Fungicide Trials to Control Botrytis Blight at Nurseries in Idaho and Montana[1]

R. L. James and J. Y. Woo

Plant Pathologist, USDA Forest Service, Cooperative Forestry and Pest Management, Missoula, Montana and Research Plant Pathologist, Intermountain Forest and Range Experiment Station, Moscow, Idaho.

Iprodione, chlorothalonil, and captan adequately controlled Botrytis blight of containerized western larch and lodgepole pine seedlings. Less satisfactory results were obtained with benomyl and dicloran. Vinclozolin caused severe phytotoxicity to young containerized western larch seedlings but not to 2-0 bareroot seedlings. All fungicides tested reduced height growth of conifer seedlings.

Botrytis cinerea (Fr.) Pers. is an important pathogen in conifer nurseries where it causes foliage blight of seedlings. The disease is especially severe on containerized seedlings grown in greenhouses, where conditions are often ideal for infection (10). Although the disease is most destructive in greenhouses, losses have also been reported on bareroot stock (4). Botrytis blight occurs on many conifer hosts in Idaho and Montana nurseries, but most damage occurs on western larch (*Larix occidentalis* Nutt.), lodgepole pine (*Pinus contorta* Dougl.), Engelmann spruce (*Picea engelmanni* Parry), and ponderosa pine (*Pinus ponderosa* Laws).

Botrytis blight has been traditionally controlled by using cultural methods to reduce chances of infection and applying fungicide during periods of when seedlings are highly susceptible (7, 10). Fungicides are usually applied through overhead irrigation systems in green-houses and after irrigation or rain on bareroot seedlings. Unfortunately, frequent applications and high dosage rates have often led to development of *Botrytis* strains that are tolerant to many commonly used fungicides (2, 3, 8).

Because of recurring problems with fungicide tolerance at several nurseries in Idaho and Montana (1, S), tests were conducted to determine how effective different fungicides are in controlling Botrytis blight in greenhouses and bareroot beds. These tests provided the basis for recommendations of specific fungicides to reduce future losses from this disease.

Materials and Methods

Tests to control Botrytis blight with fungicides were conducted on containerized western larch and lodgepole pine seedlings in greenhouses and on western larch seedlings in outdoor bareroot beds at the USDA Forest Service Nursery in Coeur d'Alene, Idaho, and on containerized western larch in greenhouses at the Champion Timberlands Nursery in Plains, Montana. Fungicides tested (table 1) included four chemicals previously used at these nurseries (benomyl, chlorothalonil, captan, and dicloran) and two never used (iprodione and vinclozolin).

Five replications of 200 seedlings each (Coeur d'Alene) or 160 seedlings each (Plains) were used for each of the greenhouse treatments and the distilled water check. Fungicides were applied at label rates (table 1) with a standard garden sprayer until they began to run off the seedling foliage. This was repeated eight times at biweekly intervals, starting when seedlings were 2 to $2^{1}/_{2}$ months old. Treated seedlings were randomly placed in greenhouses among nontreated seedlings. To ensure uniform exposure to *Botrytis* inoculum, all test seedlings were inoculated with a spore suspension of the fungus after applying fungicide twice. Each container tray of 200 or 160 seedlings was inoculated with 10 milliliters of the spore suspension (1.15 to 1.5 x 10^{6} spores/ml) using a fine-mist atomizer. *Botrytis* isolates used in all inoculations were local fungal strains obtained from western larch seedlings.

A randomized block design was used for the bareroot tests. Each treatment block consisted of 0.9 linear meters of seedbed containing western larch seedlings in their second growing season. A 0.3-meter, untreated buffer strip separated each treatment block.

[1] We wish to acknowledge the assistance of J. F. Myers and P. L. Malone of the USDA Forest Service Nursery in Coeur d'Alene and D. Genz of the Champion Timberlands Nursery in Plains.

Table 1—*Fungicides tested to control Botrytis blight on western larch and lodgepole pine*

Fungicide	Trade name	Chemical name	Application rate per 100 gallons water	Manufacturer	Test location
Benomyl	Tersan 1991	Methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate	1 lb	Dupont	CDA-G CDA-B
Dicloran	Botran	2,6-Dichloro-4-nitroaniline	1-1/3 lb	Tuco	CDA-G P-G CDA-B
Chlorothalonil	Bravo 500	Tetrachloroisophthalonitrile	2-3/4 pt	Diamond Shamrock	CDA-G P-G CDA-B
Chlorothalonil	Daconil 2787	Tetrachloroisophthalonitrile	1-1/2 lb	Diamond Shamrock	CDA-G CDA-B
Captan	Captan	*N*-[(trichloromethyl) thio]-4 cyclohexene-1, 2-dicarboximide	2 lb	Stauffer	CDA-G P-G CDA-B
Iprodione	Chipco 26019	3-(3,5-dicholophenyl)-*N*-(1-methylethyl)-2,4-dioxo-1-imidazolidine carboximide	1 lb	Rhone-Poulence	CDA-G P-G CDA-B
Vinclozolin	Ornalin	3-(3,5-dichlorophenyl) -5-ethenyl-5-methyl-2,4-oxazolidinedione	1 lb	Mallinckrodt	P-G

[1]CDA-G = Forest Service Nursery, Coeur d'Alene—greenhouse.
CDA-B = USDA Forest Service Nursery, Coeur d'Alene, Idaho—bareroot beds.
P-G = Champion Timberlands Nursery, Plains, Montana—greenhouse.

Each treatment and a distilled water check was replicated five times. Treatment blocks were clearly delineated at each end by string that was tied to wooden stakes placed at each corner so that the number of test seedlings in each block at the beginning and end of the test could be accurately compared. Seedlings were treated with the fungicides or distilled water six times at biweekly intervals starting in the spring. The seedlings in each block were thoroughly drenched with approximately 9.5 liters of fungicide, solution, or water. Seedlings in each block were inoculated with 20 milliliters (2.6×10^6 spores/ml) of a *Botrytis* spore suspension twice during the test-once after two fungicide or distilled water applications had been made and again about $1\frac{1}{2}$ months later. The second inoculation was considered necessary because of dry, windy weather during and shortly after the first inoculation, resulting in little apparent infection.

At the end of the trials, the number of seedlings killed by *Botrytis* infection and heights of all treated seedlings were compared using Duncan's multiple-range comparison test.

Results

All fungicides reduced *Botrytis* infection and improved survival of western larch seedlings in the greenhouse test at Coeur d'Alene (table 2). Heights of both western larch and lodgepole pine seedlings were reduced as a result of fungicide application, but the reduction did not cause seedlings to be below acceptance standards. Chlorothalonil, iprodione, and captan provided best protection against *Botrytis* infection. Benomyl did not effectively reduce infection of either western larch or lodgepole pine. Dicloran reduced infection of lodgepole pine but was less effective on western larch.

The greenhouse test conducted at Plains did not produce conclusive results because of the infection. Vinclozolin was not the only fungicide in this test that significantly reduced seedling survival, even though label seedlings were used (table 3). We believe this was due to phytotoxic

Table 2—*Effects of fungicides on survival and height of containerized western larch and lodgepole pine seedlings inoculated with* Botrytis cinerea *(Coeur d'Alene, Idaho)*[1]

	Western larch			Lodgepole pine		
Fungicide	Seedling infection	Seedling survival	Average seedling height	Seedling infection	Seedling survival	Average seedling height
	%	%	*mm*	%	%	*mm*
Water (check)	96.2a	86.9d	165.4a	27.6a	100.0a	125.6a
Dicloran	58.5b	94.0c	159.7c	0.5c	99.9a	121.4b
Benomyl	54.8c	87.1d	166.6a	12.8b	99.6b	119.1bc
Captan	29.7d	97.6a	153.3d	0.1c	100.0a	121.3b
Chlorothalonil (Daconil 2787)	8.4e	95.8abc	160.8bc	1.7c	100.0a	118.6cd
Iprodione	6.8e	96.8ab	163.8ab	0.2c	100.0a	120.9bc
Chlorothalonil (Bravo 500)	5.9e	95.1bc	152.3d	0.2c	100.0a	116.7d

[1]Within each column, means followed by the same letter are not significantly different (p=0.05) using Duncan's multiple range comparison test.

Table 3—*Effects of fungicides on survival and height of containerized western larch seedlings inoculated with* Botrytus cinerea *(Plains, Montana)*

Fungicide	Seedling survival	Average Seedling height
	%	*mm*
Water (check)	98.8a[1]	152.6a
Dicloran	98.4a	137.4b
Captan	99.2a	116.8c
Chlorothalonil	99.1a	118.9c
Iprodione	99.9a	150.0a
Vinclozolin	78.0b	141.2b

[1]Means followed by the same letter are not significantly different (p=0.05) using Duncan's multiple range comparison test. Percentages were converted to arc sin for statistical analysis.

response of larch seedlings rather than to *Botrytis* infection. As with the Coeur d'Alene greenhouse test, all fungicides reduced seedling height, especially captan and chlorothalonil.

Results of the bareroot seedling test at Coeur d'Alene were similarly inconclusive because of low infection rates, despite two inoculations at different times. There were no significant differences in seedling survival among any of the treatments (table 4). With the exception of one chlorothalonil treatment (Bravo 6F), all fungicides reduced seedling heights.

Table 4—*Effects of fungicides on survival and height of bareroot western larch seedlings inoculated with* Botrytis cinerea *(Coeur d'Alene, Idaho)*

Fungicide	Seedling survival	Average seedling height
	%	*mm*
Water (check)	98.6a[1]	351.2c
Dicloran	96.8a	311.6a
Captan	97.9a	327.9b
Chlorothalonil (Daconil 2787)	97.2a	336.4b
Chlorothalonil (Bravo 6F)	98.3a	370.9d
Iprodione	99.3a	311.3a

[1]Means followed by the same letter are not significantly different (p=0.05) using Duncan's multiple range comparison test. Percentages were converted to arc sin for statistical analysis.

Discussion

Low infection levels obtained from inoculations in two of the three tests make it difficult to evaluate efficacy of tested fungicides to control Botrytis blight. Nevertheless, the greenhouse test at Coeur d'Alene provides some clues as to how well these chemicals control *Botrytis.*

Benomyl did not effectively control the disease on either western larch or lodgepole pine seedlings. We suspect that the *Botrytis* population at the Coeur d'Alene nursery may have developed tolerance to the chemical. Several isolates of the fungus from this nursery showed high levels of tolerance to benomyl in previous tests conducted by the Pacific Northwest Region (1). Tolerance of *Botrytis* to benomyl has also been reported at several other nurseries (3, 5, 7), and the fungicide often does not effectively control the disease at these places. As a result, many growers

have stopped using benomyl to control *Botrytis.*

Dicloran was also not effective against Botrytis blight on containerized western larch at Coeur d'Alene, but provided satisfactory control in the lodgepole pine test. Previous tests of *Botrytis iso*lates from Coeur d'Alene did not show that they were tolerant to dicloran (1). However, according to Webster et al. *(11), Botrytis* can readily develop tolerance to dicloran. We believe that dicloran performs best when rotated or mixed with other fungicides.

The other fungicides gave satisfactory control of *Botrytis* on both containerized larch and lodgepole pine in the greenhouse test at Coeur d'Alene. Captan is widely used to control the disease (9) and should continue to provide adequate control, especially if rotated with other fungicides. Chlorothalonil is also usually effective against Botrytis blight, although tolerance to this fungicide may develop (1, 3, 5). Iprodione, a relatively new fungicide used for *Botrytis,* provided good control in our tests. This fungicide needs to be evaluated for tolerance development of the fungus and is not registered for use on conifers in many states.

All tested fungicides reduced seedling heights. Extensive phytotoxicity was evident only in the vinclozolin treatment of western larch in the greenhouse test at the Plains nursery. It is unclear why vinclozolin caused high seedling mortality in this test. Similar phytotoxic responses to this fungicide were not evident in the bareroot western larch test at Coeur d'Alene. However, bareroot seedlings in their second growing season were perhaps not as sensitive to this fungicide as young, container-grown seedlings.

Recommendations

We recommend that fungicides be rotated and applied at the lowest possible dosages consistent with adequate disease control. Otherwise, *Botrytis* may develop tolerance to them and become more damaging and difficult to control. Screening for fungicide-tolerant strains of *Botrytis* should be conducted periodically to determine if currently used fungicides are still effective. As new fungicides become available, they should also be evaluated for their effectiveness against Botrytis blight.

Literature Cited

1. Cooley, S. J. Fungicide tolerance of *Botrytis cinerea* isolates from conifer seedlings. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region; 1981. 13 p.
2. Dekker, J. Acquired resistance to fungicides. Annual Review of Phytopathology. 14: 405-428; 1976.
3. Gillman, L. S.; James, R. L. Fungicidal tolerance of Botrytis within Colorado greenhouses. Tree Planters' Notes 31(l) : 25-28; 1980.
4. James, R. L. Engelmann spruce needle blight at the Coeur d'Alene Nursery, Idaho. Rep. 80-21. Missoula, MT. U.S. Department of Agriculture, Forest Service, Northern Region; 1980. 5 p.
5. James, R. L.; Gilligan, C. J. Fungicide tolerance of *Botrytis cinerea* from the Flathead Indian Reservation Greenhouse, Ronan, Montana. Rept. 83-5. Missoula, MT. U.S. Department of Agriculture, Forest Service, Northern Region; 1983. 15 p.
6. McCain, A. H.; Smith, P. C. Evaluation of fungicide for control of Botrytis blight of container-grown redwood seedlings. Tree Planters' Notes 29(4): 12-13; 1978.
7. Miller, M. W.; Fletcher, J. T. Benomyl tolerance in *Botrytis cinerea* isolates from glasshouse crops. Transactions of the British Mycological Society 62: 99-103; 1974.
8. Ogawa, J. J.; Manjii, B. T.; Chastagner, G. A. Field problems due to chemical tolerance of plant pathogens. Proceedings of the American Phytopathology Society 3: 7-53; 1976.
9. Smith, R. S., Jr.; McCain, A. H.; Srago, M. D. Control of Botrytis storage rot of giant sequoia seedlings. Plant Disease Reporter 57: 67-69; 1973.
10. Webster, R. K.; Ogawa, J. M.; Bose, E. Tolerance of *Botrytis cinerea* to 2, 6-Dichloro-4 nitroaniline. Phytopathology 60: 1489-1492; 1970.