Integrated Pest Management in Forest Nurseries[1]

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Filer, T.H.; Cordell, C.E. 1987. Integrated Pest Management in Forest Nurseries. In: Landis, T.D., technical coordinator. Proceedings, Intermountain Forest Nursery Association; 1987 August 10-14; Oklahoma City, OK. General Technical Report RM-151. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 116-119. Available at: http://www.fcnanet.org/proceedings/1987/filer.pdf

Abstract.--INPM techniques and procedures provide the necessary information to assist nursery managers in planning the most effective practices to produce quality seedlings. An integrated program that considers the following factors will minimize losses from diseases, insects, and weeds: site selection, fumigation, crop rotation, cover crops, sowing date, fertilization, irrigation, seedbed density, and chemical and biological control methods.

INTRODUCTION

Conservation reserve and other tree planting programs have caused an accelerated rate of reforestation in the United States, which has caused an increase in seedling production. New state and industry nurseries are being established, as well as old ones being expanded. More than 80 industry, state, and federal nurseries in the South produce over 1 billion seedlings annually. This represents over 75x of the total annual bare-root production in the United States. Nurseries grow a wide variety of both conifers and hardwood species.

Increased production and tree species confront nursery managers with a wider array of potential pest problems. The high value of genetically improved seedlings has significantly increased the impact of pest problems.

Seedling quality represents the most important economic aspect of forestation. However, seedling cost will average less than 15% of total plantation establishment cost per acre. To meet future wood demands, high quality and quantity of tree seedlings must continue to be available to the forest manager.

Major pest problems in the nursery are an exception rather than the rule. When major problems do occur, nursery managers can utilize integrated pest management practices.

The integration of suitable techniques and procedures into one concerted, harmonious effort is needed for effective, efficient control of nursery pests.

Integrated Nursery Pest Management (INPM) is defined as the reduction of pest problems in the nursery by employing decisions, plans, and a combination of management procedures in a coordinated pest management program. This system, to be successful, requires a systematic, interdisciplinary approach from such related disciplines as soil science, silviculture, forest pathology, entomology, and weed science. Emphasis must be placed on pest prevention, containment, and exclusion.

Nursery pest management practices are closely related to and must be harmoniously used with prescribed cultural practices to be practical and effective. The selection of the most effective, practical, and environmentally safe combination of INPM practices for target pest problems is the key to successful pest management.

PREVENTION

An effective quarantine program will prevent the transfer and spread of pathogens, nematodes, insects, and weeds into nursery and field forestation areas. These pests may be present on seeds, seedlings, soil, water, equipment, or personnel. Preventive measures represent the most effective and efficient pest management practice.

PEST DETECTION, DIAGNOSIS, AND EVALUATION

Early pest detection, combined with rapid diagnosis of problems, is a prerequisite to successful nursery pest management. Rapid diagnosis will permit the selection and timely application of control procedures before the pest becomes unmanageable.

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[1]Paper presented at the Intermountain Nursery Association Meeting, Oklahoma City, August l0-14, 1987.

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NURSERY SITE SELECTION

Selection of the nursery site is the most important cultural practice for consideration in the nursery pest management plan. Select new locations or expand existing nurseries only after considering the following factors and their relationship to pest management: soil types, texture, pH, past land use, presence of harmful pests, adequate supply of clean water with proper pH. The soil type for most tree species should be of a coarse texture, primarily sand with some silt and a low clay content. The soil profile should not have any impermeable subsoil. This type of soil promotes good tillage, fumigation, and drainage. Pre-emergence damping-off, caused by soil-borne fungi, is less severe in coarser soil with good drainage. The pH of soil and irrigation water can influence the development of soil-borne diseases. Pre- and post-emergence damping-off diseases often occur in conifers when the soil pH exceeds 6.0.

CROP ROTATION

Crop rotation is used in INPM programs to reduce seedling losses from fungi, insects, nematodes, and weeds. The pests often become serious problems when continuous seedling production is practiced without rotation. Alternating susceptible and nonsusceptible crops in proper sequence will minimize seedling losses. The alternation of cover crops with seedling production is standard practice in many forest tree nurseries.

COVER CROPS

Cover crop species vary in their susceptibility to different root rot pests. Corn, peas, soybeans, and sorghum are susceptible cover crop hosts for charcoal root rot of conifers (Seymour and Cordell 1979). Alfalfa, soybeans, and other legumes are susceptible to the Cylindrocladium root rot fungus of hardwoods (Cordell and Skilling 1975).

To allow for adequate decomposition, cover crops should be plowed under a minimum of 2 months before fumigation. Non-decomposed organic matter will absorb large quantities of fumigants, thereby reducing pest control. Organic matter amendments may reduce root pathogens because increased organic matter promotes high populations of saprophytes and soil organisms that compete with root pathogens.

ORGANIC MATTER AMENDMENTS

Annual applications of organic matter to nursery beds help to improve tilth, nutrient, water retention, and soil aeration. However, precautions are required concerning the type and composition. The addition of fresh sawdust or pine bark may have adverse effects on tree seedling development by changing the carbon/nitrogen ratio of the seedbed. Micro-organisms tie up the available nitrogen and the seedlings suffer from nitrogen deficiency.

SOIL AND WATER PH

Soil pH, excessively high or low, influences the severity of diseases caused by soil-borne fungi. The addition of elemental sulfur is useful to lower soil pH and reduce disease losses such as damping-off on conifer and hardwood seedlings. The addition of lime will increase the soil pH to more desirable levels. The pH of irrigation water can be lowered by metering sulfuric or phosphoric acid into the irrigation system. Desirable soil and water pH levels range between 5.0 and 6.0.

SEEDBED SOWING DATES

Minimize seedling losses from soil-borne pathogens by selecting the proper planting date. Cold, moist soils are conducive to growth and development of Pythium and Phytophthora fungi that cause pre- and post-emergence damping-off of seedlings (Filer and Peterson 1975). A delay in spring seeding until soil temperatures are favorable for seed germination will often avoid losses from damping-off fungi.

In the southern states, an equally serious problem is high soil surface temperature in late spring, which causes sun scald of young seedlings. Fall sowing is an alternative choice to avoid sun scald problems of several hardwood species.

SEEDBED DENSITY

The correct seedbed density will reduce certain pest problems. Seedbeds planted too dense, increasing competition for the available soil nutrients and water, will result in reduction in seedling growth and vigor. Poor seedling vigor increases susceptibility to diseases and insects. High seedbed density also reduces air circulation, which results in more foliage diseases. The increased demand for seedlings to meet accelerated reforestation programs suggests a possible trend to denser nursery seedbeds.

MULCH FUMIGATION

Mulches, such as pine needles and grain straw, should be fumigated to eliminate pathogenic fungi, weed seeds, and nematodes. Sanitation by fumigation prevents unnecessary introduction into the seedbed of pathogenic fungi, insects, and other pests. If pine needles, etc., are used for mulch, fumigate under tarp with methyl bromide 98% - chloropicrin 2% or methyl bromide 67% - chloropicrin 33% at the rat6 of 1 pound per cubic yard of mulch. Aerate the mulch at least 48 hours before it is applied to nursery beds.

FERTILIZATION

Fertilizer composition, rate, timing, and application methods can have adverse or beneficial effects on disease problems. ,Sub-optimal rates, inadequate formulation, and improper use of fer-

tilizer often results in seedling stunting, yellowing, poor root development, and mortality. Excess nitrogen application in early spring in soils deficient in calcium and phosphorus may increase seedling damage by damping-off fungi. Excessive levels of phosphorus (200 lbs. available P 05 per acre) will inhibit both naturally occurring and artificially inoculated ecto- and endomycorrhizae on conifer and hardwood seedlings.

SANITATION

Sanitation is an important practice in nursery pest management to prevent the spread of pest problems within the nursery and to field plantings. The practice includes roguing diseased seedlings and weed species in seedbeds. Existing susceptible windbreak species may require elimination to avoid build up of fungus inoculum and insects. Weed-free riser lines and fence roads will help reduce the spread of weed seeds, fungi, and insects into the nursery bed.

SEEDLING GRADING AND CULLING

Grading of seedlings before packing will minimize the transport of pest-infested seedlings to the planting site. Conspicuous root, stem, and foliage diseased seedlings should be culled in the packing shed. Particular seedling grading and culling efforts should be afforded potentially significant pest problems, such as the root rots (charcoal - Macrophomina phaseolina, cylindrocladium - Cylindrocladium spp., and phytophthora - Phytophthora spp.) and southern pine fusiform rust (Cronartium quercuum f. sp. fusiforme) (Rowan, Cordell, and Affeltranger 1980). Although it is costly, nursery managers who have eliminated seedling grading in packing sheds should consider reinstating this practice when severe pest problems appear.

BIOLOGICAL AGENTS

Biological techniques represent one of the most desirable INPM practices, but effective pest control procedures are very limited for nursery production. Perhaps the best example of biological application in nurseries involves the artificial inoculation and/or management of selected mycorrhizal fungi to increase seedling quality (Cordell and Webb 1980).

Most micro-organisms in the soil are either saprophytic or nitrification agents. Some micro-organisms are antagonistic or competitive with soil-borne pathogens. Without sufficient populations of these beneficial microflora, organic matter decomposition and nutrient fixation are greatly impeded. Most of the organisms are the pioneer colonizers of recently fumigated soil. Their presence is essential for the conversion of ammonia nitrogen to the nitrate form, which can be used by seedlings.

CHEMICAL TREATMENTS

Chemical treatments involve a variety of pre- and post-planting pesticide applications. Although the use of pesticides is considered a significant component of INPM, pesticides should be used only when other INPM procedures are not available or have failed to give satisfactory control of pests.

SOIL FUMIGATION

Soil fumigation is the most effective chemical control technique for a variety of soil-borne nursery pests, including soil fungi, insects, nematodes, and weeds. The most effective soil fumigants are the methyl bromide-chloropicrin formulations. The methyl bromide 67% - chloropicrin 33% formulation is most effective in controlling root pest problems and certain weeds and grasses, such as nutsedge. Additional benefits from thermal energy can be obtained by allowing the tarp to remain on the seedbed after fumigation for 10 to 14 days or until the beds are prepared for planting.

SEED TREATMENT

In southern nurseries, most pine seeds are coated with Thiram fungicide-latex sticker to retard damping-off and repel birds. Thiram at the rate of 2 pounds per 100 pounds of seed is commonly used. For the control of fusiform rust in southern nurseries, the systemic fungicide triadimefon (Bayleton) is presently being used as either a liquid seed soak or dry powder coating to protect the young pine seedlings during the first few weeks following emergence (Rowan and Kelley 1983).

PROTECTIVE FOLIAGE SPRAYS

There is often a need for protective foliage sprays to control foliage diseases and insects on both conifer and hardwood seedlings (Smyly and Filer 1973). However, only a relatively few chemicals are available for effective and practical control of foliage pest problems. Effective control of foliage diseases requires complete and continuous coverage of the susceptible foliage during the fungus infection period when using a protective contact fungicide. However, effective control of fusiform rust can be obtained with reduced applications (i.e., 3 to 4 well-.timed sprays) of the systemic fungicide triadimefon (Rowan and Kelley 1983).

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