Survey of Pest Problems and Pesticide Use in Canadian Forest Seedling Nurseries

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Abstract

A survey regarding pest problems and pesticide use was distributed to forest seedling nurseries across Canada in the spring of 2017. Growers were asked to volunteer information relevant to their site for the pests found and the pesticides applied over the previous 5 years. Botrytis gray mold was identified as the main disease of concern, requiring at least one pesticide application over the previous 5 years at 89 percent of nurseries. Fusarium root rot is also a disease of concern. The survey identified Lygus bug as the main insect problem and liverwort as the main weed problem. The results highlight the need for new pesticide registrations for forest seedling nurseries in Canada. A full summary of the survey methodology and findings are reported. This paper was presented at the 2019 Joint Annual Meeting of the Forest Nursery Association of British Columbia and the Western Forest and Conservation Nursery Associations (Sydney, British Columbia, September 30–October 2).

Background

Forest nurseries produce tree seedlings to meet reforestation needs after logging. In Canada, tree seedlings are grown from seeds within a greenhouse environment (figure 1) with approximately 95 percent grown in Styrofoam™ containers, also called Styroblocks® (Peterson 1991). Pest management is an important part of the production and frequently requires the use of pesticides.

In British Columbia, annual nursery production is approximately 250 to 300 million trees (BC Ministry of Forests 2017). This accounts for about 50 percent of the total Canadian seedling production (Canadian Council of Forests Ministers 2020). The most commonly produced seedlings are conifers, including lodgepole pine (*Pinus contorta* Douglas ex Loudon var. *latifolia* Engelm. Ex. S. Watson), interior spruce (referring to white spruce: *Picea glauca* (Moench) Voss; Engelmann spruce: *P. engelmannii* Parry ex Engelm.; and their hybrids), Douglas-fir (*Pseudotsuga menziesii* Mirb. Franco), western redcedar (*Thuja plicata* Donn ex D. Don), and western larch (*Larix occidentalis* Nutt.).

The federal agency in charge of pesticide registrations is the Pest Management Regulatory Agency (PMRA), a branch of Health Canada. In 2016, the PMRA published preliminary decisions on chlorothalonil and iprodione, two fungicides commonly applied by forest seedling nurseries. Both products were proposed for cancellation on conifer crops (Health Canada 2016b, 2016c). The Forest Nursery Association of British Columbia (FNABC, http://www.fnabc.com/) recognized the major impact on the industry from the proposed changes. A survey was undertaken to assess pest problems and pesticide use by Canadian forest seedling nurseries to clarify the need for new pesticide registrations. The project was funded by FNABC and conducted by CropHealth Advising & Research (Kelowna, BC, http://www.crophealth.com). This article summarizes the results of that survey.

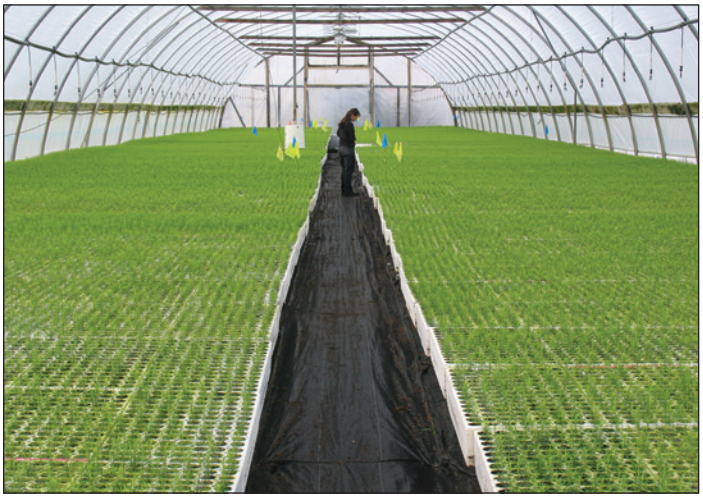

Figure 1. Forest nurseries produce tree seedlings to meet reforestation needs after logging. Most trees in Canada are grown from seeds in containers within a greenhouse environment. (Photo by Mario Lanthier 2007)

Methodology

Survey questions were developed based on pest problems commonly reported in the industry. Nurseries were asked 30 questions about insect pests, diseases, weeds, rodents, and disinfection. Pest problems were listed by their common English names without attempting to identify at the species level at each seedling nursery. Some questions required yes or no answers (e.g., respondents were asked to check a box to indicate whether or not a pest was found at their operation). In other questions, participants were asked to rate the importance of each pest based on expected damage if left unmanaged: 3 for the first pest in importance, 2 for the second in importance, and 1 for the third in importance. The values were summed, then divided by the total number of responses to each question to calculate the overall relative importance of each pest; a higher numerical value indicates a pest of higher importance.

The list of forest seedling nurseries was prepared from industry sources, government listings, a search of the internet, and suggestions by participants. For British Columbia, a list was compiled from the BC Ministry of Forests and Range and from the FNABC membership list. The final list of 27 entries was exhaustive for this province. For nurseries outside of British Columbia, a list was prepared using the Canadian Forests website (http://www.canadian-forests.com/silviculture-nurseries.html), a search of companies on the web, and other suggestions by participants. The final list of 28 nurseries was incomplete for Ontario and Québec, where there were no industry organizations to consult. The survey materials were translated into French for distribution to nurseries in Québec.

All operations were contacted via email or personal telephone calls. Growers were asked to volunteer information relevant to their site. Approximately 1 month was given for participants to respond via Survey Monkey (https://www.surveymonkey.com/), or by entering answers into a Word document, or by filling space within an email. No attempt was made to verify the information provided.

Of the 53 operations contacted across Canada, 38 sent replies (72 percent of the total). The response rate was 88 percent in British Columbia and 57 percent for the remainder of the country (table 1).

Table 1. Forest seedling nurseries contacted, and replies received, by province across Canada.

Province	Contacted	Responded
British Columbia	25	22
Alberta	5	5
Saskatchewan	2	1
Manitoba	1	0
Ontario	9	2
Québec	9	7
New-Brunswick	2	1
Newfoundland	0	0
Total across Canada	53	38

Survey Results for Diseases and Fungicides

The survey showed that Botrytis gray mold is, by far, the main disease of concern in forest seedling nurseries across Canada, requiring at least one pesticide application over the previous 5 years at 89 percent of nurseries (table 2). On a scale of 0 (lowest concern) to 3 (highest concern), this disease was rated at 2.1, whereas all other diseases were rated 1.0 or lower.

Fusarium root rot is another disease of concern, requiring at least one pesticide application over the past 5 years at 61 percent of nurseries across Canada (71 percent in British Columbia). Sirococcus tip blight was reported as a "top-3 disease of concern" by 30 percent of respondents (table 2).

The relative importance of various diseases is markedly different across Canada. Fusarium root rot was rated as a top-3 disease by 77 percent of facilities in British Columbia but only 20 percent of facilities elsewhere in Canada. By contrast, Scleroderris canker was not mentioned by British Columbia nurseries but was rated as a top-3 disease elsewhere in Canada.

Fungicides made with thiophanate-methyl, chlorothalonil, and iprodione are used extensively in the Canadian nursery industry (table 3). In British Columbia, the preferred formulations are iprodione (such as Rovral) and thiophanate-methyl (such as Senator), each being applied by 86 percent of respondents. Outside of British Columbia, however, the preferred formulations were chlorothalonil and thiophanate-methyl, applied by 93 and 80 percent of respondents, respectively.

Table 2. Diseases that required a pesticide application between 2012 and 2017 (based on 36 replies) and diseases of most concern, ranked from first to third (based on 37 replies).

Disease	Pathogen	Number requiring an application	Importance			Weighted rating
			1st	2nd	3rd	
Gray mold	*Botrytis cinerea*	32	21	6	3	2.1
Root rot	*Fusarium* spp.	22	5	6	9	1.0
Tip blight	*Sirococcus strobilinus*	18	2	8	1	0.6
Root rot	*Pythium* spp.	16	1	3	6	0.4
Damping off	Various pathogens	15	2	2	4	0.4
Root rot	Various pathogens	11	2	2	7	0.5
Root rot	*Cylindrocarpon* spp.	9	0	2	0	0.1
Needle dieback	*Phoma* spp.	4	0	1	2	0.1
Shoot blight	*Phomopsis* spp.	3	0	1	0	0.1
Scleroderris canker	*Gremmeniella abietina*	3	2	1	0	0.2
Snow mold	Not mentioned	3	0	2	0	0.1
Keithia needle blight	*Didymascella thujina*	3	0	0	0	0
Root rot	*Phytophthora* spp.	2	0	0	0	0
Needle blight	*Dothistroma septosporum*	1	0	0	0	0
Root rot	*Thielaviopsis basicola*	1	0	0	0	0
Others	*Diplodia*, *Melaspora*, *Meria*, poplar rust	4	0	0	1	0.0

Across Canada, 81 percent (based on 37 respondents) of nurseries rely on past experience with the disease to determine the main pathogens affecting their crop. Other methods used to diagnose were: recognizing visual symptoms (78 percent); commercial diagnostic laboratories (76 percent); comparing symptoms with publication photos (46 percent); and consulting with outside specialists (41 percent).

Table 3. Fungicides applied between 2012 and 2017 (based on 36 replies).

Active ingredient	Examples of trade names	Number of responses
thiophanate-methyl	Senator®	30
chlorothalonil	Daconil 2787®	29
iprodione	Rovral®	27
metalaxyl-m	Subdue Maxx®	14
captan	Maestro® / Captan®	14
Streptomyces strain K61	Mycostop® Biofungicide	7
Trichoderma h.	Rootshield® Biofungicide	6
fludioxonil	Medallion®	5
fenhexamid	Decree®	4
propiconazole	Banner Maxx®, Pivot ®, Topas®	3
Streptomyces lydicus	Actinovate®	3
fludioxonil + cyprodinil	Palladium®	1
Other	Banner Maxx®, Pivot®, Topas®	3

Survey Results for Insects and Insecticides

Survey results showed that *Lygus* bug is, by far, the main insect problem of forest seedling nurseries across Canada. This pest, also called tarnished plant bug, required at least one pesticide application over the previous 5 years at 83 percent of nurseries across Canada (table 4). On a scale of 0 (lowest concern) to 3 (highest concern), lygus bug was rated as 2.2 across Canada. The rating was 2.4 in British Columbia and 1.9 elsewhere in Canada. All other insect pests were rated below 1.0. Other insect pests of concern are aphids, cutworms, and fungus gnats. Root weevil is a large concern in British Columbia but less elsewhere in Canada.

The insecticides most commonly applied across Canada are permethrin and cypermethrin (table 5). In British Columbia, the preferred products are formulations of cypermethrin and permethrin, applied by 70 and 50 percent of respondents, respectively. Outside of British Columbia, the preferred products are formulations of permethrin and chlorpyrifos, applied by 60 and 40 percent of respondents, respectively.

Table 4. Insect pests and mites that required a pesticide application between 2012 and 2017 (based on 35 replies) and of most concern, ranked from first to third (based on 38 replies).

Insect or Mite	Latin name	Number requiring an application	Importance			Weighted rating
			1st	2nd	3rd	
Lygus bug	*Lygus* spp.	29	23	5	4	2.2
Aphid	Various species	18	5	4	8	0.8
Cutworm	Various species	15	3	4	5	0.6
Root weevil	Various species	13	4	6	0	0.6
Caterpillars[1]	Various species	10	0	4	4	0.3
Fungus gnat	*Bradysia* spp.	8	0	6	5	0.5
Spider mite	*Olygonychus ununguis*	6	2	1	1	0.2
Thrips	Various spp.	5	0	1	1	0.1
Shore fly	*Scatella stagnalis*	5	0	3	4	0.3
Cranberry girdler	*Chrysoteuchia topiarius*	3	0	0	0	0.0
Other (slugs, cranefly, beetles)		3	0	0	1	0.0

[1] Caterpillars included tussock moth (*Orgyia detrita*), spruce budworm (*Choristoneura fumiferana*), western black headed budworm (*Choristoneura freemani)*, webworm (*Hyphantria cunea*), tent caterpillar (*Malacosoma* spp.).

Survey Results for Weeds and Herbicides

Liverwort is the main weed problem of forest seedling nurseries across Canada. This weed required at least one pesticide application over the previous 5 years at 73 percent of nurseries across Canada (table 6). On a scale of 0 (lowest priority) to 3 (highest priority), liverwort was rated as 1.6 across the country. All other weeds were rated below 1.0.

Glyphosate-based products are the most widely used herbicide in forest seedling nurseries, being applied by 89 percent of respondents across Canada (table 7). Other commonly applied herbicides are formulations of flumioxazin and simazine, applied by 57 and 51 percent of respondents, respectively.

Table 5. Insecticides and miticides applied between 2012 and 2017 (based on 35 answers).

Active ingredient	Examples of trade names	Number of responses
Permethrin	Ambush®, Perm-UP, Pounce®	19
Cypermethrin	Cymbush®, Ripcord ™	15
Carbaryl	Sevin®	9
Chlorpyrifos	Citadel®, Pyrate, Pyrinex™	6
Potassium salts of fatty acids	Safer® Insecticidal Soap	6
Malathion	Malathion	4
Diazinon	Diazinon	2
Others[1]		9

[1] Other products mentioned were abamectin (Avid®), acephate (Orthene®), acetamiprid (TriStar), Bacillus thuringiensis var. kurstaki (Dipel®), bifenazate (Floramite®), deltamethrin (Decis®), diflubenzuron (Dimilin®), dimethoate (Cygon®), endosulfan (Thiodan®), fenbutatin oxide (Vendex®), and spirotetramat (Movento®).

Survey Results for Rodents and Rodenticides

In British Columbia, the house mouse required a pesticide treatment at 86 percent of facilities, compared with 50 percent of facilities outside the province. Outside of British Columbia, the field mouse required a pesticide treatment at 79 percent of facilities, compared with 48 percent at BC facilities. Other rodents mentioned were rats, gophers, marmots, skunks, and squirrels.

The house mouse (*Mus musculus*), the meadow vole (*Microtus* sp.) and the roof rat (*Rattus rattus*) are common rodents in Canadian agriculture production. Where they are present, mice and voles can cause severe damage to crops.

Based on this survey, the most commonly used rodenticides are made of warfarin, diphacinone, and chlorophacinone (table 8).

Survey Results for Sanitation and Disinfectants

Based on 35 nursery respondents across Canada, 49 percent annually sanitize growing areas such as benches, floors, and walls, 26 percent seldom sani-

Table 6. Weeds that required a pesticide application between 2012 and 2017 (based on 33 replies) and weeds of most concern (based on 36 replies).

Weed	Latin name	Number requiring an application	Importance			Weighted rating
			1st	2nd	3rd	
Liverwort	*Marchantia polymorpha*	24	15	4	3	1.6
Dandelion	*Taraxacum officinale*	22	2	1	5	0.4
Grasses	Various species	21	4	7	1	0.8
Chickweed	*Stellaria media*	19	0	4	5	0.4
Moss	Various species	19	3	3	3	0.5
Pearlwort	*Sagina procumbens*	15	2	1	3	0.3
Fireweed	*Chamaenerion angustifolium*	15	1	3	3	0.3
Horsetail	*Equisetum arvense*	13	1	3	2	0.3
Bittercress	*Cardamine hirsute*	12	4	4	1	0.6
Groundsel	*Senecio vulgaris*	11	1	0	1	0.1
Bindweed	*Convolvulus arvensis*	8	0	0	0	0.0
Woodsorrel (Oxalis)	*Oxalis* spp.	8	0	0	0	0.0
Pineapple weed	*Matricaria discoidea*	7	0	0	1	0.0
Nostoc algae	*Nostoc commune*	6				
Other perennial broadleaf[1]	Various species	9	2	3	2	0.4
Other annual broadlea[f1]	Various species	8	0	2	1	0.1

[1] Other weeds mentioned were amaranth, annual bluegrass, aspen seedlings, birch seedlings, Canada thistle, cattail, elm seedlings, fleabane, knapweed, kochia, henbit, lamb's quarters, mustard, nettle, night shade, *Poa annua*, poplar seedlings, popweed, portulaca, purslane, quack grass, red root pigweed, Russian thistle, sensitive onoclea, shepherd's purse, *Spergularia rubra*.

tize, 14 percent sanitize between each crop, 9 percent sanitize only when practical, and 3 percent sanitize irregularly. Chlorine-based products are used by 63 percent of nurseries (table 9). Quaternary ammonia products are also used across Canada and sodium metabisulphite is reported only in British Columbia.

Table 7. Herbicides applied between 2012 and 2017 (based on 37 replies).

Active ingredient	Examples of trade names	Number of answers	% of responses
Glyphosate	Roundup® or other brands	33	89
Flumioxazin	SureGuard®, Broadstar®	21	57
Simazine	Simazine, Princep Nine-T®	19	51
Paraquat	Gramoxone®	5	14
2, 4-D	Par III®, Target®, Trillion®	5	14
MCPA	MCPA Amine 500	2	1
Indaziflam	Alion	1	0
Other[1]		5	14

[1] Other products mentioned were amitrole (Amitrol), baking soda, hydrogen peroxide, isoxaben (Gallery™), napropamide (Devrinol®), oxyfluorfen (Goal™), propyzamide (Kerb™), and horticultural vinegar.

Discussion

Survey Findings

This survey is based on common English pest names. It is likely that some participants reported for the same pest problem caused by different pest organisms.

Participants were not asked to report the non-pesticide methods of their management program. One participant mentioned their operation has been "pesticide free for the last 5 years." The industry makes extensive use of cultural pest control methods, especially to reduce conditions that favour specific diseases. Examples include management of relative humidity and air temperature to reduce incidence of gray mold (Peterson et al. 1988) and heat treatments for sanitation of Styrofoam™ containers (Peterson 1991). Many participants reported using hot water or steam in their operations.

For diseases, the survey identified gray mold as the main concern. Caused mostly by *Botrytis cinerea*, this disease is a concern in late summer to early fall when

Table 8. Rodenticides applied between 2012 and 2017 (based on 36 replies).

Active ingredient	Examples of trade names	Number of responses
Warfarin	Hillcrest, Warfarin Baitpaks®	9
Diphacinone	Ramik®, Ditrac®	8
Chlorophacinone	Ground Force™, Rozol®	7
Brodifacoum	Jaguar®, Ratak®	4
Cellulose from corn cobs	Wilsarin® Rat & Mouse Killer	2
Bromadiolone	Boot Hill®, Hawk®	1
Traps without pesticide		8
Other products, difethialone	FastDraw®, Hombre®	3
Other	fungicide repellent	1

Figure 3. *Lygus* bug is the main insect of concern in forest seedling nurseries in Canada. Feeding on rapidly growing tissue can affect growing tips, buds, and flowers, leading to a loss of apical dominance and the development of weak, multiple leaders as seen on the two seedlings on the right. (Photo by Mario Lanthier 2019)

plants reach their desired size, creating stagnant air within the canopy. Mold may be visible and affected needles may be killed (figure 2). The problem then moves with the plants during outplanting (Sutherland and van Eerden 1980). Fusarium root rot is a major concern on Douglas-fir; several species are involved, the most common being *F. oxysporum* and *F. acuminatum* (James et al. 1990).

For insects, the survey identified *Lygus* bug as the main insect problem. *Lygus* bug, also called tarnished plant bug, refers to various species but most commonly *L. lineolaris* and *L. hesperus*. The insect feeds on rapidly growing tissue such as growing tips, buds, and flowers, leading to a loss of apical dominance and the development of weak, multiple leaders (Sutherland et al. 1989) (figure 3). The pest is often a concern at forest nursery facilities adjacent to agriculture fields. The insects are displaced when the agriculture crop is mowed or harvested and winged adults fly into the nearby seedling nursery.

For weeds, liverwort was the main problem. The common liverwort (*Marchantia polymorpha* L.) is commonly found in greenhouses and has been reported as "probably the most severe weed problem in container nurseries," especially in 2-year-old crops (Scagel and Evans 1990). In general, this weed can reduce seedling growth by competition for light, water, and nutrients, may be a reservoir for insects and disease pests, and can give the impression of overall poor nursery management (Landis 1989) (figure 4).

Figure 2. Gray mold, caused mostly by *Botrytis cinerea*, is the main disease of concern in forest seedling nurseries in Canada. The pathogen can develop rapidly in late summer to early fall when plants reach their desired size, creating stagnant air within the canopy. The mold becomes visible and affected needles may be killed. (Photo by Mario Lanthier 2018)

Figure 4. Liverwort is the main weed problem reported by forest seedling nurseries in Canada. The common liverwort (*Marchantia polymorpha* L.) can reduce seedling growth by competition for light, water, and nutrients, and may be a reservoir for insects and disease pests. (Photo by Mario Lanthier 2013)

Table 9. Disinfectant products applied between 2012 and 2017 (based on 35 replies).

Active ingredient	Number of responses
Chlorine and Sodium hypochlorite (bleach)	22
Quaternary ammonia products	12
Sodium metabisulphite	7
Hydrogen peroxide + peroxyacetic acid (Sanidate®)	5
Hydrogen dioxide + peroxyacetic acid (Zerotol®)	2
Hydrogen peroxide	2
Others[1]	8

[1] Other answers provided were Chemprocide, dish soap, Horti-Klor™, Lysol®, sweeping, Velosan, and vinegar.

Pesticide Registrations

Results from this survey highlighted the need for new fungicide registrations for forest seedling nurseries in Canada. Fungicides made with chlorothalonil, iprodione, and thiophanate-methyl are used in more than 75 percent of nurseries. All three active ingredients have been recently reviewed by the Pest Management Regulatory Agency (PMRA), the federal agency in charge of pesticide registrations. For chlorothalonil, the final decision is to limit the number of applications per year for outdoor and greenhouse-grown conifers, with a restricted re-entry of 15 days for harvesting in seedling production (Health Canada 2018a). For iprodione, the final decision is to limit the number of applications per year, with a restricted re-entry of 1 day for greenhouse production (Health Canada 2018b). For thiophanate-methyl, the current proposal is for the product to remain available but label wording will include extensive personal protective equipment and a maximum of 2 applications per season (Health Canada 2019b).

Additionally, new insecticide registrations may also be required for forest seedling nurseries in Canada. Insecticides most commonly applied across the country are pyrethroids (active ingredients cypermethrin and permethrin). This is Group 3 for resistance classification (IRAC 2019). Many of the other insecticides reported are currently subject to review by Health Canada. Insecticides based on acephate, carbaryl, chlorpyrifos, diazinon, dimethoate, and endosulfan were applied in the past 5 years by 66 percent of respondents. Carbaryl is no longer registered for use in greenhouses (Health Canada 2016a); chlorpyrifos is proposed for cancellation for most uses, except greenhouse ornamentals (Health Canada 2019a); diazinon is no longer registered for ornamental plants (Health Canada 2009); dimethoate is now subject to long restricted re-entry in seed orchards (Health Canada 2015); and endosulfan has been discontinued since 2016 (Health Canada 2011).

Following the initial distribution of the survey results, efforts were undertaken to pursue new pesticide registrations, especially for fungicides. The British Columbia industry association has secured funding for efficacy trials with newer fungicides to generate data that will support label extension and include the forest seedling industry. This work will likely continue for multiple years until the registration of a range of products with varied modes of action. At the same time, clarifications were obtained from the federal agency on pesticide label wording. Based on the User Site Classification in place in Canada, forest seedling nurseries are considered "ornamentals" (Health Canada 2003). This clarification has opened access to more products previously thought to be unavailable and forest seedling nurseries in Canada can now legally use many pesticides registered for ornamental plants.

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REFERENCES

BC Ministry of Forests. 2017. Factsheet: Reforestation in B.C. https://news.gov.bc.ca/factsheets/factsheet-reforestation-in-bc. (May 2020).

Canadian Council of Forests Ministers. 2020. Area artificially replanted and number of seedlings planted. National Forestry Database. http://www.nfdp.ccfm.org/en/data/regeneration.php#tab621. (May 2020).

Health Canada. 2003. Guidance on selecting the correct category for pest control product submissions. REG2003-01. Ottawa, ON. 27 p.

Health Canada. 2009. Diazinon – Re-evaluation Decision. RVD2009-19. Ottawa, ON. 58 p.

Health Canada. 2011. Discontinuation of Endosulfan. Re-evaluation Note. REV2011-01. Ottawa, ON. 11 p.

Health Canada. 2015. Dimethoate. Re-evaluation Decision. RVD2015-04. Ottawa, ON. 99 p.

Health Canada. 2016a. Carbaryl. Re-evaluation Decision. RVD2016-02. Ottawa, ON. 82 p.

Health Canada. 2016b. Chlorothalonil. Amendment to the Proposed Re-evaluation Decision. Re-evaluation Note. REV2016-06. Ottawa, ON. 55 p.

Health Canada. 2016c. Iprodione. Proposed Re-evaluation Decision. PRVD2016-09. Ottawa, ON. 135 p.

Health Canada. 2018a. Chlorothalonil and its associated end-use products for agricultural and turf uses – Final Decision. RVD2018-11. Ottawa, ON. 87 p.

Health Canada. 2018b. Iprodione and Its Associated End-use Products. Final Decision Document. RVD2018-16. Ottawa, ON. 52 p.

Health Canada. 2019a Chlorpyrifos and its associated end-use products: updated environmental risk assessment. Consultation Document. PRVD2019-05. Ottawa, ON. 92 p.

Health Canada. 2019b. Thiophanate-Methyl and its associated end-use products. Consultation Document. PRVD2019-07. Ottawa, ON. 179 p.

IRAC (Insecticide Resistance Action Committee). 2019. The IRAC Mode of Action Classification. https://www.irac-online.org/modes-of-action/. (May 2020).

James, R.L.; Dumroese, R.K.; Wenny, D.L. 1990. Fusarium diseases of conifer seedlings. In: Sutherland, J.R.; Glover, S.G., eds. Proceedings of the first meeting of IUFRO Working Party S2.07-09 (Diseases and Insects in Forest Nurseries). Information Report BC-X-331. Victoria, BC: Forestry Canada: 181–190.

Landis, T.D. 1989. Disease and pest management. In: Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P., eds. The Container Tree Nursery Manual. Volume 5. Agriculture Handbook 674. Washington, DC: U.S. Department of Agriculture, Forest Service: 1–99.

Peterson, M.J. 1991. Guidelines for the sanitation of nursery seedling containers. Supplement to FRDA 140. Victoria, BC: British Columbia Ministry of Forests. 16 p.

Peterson, M.J.; Sutherland, J.R.; Tuller, S.E. 1988. Greenhouse environment and epidemiology of grey mould of container-grown Douglas-fir seedlings. Canadian Journal of Forest Research. 18(8): 974–980.

Scagel, R.; Evans, R. 1990. Consumer's guide to tree seedlings. FRDA Report. Victoria, BC: B.C. Ministry of Forests and Canadian Forestry Service. 84 p.

Sutherland, J.R.; van Eerden, E. 1980. Diseases and insect pests in British Columbia forest nurseries. Joint Report No. 12. Victoria, BC: British Columbia Ministry of Forests and Canadian Forestry Service. 55 p.

Sutherland, J.R.; Shrimpton, G.M.; Sturrock, R.N. 1989. Diseases and insects in British Columbia forest seedling nurseries. FRDA Report 065. Victoria, BC: British Columbia Ministry of Forests and Canadian Forestry Service.