphasis on field forestation in the United States is placing considerably increased emphasis on nursery seedling production. Additional nurseries and expansions of old ones are being added throughout the country. A wider variety of both conifer and hardwood species are being produced on an expanding variety of nursery sites.

These conditions combine to provide a wider variety and higher intensity of nursery pest problems. Fortunately, however, seedling pest problems are the exception, rather than the rule, in the nursery.

The nurseryman has an arsenal of readily available weapons to combat pest problems. The integration of these weapons into one concerted harmonious attack represents the most effective and efficient strategy in conquering nursery pests.

1/ Nursery Disease Specialist, Forest Insect & Disease Management, Resource Protection, Southeastern Area, S&PF, U.S.D.A., Forest Service, Asheville, NC.

INTEGRATED CONTROL

Reduction of the pest problem in the nursery by use of a combination of procedures utilized together to form a more complete harmonious, coordinated, and effective control response. The present control strategy is prevention, management and containment versus seek and destroy.

INTEGRATED CONTROL PROCEDURES

Prevention

This procedure includes an effective pest information and education program with periodic training sessions and scheduled nursery inspections for potential pest problems. Standardized systematic quarantine measures should be employed to either avoid or minimize pest problems. This involves such practices as preventing the transport of contaminated (parasitic fungi nematodes, insects, weed seeds, etc.) seedlings, soil, water, equipment, etc. into pest-free areas. This is probably the most effective and efficient pest control practice that is readily available and environmentally safe for nursery application. Preventive measures also frequently represent the last means of controlling a nursery pest problem.

Pest Detection, Diagnosis, and Evaluation

This includes early pest detection, rapid diagnosis, and evaluation of existing and/or potential pest damage losses. All nursery personnel should stay alert for any indications of pest occurrence. Observations of pest occurrence should be reported immediately to appropriate state, Federal, industry, or university pest specialists to facilitate rapid diagnosis and evaluation of the pest problem. This will facilitate the selection and application of the most effective, efficient, and safe control action for the particular pest problem.

CULTURAL PRACTICES

The manipulation of the following related nursery cultural practices to minimize pest occurrence and subsequent seedling damage:

Site Selection - This is one of the first and probably most important cultural practices employed regarding pest management. In selecting nursery sites, either new locations or expansion of existing ones, particular consideration should be given to the soil type, pH, and drainage; past history and present

indications of pest occurrence; and adequate supply of uncontaminated water with sufficient mineral composition and pH levels to promote desired seeding growth. The soil type for most species should be of light texture (sand and silt, with low clay content) and without any impermeable subsoil to promote good tillage, effective soil fumigation, and good drainage. Seedbeds should also be designed to promote water drainage away from the seedlings. Heavy clay soils and poor drainage impede soil fumigation and are conducive to the development and buildup of certain soil fungi. Improper seedbed drainage patterns are also conducive to the development of soil fungus, nematode, and weed pest problems. The soil and water pH are highly significant factors affecting the development of soil fungus diseases. Pre- and post-emergence damping-off problems caused by several parasitic soil-borne fungi are frequently encountered in conifers when the soil pH exceeds 5.5. Contaminated water sources may contain reservoirs of parasitic fungi, nematodes, insects, weed seeds, mineral composition, herbicides, and pH levels that are detrimental for seedling production.

Crop Rotation - A highly valuable practice in the management of nursery pests. Populations of pathogenic fungi, insects, nematodes and weeds may increase substantially following prolonged association with susceptible hosts in favorable pest environments. Crop rotation affects the pest population through alterations in host species susceptibility and the microenvironment along with pest, predator, parasite, and competetive microorganism populations. Standard nursery culture practices presently involve various seedling-cover crop combinations.

Species Selections - Considerations should be given to species-site requirements in the nursery similar to those required for field plantings. For example, conifers and hardwoods have different site requirements, soil microbiological associations, and cultural procedures. In addition, different species of conifers and hardwoods grown in the same nursery may vary significantly in these requirements. The resistance of various conifer and hardwood species to particular pests are also frequently variable and should be considered accordingly. Species discrimination may represent the most effective and efficient pest control practice under some circumstances.

Soil pH Manipulations - This is a very effective cultural practice in controlling certain soil fungus diseases. As previously stated in the section on site selections, pH levels above 5.5 are conducive to the development of damping-off problems in conifers. The soil pH can be reduced by the addition of prescribed amounts of elemental sulfur. In nursery soils with undesirably low pH levels (i.e., below 4.5 for conifers or 6.0 for hardwoods), the pH can be increased by the addition of lime. The water pH can also be reduced when needed by metering prescribed amounts of sulfuric acid into the water supply.

Seedbed Sowing Dates - The timing of nursery seedbed establishment is an important factor in reducing subsequent seedling losses caused by soil parasitic fungi and the environment. Cold moist soils, characteristic of early spring conditions, are conducive to the development of damping-off soil fungi such as Pythium and Phytophthora. In warmer climates, the high soil

surface temperatures that predominate in late spring frequently cause a high incidence of "sun scald" and mortality on young tender seedlings. Fall sowing is becoming a standard practice with several species to help alleviate these and other problems.

Seedbed Density - Denser nursery seedbeds are more susceptible to a variety of pest problems. To begin with, these compacted seedlings are growing under highly competetive conditions for the available soil nutrients and water. This frequently reduces their growth and development and increases their susceptibility to nursery pests such as the parasitic fungi, nematodes, and insects. Dense seedbeds, with corresponding dense root development, are also more conducive to the buildup and spread of root parasitic pests. In addition, dence seedbeds provide heavier foliage development that provide more favorable microclimates for foliage fungus diseases. The present increased emphasis on reforestation and corresponding demand on nursery seedling production reflects a trend to denser nursery seedbeds with corresponing increases in pest problems and seedling losses.

Mulches - Consideration should be made in selecting and utilizing mulch materials to minimize the introduction and development of pest problems. Pine needles, sawdust, and grain mulches may contain parasitic fungus spores and weed seeds that later invade susceptible seedlings and soil. These mulch materials should be fumigated prior to use with either a methly bromide - 98 percent; chloropicrin - 2 percent or methyl bromide - 67 percent: chloropicrin - 33 percent fumigant formulation at a dosage rate of 1 lb. per cubic yard of material. The mulch should also be aerated a minimum of 48 hours prior to use.

Fertilization - Fertilizer composition, rate, timing, and application methods can have significant effects on both fungus-caused and physiological (abiotic) disease problems as well as associated soil fungi. Insufficient amounts of required nutrients promotes seedling stunting, foliage yellowing (summer chlorosis caused by insufficient iron or nitrogen), poor root development, and subsequent mortality in advance stages. Seedlings in this condition are considerably more susceptible to soil and foliage parasitic fungi, nematodes, and insects. Excessive or improper fertilization results in foliage "burning" or browning and/or root mortality. Excessive levels of phosphorus (above 200 lbs. available P_2O_5 per acre) have been shown to inhibit ectomycorrhizae formation on conifer seedling feeder roots.

Irrigation - Inadequate, excessive, or improper irrigation may favor the development and intensification of pest problems in the nursery. As with inadequate fertilization, inadequate water may cause seedling yellowing, stunting, and mortality--particularly during hot dry weather. Excessive water may inhibit soil aeration, cause root mortality, and promote damage by soil fungi such as *Pythium* and *Phytophthora* and nematodes.

Soil Drainage - Good seedbed soil drainage is essential in minimizing damage by soil parasitic fungi such as *Pythium* and *Phytophthora.* Seedbed raising and crowning along with subsoiling and construction of drainage tiles are frequently required to promote soil drainage. Low spots in nursery beds

should also be filled in to minimize water collection and stagnation in these areas. Bed ends are also frequently the lower poorly drained areas in the nursery where populations of Pythium and Phytophthora tend to accumulate. These areas should also either be raised to the other bed heights or avoided when seeding.

Pest Alternate Host Eradication - Some nursery pests such as the rust fungi are obligate parasites and require an alternate host to complete their life cycle. Where feasible and practical, these alternate hosts should be eliminated in and around the nursery to eliminate or minimize these disease problems. White pine blister rust with the ribes or currant alternate hosts and fusiform rust with the oak alternate hosts can he controlled in this manner.

Windbreak Species - Tree species used for windbreaks should be neither alternate hosts nor susceptible to potential nursery seedling pests. The use of similar windbreak and seedling species may provide ready supplies of fungus inoculum and insects for the susceptible nursery seedling species. Existing susceptible windbreak species may reouire either sanitation pruning or elimination in some cases to avoid the buildup of reservoirs of fungus inoculum and insects.

Cover Crops - The use of cover crops alternated with seedling production is standard practice in many forest tree nurseries. Cover crops are used for various purposes such as erosion control and organic matter buildup. Cover crop species vary in their susceptibility to different nursery pests. Some cover crop species are highly susceptible and promote the buildup of specific soil parasitic fungi. For example, corn, cowpeas, and sorghum are susceptible cover crop hosts for the charcoal or black root rot fungus of conifers while the legumes and soybeans are susceptible to the cylindrocladium root rot fungus of hardwoods.

Sanitation - This should be a standard utilized practice to eliminate or minimize pest populations in the nursery. This includes roguing diseased or insect-infested seedlings and weeds in nursery seedbeds along with the elimination of pest host plants and weeds in and around the nursery to reduce fungus inoculum, insect, and weed seed sources.

Seedling Grading and Culling - This practice may frequently be required to minimize the transport of pest infested seedlings to field planting sites. Seedling grading prior to packaging may be highly beneficial in detecting inconspicuous root rot diseases and diseases that frequently develop detectable symptoms late in the growing season such as the stem rusts and some foliage diseases. In addition, disease problems within nursery seedbeds are frequently very erratic in distribution which makes any attempts at bed grading and culling considerably more difficult and ineffective than in the packing shed. The present nursery operating funds and labor supplies, however, have eliminated packing shed seedling grading and culling practices in most nurseries.

BIOLOGICAL AGENTS

Parasites and Predators - These agents may assume significant roles in the reduction of pest populations (particularly insects) in the nursery. They are of natural origin and their development usually coincides with the development of pest populations. The artificial use of parasites and predators for pest control has provided results with limited success and practical application.

Antagonistic and Saprophytic Fungi and Bacteria - The majority of the fungal and bacterial populations in the nursery are beneficial rather than harmful. In fact, certain types of fungi and bacteria are needed for successful tree seedling and cover crop production. Many soil fungi are antagonists or competitors in association with soil parasitic fungi. Other fungi and bacteria are either primary soil organic matter saprophytes or nitrification agents. Without sufficient populations of these beneficial soil organisms, the processes of organic matter decomposition and nutrient fixation are greatly impeded. Most of these types of fungi and bacteria are the "pioneer" types and are among the first invaders of severely disturbed nursery sites such as occurs following soil fumigation. Some of these pioneer soil fungi (i.e., *Trichoderma* spp.) have been shown to be highly antagonistic and competitive against subsequent invasions of parasitic fungi.

Mycorrhizae - These are the beneficial and, most likely, the most important fungi in forest tree nurseries. The two primary types of mycorrhizae are the ectomycorrhizae, primarily on conifer species, and the endomycorrhizae, primarily on hardwood species. Various fungus species associated with both mycorrhizal types occur naturally in both conifer and hardwood nurseries. The mycorrhizal fungus - tree root symbiotic association is apparently the rule rather than the exception in nature and is required for the successful production of the majority, if not all, conifer and hardwood seedling species. Extensive research and field evaluation work is presently aimed at the practical application of specific ecto- and endomycorrhizal fungus species to conifer and hardwood nurseries. The endomycorrhizae with their obligate parasitism and subsurface spore production characteristics require different nursery application and cultural practices than do the ectomycorrhizae with their prolific aboveground spore production and saprophytic characteristics.

GENETIC RESISTANCE

Resistant Species and Varieties - Considerable variations in pest resistance are demonstrated between species and varieties within species of conifer and hardwood seedlings. Examples of this include the variable resistance of pine species to the rusts and foliage diseases along with species varietal resistance to specific pest problems such as lophodermium needle cast on Scotch pine. The utilization of these resistance characteristics represent a very effective and more permanent nursery pest management practice.

Rust Resistance - Selections and Development - The application of natural pest resistance patterns has been very effective in the selection, development, and breeding of rust-resistant pine trees. During the past several years, the U. S. Forest Service has conducted extensive research, field evaluations, and controlled testing on pine rust diseases such as fusiform rust in the Southeast and white pine blister rust in the West and North Central states. Seed from proven rust-resistant trees is becoming available for the production of rust-resistant pine seedlings that will be planted on high rust-hazard sites.

CHEMICAL CONTROLS

Soil Fumigation - This is the most effective chemical control practice for nursery soil parasitic fungi, insects, and nematodes. Additional benefits are derived from the control of other pests such as most weed species and increased seedling growth and quality. Several soil fumigants are commercially available and registered by the U. S. Environmental Protection Agency for preplant nursery soil treatments. The most effective soil fumigants for controlling several soil pests--particularly parasitic soil fungi--are the methyl bromide - chloropicrin formulations. The methyl bromide - 67%; chloropicrin - 33% formulation is most effective in controlling root rot disease fungi with tough resistant spore stages such as charcoal or black root rot on conifers and cylindrocladium root rot on hardwoods. Effective soil fumigation can be consistently obtained by considering and utilizing the basic physical, biological, and chemical factors associated with this practice.

Soil Drenches - Postplant chemical soil drenches are occasionally needed to help control or contain several soil pest problems such as postemergence damping-off, and root rot diseases, insects, and nematodes that may develop following ineffective soil fumigation. Several registered pesticides are available for use against different pests. They are used in water solutions followed by adequate irrigation (i.e., 1/2-inch water) to move the pesticide down into the seedling root zones. Repeated soil drench applications are also usually required to achieve desired control results.

Protective Foliage Sprays - Protective foliage sprays are frequently required to control stem rust and foliage diseases such as the southern pine fusiform rust and brown spot on longleaf pine, along with several other foliage diseases and insects on both conifer and hardwood seedlings. Effective control requires complete and continuous coverage of the susceptible foliage with these protective pesticides. For example, 30-40 fermate protective spray applications are routinely applied from seed germination date to July 1 for the control of fusiform rust on slash and loblolly pine seedlings in southern nurseries.

Herbicides - A variety of herbicides have been developed, field evaluated, and registered for weed control in nurseries. Herbicides are now commercially available and registered for weed control in both conifer and hardwood seedbeds with both pre- and post-plant (conifers) applications. The development,

field evaluation, and registration of these herbicides have revolutionized weed control practices in nurseries. For example, soil fumigation for weed control alone and hand weeding with their corresponding high costs have either been eliminated or greatly minimized. Equal or better weed control can be obtained with the new herbicides at a fraction of the costs involved with previous routine nursery weed control practices.

SUMMARY AND CONCLUSIONS

The consideration and application of the preventive, cultural, biological, and chemical control practices described above will provide satisfactory nursery pest management results. These nursery management practices are all closely related and most of them are routinely employed in the sustained and, more recent, accelerated production of hi[g]h-quality tree seedlings. This paper is primarily aimed at "surfacing" various integrated control practices available to the nurseryman and relating their application to an effective nursery pest management program.

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