Reducing Pesticide Use Without Reducing Yield

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Because of concern about environmental, human, and seedling health, the University of Idaho Forest Research Nursery has reduced the number of pesticide applications and the amount of pesticide applied by 80%, while maintaining a high level of productivity. Sanitation and modifications of cultural practices have successfully reduced dependence on preventative pesticide applications. Tree Planters' Notes 41(4):28-32; 1990.

Nursery managers have long been concerned with overuse of pesticides because of the potential development of pest resistance (1, 2). However, with increasing risks to groundwater quality and human health (7), nursery pesticide programs will continue to come under closer scrutiny. Inevitably, nursery operations will have to wean themselves from chemical pesticide applications as the availability of these chemicals decreases because of stricter environmental laws (13) and increasing public pressure (14).

A primary concern of nursery managers is that reduced availability of chemical pesticides will lead to a reduction in seedling production. However, this concern may be unwarranted.

The University of Idaho has produced container seedlings since 1980. An aggressive spraying program evolved during the first five growing seasons. These first crops at the University of Idaho Forest Research Nursery were grown from seed obtained from cooperators or bought on the open market that was often of poor quality. Seedlings became diseased. Damping off was an annual problem in many seedlots; *Fusarium* root disease caused problems in Douglas fir [*Pseudotsuga menziesii* (Mirb.) Franco); and Botrytis ran rampant in western larch (*Larix occidentalis* Nutt), true firs (*Abies* spp.) and spruces (*Picea* spp.). Approximately 80% of the pesticides used were fungicides; the remaining 20% were insecticides.

From 1983 until 1986, the research nursery annually grew 10 species of conifers in containers, about 500,000 cells, in two fiberglass greenhouses. In 1986, the addition of a double-polyethylene greenhouse and rolling benches in all greenhouses increased annual production to 12 species and 830,000 cells (table 1). Seedlings are grown in Ray Leach pine cells® (66 cm^3, 100 seedlings per square foot) and watered with an overhead, traveling boom irrigation sys-

Table 1—*Total cells sown and species mix at the Idaho Forest Research Nursery between 1983 and 1990*

Species	1983-1986 Total cells (× 10^3)	1983-1986 Percentage of total	1987-1990 Total cells (× 10^3)	1987-1990 Percentage of total
Western white pine (*Pinus monticola* Dougl. ex D. Don)	125	25	240	29
Ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.)	125	25	275	33
Other *Pinus* spp.	20	4	30	4
Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco]	60	12	60	7
Western redcedar (*Thuja plicata* Donn ex D. Don)	15	3	15	2
Western larch (*Larix occidentalis* Nutt.)	70	14	105	12
Grand fir [*Abies grandis* (Dougl. ex D. Don) Lindl.]	40	8	40	5
Spruces [*Picea abies* (L.) Karst.; *P. engelmannii* Parry ex Engelm.; *P. pungens* Engelm.]	35	7	50	6
Other conifers	—	—	15	2
Total	500	100	830	100

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tem. Air circulation and heat are provided via under-the-bench polyethylene tubes and fans. One full-time staff person is responsible for all cultural practices.

Our Integrated Pest Management Program

In an attempt to curb pesticide use while continuing to reduce disease losses, the nursery began a modest two-point program in 1985 based on sanitation and growing regimes.

Sanitation. Sanitation is the foundation of our program. Sanitation begins during seed harvest and processing. We brief our cooperators on the importance of seed quality and seed testing. Many disease problems can be circumvented by using high-quality seed. We routinely use a 10-minute soak in an agitated bleach solution-2 parts bleach (5.25% sodium hypochlorite) to 3 parts water-followed by a thorough rinse in running water to reduce microorganism levels on Douglas fir and pine seed before stratification (11).

Before sowing, all used cells are emptied, then rinsed with a high-power hose to remove any remaining medium, broken pieces of roots, salt accumulation, and superficial growth of algae and fungi. Blocks are rotated so the high-pressure stream is directed toward cells from all directions. Blocks are then placed on their sides so their bottoms can also be treated. We pay close attention to cleaning the cell bottoms because most *Fusarium* root disease and other pathogen inocula are found there (3). This treatment has resulted in very low levels of potential pathogens (4). Previously used cells are dipped in a 1:10 bleach-water solution before they are filled. Disease-susceptible species such as Douglas-fir, western larch, and spruces are sown in new cells, lessening the chance of infection by container-borne inocula.

Blocks are filled with a Gleason® flat filler with medium return. Any medium that falls on the floor and is trampled is discarded. Before filled blocks are put inside the greenhouse, the facility is thoroughly swept out, hosed down, and washed with a 1:10 bleach solution (including the walls, roof, and benches). Any algal buildup on our concrete floors is sprayed with a copper sulfate solution (20 pounds copper sulfate per 100 gallons of water).

Once sowing is complete, the crop is monitored daily for problems. Diseased seedlings are immediately rogued and tallied by species and seedlot. If the incidence of damping-off passes our damage threshold level (at least 15% of the blocks within the seedlot have at least 5% of their cells with disease), fungicide is applied to the problem seedlot. Thinning crews also rogue diseased seedlings and help with monitoring. The process of rogueing dead or dying seedlings continues until the seedlings are extracted. We use rolling benches so that all trays are easily accessible. We believe that rogueing is especially important in removing potential hosts for Botrytis and for minimizing build up of *Fusarium* and other pathogen spores in our containers. Weeds, algae, and moss are not tolerated anywhere in the facility, and their presence is kept to a minimum by spraying them with 100% bleach (5.25% sodium hypocholorite) through a hand spray bottle. A weed-free, clutter-free buffer zone is maintained around the greenhouse perimeter to reduce breeding and hiding grounds for pests, including mice.

Growing regimes. Growing regimes have an impact on the occurrence of disease and insects. At the research nursery, western larch provides a fine example of how growing regimes influence pesticide applications. Since 1984, we have modified our western larch growing regime to decrease height, which has also decreased needle length and promoted earlier hardening-off (12). Because smaller seedlings require less water, the frequency of irrigation and the time foliage is wet are decreased; our larch seedlings are 50% smaller (15 cm tall with 2.5-mm root collar diameter) and pesticide applications have been reduced 60%.

Because of reduced seedling size, irrigation frequency, rogueing of dead seedlings, and under-the-bench ventilation, no pesticides have been necessary to control *Botrytis* infection during the last three growing seasons. Users of our western larch are very pleased with stock size and outplanting performance.

Ventilation. We use under-the-bench ventilation. It improves aeration and decreases humidity around seedlings, reduces algal build-up on floors, and aids airpruning of roots. We have also concluded good air circulation is effective in reducing the incidence of *Botrytis* infection, an observation supported by recent research (9).

Pesticide use philosophy. Our philosophy for chemical pesticide use takes the curative, rather than preventive, approach. That is, chemical pesticides are used only after all other environmental and cultural control techniques have been examined or used, not as the sole means of preventing the pest from occurring (6). Streu (10) and Linquist (8) discuss the advantages and disadvantages of a curative approach, but for our operation, the advantage is reduced pesticide use and reduced exposure of employees, students, and visitors to these pesticides.

For a curative approach to be successful, pests must be identified early, before damage becomes significant. Initially, the main disadvantage of our curative spraying approach was an increased effort to monitor the crop for pests. We

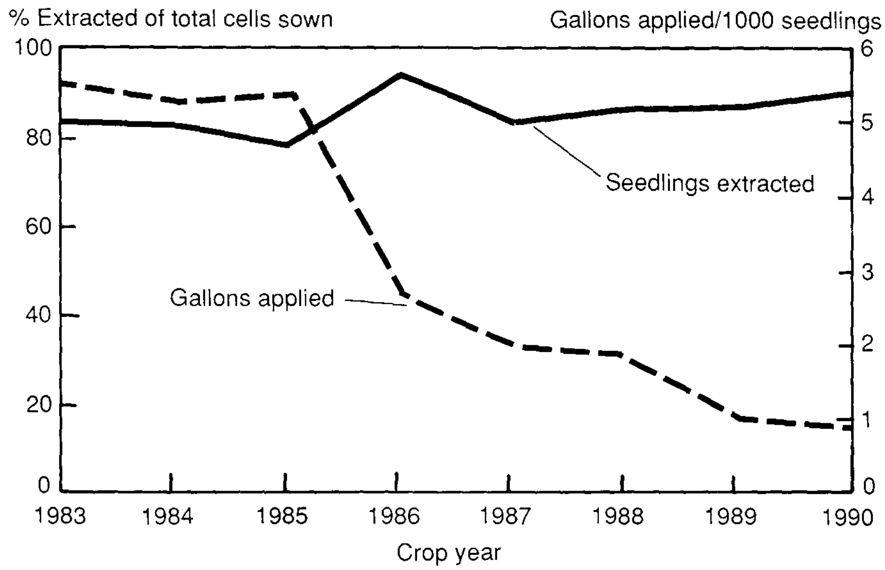

Figure 1—*Percentage of extractable seedlings for crop years 1983 through 1990 and associated gallons of pesticide applied per 1,000 seedling cells sown.*

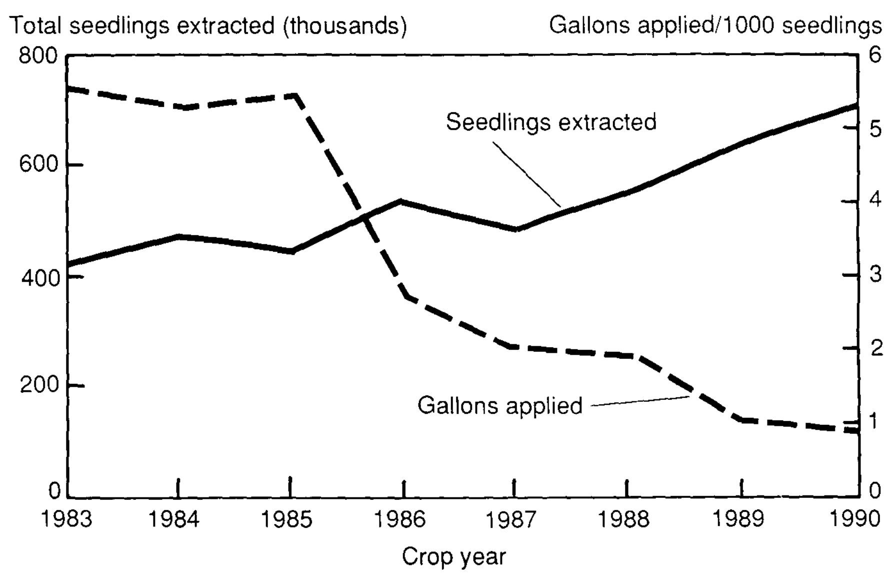

Figure 2—*Total seedlings extracted for crop years 1983 through 1990 and associated gallons of pesticide applied per 1,000 seedling cells sown.*

Table 2—*Pesticide applications and amount applied per 1,000 conifer seedlings grown at the University of Idaho Forest Research Nursery (1983–1990)*

Year	No. of applications*	Gallons per 1,000 seedlings
1983	30	5.5
1984	26	5.3
1985	28	5.4
1986	12	2.7
1987	11	2.0
1988	9	1.9
1989	10	1.0
1990	6	0.9

*An application is defined as the event of applying a fungicide or insecticide to any or all of the crop within a single greenhouse.

have found, however, that the quality of our crop has improved over the years because our staff members, in looking for problems, have spent more time observing seedlings. A greater awareness of the condition of the seedlings has aided our "fine-tuning" of growing regimes and pest management.

Some species, such as ponderosa pine and western redcedar, are generally problem free and rarely need pesticides. Species that are more disease-susceptible, such as western larch, spruce, and Douglas-fir, must be watched more carefully. However, even in these species, it is possible to apply pesticides only to problem seedlots (that is, those showing poor germination, low vigor, past history of disease problems), further reducing the total amount of pesticide applied.

The Resultant Decrease in Pesticide Use

From crop history records for the past 8 crops, the magnitude of reductions in pesticide usage is apparent. Plotting the percentage of extractable seedlings from cells sown (fig. 1) and total seedlings produced (fig. 2) against gallons of pesticide solution applied per 1,000 cells sown shows the positive effects of sanitation and growing regime manipulation on pesticide use. Gallons of pesticide solution per 1,000 cells sown has decreased from 5.5 (20.8 liters) in 1983 to less than 1 (3.8 liters) in 1990 (table 2). This decrease occurred even though the species mix of the nursery remained fairly constant but total cells sown increased more than 60% (table 1). Furthermore, the percentage of extractable seedlings has remained nearly constant over time and the total number of seedlings produced has steadily increased.

Conclusions

As Jarvis (5) concludes, we now have a comprehensive assortment of control methods for crop production. Proper use of these pest management tools is a decision making process. Integrating pesticides and environmental and cultural controls is a necessity for seedling production. Balancing the economic and environmental concerns can be accomplished only by monitoring the production system and keeping concise records of growing regimes. Placing an emphasis on using these pesticide reducing techniques can effectively control pests while maintaining a high level of productivity.

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