Integrated Nursery Pest Management

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What is integrated pest management? Take a look at the definition of each word to better understand the concept. Two of the words (integrated and management) are relatively straightforward. Integrated means to blend pieces or concepts into a unified whole, and management is the wise use of techniques to successfully accomplish a desired outcome. A pest is any biotic (biological) stress factor that interferes with healthy seedling development and causes a sustained departure from the normal physiological or morphological condition that characterizes a healthy seedling. So pests can be microorganisms (for example, fungi, bacteria, viruses), weeds, and animals (for example, insects, nematodes, rodents, deer, and a well-meaning, but inept-tractor operator or chemigator). Therefore, integrated pest management (IPM) incorporates a variety of techniques to limit losses caused by a variety of biotic stresses to successfully produce a healthy seedling crop.

Most nurseries have the same comprehensive goals of producing high-quality seedlings in a cost-effective manner, and ensuring employee and environmental safety. Formalizing those goals ensures that any pest treatments are consistent with those objectives. Prudent nursery managers also have a formal, clearly articulated, decisionmaking or management policy. Such a document transcends changes in staffing, and when combined with historical records (see the next section), can assist nursery managers in making correct pest management decisions. Nursery pests are always present; the best IPM plans describe potential pests and define the critical threshold for the pest to be classified as a problem. After a pest population crosses that designated threshold, a series of control options can be applied.

Training, Monitoring, and Recordkeeping

Employees should be encouraged to attend extension workshops and regional nursery meetings. These sessions offer opportunities to hear the latest about new pest problems, control techniques, pesticides, and other important nursery topics, such as fertilization and irrigation. Such gatherings also provide excellent opportunity for employees to network among other nursery professionals, and often the information gleaned during conversations held during breaks at these meetings is invaluable. Generally, such gatherings are also more focused on pests encountered in forest and conservation nurseries, as compared with generic "pest" workshops required to maintain pesticide applicators licenses. Prudent managers can combine IPM training and implementation as part of their overall U.S. Environmental Protection Agency Worker Protection Standard training. Using a variety of IPM techniques to reduce the need for chemical applications (that require reentry intervals) has advantages; supervisors will spend less time notifying employees about upcoming restrictions and access to the entire facility by workers can be better maintained.

Early detection of pest problems often results in pest control before damage is severe. All employees are responsible for continually monitoring the seedlings for pests and factors that disrupt appropriate environmental conditions for healthy seedling growth. After pests are detected, designated employees who are specifically trained to identify and document problems can recommend appropriate IPM treatments. These employees need to be equipped with a hand lens; small notebook, personal digital assistant, or digital recorder; digital camera; and maybe even a global positioning system receiver in larger nurseries (fig. I.1). If nursery staff cannot make an accurate diagnosis, samples should be sent immediately to appropriate pest specialists for identification. Proper pest identification is essential in selecting the most cost-effective, practical, economical, and environmentally sound IPM practice. Full details about the pest incidence should

Figure I.1—*Observant employees and a hand lens are critical to any integrated pest management plan.* Photo by Niklaas K. Dumroese.

be recorded and retained in a central location. Historical records are valuable assets used to accurately diagnose future problems and increase the effectiveness of subsequent treatments.

Managing Pests

Because good IPM plans incorporate many pest control techniques, this holistic approach is more practical, economical, and ecologically sound than a control program that relies, for example, on a single control technique. IPM can be discussed and implemented many ways. An effective IPM plan focuses on the three elements necessary for pests to cause problems in nurseries: (1) the pest is present, (2) the environment is conducive for the pest, and (3) the hosts (nursery crops) are susceptible to the pest (fig. I.2). These collective elements are referred to as the "disease triangle" because all three elements are necessary for biotic disease to occur. A good IPM program, therefore, coordinates and targets multiple control methods against all three components. Moreover, using multiple methods to control pests makes the nursery crops less vulnerable and more resilient when either litigation or regulation remove or restrict the ability to use a particular pest prevention technique.

It is impossible to provide an IPM "recipe" for all nurseries, simply because each nursery has unique goals and different ideas of what constitutes acceptable pest populations or damage thresholds. Additionally, each nursery has varying pest issues based on its geographic location and associated environment. Some general information is provided in the following sections to help nursery managers and their workers gain an improved understanding of the wide scope of activities that can be part of an IPM plan. Keep in mind that this discussion is far from an exhaustive list of potential techniques; hopefully, the examples provided will stimulate additional, innovative techniques. Some techniques described may block more than one component of the disease triangle. Because separating the interaction of seedling health and proper environmental conditions is often difficult, those two components of the disease triangle are combined in the following discussion; these two components also are the logical starting point for any IPM plan because they primarily focus on pest prevention rather than what can be done after a pest is causing damage.

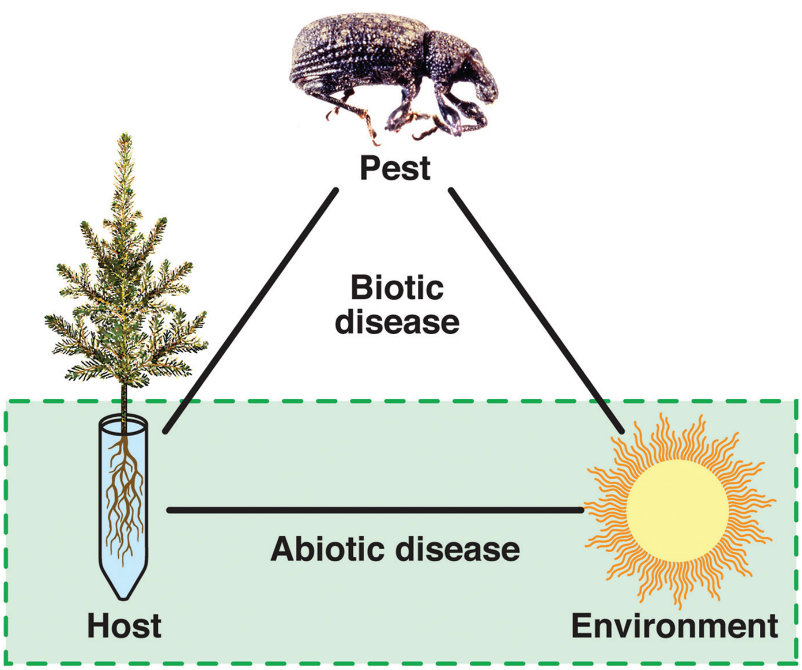

Figure I.2—*The "disease triangle" illustrates the concept that a host, a pest, and a conducive environment are necessary to cause biotic disease. Abiotic disease occurs when environmental factors, such as frost, injure the host plants.* Illustration by Jim Marin Graphics.

Providing a Healthy Environment and Improving Seedling Resistance and Resilience

A healthy environment and seedling resistance and resilience are intertwined. When seedling damage is noted but pests are absent, the cause can often be traced to an environmental factor, which highlights the importance of examining these two components concurrently.

Abiotic (environmental) and biotic (living) factors contribute to seedling health. For a bareroot nursery or a container nursery without greenhouses, site selection is the most important abiotic variable to consider. Having a site that meets criteria for optimum soil texture, pH, drainage, air flow, and water quality (low salinity, proper pH) contributes to healthy seedlings and is paramount in selecting new sites or expanding existing sites. Optimum soil is well drained, low in clay content, and lacks any impermeable layers (especially close to the surface). Poorly drained soils can lead to root rot development in bareroot nurseries or can result in slow drainage from a container nursery site. If poor drainage is a problem in a portion of the nursery, subsoiling (deep plowing to fracture impermeable layers) or tiling may mitigate the problem. Fields may also be leveled or seed beds oriented to improve water flow across the site.

Although soil pH can be modified, beginning with a pH conducive for seedlings (generally 4.5 to 6.5 depending on species) is best. For conifers, a pH above 5.5 generally leads to more damping-off and root rot, and a pH above 6 can reduce ectomycorrhizae development. A good site is not in a frost pocket and is protected from harsh winds.

For any nursery type, water needs to be tested for pH and the presence of detrimental fungi, nematodes, insects, weed seeds, salts, and pesticides, especially if a surface source (river, pond, or reservoir) is used (fig. I.3). Although pH can be readily adjusted downward by injecting acid into irrigation water, it may be difficult, expensive, or impossible to remove these other contaminants; test results can help managers use appropriate methods to mitigate their influence.

Proper temperatures are required for optimum seedling growth. Improper temperatures can reduce germination, induce fungal attack, or directly cause seedling mortality. For crops grown in greenhouses equipped with environmental controls, temperature is easily maintained by a combination of heaters, air conditioners, cooling pads, removable roofs, shading, and irrigation. For bareroot nurseries and outdoor container operations, maintaining desired temperatures is difficult. High temperatures are usually mitigated by irrigation, although some species may require shading provided by laths. Low temperatures in early spring can be avoided by delaying sowing until the soil temperature is suitable for rapid seed germination and early seedling growth. Damage from an early frost in the fall can be mitigated by applying irrigation water. Using a cover crop can also help protect germinating seeds from cold temperatures; wheat or rye, planted with fall-sown crops, particularly hardwoods, germinates in the fall and provides a thermal blanket for the crop seeds. Similarly, insulating fabrics can protect fall- or spring-sown crops from excessively cold temperatures; in greenhouses, such fabric can help retain nighttime media temperatures and foster more rapid germination with less energy consumption.

Strong, healthy plants are more resilient to pests. Choosing species and seed sources appropriate to the nursery location is important (especially for bareroot nurseries); seedlings grown off site will be more susceptible to environmental stresses. Vigorous seed lots that have rapid and uniformly high germination are often more immune to biotic and abiotic stresses. Seeds produced in seed orchards usually have high vigor, and often the clones have been selected for resistance to pests, such as fusiform rust.

Crop density should be controlled to ensure seedlings have access to sufficient resources (nutrients, water, and sunlight), whether they are grown in bareroot or container nurseries. High crop density can reduce seedling vigor, making them more susceptible to pests. In addition, intermingling of canopies can promote high relative humidity, which is conducive to foliar diseases, such as powdery mildew and gray mold.

Water is the most dangerous input used in nurseries. Insufficient irrigation can lead to improper seedling nutrition, poor growth, greater susceptibility to pests, and mortality. Excessive irrigation, which reduces gas exchange to and from soil and media, can kill roots and

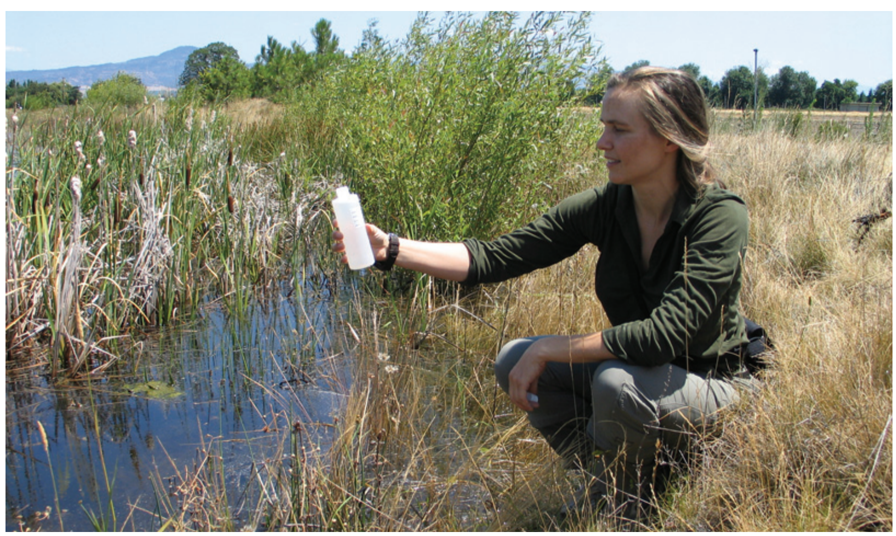

Figure I.3—*Nursery water needs to be tested for pH, salinity, pesticides, and the presence of fungi, nematodes, insects, and weed seeds, especially if a river, pond, or reservoir is the water source.* Photo by Thomas D. Landis, USDA Forest Service.

reduce plant vigor, enabling waterborne organisms (for example, *Pythium*, *Phytophthora*, and some nematodes) to become pests. *Pythium* spores require water to move to new hosts, so saturated soils are especially conducive to spread of this disease. Excessive irrigation also favors shoot development at the expense of root development, which could decrease mycorrhizae development. Irrigation timing can also be critical. Applications made early in the day enable the foliage to dry, which decreases the likelihood of foliar diseases, such as gray mold.

Providing crops with proper nutrition levels is paramount. In addition to knowing proper nutrition levels and which fertilizer formulations work best for specific species, employees need training to efficiently and accurately administer applications. Insufficient fertilizer use can reduce seedling vigor and growth and increase susceptibility to pests. Excessive fertilizer use can stimulate damping-off during germination, burn foliage, stunt growth, cause excessive shoot growth and diminish root growth or, in the case of nitrogen and phosphorus, delay or inhibit formation of symbiotic relationships, such as mycorrhizae. Optimum rates yield the healthiest seedlings.

Symbiotic microorganisms (for example, mycorrhizae and nitrogen-fixing bacteria) can improve nutrient and water uptake toward enhancing seedling health. Colonization by symbiotic microorganisms and other favorable biotic species (for example, *Trichoderma* to reduce root disease incidence) can reduce potential infection by pathogenic fungi.

Managers should properly harden crops prior to harvest to reduce seedling stress levels. Keeping seedlings cool and moist and handling them with care during harvest ensures seedling quality is retained. Seedlings are more susceptible to stresses and pests when roots are allowed to dry or seedling boxes are dropped onto the ground.

Nursery managers often realize that portions of their container or bareroot nurseries are more favorable to growing some species than other areas. Growing seedlings in areas where the environmental and biotic features are more conducive to that species yields healthier, more pest-resistant crops. Continuous cropping of a particular species in the same area, especially in bareroot nurseries, can promote the buildup of a variety of fungal, insect, nematode, and weed pests. Rotating crops, especially susceptible and nonsusceptible species, and alternating seedling production with cover crops is one way to prevent such buildup.

Adding organic mulches is one method for improving soil organic matter levels; improved nursery soil tilth enhances aeration, water-holding capacity, and improved soil microorganism populations that may help suppress root disease. Commonly used mulches include pine needles, compost, sawdust, and straw. Nursery staff should have any mulch material tested to ensure it is free of pests, especially fungal inoculum and weed seeds. Although mulches can be fumigated, it is probably more efficient to incorporate any organic material before the traditional presowing fumigation occurs. Avoid mulches with high carbon-to-nitrogen ratios (for example, fresh sawdust or straw) that can lead to nitrogen immobilization as microorganisms use the nitrogen to digest the mulch.

Reducing Pest Populations

Pests range in size from microscopic (fungi, nematodes, bacteria, and viruses) to small (insects) to megafauna (rabbits and deer), and methods for reducing pest populations are just as varied. Often, nursery managers equate pest control or pest management with a repeated pesticide application regime. At some nurseries, such applications are made whether the pest is present or not; some managers consider it to be cheap insurance. Other nurseries have discovered, however, that reducing initial pest populations through other techniques and resorting to chemicals only when pests cross a critical damage threshold, can dramatically reduce the amount of pesticides required. This approach can result in financial savings and less down time because of required reentry intervals after pesticide applications.

Physical: Sanitation and Exclusion

One easy method to reduce pests is by increasing sanitation across the nursery. Sanitation can take many forms, including keeping the landscape, seed production areas, and nursery perimeter free of weeds, which can reinfest bareroot and container crops and harbor other insect and fungal pests. Maintaining growing areas and nearby grounds free of accumulated junk reduces hiding places for larger pests, such as rodents, that can consume seeds or seedlings. Clean field machinery before moving from one field to another to help prevent movement of weeds, nematodes, and fungal pathogens. Employees can rogue dead and dying seedlings from beds and containers to reduce the spread of disease. Diseased culls should be buried or composted at a spot away from the growing area.

Employees should wash their hands to prevent spreading contaminants when moving from one seed source to another. In container nurseries, tables, floors, and the containers need to be cleaned between crops. Solid floors are easier to keep clean and prevent weeds and some insects, such as fungus gnats that commonly reproduce in the organic matter under benches. Fungus gnats can consume seedlings roots and act as vectors for Fusarium root disease and gray mold by carrying spores on their bodies. Reused containers that have not been cleaned often reduce seedling growth, even if traditional root disease symptoms are absent.

Some pests are easier to exclude than others. Screens over entry points into greenhouses can exclude many insects, and fences can be used to prevent larger animals from damaging plants. Seed germination cloths or lath or cage structures deployed over seedbeds and containers in outdoor growing areas can reduce bird predation until germination is complete (fig. I.4). Refraining from accepting stock from other nurseries can also reduce the likelihood of introducing pests. Some pests can also be excluded through trapping. Aphids, fungus gnats, thrips, whiteflies, and others can be lured to colored sticky traps; these traps can also serve to monitor population levels and control these pests. Rodents can be removed using lethal or humane traps. Nursery managers in the Midwest use thick mulches of straw above their fall-sown bareroot crops of oaks and hickories to exclude turkey and deer predation.

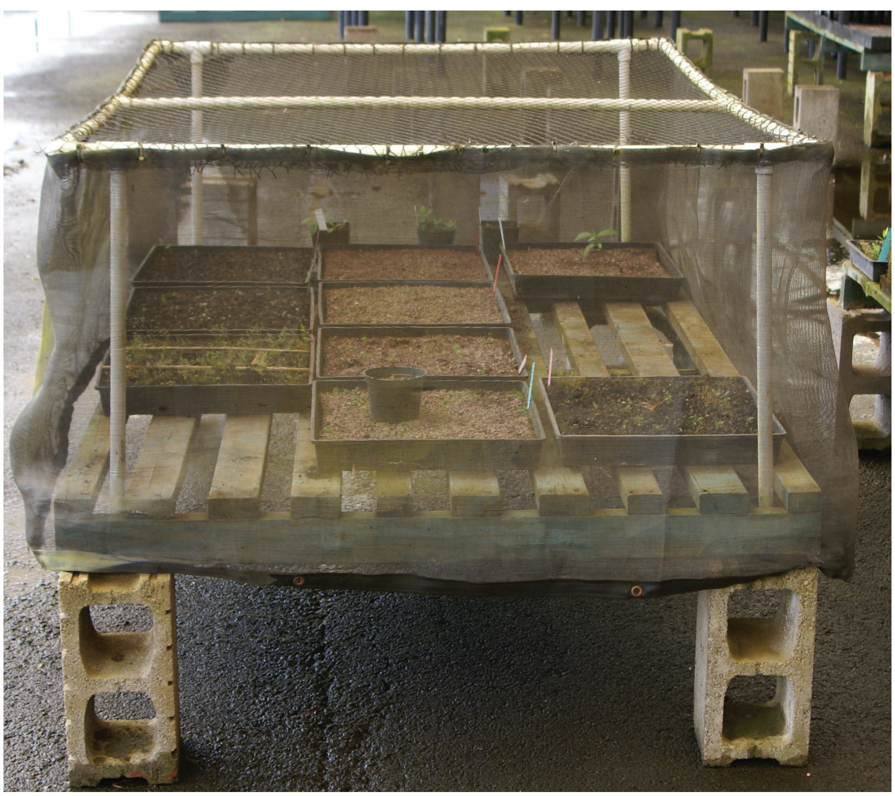

Figure I.4—*A screen exclosure prevents seed predation at the Hawai'i Division of Forestry and Wildlife Kamuela (Waimea) State Tree Nursery on the Island of Hawai'i.* Photo by R. Kasten Dumroese, USDA Forest Service.

Although windbreaks around nurseries can improve aesthetics, reduce soil erosion, and decrease wind damage, careful evaluation of the windbreak species is important to ensure that candidates are neither an alternate host for fungi nor a food source or refuge for other pests. For example, oaks serve as alternate hosts for fusiform rust, which can infect southern pine crops. Austrian pine, commonly planted as a windbreak tree in the Lake States, is susceptible to Diplodia blight, which can severely damage pine seedlings. Therefore, judicious windbreak species selection is necessary, as is keeping the windbreak healthy and vigorous so that pests are less likely to become a problem. Unfortunately, spores of these fungal pests can travel long distances, making complete eradication, even to extended distances around the nursery, impractical to achieve.

Weeds are often excluded from fallow nursery fields by repeated tillage or through suppression using a cover crop. Cover crops reduce erosion and increase soil organic matter but need to be selected carefully. Intuitively, legumes that fix nitrogen seem to be good candidates for cover crops, but they are also known to promote development of charcoal root rot, black root rot, and nematodes in the Southern States, and Fusarium root disease in the Pacific Northwest. This concern may be irrelevant if fields with legume cover crops are plowed under and enabled to decompose, or if the fields are fumigated before establishing the next seedling crop.

Biological Control

Biological controls can also reduce pest populations. Incidence of root rots can be reduced by drenching soil or media with *Trichoderma*, a species antagonistic to many pathogenic fungi. Inoculating crops with mycorrhizal fungi may help reduce incidence of root rots, either by improving host resistance or by decreasing the number of potential infection points on seedling roots. Biological control of insects is a bit more difficult. Although many insect pests can be controlled with beneficial insects, ensuring that sufficient beneficial insects are in place at the correct time to counteract undesirable insects can be difficult to achieve. Often, a minimal pest level is required to ensure that the biological agent survives, and this minimal level may exceed acceptable damage thresholds. Nursery managers must exercise care to ensure that other pest control measures do not diminish the efficacy of potential biological controls. For example, some systemic fungicides can suppress mycorrhizae development. Predator nematodes are available for biological control of fungus gnats in container nurseries and harmful nematodes in fields.

Chemicals

Chemical treatments are another piece of any IPM plan and are useful in situations in which other IPM practices are unavailable or ineffective (either from a pest control or financial aspect). Chemical pesticides (biocides, herbicides, insecticides, rodenticides, and nematocides) can be synthetic (for example, glyphosate) or natural or botanic (for example, neem oil). This distinction is becoming blurred, as many botanic chemicals are now produced synthetically, rather than extracted from their natural sources.

Chemicals can be applied to seeds to protect them against birds, animals, and fungi. Thiram is one such chemical; it decreases predation by birds and small animals and has efficacy against some seed- and soil-borne pathogenic fungi. Many other chemicals (for example, bleach, hydrogen peroxide, and fungicides) have been used on forest tree seeds; their efficacy varies by tree species, pathogen, chemical concentration, and treatment duration. In the South, systemic fungicides are commonly used to treat loblolly and slash pine seeds so that newly emerged seedlings are protected from fusiform rust.

Chemicals can be applied to soil several ways. Fumigants are nonselective biocides. Fumigating soil before sowing effectively reduces or eliminates fungi, insects, nematodes, and weed seeds. Although fumigants are effective in reducing or eliminating soilborne pathogenic fungi and weed seeds, they also negatively affect beneficial microorganisms, such as mycorrhizal fungi and *Trichoderma* species. Usually fields are rapidly recolonized by ectomycorrhizal fungi because the fungi reproduce through windborne spores, therefore, most conifer crops become mycorrhizal. Spores of arbuscular mycorrhizal fungi are not airborne, so they take much longer to recolonize hardwood (and some conifers, such as giant sequoia and bald cypress) nursery beds. Arbuscular mycorrhizal fungi can recolonize nursery beds from adjacent, nonfumigated soils, but applying arbuscular mycorrhizal inoculum after fumigation can ensure seedlings have their symbiotic fungi.

Pre- and post-emergent herbicides are commonly applied to the soil immediately before and after germination of crop seeds to prevent weed seed germination. Judicious, conscientious, and safe herbicide use has reduced the need for more expensive hand weeding. Some pre- and post-emergent herbicides can be used with a variety of hardwood and conifer crops in bareroot and container nurseries. Nonfumigant fungicides are less commonly applied to soil, and insecticides are rarely applied, if ever. When used, these pesticides may be applied as soil drenches or granular formulations. Fungicides are sometimes applied in bareroot and container nurseries to control root rot, but their efficacy is often low or poor, mostly because it is difficult to move these short-lived products to sufficient soil depths in sufficient quantities to be useful.

Chemicals can be applied to plants either to protect crop plants (fungicides and insecticides) or to kill weeds (herbicides). Fungicides and insecticides can be contact (kills the pest on contact) or systemic (absorbed by the seedling, and the pest is killed when it consumes a portion of the crop plant) pesticides. Typically fungicides and insecticides are applied with spray equipment although sometimes they are injected into irrigation lines. Contact pesticides have low residual activity and therefore usually require multiple applications, especially to protect new growth or if reinfestation by the pest occurs. Systemic pesticides, translocated throughout a seedling, have longer residual activity. Although simple hydraulic sprayers are commonly used to apply chemicals, electrostatic and other specialty sprayers can reduce water and pesticide volumes and increase pesticide efficacy (fig. I.5). Herbicides can reduce weeds in containers, fields, and other nursery areas. Nonselective herbicides are often used in places where crops are not involved, such as along irrigation lines, fences, and near buildings, but selective herbicides are used with seedling crops. Recent development of “shielded sprayers” enables nursery personnel to apply nonselective herbicides to weeds between conifer or hardwood rows in nursery beds.

Figure I.5—*This modified orchard sprayer applies pesticides thoroughly to seedlings being grown at the Missouri Department of Conservation George O. White Nursery at Licking.* Photo by R. Kasten Dumroese, USDA Forest Service.

Embrace Integrated Pest Management

Many good nursery managers practice IPM without realizing it or calling it by name. IPM becomes easier to apply if nursery managers make an effort with themselves and their employees to embrace IPM as a management philosophy—a priority. Doing so will enable nursery managers to reap the maximum benefit of any IPM program.

Selected References

Barnett, J.P. 2008. Relating seed treatments to nursery performance: experience with southern pines. In: Dumroese, R.K.; Riley, L.E.; tech. coords. National proceedings: forest and conservation nursery associations—2007. RMRS-P-57. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 27–37.

Cordell, C.E. 1979. Integrated control procedures for nursery pest management. In: Proceedings, Northeastern Area nurserymen's conference. Broomall, PA: USDA Forest Service, Northeastern Area, State and Private Forestry: 43–51.

Cordell, C.E.; Filer, Jr., T.H. 1985. Integrated nursery pest management. In: Lantz, C.W., ed. Southern pine nursery handbook. Atlanta: USDA Forest Service, State and Private Forestry, Region 8. Chapter 13.

Cordell, C.E.; Kelley, W.D.; Smith, Jr., R.S. 1989. Integrated nursery pest management. In: Cordell, C.E.; Anderson, R.L.; Hoffard, W.H.; Landis, T.D.; Smith, Jr., R.S.; Toko, H.V., tech. coords. Forest nursery pests. Agriculture Handbook 680. Washington, DC: USDA Forest Service: 5–13.

Cram, M.M.; Fraedrich, S.W. 2005. Management options for control of a stunt and needle nematode in Southern forest nurseries. In: Dumroese, R.K.; Riley, L.E.; Landis, T.D., tech coords. National proceedings: forest and conservation nursery associations—2004. RMRS-P-35. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 46–50.

Dumroese, R.K. 2008. Observations on root disease of container whitebark pine seedlings treated with biological controls. Native Plants Journal. 9: 92–97.

Dumroese, R.K.; James, R.L. 2005. Root diseases in bareroot and container nurseries of the Pacific Northwest: epidemiology, management, and effects on outplanting performance. New Forests. 30: 185–202.

Dumroese, R.K.; James, R.L.; Wenny, D.L. 2002. Hot water and copper coatings in reused containers decrease inoculum of *Fusarium* and *Cylindrocarpon* and increase Douglas Fir seedling growth. Horticultural Science. 37: 943–947.

Dumroese, R.K.; Pinto, J.R.; Jacobs, D.F.; Davis, A.S.; Horiuchi, B. 2006. Subirrigation reduces water use, nitrogen loss, and moss growth in a container nursery. Native Plants Journal. 7: 253–261.

Dumroese, R.K.; Wenny, D.L.; Quick, K.E. 1990. Reducing pesticide use without reducing yield. Tree Planters' Notes. 41(4): 28–32.

Enebak, S.; Carey, B. 2002. Pest control for container-grown longleaf pine. In: Barnett, J.P.; Dumroese, R.K.; Moorhead, D.J., eds. Proceedings of workshops on growing longleaf pine in containers—1999 and 2001. GTR-SRS-56. Asheville, NC: USDA Forest Service, Southern Research Station: 43–46.

Hansen, E.M.; Hamm, P.B.; Campbell, S.J. 1990. Principles of integrated pest management. In: Hamm, P.B.; Campbell, S.J.; Hansen, E.M., eds. Growing healthy seedlings: identification and management of pests in northwest forest nurseries. Corvallis, OR: Oregon State University, Forest Research Laboratory. Special Publication 19: 92–105. Chapter 33.

Hawkins, B. 2004. Use of living mulches to protect fall-sown crops. Native Plants Journal. 5: 171–172.

James, R.L.; Dumroese, R.K.; Wenny, D.L. 1990. Approaches to integrated pest management of Fusarium root disease in container-grown seedlings. In: Rose, R.; Campbell, S.J.; Landis, T.D., eds. Target seedling symposium: proceedings, combined meeting of the Western Forest Nursery Association and Intermountain Nursery Association. GTR-RM-200. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 240–246.

James, R.L.; Dumroese, R.K.; Wenny, D.L. 1993. Principles and potential for biocontrol of diseases in forest and conservation nurseries. In: Landis, T.D., tech. coord. Proceedings, Western Forest Nursery Association. GTR-RM-221. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 122–131.

James, R.L.; Dumroese, R.K.; Wenny, D.L. 1995. *Botrytis cinerea* carried by adult fungus gnats (Diptera: Sciaridae) in container nurseries. Tree Planters' Notes. 46(2): 48–53.

Kelley, W.D.; Cordell, C.E. 1984. Disease management in forest tree nurseries. In: Proceedings, integrated forest pest management symposium. Athens, GA: University of Georgia, Center for Continuing Education: 238–246.

Landis, T.D.; Luna, T.; Dumroese, R.K. 2008. Holistic pest management. In: Dumroese, R.K.; Luna, T.; Landis, T.D., eds. Nursery manual for native plants: a guide for tribal nurseries. Vol. 1: nursery management. Agriculture Handbook 730. Washington, DC: USDA Forest Service: 262–275.

Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1990. The biological component: nursery pests and mycorrhizae, vol. 5. The container tree nursery manual. Agriculture Handbook 674. Washington, DC: USDA Forest Service. 171 p.

Schmal, J.L.; Woolery, P.O.; Sloan, J.P.; Fleege, C.D. 2007. Using germination cloths in container and bareroot nurseries. Native Plants Journal. 8: 282–286.

South, D.B. 1984. Integrated pest management in nurseries—vegetation. In: Proceedings, integrated forest pest management symposium. Athens, GA: University of Georgia, Center for Continuing Education: 247–265.

South, D.B. 2009. A century of progress in weed control in hardwood seedbeds. In: Dumroese, R.K.; Riley, L.E., tech. coords. National proceedings: forest and conservation nursery associations—2008. RMRS-P-58. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 80–84.

South, D.B.; Enebak, S.A. 2006. Integrated pest management practices in southern pine nurseries. New Forests. 31 :253–271.

Sutherland, J.R. 1984. Pest management in Northwest bareroot nurseries. In: Duryea, M.L.; Landis, T.D., eds. Forest nursery manual: production of bareroot seedlings. Boston, MA; The Hague, The Netherlands; Lancaster, PA: Martinus Nijhoff/Dr. W. Junk Publishers: 203–210. Chapter 19.

Wichman, J.; Hawkins, R.; Pijut, P.M. 2005. Straw mulch prevents loss of fall-sown seeds to cold temperatures and wildlife predation. Native Plants Journal. 6: 282–285.