Diseases and insects in forest nurseries in Canada

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Abstract

This paper reviews the damage and hosts, disease or life cycles and management practices for the major diseases and insects affecting forest nursery seedlings in Canada.

Resume

Cette Ctude passe en revue les dégâts, les hôtes, les cycles de vie et les moyens de gestion des principales maladies et des principaux insectes attaquant les semis des pépinières forestikres au Canada.

Introduction

Since the late 1960s, an ever increasing number of seedlings produced in Canada have been grown in containers. In 1984 (Glerum 1990) there were 144 forest nurseries in Canada of which 70% (101) were producing container-grown seedlings while the remaining **30%** were bareroot facilities. This trend of growing seedlings in containers has continued; in 1989 over 75% of Canada's annual production of 904 million seedlings were container-grown (Glerum 1990). This technological change of growing seedlings in containers rather than in bareroot beds has had a major impact on the abundance and importance of particular nursery diseases and insects across the country. For example, soil-bome diseases such as damping-off which are important in bareroot nurseries are much less severe in container facilities where the growing medium (mainly peat) is normally pathogen-free. Conversely, shoot diseases and in particular gray mold (caused by *Botrytis cinerea* Pers.), which seldom affects bareroot seedlings, are major impediments to container seedling production. Seed-bome pathogens including species of *Fusarium* and *Sirococcus strobilinus* Preuss are another group of pathogens whose importance has increased with the increased emphasis on container-grown seedlings. Similarly, the importance of certain insects has changed as exemplified by the decreasing importance of white grubs [(e.g. *Polyphylla decemlineata* (Say)] which damage bareroot seedlings while the importance of fungus gnats (most commonly *Bradysia* species) has paralleled the increased production of seedlings in containers. Another recent change is in the way nursery diseases and insects are managed. Recent environmental concerns about use of pesticides have given added importance to nursery pests; not only do they cause direct losses, but their occurrence may necessitate use of fungicides or insecticides. Because of these concerns, today's nursery managers and workers, and tree planters, are becoming more interested in the use of cultural and biological controls for nursery diseases and insects.

The purpose here is to review the major disease and insect problems currently affecting forest nursery seedlings in Canada. Topics covered include types of damage and hosts, disease and life cycles, and present day management practices. Because most research (and unpublished information) on nursery diseases and insects in Canada has been done in British Columbia, Ontario and Quebec, the majority of our examples are from those provinces. More detailed information on many of the topics is available in Sutherland *et al.* (1989). Because of space limitations, we have not covered diseases and insects of minor importance.

Major diseases

Damping-off

Both pre-emergence and post-emergence damping-off affect a wide range of seedling species (both coniferous and broadleaf) in nurseries across Canada. Since most damping-off fungi are soil-bome, losses are much more serious in bareroot than in container nurseries. In container nurseries, seed and seedling losses are often traced to contaminated growing media, especially peat, or to pathogens introduced on seeds (e.g. *Fusarium)* or in irrigation water. In bareroot nurseries the same pathogens cause damping-off and many root rots, and mostly include species of *Pythium,* and occasionally *Phytophthora, Fusarium, Rhizoctonia* and *Cylindrocladium* while *Pythium* and *Fusarium* most commonly affect seeds and seedlings n container-nurseries. *Caloscypha fulgens* (Pers.) Boudier (the seed or cold fungus) causes pre-emergence failure of spruce seeds and nonserotinus pines in both container and bareroot nurseries. Whereas damping-off tends to be sporadic in containers, the disease is endemic in most bareroot nurseries with annual losses of 5 to 20% of the seeds and seedlings. In years when weather, soil and other factors favor damping-off, losses of 60 to 80% of the crop are not uncommon. Besides the direct losses from killing seeds and seedlings, damping-off frequently kills adjacent seedlings or patches of seedlings, thereby affecting stand uniformity and resulting in uneven-sized stock at lifting.

The general biology and disease cycle of most damping-off pathogens is similar and although they are soil-bome they are usually poor competitors in soil. Instead they survive by colonizing pieces of organic matter including old root pieces and sawdust (often used for mulching) from which they grow to attack nearby seeds or germinants (pre-emergence damping-off) or succulent stems about groundline (post-emergence damping-off). Thus, infection occurs via vegetative mycelium whereas asexual conidiospores serve mainly in pathogen dispersal. Many damping-off fungi form sclerotia, oospores or chlamydospores for over-wintering or survival of other adverse conditions. Sexual spores are, overall, rare. Damping-off ceases to be a problem once seedling stems become woody.

Measures used to control damping-off vary across Canada and especially among nurseries: the intensity of individual efforts is largely related to the severity of damping-off experienced in the past at a particular nursery. Nurseries where the disease has been habitually severe may rely on soil fumigation (e.g., dazomet), particularly when weeds or insects are also problems. Where damping-off is less damaging or only sporadic, the nursery may rely solely on one or a combination of cultural practices. Such cultural practices include sowing stratified seeds in the spring, sowing seeds after soil temperatures are warm enough to promote germination, maintaining soil pH at 4.5-5.5, using damping-off prone areas for transplants, and withholding nitrogenous fertilizers until seedling stems are woody. All too often, the most important remedy for managing damping-off is overlooked in selecting the nursery site: nurseries with light, sandy, well drained soils suffer less damping-off than those on heavy, poorly drained, clay soils. Not only do nurseries with heavy soils have more damping-off, but management practices such as soil fumigation and fallowing are consistently less effective on these soils.

Cylindrocladium *root rot*

Cylindrocladium species cause an important root rot of conifers and hardwoods in eastem Canadian (especially Ontario and Quebec) forest nurseries. *Cylindrocladium floridanum* Sobers & Seymour was first detected in both Quebec and Ontario nurseries in the late 1960s and early 1970s. By 1988, the fungus had been detected in all 10 provincial bareroot nurseries in Ontario. All conifer species grown in Ontario and Quebec bareroot nurseries are susceptible to the fungus, except perhaps eastem white cedar *(Thuja occidentalis* L.). In both Ontario and Quebec, black *(Picea mariana* (Mill.) B.S.P.) and red *(P. rubens* Sarg.) spruce transplants are the most susceptible conifers grown. Several nursery-grown hardwoods, particularly black walnut (*Juglans nigra* L.) and yellow poplar *(Liriodendron tulipifera* L.), are also susceptible.

In 1986 and 1987, 430 000 spruce seedlings were culled due to *Cylindrocladium* root rot in five Ontario nurseries. Assessments in 1988 and 1989 revealed incidence levels of 1 to 40% within individual fields in various Ontario nurseries.

Although *Cylindrocladium* can cause damping-off, foliage and shoot blight, stem cankers, and root rots, it usually causes root and root collar rot. The fungus overwinters as thick-walled microsclerotia in the soil or in infected plant material. Microsclerotia can survive in fallow nursery soil for at least 15 years. Favorable environmental conditions stimulate germination of microsclerotia and the fungus infects seedling roots. Disease symptoms first become evident from mid-summer to early fall. Foliage of root-rotted seedlings becomes chlorotic or yellow, lateral shoots may droop, and finally foliage becomes reddish brown. Cortical cells of infected roots are first water-soaked and then discolored and finally, in advanced stages, roots are necrotic.

Recent efforts at disease management include restricting movement of infested soil and infected stock, root raking of infested soil to remove plant material following seedling lifting, and fumigation with dazomet. Nursery machinery is washed to remove soil after leaving fields with a high disease incidence. Cover crops are commonly used in nurseries to prevent soil erosion during non-crop years; this builds up soil organic matter and retains or increases soil nutrients. The "Green Leaf' variety of sorghum-sudangrass which was previously used in southem Ontario nurseries failed to reduce fungus populations and disease incidence. Alfalfa and other leguminous species should not be used on nursery fields where *Cylindrocladium* occurs. Soil solarization significantly reduced levels of fungus microsclerotia in soil in experiments in southem Ontario in 1987 and 1988, but solarization has not been tried operationally. Repeated cultivation of fallow fields during hot summer months did not reduce levels of the fungus in Ontario nursery soils. Moreover, the practice adversely affected survival and growth of spruce transplants.

Other root problems

Other root diseases less devastating than *Cylindrocladium* root rot damage both broadleaf and conifer seedlings throughout Canada. The main fungi implicated are species of *Pythium*, *Fusarium* and *Cylindrocarpon;* unfortunately, not much is known about their biology or pathology in Canadian nurseries. The soil-borne nature of these fungi almost certainly implies that they are indigenous in most bareroot nursery soils. Their origin is far from clear in containers, but they could be introduced by wind, on growing media peat, with irrigation water *(Pythium* in particular), or on seeds (as in the case of *Fusarium)*. Damage varies from severe to inconspicuous; in the latter case the term "root thief' (Unestam and Beyer-Ericson 1991) is appropriate. Disease occurrence and intensity, as shown in Sweden (Unestam *et al.* 1989), is undoubtedly related to stress resulting from such cultural practices as using drought to restrict seedling shoot height. Hopefully, research initiated recently in British Columbia by P. Axelrood, J. Sutherland and H. Kope will clarify the biology and pathology of these root problems and allow biological and cultural controls to be used for their management.

Nematodes

Several genera of soil inhabiting nematodes (Phylum Nematoda) have been recorded from Canadian bareroot nurseries. These include (genera in parentheses) root lesion nematodes *(Pratylenchus)*, pin nematodes *(Paratylenchus)*, and the stubby root nematode *Paratrichodorus pachydermus* (Seinhorst) Siddiqi which damages bareroot eastem white pine *(Pinus strobus* L.) seedlings in southem Ontario. However, *Xiphinema bakeri* Williams, the cause of corky root disease, is the only nematode which so far has been documented as causing serious damage. In the 1960s, corky root resulted in several million seedlings (mainly Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco) being culled in coastal British Columbia bareroot nurseries. The nematode, indigenous to coastal forests, is found in coastal nurseries recently established on such sites, especially those with very sandy soils. Besides being sandier and with many more *X. bakeri* nematodes than disease-free soils, soils conducive to corky root are also less fertile. *Xiphinema bakeri* can also be brought into disease-free nurseries on X. bakeri-infested soils used to "lighten up" heavier soils. Although Douglas-fir is most susceptible, *X. bakeri* damages all species of seedlings grown in coastal nurseries including spruces and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.). Westem hemlock is now grown exclusively in containers. Symptoms appear in mid to late summer of the first growing season; diseased root systems lack laterals and have a dark, swollen, often club-tipped tap root. Affected seedlings have chlorotic, stunted shoots. Initially, symptoms appear on individual seedlings, and as the disease progresses patches of diseased seedlings appear. These may coalesce to form larger patches up to 1 ha in size. The disease intensifies during the second growing season so that corky root seedlings are discarded at lifting. The life cycle of *X. bakeri* consists of the egg stage, four pre-adult stages, and the adult stage; males are rare. Sutherland *et al.* (1989) give a detailed account of the biology and pathology of X. *bakeri.*

Corky root can be controlled with broad spectrum soil fumigants or nematicides, but in British Columbia bare fallowing between crops accompanied by frequent cultivation during the summer are used to reduce nematode numbers to non-damaging levels.

Gray mold

Gray mold caused by the fungus *Botrytis cinerea* is the most serious disease of container-grown seedlings in Canada. Although both cultural and fungicidal controls are available, significant losses are still experienced in some nurseries. *Botrytis cinerea* occurs throughout the world, and has a host range of up to **235** species. The disease, which is seldom a problem in bareroot nurseries, is a classic example of how a technological change can result in a pathogen increasing in importance. The container nursery environment is ideal for the disease as large numbers of highly fertilized, succulent seedlings are grown under crowded conditions. Another factor which favors this disease is overhead irrigation in container nurseries. This results in long periods during which the foliage is wet or in which humidity is very high within the seedling canopy. Crowding of seedlings provides an abundance of senescent or dead needles which allows the fungus to become established as a saprophyte before moving onto green needles as a parasite.

Most forest tree species are susceptible to gray mold, although conifers are the most seriously affected. In eastem Canada, jack pine *(Pinus banksiana* Lamb.), white spruce *(Picea glauca* (Moench) Voss) and especially black spruce seedlings are affected; in westem Canada, spruces, westem hemlock and Douglas-fir suffer the most damage. In eastem Canada, losses to *Botrytis* have also been observed in Norway spruce *(Picea abies* (L.) Karst.) cuttings.

Signs of the disease include the presence of gray mycelium and spores and black sclerotia on the senescent lower needles and stems of affected seedlings. Visible clouds of spores are released when severely affected seedlings are handled. Brownish, water-soaked lesions can be found on stems, and seedlings may be girdled. Damage varies among nurseries and from year to year. Gray mold destroyed 1% of the container-grown seedlings in Ontario in 1988 and 1989. Variation in damage levels is caused by local weather conditions and varying nursery cultural practices.

Botrytis cinerea lives as a saprophyte on organic material within and around the nursery where it produces large numbers of air-bome spores. These spores are introduced into the nursery by wind and are drawn into greenhouses by ventilating fans where in early summer they are thought to infect senescent or dead needles in the lowest portion of the seedling crown. After infection, the fungus is thought to remain latent until late summer or early fall, when environmental conditions (high relative humidity and moderate temperatures) become favorable. The disease first becomes evident as cottony, gray-brown mycelium and spores on the lower needles of seedling shoots. If favorable conditions persist, the disease spreads upward and laterally, killing foliage and sometimes the seedling stem and lateral branches. Sclerotia form on infected tissue, allowing the fungus to overwinter and survive other unfavorable conditions.

Gray mold requires specific environmental conditions to cause severe damage; therefore it is a disease which can be controlled largely by altering cultural practices. Humidity can be lowered by reducing irrigation and by spacing containers to increase air circulation among seedlings. Using ventilation fans to increase ventilation through the greenhouse also helps. Controlling seedling height reduces the amount of senescence of the lower needles and results in lower humidity within the seedling canopy. Maintaining healthy, vigorous stock also decreases senescence of lower needles. One of the main cultural practices used against gray mold in British Columbia is to remove greenhouse covers (plastic sheeting) during the frost-free portion of the growing season. This results in shorter, stockier seedlings which are less susceptible to gray mold. Preventing abiotic damage such as fertilizer-bums on foliage also aids in control of gray mold, as damaged seedlings allow the fungus to become established before moving onto healthy foliage. In Ontario, container seedlings are usually overwintered outside in cold frames. Crops "flattened" by winter snow, particularly excessively tall spruce seedlings, often develop gray mold in the spring. Containers of such seedlings are spaced to allow them to dry out as soon as possible. Such seedlings should be outplanted quickly to prevent further losses. In Ontario the appropriate use of blackout curtains to initiate bud formation in container-grown spruce results in a uniform crop of shorter, hardier seedlings that are less susceptible to gray mold.

Fungicides are used regularly as a preventative measure at many container nurseries in Ontario and Quebec. A schedule in which benomyl, chlorothalonil and iprodione applications are alternated is recommended, as *Botrytis* may become resistant to a fungicide if it is used continuously. In westem Canada, fungicides are applied as needed to control *Botrytis* outbreaks and sprays are also applied just before canopy closure and before seedling lifting and storage.

Snow blight

Snow blight of various conifer species may be caused by several fungi including *Phacidium abietis* (Deam.) Reid & Cain, *Lophophacidium hyperboreum* Lagerb., *Sarcotrochila piniperda* (Rehm) Korf, *S. balsameae* (J.J. Davis) Korf, and *Hemiphacidium planum* (Davis) Korf. In Ontario nurseries, eastem white cedar, jack pine, and black and white spruce are the species most affected by snow blight. Damage occurs in patches where snowmelt is delayed. Disease severity ranges from only the foliage below the snowline being killed to seedling death. The greatest damage in northern Ontario nurseries has occurred following winters with heavy snowfall and prolonged snowmelt in the spring. About 120 000 black spruce transplants were killed or had to be culled in an Ontario bareroot nursery in 1989. Although the disease has occurred in other Ontario and Quebec bareroot nurseries, recent losses have been insignificant. Recently, gray mold damage has increased significantly under snow on overwintered, container-grown black spruce seedlings.

Spores of the pathogens are released and disseminated by wind during late summer and fall. Spores germinate on snow-covered foliage. The fungus grows under a snow cover during late winter and early spring. Implementation and regular use of cultural and chemical controls have greatly reduced losses, although significant losses sometimes occur. Snow blight is controlled by a late fall fungicide application (with a sticker added) to spruces and balsam fir. Snow fences can also be erected to prevent snow drifting over low areas in fields.

Storage molds

Although molding of stored stock is one of the most important diseases of forest nursery seedlings in Canada (it harms the nursery managers final product), the problem has received little attention. The disease is in fact two diseases: in container-grown seedlings it is invariably gray mold *(Botrytiscinerea)* which becomes established on the seedlings in the nursery and continues to develop further in storage; in bareroot seedlings, molds may include a variety of ubiquitous fungi such as species of *Penicillium, Aspergillus, Mucor*, and *Botrytis*. Such molds are likely part of the seedling's natural microflora or are acquired as contaminants from soil that accumulate on seedling shoots during lifting.

The biology of storage molding of both container and bareroot stock is poorly understood: however, incidence and severity of molding of container-grown stock almost certainly relates to incipient or developed *B. cinerea* on the seedlings prior to storage, and to storage conditions. Host seedlings affected are the same as for gray mold in the nursery. To date, no relationship has been established between storage mold severity and survival of outplanted (container-grown) stock, but logic dictates that severely damaged stock, particularly if the stem has been killed, would not survive as well as healthy stock. The best strategies against storage mold on container-grown seedlings are to prevent mold from becoming established in the nursery and, where possible, to store seedlings at - 1 or -2°C to reduce *B. cinerea* growth.

Initial evidence of molding of bareroot stock is often a cottony mold on the lowermost needles of seedlings stored in bundles. As the disease develops, the mold spreads upward on the shoots of the seedlings. Depending upon the fungi involved (normally several) the molding varies in color (e.g. orange, pink or white) and frequently seedlings have a moldy odor. Sometimes clouds of spores are emitted when boxes of moldy seedlings are opened. With advanced molding, part or all of the stem and branches have water-soaked lesions from which the bark can easily be stripped to reveal the dead, butterscotch-colored, cambium. All seedling species are affected but, at least on the west coast, pines seem to be less susceptible than other conifers. Transplants are very susceptible to storage molding.

Since severity of molding increases with storage time and above-freezing temperatures, losses can be reduced by storing stock at -1 or -2°C for as short a time as possible. Other helpful measures include frequent inspection of stored stock and then outplanting stock soon after molding starts.

Sirococcus *blight*

This disease, caused by *Sirococcus strobilinus* Preuss, affects forest trees, particularly regeneration, and both bareroot and container-grown nursery seedlings. On container-grown seedlings the disease is often seedbome. In the nursery, *Sirococcus* blight occurs on all species of spruce and pines across Canada and sometimes on Douglas-fir in British Columbia. In the bareroot nursery, wind-borne and rain-bome inoculum comes from affected trees and cones adjacent to nurseries; while such inoculum can infect seedlings in container nurseries, inoculum there is more often seed-bome. Thus, in containers the disease primarily affects young germinants and seedlings, whereas on bareroot seedlings it occurs later in the growing season, sometimes being confused with early frost damage. In containers, germinants and young seedlings are killed with needles dying from the base upward. A similar pattern of needle killing may occur on shoots of bareroot seedlings where killing of the shoot results in a lateral branch turning upward as the leader. Since the disease is seed-borne in container nurseries, blight occurrence there often occurs in specific seedlots. There is evidence that lodgepole pine *(Pinus contorta* Dougl.) provenances (Illingworth 1973) vary in their susceptibility to *S. strobilinus*. Another distinguishing feature of the disease is that it is most likely to prevail in nurseries with cool, rainy, overcast weather. Besides being ideal for fungus infection and spread, seedlings grown in such nurseries may be light stressed, further favoring the disease (Wall and Magasi 1976). In both containers and bareroot production, *Sirococcus* can affect up to 60% of the seedlings within a provenance or seedlot. Besides direct seedling losses, an additional cost factor is that of control where several fungicide applications may be needed to control blight on young, fast growing container seedlings.

For the most part, *Sirococcus* shoot blight is still managed with fungicides. However, early detection of seed-borne inoculum by conventional techniques (Sutherland 1987) or monoclonal antibodies (Mitchell 1988) can be used to forewarn managers of infested seedlots. Knowing the incidence of seed-bome inoculum, nursery managers can, where practical, reduce irrigation or increase greenhouse temperatures slightly, or they can apply protective fungicides to reduce spread of the disease.

Insects and mites

Spruce spider mite

The spruce spidermite, *Oligonychus ununguis* (Jacobi), is an important pest of conifers in nurseries throughout the north temperate zone. In Ontario and Quebec the mite was first observed in the mid-1920s. In nurseries in these provinces the mite damages white spruce, black spruce, Norway spruce, eastem white cedar, and larch; spruce is the preferred host. The mites feed by inserting their stylet-like mouthparts into needles and tender twigs and sucking out the juices, thus causing a mottled discoloration and subsequent drying of tissue. Feeding usually begins on the lower branches and progresses upward. Mites are most destructive during hot, dry weather; heavy rainfall tends to wash many mites off seedlings. Both immature and adult mites produce a fine webbing around twigs and between the needles, which protects them from enemies and from being dislodged. Webbing is usually more noticeable on the underside of branches.

The mite develops through five stages: egg, larva, two nymphal stages, and adult. Adults are barely visible to the naked eye. Overwintering occurs as eggs which initially are pale yellow and gradually become reddish-brown. Overwintered eggs hatch in May and newly hatched larvae are mottled pink, and become needle-green to dark green after feeding. Larvae have three pairs of legs and nymphs and adults four. Development of larvae and nymphs each requires 3 to 6 days. Nymphs become adults by early June and under favorable conditions can live up to 30 days. Mature females lay 40 to 50 eggs which after 13 to 16 days incubation result in a second generation by late June. This cycle is repeated up to six times during the remaining summer. Overwintering eggs are laid from late September to the onset of severe frost.

All active forms of the spruce spider mite occur on needles and to some extent on tender twigs. Larvae and first-stage nymphs do little wandering and feed on the basal parts of needles while second-stage nymphs and adults move about freely, feeding on needles.

Because of the high reproductive capacity and short life cycle of this pest, populations can build up very rapidly, especially during long dry periods. Adults are carried on the wind to adjacent trees and spread longer distances on infested outplanted stock. Pressure washing infested trees at weekly intervals during the spring and summer dislodges adults and breaks up webbing. Heavy infestations may require use of miticides which should be applied at a high pressure to ensure adequate coverage. Several applications at 10-day intervals are usually required as eggs survive treatment.

Root weevils

Both the strawberry root weevil, *Otiorhynchus ovatus* (Linnaeus) and black vine weevil, O. *sulcatus* (Fabricius), seriously damage both bareroot and container-grown seedlings across Canada. Of the two, O. *ovatus* is usually the most serious. Several other weevils are also common in Canadian nurseries, but they rarely cause serious damage. The strawberry root weevil has caused varying amounts of damage to container-grown white and black spruce in Ontario, while losses to black, white and Norway spruce, larch, and red and jack pine have been reported in Quebec bareroot nurseries. In British Columbia, hosts include spruces, westem red cedar, western hemlock, western larch *(Lurix orridentulis* Nutt.), ***Abies*** spp., and pines.

Adult weevils primarily affect 1+0 seedlings by girdling a 1-cm band of the fleshy, uppermost part of the hypocotyl. Feeding damage occurs primarily in early June or July before stems become woody. Adult weevils feed all summer. They are primarily noctumal feeders and hide in debris during the day. Larvae of the strawberry root weevil damage roots of older 2+0 conifers. Larvae normally occur in groups in the top 2.5 cm of soil around the roots of the host plant. They feed on fibrous roots, strip most laterals, and girdle stems at the root collar. Often damage by adults or larvae is not noticed until trees are lifted or until they suddenly wilt.

Root weevils overwinter as adults in debris or more commonly as larvae in the soil. Overwintered larvae and adults become active in spring and continue feeding. Larvae, which are slightly curved and creamy white with brown heads, pupate in cells as deep as 20 cm below the soil surface in mid-spring. Adults emerge in late spring and immediately begin feeding. The parthenogenic, wingless adults are dark brown, gray or black with a short snout and elbowed antennae. Both overwintered and emerging adults oviposit for about 7 weeks, ceasing in late summer to early fall. Eggs have an incubation period of 10 to 20 days. After hatching, larvae begin feeding on seedling roots. Most damage is done by larvae in the fall.

Root weevil larvae are hard to kill; therefore, control measures are aimed at adults. Various detection methods, such as flat sticky traps or surveying for fresh girdling on conifer seedlings in early summer can be used to determine adult populations in the nursery. When control is justified, insecticides should be applied in late spring or as soon as adults become active. A second application is desirable about a month later to control late-emerging adults. It is also useful to remove weeds (altemative food supplies) from seedbeds and beneath nearby trees.

Lygus bug

The lygus bug, *Lygus lineolaris* (Palisot de Beauvois), and other species of *Lygus*, damage bareroot and container-grown seedlings in British Columbia and recent evidence in Ontario points to similar damage in bareroot pines and container-grown spruce. So far, in British Columbia, damage has been mainly on 1+0 bareroot and container-grown lodgepole pine, but western larch, Douglas-fir and 1- and 2-year-old spruce (all species) are also damaged. Adults and nymphs feed on terminal shoots, resulting in seedlings with multiple leaders. An elongated scar often forms on one side of damaged terminals, which have thick, short, twisted needles. The terminal of such shoots usually assumes a crozier shape. At both bareroot and container facilities, damage is most prevalent around the periphery of the nursery where the insects fly in from adjacent areas (e.g., alfalfa fields).

Lygus bugs overwinter as adults which are shield-shaped and yellowish-green to reddish-brown. In spring they feed on young shoots, mate, and the females oviposit into numerous host plants. Nymphs, similar in appearance to adults, emerge about 10 days later and molt five times as they develop. In British Columbia, the life cycle is completed in 3 to 4 weeks and there are two or three lygus bug generations per growing season.

In British Columbia, where lygus bug populations may reach damaging levels, seedlings are protected by insecticide sprays during the first quarter of June, July, and August. Keeping the nursery and nearby areas free of weeds and other host plants also helps reduce lygus damage.

Cutworms

Cutworms, larvae of moths in the order Lepidoptera (family Noctuidae) damage very young bareroot and container-grown seedlings all across Canada. Some damage occurs in most nurseries each year and sometimes damage is heavy. One of the most damaging cutworms is *Peridroma saucia* (Hubner), the variegated cutworm. Cutworms damage many plants including most species of conifers.

Damage is mainly restricted to very young seedlings (before stems become woody): cutworms eat foliage and cut off stems just above soil line, leaving a stump. Feeding occurs mostly at night and the cutworms hide in loose sand and soil during the day. Adults (moths) are robust, large, buff-colored, and fly mainly at night. The larvae, which damage seedlings, are large, soft, dull-colored caterpillars with hairless bodies and shiny heads. They characteristically curl into a circular shape when disturbed.

The life cycle consists of eggs, larvae, pupae and adults; depending on the location and cutworm species, there can be one to three generations each year. Most cutworms overwinter as eggs or pupae, although some species overwinter as larvae. The first generation is normally the most harmful as it occurs when seedlings are young and succulent.

Bareroot fields and container facilities should be kept free of weeds which may attract egg-laying females. Adults can be caught in light traps and greenhouses can be insect-proofed to exclude moths. When populations are small, cutworms can be hand-picked and destroyed. Poison baits can be used against larvae, but insecticides must be used when populations are large. Insecticides are most effective when applied late in the day when cutworms are active, especially when temperatures are warm.

Aphids

Many species of aphids (Order Homoptera) affect forest nursery seedlings in Canada. Needle and stem feeding aphids such as giant conifer aphids (*Cinara* spp.) and woolly aphids (*Adelges* and *Pineus* spp.) are quite common on bareroot seedlings. Root feeding aphids such as those of the genus *Pachypappa* are especially prevalent on roots of container-grown conifers. Damage is seldom severe although species of *Adelges* often cause twisting, distortion and chlorosis of seedling needles, particularly in Douglas-fir. In coastal British Columbia, the green spruce aphid, *Elatobium abietinum* (Walker), may cause year-old needles of spruce seedlings to fall off. Because the life cycle of aphids varies with factors such as host alternation, parthenogenesis, viviparity, and geographic locality, it is not possible to outline a life cycle for all aphids. It is common for most aphids to pass through several generations per year and for populations to fluctuate widely and quickly. Except for size, adults and juveniles are generally similar in appearance. Most aphids overwinter as eggs.

The mere presence of aphids may not justify their control as large populations are often necessary before seedlings are damaged. In fact, there is no evidence that many aphids, including those that feed on seedling roots, do sufficient harm to warrant control. Rarely are insecticide sprays appropriate, but even then insecticidal soaps are usually quite effective. For aphids **that** complete their life cycle on two or more hosts, it is worthwhile to remove alternate hosts (e.g., hedges) from within or adjacent to the nursery.

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