

Crop Profile for Apple in Canada

Prepared by:

Pesticide Risk Reduction Program

Pest Management Centre

Agriculture and Agri-Food Canada

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Product trade names may be included and are meant as an aid for the reader, to facilitate the identification of products in general use. The use of these trade names does not imply endorsement of a particular product by the authors or any of the organizations represented in this publication.

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Crop Profile for Apple in Canada

The domestic apple, *Malus domestica*, is a member of the Rose (*Rosaceae*) family. When Samuel de Champlain first arrived in what is now Nova Scotia in 1604, one of his main objectives was the establishment of agricultural crops in the new world. Among those crops were apple trees, first recorded in the Annapolis Valley in 1610. In subsequent decades, the Hudson's Bay Company played an important role in the dissemination of apple seeds and seedlings across Canada. Early settlers in southern Ontario and Quebec planted apple trees on their homesteads and farms throughout the 18th and 19th centuries. The first reference to commercial apple production in Ontario was in 1796. In the late 1800's, apple production was initiated in the fertile and mild climate of the Okanagan Valley in B.C.

General Production Information

Canadian Production (2002)	41,900 metric tonnes 24,411 hectares
Farm gate value (2002)	\$166 million
Domestic consumption (2001)	11.35 kg/person (raw) 0.66 kg/person (processed)
Export (2001)	\$54 million
Imports (2001)	\$120 million
Source(s): Statistics Canada	

Production Regions

Today, apples are grown in Canada in those areas where warm summers are complemented by mild winters. Major production areas include BC (5858 ha or 24%); ON (8903 ha or 36%); QC (6677 ha or 27%); NB (413 ha or 2%); and NS (2550 ha or 10%). Small (less than 1% of total acreage) plantings also exist in P.E.I. (approximately 40 ha) and in the Prairie Provinces (about 40 ha combined).

Cultural Practices

Orchards grow best on slightly sloping hills, allowing cooler air to flow down the slope. Ideally, slopes should be graded between 4 and 8 % and face south, allowing for the greatest exposure to the sun. Loam soils are preferable because they are easy to manage and generally have higher organic matter content and a balanced pH. Sandy soils produce less vigorous growth, have a greater requirement for irrigation, are more prone to leaching and have lower levels of organic matter. Clay soils produce more vigorous growth and are generally higher in organic matter, but provide poorer drainage and are less suitable for root growth.

In the last century, the apple industry in Canada has experienced significant changes in production and storage technologies. Cold storage has given way to controlled atmosphere storage, permitting year round storage of fruit. New lower-risk pesticides and integrated pest management has helped reduce the environmental impact of growing apples. New apple cultivars are gradually replacing old standard varieties and dwarfing rootstocks have allowed the intensification of apple production through high-density plantings. Industry downsizing due to global competition and overproduction of apples, along with more efficient production methods geared towards quality fruit production, has meant a reduction in overall acreage of apples grown

in Canada. The 1990s brought more than the usual amount of extreme weather conditions to Canadian producers, varying from severe drought, hail, sun damage, winter thaws and the ice storm of 1998 in areas of Ontario and Quebec. The trend towards extreme weather patterns has so far extended into the new millennium. Drought-reduced crops have almost become a pattern over the last four or five years in some areas of the country.

Product Types

The primary intent of Canadian apple growers is to produce high quality, fresh fruit for direct consumption, so as to receive the best price for their fruit. Additionally, some cultivars (e.g. Northern Spy and Idared) are grown for use as a processing apple for pie filling and other baked goods. Other processed uses are cider, apple wines, hard ciders, dried apples, baked goods, and apple butter. Apple juice is produced from “C” grade apples. Major processors producing apple juice are located in B.C., Ontario, Quebec and Nova Scotia.

Production Issues

Apple production in Canada is affected by numerous abiotic and biotic factors. Abiotic factors include low winter temperatures, cold temperatures at critical stages of blossom and fruit development, drought, hail, freezing rain, heavy snow loads on branches and heat scorch on leaves and fruit. Poor soils (low organic matter, water logged, etc.) can delay or prevent adequate growth. Various pesticides and foliar nutrients may cause fruit to russet or scorch. Low temperatures and incorrect carbon dioxide and oxygen levels can negatively affect fruit in storage. Biotic factors include insects, mites, plant diseases (fungal, bacterial and viral), nematodes, birds and mammals. Weed species compete with tree roots for moisture and nutrients and may harbour pest populations.

Table 1. Canadian apple production and pest management schedule

Time of Year	Activity	Action
winter-dormancy (December to late March)	Plant Care	Winter prune trees; apply nitrogen and zinc sulphate (B.C.) spray if needed
	Soil Care	Prepare sites of new plantings
	Disease Management	Prune off shoots that have white tips (mildew) and cankers
	Insect Management	Apply delayed dormant spray for aphids, scales, and mite eggs
	Other	Reapply rodenticides, as needed
spring-green tip to fruit set (late March to May)	Plant Care	Finish pruning trees; plant and prune new trees; install tree supports and begin training new trees; apply foliar nutrients as needed; place bees in fields when blossom begins; apply blossom thinning sprays; irrigate as needed; begin fertigation in established stands (B.C.); apply post-bloom chemical thinners
	Soil Care	Fertilize new trees; apply soil nutrients as needed; apply lime if needed
	Disease Management	Monitor for scab infections, fire blight, and powdery mildew; apply controls if needed
	Insect Management	Apply oil spray for mite eggs at 1/2 inch green – tight cluster; set out and monitor pheromone traps for moth pests (e.g. codling moth, Oriental fruit moth); begin monitoring for spring-feeding caterpillars, mullein bug, plum curculio, mites, aphids, leafhoppers, and beneficials; apply controls as needed
	Weed Management	Monitor for weeds, and apply controls if needed
summer – fruit growth (June to August)	Plant Care	Apply supplemental nutrient sprays as needed; irrigate as needed; begin fertigation of new trees (B.C.); hand thin fruit; apply calcium for bitter pit and other calcium deficiencies, if needed; have leaf analyses performed; continue training young trees; apply growth regulator to prevent drop, as needed; monitor fruit maturity; summer prune if needed
	Soil Care	Apply boron if needed; take soil samples
	Disease Management	Continue monitoring for scab and other diseases; prune out wood with cankers and fire blight; treat for pinpoint scab
	Insect Management	Control codling moth as needed; continue monitoring for leafrollers, codling moth, apple maggot, mites, aphids, leafhoppers, and beneficials; begin monitoring for scales; apply controls as needed
	Weed Management	Monitor for weeds, and apply controls if needed
	Other	Monitor for birds, and control if needed
fall – harvest period (September to November)	Plant Care	Harvest apples; irrigate as needed after harvest; remove dead, weak, or diseased trees
	Soil Care	Fumigate sites of new plantings, as needed; take soil samples
	Other	Apply rodenticides

Template adapted from BC Ministry of Agriculture, Food and Fisheries apple crop profile, July 2002.

Abiotic Factors Limiting Production

Key Issues

- There is a need for continued cultivar and rootstock demonstration trials in different geographic regions to determine climatic limitations.
- Breeding of marketable cultivars that are developed for the diverse Canadian climates is required.
- Strategies to reduce the risk of sun scorch to fruit in hotter, drier apple growing areas in the country is needed.
- There is a need for the development and testing of economically affordable hail prevention devices.

Temperature extremes

Excessive heat in the summer months may result in trees with reduced photosynthetic and carbon production functions, which can negatively impact fruit growth and quality. Extremely cold winters may lead to bud, twig, branch or whole tree dieback. Some cultivars cannot be grown in the more northern apple-producing regions. Cold temperatures during bud-break through early fruit development can adversely affect flower and fruit production. Critical temperatures during this time vary from -1 to 4 °C, depending on the cultivar. A frost during bloom can reduce fruit yield by as much as 90%.

Other climatic factors

Summer droughts negatively impact tree health and fruit production. Hail can physically bruise or cut fruit, making it useful only for juice. Sharp hail can even cut woody tissue, allowing entry of fire blight and other canker organisms. Heavy snow loads and freezing rain can break branches from smaller trees, a problem especially in orchards with trees on dwarfing rootstocks (branches low to ground) and cultivars with brittle wood (e.g. Gala).

Soil quality

Soils low in organic matter and nutrient content or with poor drainage properties can negatively impact tree growth. Efforts must be made to correctly prepare the ground before planting. Old, “tired” soils which have been planted to apple trees (or otherwise used for agriculture) often do not provide enough vigour and trees may exhibit replant disorder, a complex combination of physical and biotic factors that impact tree growth and production.

Fruit russetting and scorch

Excessive direct sunlight and a thin ozone layer can lead to sun scorch of fruit, a phenomenon most often experienced in B.C., but occasionally in Ontario as well (during dry, hot summers). Fruit russetting also may occur when pesticides or foliar nutrients are applied during times of slow drying or during excessively hot temperatures (>28 °C).

Excessive Rainfall

Excessive rainfall can result in fruit quality issues and contribute to tree loss.

Diseases

Key Issues

- The most important issue facing the Canadian apple industry is the possible loss of the registration for streptomycin. The antibiotic is the only product that is effective against the devastating disease fire blight. The registration of alternative control products, such as Blightban, Serenade, Apogee and Actigard could reduce the reliance on streptomycin, but the efficacy of these products is currently insufficient to replace streptomycin.
- There is concern that the high susceptibility to fire blight of newer cultivars being planted and the wide use of dwarfing rootstocks will increase the potential for disease outbreaks.
- The control of apple scab relies on the use of several families of registered fungicides used in rotation. Resistance to some of these families has already been documented, making it very important to register new types of fungicides to enlarge the spectrum of products used and limit the development of resistance. The development and marketing of resistant cultivars can also help reduce pathogen resistance.
- Storage rots are responsible for losses in the millions of dollars in some years. *Botrytis* is one of the most prevalent post harvest rots and does occasionally cause disease in the orchard. There are few fungicides registered on apple that have good activity against the disease. Products that have the potential for being registered include cyprodinil, fludioxonil, fenhexamid and boscalid.
- There is a need for fungicides to be registered to control aggressive canker diseases.
- There is concern over the use of mancozeb and metiram, as they are harmful to some predatory mite species.
- There is concern over the limited options available for the control of replant disease.
- There is a need for regional testing of new cultivars and the collection of information on the disease susceptibility of new varieties. There is a need for market development for scab-resistant cultivars.
- There is a need for further development of integrated pest management strategies for controlling diseases in apple.

Table 2. Degree of occurrence of disease pests in Canadian apple production

Major Diseases	Degree of occurrence					
	BC	ON	QC	NB	PE	NS
Apple scab	E	E	E	E	E	E
Fire blight	E	E	E	E	E	E
Post-harvest diseases	E	E	E	E	E	E
Lesser Diseases	BC	ON	QC	NB	PE	NS
Powdery mildew	E	E	E	E	E	E
Cedar-apple and quince rust		E	E			
Flyspeck and sooty blotch		E	E	E	E	E
Canker diseases and root rots	E	E	E	E	E	E
Blister spot	E	E				E
Replant disease complex	E	E	E	E	E	E
Crown Gall	E	DNR	DNR	DNR	DNR	DNR

Widespread yearly occurrence with high pest pressure
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure
Widespread yearly occurrence with low to moderate pest pressure
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure
Pest not present
DNR - Data not reported
E – established
D – invasion expected or dispersing

Source(s): Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec; NB Department of Agriculture, Fisheries and Aquaculture; BC Ministry of Agriculture, Food & Fisheries; B.C. Crop Profile for Apple; AgraPoint International Inc.; Ontario Ministry of Agriculture and Food

Major Diseases

Apple Scab (*Venturia inaequalis*)

Pest Information

Damage: Symptoms include lesions on both sides of leaves, usually developing earliest on the lower side. On fruit, dark lesions form and are characterized by small black spots that enlarge more slowly than those on leaves. Immature fruit that are infected are distorted with cracking on the surface covered by the lesion. Infections occurring late in summer may not be visible to the naked eye at harvest, but may develop to pinhead size in storage. Yield losses up to 100% are possible.

Life Cycle: There are both primary and secondary infections caused by this disease. Primary infection arises from ascospores released from overwintered infected leaves on the orchard floor. Secondary infection results from conidia (spores) released from lesions created at primary infection sites. The disease is favoured by warm temperatures and wet conditions.

Pest Management

Chemical Controls: Registered materials include sulphur, metiram, mancozeb, captan, cyprodinil, thiophanate-methyl, dodine, myclobutanil, flusilazole, kresoxim-methyl, and trifloxystrobin. Generally metiram, mancozeb and cyprodinil are used for primary scab infections in spring and early summer. Myclobutanil, flusilazole, kresoxim-methyl are used in rotation or combination with the aforementioned. Captan is used for post bloom infections. Sulphur is used mainly by organic apple producers.

Cultural Controls: A good orchard design that optimizes air movement through the canopy can reduce the number of infection periods by allowing foliage to dry more quickly. Pruning to open the tree canopy and promote air and light penetration may reduce the time it takes leaves and fruit to dry and improve pesticide spray coverage. Removing wild or abandoned trees within 200 meters of an orchard helps reduce the number of ascospores entering the orchard from outside sources. Sanitation practices, such as flail-mowing fallen leaves in autumn or early spring before bud break, or applying urea to foliage prior to leaf fall, or on fallen leaves, can decrease the amount of ascospores by 50 to 75%.

Alternative Controls: Apple scab forecasting can be done by monitoring temperature and the length of time leaves are wet. A threshold of 0.7% of leaves with scab in the fall can be used to determine if inoculum is expected to be low or high during the next growing season. If there is no possibility of rain in the forecast, fungicide sprays can be delayed. Ascospore monitoring can be used to more accurately predict the beginning, peak and end of the primary apple scab season. It may be possible to eliminate one or two early season sprays or unnecessary sprays at the end of the season if microscope observation indicates spores are not yet mature or that the majority of spores have been discharged earlier than anticipated.

Cultivar Susceptibility: There are several scab resistant cultivars now available to the commercial grower. Scab resistant cultivars can be susceptible to other diseases. Until recently, these cultivars were not widely accepted by apple growers due to various problems, such as poor color, quality, taste and storage, as well as difficulty marketing at wholesale and retail market levels. Resistant varieties developed in Canada include Belmac, Britgold, Macfree, Moira, Murray, Navo Easygro, Novamac, Novaspy, Primevere, Richelieu, Rouville and Trent. Other resistant varieties include Entreprise, Liberty, Freedom, Florina and others.

Resistance of these cultivars is expected to be short lived, as new races of the pathogen spread.

Issues for Apple Scab

1. There is concern over the development of resistance to all systemic fungicides, including sterol inhibiting fungicides (myclobutanil and flusilazole) and recently registered products, such as strobilurins (kresoxim-methyl, trifloxystrobin) and anilinopyrimidins (cyprodinil).
2. There is concern over the loss of the registration for EBDC fungicides (mancozeb and metiram) and captan.
3. There are difficulties in preventing scab infections during years with high and frequent rainfalls in the spring with extended wetting periods.
4. There is a need for non-chemical alternatives, such as biocontrol agents.
5. There is a need for research and development of a scab resistance gene that could be transferred to commercially grown cultivars, substantially reducing fungicide use.

Fire Blight (*Erwinia amylovora*)

Pest Information

Damage: This bacterial disease can be economically devastating to apple growers in Canada.

Whole orchard blocks can be killed, resulting in years of lost income. Fire blight can attack many different parts of the tree. Blossom, shoot, twig, fruit, limb, trunk, collar and rootstock blights are all terms used to describe different locations where infection can take place. The type of damage caused depends on where the infection occurs.

Life Cycle: Infections begin at bloom and continue well into the summer if weather conditions are favourable.

Pest Management

Chemical Controls: Streptomycin is the only registered bactericide. Applied properly, it is very effective in preventing blossom infections of the disease. Copper is also registered and is used early in the season to reduce overwintering inoculum levels in the orchard.

Cultural Controls: Excessive winter pruning should be avoided. Regular annual pruning should be done, while minimizing the number of cuts made. This will help calm the growth of the tree. Sucker growth are good entry points for the disease and should be broken out periodically during the early growing season. Infected trees must be pruned while dormant to remove all overwintering cankers and sources of inoculum. Pruning should be done below visibly affected areas. Excessive nitrogen fertilization should be avoided. To prevent vegetative growth, overhead irrigation should not be used. A sound, integrated pest management program should be used to minimize the spread of fire blight bacteria by insects and to reduce insect-caused wounds to leaf and shoot tissue, which can act be entry points for the disease. Good control of plant-sucking insects such as leafhopper, aphid and plant bugs is particularly important. Blight forecasting computer programs can be used to forecast when fire blight symptoms will appear, determine whether or not sprays are needed and how to best time sprays during bloom.

Alternative Controls:

Cultivar Susceptibility: There are some varieties that are more tolerant to fire blight, such as Red Delicious, Liberty, Enterprise and Freedom. Susceptible varieties include Gala, Idared and Jonagold.

Issues for Fire Blight

1. There is great concern over the possible loss of the registration of streptomycin. Currently there are no other products available as effective as streptomycin for the control of the disease.
2. There is a need for research into viable alternatives to streptomycin.
3. There is a need for genetic engineering research to develop commercial cultivars and rootstocks with fire blight resistance.
4. There is a need for registrants to pursue registration in Canada for products that manage fire blight.

Post Harvest Diseases

Pest Information

Post harvest diseases include blue mould (*Penicillium expansum* and other *Penicillium* spp.), grey mould (*Botrytis cinerea*) and others.

Damage: Blue mould is the most important postharvest rot of apple. It causes a soft rot, light brown in colour. Grey mould produces a soft spongy area on the fruit surface that soon fills with grey coloured spores.

Life Cycle: Blue mould spreads in storage through spores that are produced in developing infections. Spores are capable of infecting other nearby fruit. Grey mould spreads by spores as well, creating pockets of decayed fruit. Infection is through skin breaks or where the stem is cut.

Pest Management

Chemical Controls: The application of fungicides during the growing season to prevent scab does reduce the occurrence of postharvest diseases. Thiabendazole is the only fungicide registered for postharvest application in Canada.

Cultural Controls: Careful handling and strict hygiene in the field, in transport and in storage is important for the control of postharvest diseases. Orchards should be cleared of dead material to reduce inoculum levels. Harvesting apples at optimum maturity helps prolong storage life.

Alternative Controls: Controlled atmosphere (CA) storage allows the optimization of environmental conditions to prevent rot and prolong the storage life of the produce. Properly designed CA storage facilities can prolong storage life. Apples should be inspected before being placed into storage to determine their storage potential. Cooling (0-3°C) should be done as quickly as possible and atmospheric oxygen (2.5-3%) and carbon dioxide (2.5-4.5%) should be at optimum levels 5-7 days after initial harvest. Research has been done on optimizing temperature, oxygen and carbon dioxide levels for specific varieties of apple and on changing the concentrations at specific times during the storage period.

Cultivar Susceptibility:

Issues for Post Harvest Diseases

1. Blue mould and grey mould resistance to thiabendazole is a concern, as it is the only product registered for its control in Canada.
2. To manage fungicide resistance, there is a need to test newer reduce-risk fungicides and biological control agents for the control of storage diseases.
3. 1-methylecyclopropene (1-MCP), a product which extends the storage life and improves fruit quality by reducing ethylene production in storage, received registration in June 2004. There is little information on the effect of 1-MCP on storage diseases of apples. Interactions of 1-MCP and storage diseases need to be studied.

Minor Diseases

Powdery Mildew (*Podosphaera leucotricha*)

Pest Information

Damage: The disease can kill vegetative shoots and prevent fruit formation when blossoms are infected. Russeted fruit is downgraded to juice. On young trees, or in heavily infested trees, vigour and productivity are reduced. Infected buds are more sensitive to cold temperature injury than healthy buds.

Life Cycle:

Pest Management

Chemical Controls: The disease is generally controlled by many of the same fungicides used for apple scab. Registered materials include sulphur, myclobutanil, flusilazole, kresoxim-methyl and trifloxystrobin.

Cultural Controls: Pruning of the first shoots showing mildew symptoms in the spring and taking care not to spread the infection by causing spores to fall on healthy leaves will help control the disease. Infected foliage should be cleared away. Overcrowding of trees and branches should be avoided by properly spacing and trimming trees.

Alternative Controls:

Cultivar Susceptibility: Cultivars such as Red Delicious, McIntosh, Empire, Nothern Spy, Freedom and Jonafree are only slightly susceptible. Liberty is said to be resistant, but has been moderately susceptible in B.C. Very susceptible cultivars include Cortland, Idared and Paulared.

Issues for Powdery Mildew

1. There is concern over the development of resistance to all systemic fungicides, particularly sterol inhibiting fungicides (myclobutanil and flusilazole).

Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) and Quince Rust (*Gymnosporangium clavipes*)

Pest Information

Damage: Cedar apple rust produces lesions on leaves and fruit with black centres and causes early leaf senescence and spongy, brown fruit tissue. Cuplike structures appear on the undersides of leaves and on fruit. Quince rust infects the calyx end of fruit.

Life Cycle: The complex life cycles of these two distinct pests take two years to complete and two different hosts. The alternate host is red cedar (*Juniperus virginianae*). Cedar apple rust infects both leaves and fruit of susceptible cultivars, while quince rust affects only fruit.

Pest Management

Chemical Controls: Fungicides registered for control include mancozeb, metiram, myclobutanil, zineb and trifloxystrobin. Apple scab sprays generally control rust diseases, but may not be adequate during the period from tight cluster/pink until mid June.

Cultural Controls: The removal of alternate hosts and wild apple trees in proximity to the orchard can reduce disease incidence, but may be difficult. Rust resistant varieties of ornamentals should be planted when possible.

Alternative Controls: Infection potential can be estimated by examination of red cedars in the proximity of orchards from May until mid June.

Cultivar Susceptibility: Cultivars vary in their susceptibility to the two rusts, with the most resistant varieties being McIntosh, Spartan and Liberty. Highly susceptible cultivars include Golden Delicious and Mutsu.

Issues for Cedar Apple and Quince Rusts

None identified

Flyspeck (*Gleodes pomigena*) and Sooty Blotch (*Schizothyrium pomi*)

Pest Information

Damage: These fungi grow only on the surface of fruit and do not actually damage the flesh. Surface blotches can be extensive, causing fruit to be downgraded from fresh market to processing or juice quality. Stored fruit infected with sooty blotch may shrivel more readily.

Life Cycle: Both fungi grow very slowly. They have the ability to go dormant under unfavourable conditions, such as dry, hot weather. Symptoms may only appear at harvest despite being infected much earlier. Conditions are more favourable for the development of the disease in August and September.

Pest Management

Chemical Controls: Registered control products include captan, zineb and trifloxystrobin. However the disease is controlled by most fungicides that are applied for apple scab protection.

Cultural Controls: Cultural control practices that promote the quick drying of the tree canopy can help reduce disease. This can include pruning of branches and thinning of clustered fruit.

Alternative Controls:

Cultivar Susceptibility:

Issues for Flyspeck and Sooty Blotch

1. For the most part, early season applications of fungicides to control scab also control these diseases. There is concern that some of the newer fungicides being used for apple scab (myclobutanil and fluzilazole) are not effective against these diseases.
2. During the summer, sprays targeted at these diseases may be necessary.

Black Rot (*Botryosphaeria obtuse* and other fungi)

Pest Information

Damage: Damage caused may appear in several different forms. Leaf infections result in frog-eye leaf spot, with heavy infections causing leaves to yellow and abscise may result in premature senescence, leading to winter injury. Other symptoms include trunk and limb cankers and fruit infections. Infected fruit have small black flecks that enlarge to form brown, dead, firm areas. The presence of concentric rings with black pycnidia within the areas is typical.

Life Cycle:

Pest Management

Chemical Controls: Captan provides good control. Even though EBDC fungicides (metiram and macozeb) have only weak activity against black rot, a high application rate of these fungicides in the spring for apple scab has been effective at limiting early season black rot infections.

Cultural Controls: Affected wood should be removed and destroyed to limit the spread of the disease. Fire blighted limbs can be a target for colonization of black rot spores and should also be removed. Identifying and removing hardwood trees infected with the disease in surrounding areas, may help in the control of the disease.

Alternative Controls:

Cultivar Susceptibility: The most susceptible cultivars include Northern Spy, Courtland, McIntosh and Empire. There are no resistant cultivars.

Issues for Black Rot

1. In orchards where EBDC fungicide rates have been reduced, or where they are used in combination with sterol inhibiting fungicides, an increase in incidence of black rot has been observed.

Anthracnose, Nectria and Perennial Canker (*Cryptosporiopsis curvispora* / *Neofabraea alba*, *Nectria galligena* and *Cryptosporiopsis perennans*)

Pest Information

Damage: Cankers are especially significant economically when they infest nurseries and young high-density plantings. Fungal cankers result in an area of dead bark or wood, which may become discoloured, sunken, cracked, or fall away altogether. Often the rest of the branch beyond the canker dies or becomes much less productive. Damage assessment is difficult, as they cause a general reduction in the growth and yield of individual trees.

Life Cycle: Some cankers expand year after year (*Nectria*). Others stay the same size but release spores which can begin new cankers elsewhere (*Anthracnose*). Cankers can spread rapidly when weather conditions are favourable.

Pest Management

Chemical Controls: There are no fungicides registered for control of cankers.

Cultural Controls: Pruning in the winter before sap begins to flow may minimize the chance of disease organisms being spread by pruning tools. Branches should be pruned back to the collar, avoiding stubs, but leaving the collar intact to heal the wound. All dead wood and fruit mummies should be removed as they serve as reservoirs for disease organisms. Cankers should be removed quickly by pruning the branch several inches below the canker.

Alternative Controls:

Cultivar Susceptibility:

Issues for Cankers

1. Since cankers can be devastating diseases if left unchecked and there are no registered fungicides for their control, the registration of an effective product is required.

Crown Rot and Root Rot (*Phytophthora cactorum* and *P. syringae*)

Pest Information

Damage: Affected trees show general symptoms of vascular dysfunction, with stunted growth and small fruit. Leaves may appear yellow and turn purple in the spring or fall. Trees can decline over several years before they actually die. Often, the disease will affect an area of the orchard that is low lying or poorly drained.

Life Cycle:

Pest Management

Chemical Controls: Fosetyl-al is registered for control of crown rot and can be used as a drench treatment or a foliar spray. Metalaxyl is registered to be used as a drench treatment that can be applied to newly planted trees and young non bearing trees.

Cultural Controls: Planting sites should be chosen and soil water should be managed so that soils do not remain saturated for prolonged periods of time.

Alternative Controls:

Cultivar Susceptibility: Resistant cultivars and seedling rootstocks do exist. The most susceptible cultivars include M26, M7 and MM106.

Issues for Crown Rot and Root Rot

1. There are no IPM compatible products registered for control of the disease and there is no research being done on biological alternatives and supplements.

Blister Spot (*Pseudomonas syringae*)

Pest Information

Damage: Small lesions around the lenticels on fruit appear and expand during the growing season. By harvest, lesions can grow to a size of 5 mm in diameter and 2 mm deep with blistered brown centers and dark purple borders.

Life Cycle:

Pest Management

Chemical Controls: Registered bactericides include fosetyl-al and copper.

Cultural Controls: Disease free nursery stock should be used. Planting near older Mutsu blocks where blister spot is present should be avoided. Overhead irrigation should not be used during the period of fruit susceptibility.

Alternative Controls:

Cultivar Susceptibility: The cultivar Mutsu is particularly sensitive to the disease. Other susceptible cultivars include Golden Delicious, Jonagold and Gala types.

Issues for Blister Spot

1. The two registered products only suppress the disease. An effective bactericide is needed for control.

Replant Disease Complex

Pest Information

Damage: This disease, caused by a composite of fungal and bacterial soil organisms and nematodes, can occur when a new planting of apple is located on old orchard sites. Young trees may be stunted, exhibit reduced precocity and productivity and in severe cases may die.

Life Cycle:

Pest Management

Chemical Controls: Fumigation prior to planting reduces the incidence of replant disease.

Cultural Controls: A greenhouse-based soil test has been developed to determine the presence of replant disease. It involves the planting of apple trees in samples of orchard soil and comparing them to trees planted in another soil.

Alternative Controls:

Cultivar Susceptibility:

Issues for Replant Disease Complex

1. There are no IPM compatible treatment alternatives for this disease complex.
2. There is little research being done on biological or cultural methods to reduce the incidence prior to replanting.

Table 3. Disease control products, classification and performance for Canadian apple production

Control product (active ingredient / organism) ¹	Classification ²	Mode of action – resistance group ³	PMRA status of active ingredient ⁴	Pests or group of pests targeted	Performance of product according to recommended use ⁵	Notes
captan (Maestro, Captan)	Phthalimide fungicide	M	R	Apple scab	A	Not compatible with oil sprays early in season.
				Powdery mildew	I	
				Rust diseases	A	
				Flyspeck/sooty blotch	A	
cyprodinil (Vanguard)	Pyrimidine fungicide	9	RR	Apple scab	A ^P	Poor control after bloom. Works best when temperatures are cold. Does not control any other diseases, but may prevent blossom end rot (<i>Botrytis</i>)
dodine (Cyprex)	Aliphatic nitrogen fungicide	M	R	Apple scab	A ^P	Resistance to dodine is present in certain orchard in Ontario and B.C.
fixed copper	Inorganic fungicide	M	R	Fire blight	A ^P	Bacterial inoculum reduction only. Not control. Can cause fruit russetting.
				Blister spot	A ^P	Bacterial inoculum reduction only. Not control. Can cause fruit russetting.
flusilazole (Nustar)	Conazole fungicide	3	R	Apple scab	A	Resistance has been documented in Québec.
				Powdery mildew	A	
fosetyl-aluminum (Aliette)	Organophosphorous fungicide	Unknown	R	Pythophthora	A ^P	
				Blister spot	A ^P	More Effective under low disease pressure.
kresoxim-methyl (Sovran)	Strobilurin fungicide	11	R	Apple scab	A	Resistance has been documented in Québec.
				Powdery mildew	A	

Control product (active ingredient / organism) ¹	Classification ²	Mode of action – resistance group ³	PMRA status of active ingredient ⁴	Pests or group of pests targeted	Performance of product according to recommended use ⁵	Notes
mancozeb (Manzate, Dithane)	Dithiocarbamate fungicide	M	R	Apple scab	A ^P	Harsh on some predatory mites.
				Powdery mildew	I	
				Rust diseases	A ^P	
metalaxyl-M (Ridomil)	Acylamino acid fungicide	4	R	Pythophthora	A ^P	
metiram (Polyram)	Dithiocarbamate fungicide	M	R	Apple scab	A ^P	Harsh on some predatory mites.
				Powdery mildew	I	
				Rust diseases	A ^P	
myclobutanil (Nova)	Conazole fungicide	3	R	Apple scab	A	Weak on fruit scab control. Resistance has been documented in Québec.
				Powdery mildew	A	
				Rust diseases	A	
streptomycin	Bactericide	18		Fire blight	A ^P	Label restricts sprays to blossom infection timing only.
sulphur (Kumulus)	Inorganic fungicide	M	RE	Powdery mildew	A	Multiple applications required. Toxic to predatory mites.
				Apple scab	A ^P	Repeated applications after each rain event required. Toxic to predatory mites. Only fungicide available to organic growers.

Control product (active ingredient / organism) ¹	Classification ²	Mode of action – resistance group ³	PMRA status of active ingredient ⁴	Pests or group of pests targeted	Performance of product according to recommended use ⁵	Notes
thiabendazole (Mertect)	Thiazole fungicide	1	R	Blue mould	A	Export restrictions may apply.
				Grey mould	A	Export restrictions may apply.
thiophanatae-methyl (Senator)	Carbamate (benzimidazole precursor) fungicide	1	R	Apple scab	A ^P	Resistance has been documented in several areas.
				Powdery mildew	A ^P	Resistance has been documented in several areas.
trifloxystrobin (Flint)	Strobilurin fungicide	11	RR	Apple scab	A	
				Powdery mildew	A	

¹ Common trade name(s), if provided in brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.

² Chemical classification according to “The Compendium of Pesticide Common Names”, see http://www.hclrss.demon.co.uk/class_pesticides.html

³ The mode of action group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action

⁴ R-full registration (non-reduced risk), RE-under re-evaluation (coloured in yellow), DI-discontinued (coloured in red), BI-biological, RR-reduced risk (coloured in green), OP-organophosphate replacement, NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: <http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp>

⁵ A – Adequate (coloured in green) (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^P – Provisionally Adequate (coloured in yellow) (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (coloured in red) (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control)

Source(s): Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec; NB Department of Agriculture, Fisheries and Aquaculture; BC Ministry of Agriculture, Food & Fisheries; AgraPoint International Inc.; Ontario Ministry of Agriculture and Food; Pest Management Regulatory Agency

Table 4. Availability and use of disease pest management approaches for Canadian apple production

	Practice \ Pest	apple scab	fire blight	storage diseases
Prevention	tillage			
	residue removal / management	available/used		available/used
	water management			
	equipment sanitation			available/used
	row spacing / seeding depth			
	removal of alternative hosts (weeds/volunteers)	available/used		
	mowing / mulching / flaming	available/used		
Avoidance	resistant varieties	available/used	available/used	
	planting / harvest date adjustment			available/used
	crop rotation			
	trap crops - perimeter spraying			
	use of disease-free seed			
	optimizing fertilization			
	reducing mechanical damage / insect damage		available/used	available/used
	thinning / pruning	available/used	available/used	
Monitoring	scouting - trapping	available/used		
	records to track pests			
	field mapping of weeds			
	soil analysis			
	weather monitoring for disease forecasting	available/used	available/used	
	grading out infected produce			available/used
Suppression	use of thresholds for application decisions	available/used		
	biological pesticides			
	pheromones			
	sterile mating technique			
	beneficial organisms & habitat management			
	pesticide rotation for resistance management	available/used		
	ground cover / physical barriers			
	controlled atmosphere storage			available/used
	forecasting for applications	available/used	available/used	

no information regarding the practice is available
available/used
available/not used
not available
Source(s): Information in the crop profile for individual pests

Insects and Mites

Key Issues

- There is concern over the further restriction and possible registration loss of organophosphate insecticides, as the number and reliability of registered alternatives is not adequate. Due to the broad spectrum nature of organophosphate insecticides, development of resistance within the pest population is less likely to occur than with some other chemistries. They are important for use in rotation with insecticides with more specific targets. In addition, there are a number of pests that are currently only controlled by organophosphates, making the need for the development and registration of reduced risk alternatives to organophosphate insecticides that have similar efficacy levels critical.
- There is concern over the increasing number of insecticide/acaricide applications needed to control pests. This increase is due to the replacement of wide spectrum products by selective tools and the increasing number of imported pests resulting from the globalization of commercial trade and climate changes.
- There is concern over the increasing economic damage from the codling moth, obliquebanded leafroller and other species.
- There is a need to develop economic thresholds and improve existing degree-day models for predicting life stages for pests, such as the tarnished plant bug, mullein bug and plum curculio, in order to better time pesticide applications.
- There is a lack of testing capability for pesticide resistance.
- There is concern over increased problems with the two-spotted spider mite in the east.
- Plans are needed for controlling new and emerging pests, such as the oriental fruit moth.
- Although products have been developed, there are not enough effective products registered that are considered reduced risk and able to be used in IPM programs.
- There is concern over the repeated annual use of newer chemistries, such as neonicotinoid products, which can result in phytophagous mite population flare-ups.
- There is a need for research on augmenting and conserving native predatory mite populations and to identify and understand the biology of native biocontrol agents, such as leafrollers.
- There is a need to coordinate the registration of new products in Canada with other countries that purchase Canadian apples, ensuring no conflict with MRL's.
- There is a need for effective management strategies for lepidopterous pests, including codling moth, leafrollers, winter moth and Oriental fruit moth. The development of biological control programs is needed.
- There is a need for more research and development of more efficient and affordable sprayers that are specifically designed for use in high density plantings.

Table 5. Degree of occurrence of insect pests in Canadian apple production

Major pests	Degree of occurrence					
	BC	ON	QC	NB	PE	NS
Codling moth	E	E	E	E	E	E
Apple maggot		E	E	E	E	E
Plum curculio		E	E	E	E	E
Obliquebanded Leafroller; threelined leafroller	E	E	E	E	E	E
Oriental fruit moth		E				
Minor Pests	BC	ON	QC	NB	PE	NS
Springfeeding caterpillars	E	E	E	E	E	E
Winter moth				E	E	E
Mullein bug (Campylomma)	E	E	E	E	E	E
Stinging bug complex (tarnished plant bug, apple red bug, green apple bug, stink bug)	E	E	E	E	E	E
Tentiform leaf miner	E	E	E	E	E	E
European apple sawfly		E	E	E	E	E
White apple leafhopper	E	E	E	E	E	E
Potato leafhopper		E	E	E		
Woolly apple aphid	E	E	E	E	E	E
Green apple aphid	E	E	E	E	E	E
Rosy apple aphid	E	E	E	E	E	E
Scale insects (San Jose, lecanium, oystershell, fruit)	E	E	E	E	E	E
European red mite	E	E	E	E	E	E
Two-spotted spider mite & McDaniel spider mite (B.C. only)	E	E	E	E	E	E
Apple rust mite	E	E	E	E	E	E
Dogwood borer		E	E	E		
Wood-boring beetles (Ambrosia, shothole)	E					

Widespread yearly occurrence with high pest pressure
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure
Widespread yearly occurrence with low to moderate pest pressure
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure
Pest not present
E – established
D – invasion expected or dispersing

Source(s): Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec; NB Department of Agriculture, Fisheries and Aquaculture; BC Ministry of Agriculture, Food & Fisheries; B.C. Crop Profile for Apple; AgraPoint International Inc.; Ontario Ministry of Agriculture and Food

Major Insects and Mites

Codling Moth (*Cydia pomonella*)

Pest Information

Damage: Stings, caused by the first instar larvae as they enter the fruit, are shallow excavated areas below the skin surface. Deep entries are caused as larvae continue to tunnel through the flesh. The injury causes internal breakdown of the fruit, often leading to premature drop.

There is a potential for up to 100% fruit loss, but yield losses have never exceeded 60% in unsprayed orchards in Quebec..

Life Cycle: There are 1 or 2 generations per year in Canada.

Pest Management

Chemical Controls: Organophosphates have been the main chemical control method. Recently, the registration of tebufenozide and acetamiprid have provided additional options for apple growers, but these chemicals can only be used on the first summer generation in Eastern Canada. Subsequent sprays are generally organophosphates, which also control apple maggot. Summer perimeter sprays have been used successfully in Ontario, significantly reducing pesticide load.

Cultural Controls: Alternate hosts in the vicinity of the orchard should be removed if possible.

Alternative Controls: Degree day modelling is used to help time pesticide applications. There are some wasps that parasitize codling moth eggs and larvae, but they do not provide economical control. Isomate C Plus, a pheromone registered for use on codling moth in Canada, has had some success. Several factors, including the cost, the presence of other pests that still must be controlled by other means and the presence of wild hosts and backyard apple trees, have limited the adoption of mating disruption techniques. In B.C., there is limited use of this technique. Sterile Mating Technique (SIR) has been used in the Okanogan Valley of B.C. in an attempt to reduce the abundance of this pest in orchards to sub-economic levels. Although expensive, the program is working, especially when used in combination with limited insecticide use and mating disruption.

Cultivar Susceptibility: No resistant cultivars

Issues for Codling Moth

1. Although not confirmed in Canada, there is concern over the development of resistance to organophosphates by the codling moth in other countries.
2. There is concern over the long term sustainability of the area-wide codling moth management program being conducted in B.C., as funding is available only until 2005.
3. There is a need for provincial legislation to make the removal of abandoned orchards mandatory. Abandoned orchards are breeding areas for codling moth and negatively impact commercial orchards.

Apple Maggot (*Rhagoletis pomonella*)

Pest Information

Damage: Fruit is damaged by tunnelling of the fly larva inside the fruit. As the larva grows, the tunnels become larger and begin to discolour. Up to 100% yield loss is possible. The insect is a quarantined pest due to import restrictions in some countries.

Life Cycle: The pupa of the insect overwinters in the soil and may remain dormant for several years until appropriate conditions occur.

Pest Management

Chemical Controls: Organophosphate sprays are initiated with the first fly captured and then maintained throughout the summer. In the Maritimes, dimethoate is also used to control the pest.

Cultural Controls: The removal of alternate hosts in the vicinity of the orchard is recommended but not always possible or environmentally responsible.

Alternative Controls: Adult flies are monitored using board or sphere sticky traps with apple volatiles as attractants. Economic thresholds are generally very low. Orchard inspections are conducted by professional inspectors in most provinces. Some work was done in the 1980's to introduce a pupal parasite, but the project had limited success and was never commercially released. Kaolin clay has been shown to be an effective non-chemical means of control.

Cultivar Susceptibility: No resistant cultivars

Issues for Apple Maggot

1. The loss of organophosphates for the control of the apple maggot would result in major crop losses. Reduced risk alternatives must be sought and registered to replace older insecticides.
2. Legislation is required in most provinces to make mandatory the removal of abandoned orchards, removing breeding areas for apple maggot.

Plum Curculio (*Conotrachelus nenuphar*)

Pest Information

Damage: Adult beetles feed on leaves and flowers in the spring. Females make small crescent shaped scars on fruit into which they lay their eggs. The summer generation feeds on fruit, excavating small holes and feeding on the pulp. The feeding punctures are also an entry site for decay organisms. Yield losses as high as 97% have been recorded in Quebec.

Life Cycle: The pest has one generation per year. Adults overwinter in or near orchards and reappear the following spring to complete their development.

Pest Management

Chemical Controls: Organophosphate (OP) insecticides, timed for the first sign of plum curculio activity, are commonly used. Azinphos-methyl seems to provide superior control as compared to the other OP's, but phosmet and phosalone have also been used successfully.

Cultural Controls: None

Alternative Controls: Monitoring is difficult and relies on visual observation of fruit damage along orchard perimeters and on nearby alternate hosts. New cone traps are being tested as monitoring tools. Border spraying, to prevent movement of the pest into orchards from surrounding hedgerows and woodlots, has been used successfully in Ontario. In Ontario and

N.S., kaolin clay has worked well when used from petal fall until late June to limit fruit injury from the pest.

Cultivar Susceptibility: No resistant cultivars

Issues for Plum Curculio

1. There are no registered effective alternatives to organophosphates.
2. Improved monitoring tools are needed to more accurately determine first spring activity.
3. There is a need for the development of good thresholds for this pest.

Obliquebanded Leafroller (*Choristoneura rosaceana*)

Pest Information

Damage: Feeding on buds, leaves and flowers by larvae rarely results in economic injury.

Feeding on fruitlets, resulting in deep gouges in the small apples, is of concern. Fruit that does not abort and drop have large russeted indentations and corky scars, indistinguishable from damage caused by other spring feeding caterpillars. Summer feeding on terminal shoots is only a concern in nursery stock and young non bearing plants. Summer generation fruit damage includes tiny circular excavations on the fruit surface and more extensive shallow feeding resembling railroading. The small feeding holes allow entry of rot pathogens, downgrading fruit during long-term storage.

Life Cycle:

Pest Management

Chemical Controls: Early season pyrethroids or organophosphates (OP) are effective on susceptible populations. OP-resistant populations require more accurate timing of pesticides. *Bacillus thuringiensis*, tebufenozide and spinosad have been used in Ontario with varying levels of success. In B.C., growers target the spring generation with these products to reduce the need for control of summer generations. In Ontario and B.C., OP resistant populations are also cross resistant to tebufenozide.

Cultural Controls: Avoiding lush vegetative growth by avoiding over fertilization with nitrogen may make trees less attractive to larvae. Thinning fruit to singles and summer pruning where practical, can greatly reduce fruit damage by eliminating a favoured feeding site of summer generation larvae.

Alternative Controls: In Ontario and Quebec, research and demonstration trials have been conducted with pheromones and granulosis virus, but with limited success. Pesticide applications are timed with the help of pheromone trap monitoring and degree-day modelling. Some wasps parasitize the eggs and larvae of the pest, but control is not economically significant. There are several naturally occurring viruses that impact populations in some years, but they cannot be counted on for control.

Cultivar Susceptibility: The pest seems to have a preference to feed on certain cultivars.

Issues for Obliquebanded Leafroller

1. There is a lack of pesticides to adequately manage the pest.
2. Development of resistance to tebufenozide limits options.
3. There is concern that resistance is developing to spinosad.
4. More research is required into mating disruption, native biocontrol agents and the development of reduced risk pesticides.

Oriental Fruit Moth (*Grapholitha molesta*)

Pest Information

Damage: Larvae tunnel into both terminals and fruit. Terminal infestations are detectable to the experienced eye. Late season fruit injury is particularly important, as the small stings are often not detected during harvesting operations or in packing lines. Yield losses can reach 70%.

Life Cycle: There are 3 generations per year and in some years a partial fourth.

Pest Management

Chemical Controls: Organophosphate resistance is widespread in southern Ontario. Minor use label expansions for deltamethrin and acetamiprid have helped manage outbreaks, but neither material is considered IPM friendly.

Cultural Controls: None

Alternative Controls: The pheromone isomate M-100 has been used effectively as a mating disruption tool on orchards greater than 10 acres.

Cultivar Susceptibility: No resistant cultivars

Issues for Oriental Fruit Moth

1. Organophosphate resistance in Ontario has resulted in the pest becoming a major concern.
2. Alternative pesticides are severely limited and those registered are not IPM compatible.
3. In areas where both apples and peaches are grown, management strategies must be developed in conjunction with both crops.

Minor Insects and Mites

Spring-Feeding Caterpillar Complex

Pest Information

Includes the green fruitworm (*Lithophane georgii*), speckled green fruitworm (*Orthosia hibisci*), brown fruitworm (*Eupsilia tristigmata*), eye spotted budmoth (*Spilonota ocellana*), fruit-tree leafroller (*Archips argyrospila*), European leafroller (*Archips rosans*), threelined leafroller (*Pandemis limitata*) and others.

Damage: Caterpillars feed on young developing leaves and bore into buds early in the spring. Some larvae (not all species) web and roll terminal leaves, where they hide when not feeding. Leaf feeding, when severe, can reduce photosynthetic activity. Early season feeding results in large corky scars and indentations on the fruit, which often drop prematurely. Downgrading of apples to juice quality is common with moderate summer feeding of some species.

Life Cycle: The life cycles differ between species.

Pest Management

Chemical Controls: In Ontario, Quebec and the Maritimes, pre-bloom and petal-fall applications of organophosphates or pyrethroids are effective at controlling spring feeding caterpillars. There is limited use of *Bacillus thuringiensis* and tebufenozide, but they do not control other early season pests. In B.C., growers apply either *B. thuringiensis* or tebufenozide during bloom and again at petal fall, or spinosad at petal fall as part of a resistance management

program. Organophosphate resistant populations of fruittree leafroller in B.C. are also cross-resistant to tebufenozide.

Cultural Controls: None

Alternative Controls: Monitoring involves the visual observation of feeding activity on terminal growth and flower petals. Economic thresholds exist in some provinces. Pheromone traps are available, but no relationship exists between moth abundance and potential fruit damage.

There is limited use of *Bacillus thuringiensis* as a biocontrol.

Cultivar Susceptibility: No resistant cultivars

Issues for Spring-Feeding Caterpillar Complex

1. In some years, species can attain major pest status, requiring the application of additional pesticides for their control.
2. Because of resistance developing to certain chemicals, additional pesticide applications are sometimes needed.
3. The registration of a new chemistry is required to improve resistance management options and prolong the useful life of existing active ingredients.

Mullein Bug (*Campylomma verbasci*)

Pest Information

Damage: Feeding on fruit during bloom to petal fall results in small, raised bumps on the fruit surface. Fruit are often stung many times and most of these abort around June drop. Affected fruit that remains on the tree develops small corky warts surrounded by depressions. Distortion often occurs as the fruit sizes over the summer.

Life Cycle: Mullein bugs are only considered pests early in the growing season, they are beneficial after petal fall, as predators of aphids, mites, thrips, leafrollers and pear psylla. There are two generations per year in Quebec.

Pest Management

Chemical Controls: Registered effective products include diazinon and imadacloprid. There have been failures of imadacloprid. Pyrethroids and organophosphates do not always provide effective control in Ontario.

Cultural Controls: None

Alternative Controls: Monitoring is done using trapping boards and economic thresholds are used based on the numbers of insects per specific number of taps, using a beating tray. Normally, only susceptible cultivars are monitored and treated for the pest.

Cultivar Susceptibility: The cultivar Red Delicious is most susceptible, with other cultivars such as Northern Spy, Empire, Cortland, Gala, Jonagold, Golden Delicious, McIntosh and Spartan also being susceptible.

Issues for Mullein Bug

1. There is a lack of effective IPM compatible alternatives to diazinon.

Stinging Bug Complex (including the tarnished plant bug)

Pest Information

Includes the tarnished plant bug (*Lygus lineolaris*), apple brown bug (*Atractomus mali*), green apple bug (*Lygocoris cummunis*) and apple red bug (*Lygidae mendax*).

Damage: Stinging bugs suck juices from plant tissue. Toxins are released into the fruit, blossom and leaf axil during their feeding. The toxin kills cells in the immediate vicinity of the wound, resulting in some deformation in the fruit as it continues to grow. Fruit stung up to and including petal fall often aborts during June drop. Fruit stung after petal fall often remains on the tree into the harvest period.

Life Cycle:

Pest Management

Chemical Controls: Registered insecticides for the tarnished plant bug include dimethoate, endosulfan and formetanate HCl. Malathion is registered for use on a number of stinging bug species.

Cultural Controls: None

Alternative Controls: There are no reliable monitoring techniques for most plant bugs. Some provinces have used sticky traps and thresholds have been established in the Eastern U.S. The Maritime Provinces use a tapping tray to monitor populations and an economic threshold of 8 bugs per 25 taps. In Quebec, sticky traps and visual examination of developing buds are used in association with thresholds.

Cultivar Susceptibility: No resistant cultivars

Issues for Stinging Bug Complex

1. Most of the more recently registered, reduced risk pesticides do not control plant bugs or are not registered for use against this pest.
2. There is a concern over the increase in recent years of early season damage in some areas.
3. The poorly defined monitoring strategies and the lack of good economic thresholds for tarnish plant bugs is limiting the use of IPM.

Winter Moth (*Operpthera brumata*)

Pest Information

Damage: Larvae feed on bud clusters, leaves and fruit. In severe cases, trees can be heavily defoliated, causing weakened trees and increased susceptibility to winter injury.

Life Cycle: There is 1 generation per year

Pest Management

Chemical Controls: Registered products include cypermethrin, phosmet, phosalone, *Bacillus thuringiensis* and tebufenozide.

Cultural Controls: None

Alternative Controls: A sequential sampling technique, consisting of bud evaluation for presence of larvae in early spring has been developed in Nova Scotia.

Cultivar Susceptibility: No resistant cultivars

Issues for Winter Moth

None Identified

Spotted Tentiform Leafminer (*Phyllonorycter blancardella* and *P. mispilella*)

Pest Information

Damage: Larvae mine between the leaf layers causing visible holes on the surface.

Life Cycle:

Pest Management

Chemical Controls: Pyrethroids (deltamethrin, cypermethrin, lambda cyhalothrin), dimethoate, endosulfan and carbaryl are registered but considered incompatible with IPM programs.

Abamectin, acetamiprid, imidacloprid and tebufenozide are sustainable alternatives.

Cultural Controls: Mulching leaves and applying urea to fallen leaves in late fall to enhance decomposition, may reduce overwintering numbers.

Alternative Controls: . The parasitoid *Pholetesor ornigis*, a tiny Braconid wasp, and several species of chalcid wasps are important for the control of populations in eastern Canada. In B.C., *Pnigalio flavipes* is the primary natural enemy of leafminers. Judicious use of pesticides allows these natural enemies to provide good levels of biological control of leafminers.

Cultivar Susceptibility: The cultivar McIntosh is particularly susceptible.

Issues for Spotted Tentiform Leafminer

None identified

European Apple Sawfly (*Hoplocampa testudinea*)

Pest Information

Damage: Larvae feed just under the skin of fruitlets, causing heavily russeted, winding, ribbon-like scars that spiral out from the calyx end. As the larvae feed internally, they enlarge an exit hole with wet, reddish-brown frass on the side of the fruit. The larvae may move to other fruit in the cluster to continue feeding. Damaged fruit may abort during the June drop period.

Life Cycle:

Pest Management

Chemical Controls: Only azinphos-methyl is registered to control this pest.

Cultural Controls: None

Alternative Controls: Monitoring is done using white sticky traps. A parasitic wasp has been released in Quebec and Ontario orchards with some success.

Cultivar Susceptibility: No resistant cultivars

Issues for European Apple Sawfly

1. There is concern that there are no registered alternatives to azinphos-methyl, an organophosphate under registration re-evaluation.
2. There is a need for more work on establishing biological control agents in orchards.

White Apple Leafhopper (*Typhlocyba pomaria*)

Pest Information

Damage: Both nymphs and adults have sucking mouthparts that they insert into plant cells to remove the contents. Feeding reduces photosynthetic area and fruit size, color, maturity and the hardiness of the tree. As the insect feeds, it deposits excrement on the fruit which dries into dark brown spots making fruit unacceptable for fresh market sales, especially on cultivars with light coloured skin. The insects may also act as vectors of bacterial diseases, such as fire blight.

Life Cycle:

Pest Management

Chemical Controls: Registered products include endosulfan, pirimicarb, carbaryl, dimethoate, acetamiprid, imidacloprid, formetanate HCl and pyrethroids. Organophosphates are ineffective.

Cultural Controls: None

Alternative Controls: Monitoring is used and economic thresholds have been established in most provinces.

Cultivar Susceptibility: No resistant cultivars

Issues for White Apple Leafhopper

1. There is concern over the potential for this insect to be a vector of fire blight.
2. The use of carbaryl or pyrethroids has the negative effect of eliminating predatory mite populations.

Potato Leafhopper (*Empoasca fabae*)

Pest Information

Damage: Adults and nymphs feed by sucking plant juices from leaves. Toxins are injected into the plant while they feed, blocking the vascular system. Feeding reduces vigour of the plant and prevents the normal movement of water and nutrients to the affected areas of the plant. Leaves turn pale green, curl downward at the margins and eventually turn brittle and brown.

Life Cycle: The pest does not overwinter in Canada. It is carried by wind currents from the southern gulf states across the Great Lakes and into eastern provinces. The first adults arrive as early as mid-May and continue to arrive well into June. The pest moves into apple after the first local cuts of hay, where they initially feed.

Pest Management

Chemical Controls: Most orchard insecticides are effective at managing this pest.

Cultural Controls: None

Alternative Controls: Monitoring includes visual observation for visible damage. There are no spray thresholds established.

Cultivar Susceptibility: No resistant cultivars

Issues for Potato Leafhopper

1. There is a potential for the insect to be a vector of fire blight.
2. The pest can cause significant damage to nursery trees and young, non-bearing trees in a short period of time.

Green Apple Aphid (*Aphis pomi*)

Pest Information

Damage: Insects suck sap from leaves on water sprouts and succulent terminal growth. Heavy infestations can reduce vigour and growth of shoots. Feeding can reduce bud size and internode length, cause leaf curling, and stimulate lateral branch growth that can affect tree shape, making the tree more susceptible to winter injury. Honeydew, produced by the aphids,

may drip onto fruit, allowing sooty fungi to grow which cause blemishes on fruit. Heavy infestations can result in feeding on immature fruit, causing russetting.

Life Cycle:

Pest Management

Chemical Controls: Insecticides may only be necessary on nursery and young non-bearing trees if populations of aphids are very high. Treatment of established bearing trees is rarely necessary. When necessary, the insecticides pirimicarb, imidacloprid, acetamiprid, carbaryl, endosulfan and dimethoate are all effective, with the first three being considered IPM compatible.

Cultural Controls: Over fertilization with nitrogen should be avoided to prevent excessive terminal growth, as this attracts aphids. Annual leaf analyses should be done to better manage nitrogen levels. Summer pruning should be avoided until terminal buds have set to prevent shoot regrowth.

Alternative Controls: Monitoring is done by examining terminal growth for aphid colonies. Economic thresholds do exist in some provinces and are based on the percent of terminals infested. Many predators help to suppress populations of the pest during the early stages of infestation.

Cultivar Susceptibility: No resistant cultivars

Issues for Green Apple Aphid

None Identified

Rosy Apple Aphid (*Dysaphis plantaginea*)

Pest Information

Damage Caused: This pest is the most economically important aphid pest of apple in Canada.

Feeding on apple foliage, the pest causes leaf chlorosis and curling. Feeding indirectly stunts and deforms fruits in the cluster.

Life Cycle:

Pest Management

Chemical Controls: Effective insecticides include pirimicarb, imidacloprid, acetamiprid, carbaryl, endosulfan and dimethoate. The first three are considered to be IPM compatible. When leaves have curled, spray coverage is more difficult.

Cultural Controls: The techniques used for the green apple aphid are used for the rosy apple aphid as well.

Alternative Controls: The techniques used for the green apple aphid are used for the rosy apple aphid as well.

Cultivar Susceptibility: No resistant cultivars

Issues for Rosy Apple Aphid

1. There is a need for alternative reduced risk pesticides.

Woolly Apple Aphid (*Eriosoma lanigerum*)

Pest Information

Damage: Feeding by the pest results in knots and galls on twigs and roots. Areas damaged are more prone to frost and winter injury. Root injury is found mainly in the warmer climate of B.C. Feeding can take place on healing tissues from pruning cuts, where there has been mechanical injury to the wood or canker. Honeydew is also excreted by the aphids which drips on leaves and fruit causing russet spots and promoting the establishment of sooty fungi. Fruit quality is downgraded and harvesting is a nuisance as fruit are sticky and stain clothing on contact.

Life Cycle: The aphid's waxy covering provides protection against predators and pesticide sprays.

Pest Management

Chemical Controls: Sprays of phosalone, endosulfan, pirimicarb and malathion can help control populations. Later summer pesticide use is discouraged, as treatments are ineffective due to the waxy shell of this species.

Cultural Controls: Removing suckers at the base of the tree trunk eliminates favoured establishment sites. Pruning can be done in August to remove larger colonies. Large pruning cuts should be painted with commercial pruning paint.

Alternative Controls: Monitoring is accomplished by visual observation of waxy coverings around pruning cuts and water sprouts in the spring and in leaf axils and growing shoots in mid to late summer. No economic thresholds exist.

Cultivar Susceptibility:

Issues for Woolly Apple Aphid

1. The pest is very difficult to control if it becomes established.
2. There are no chemical alternatives for controlling this pest. In warmer climates, below ground root infestations can cause severe tree stress.
3. The pest may become more of a problem as Canadian winters become more moderate.

Scale Insects

Pest Information

Includes the European fruit scale (*Quadraspidotus ostreaeformis*), oyster-shell scale (*Lepidosaphes ulmi*) and San Jose scale (*Quadraspidiotus perniciosus*).

Damage: Heavy infestations, particularly in young trees, can severely reduce vigour and even cause death to entire limbs. More common and economically significant is injury to fruit by feeding. Red blotches with a lighter center, most often near the calyx end of the fruit, result from the insects feeding. Fruit with more than two blotches are graded out by some packers, while others accept no fruit damage, especially when apples are destined for export markets.

Life Cycle: Scale insects overwinter under rough bark.

Pest Management

Chemical Controls:

Cultural Controls: New orchards must be planted away from hardwood stands and from older plantings where scale has been a problem. Nursery stock must be free from scale infestations.

Alternative Controls: Spring application of petroleum oil prior to bud break can be effective.

High water volumes are needed to achieve thorough coverage to reach insects overwintering beneath the bark. The oil kills by covering the insect and excluding air. Later in the growing season, it is difficult to control these insects due to the formation of their waxy impervious shell. Monitoring, other than simple visual observation, is rarely done.

Cultivar Susceptibility: The introduction of dwarfing rootstocks has reduced the seriousness of these pest.

Issues for Scale Insects

1. The efficacy of chemical pesticides is variable during the growing season, once scale shells are hardened.
2. There is a need for effective reduced risk alternatives for control of occasional flare-ups.

European Red Mite (*Panonychus ulmi*), Two-Spotted Spider Mite (*Tetranychus urticae*) and Apple Rust Mite (*Aculus schlechtendali*)

Pest Information

Damage Caused: The European red mite is considered to be the most important mite pest affecting Canadian orchards. The mites cause characteristic bronzing of leaves as they feed on the underside. The result is reduced photosynthesis and a reduction in nitrogen content of the leaves. Prolonged feeding causes tree stress, leading to a reduction in shoot growth and fruit bud set in following years. In addition, fruit colour, soluble solids, firmness, size and weight of the fruit are also affected.

Life Cycle: The European red mite overwinters in the egg stage on tree bark and in crevices. There are 5 to 8 generations per year, with population explosions occurring under hot, humid conditions.

Pest Management

Chemical Controls: Dormant oil is used as a first strategy for controlling the European red mite. Early season miticides include clofentezine and abamectin. Summer miticides include pyridaben and formetanate HCl. Formetanate HCl is considered highly toxic to predatory mites and is generally avoided in IPM programs. Spray coverage is very important and increased water volumes are usually used for miticide applications. Use of the miticides listed are recommended for only one application per year.

Cultural Controls: Judicious use of nitrogen fertilizers and a balanced nutrition program prevents excessive growth, making trees less attractive to mites. Maintaining an open canopy with regular dormant and summer pruning allows better spray coverage.

Alternative Controls: There are well established monitoring methods and economic thresholds in place. There are several species of predatory mites and insects that are very important in providing natural biological control of pest mite species. In demonstration trials, artificial rearing and release programs have had some success. The preferred method of pest mite control is enabling the build-up of predatory mite populations in orchards by reducing the use of toxic pesticides and maintaining good IPM programs.

Cultivar Susceptibility: No resistant cultivars

Issues for Mites

1. Miticide resistance is a major concern. Although there are only a handful of reported cases of clofentezine resistance in Canada, the limited number of available miticides does not allow

for sufficient rotation. Other than pyridaben, there are no other summer miticides registered for use.

2. Two-spotted spider mite outbreaks have become more common in the last 5 years in Ontario, Quebec and the Maritimes.
3. There is a need for more research on the biology, behaviour and habitat management of predatory mites so that populations can be built-up and encouraged.

Dogwood Borer (*Synanthedon scitula*)

Pest Information

In addition to the dogwood borer, the round headed borer, shot hole borer and European fruit tree borer can also be a problem.

Damage Caused: Larvae bore into burr knots of adventitious roots just below the graft union.

Feeding begins in the outer area of the burr knot and then progresses into healthy bark and eventually the cambium. A slow decline in yields over several years of the infestation will be noticed. With heavy infestations, trees are weakened to the point that they may be killed.

Life Cycle: Shade and high humidity encourage burr knot formation.

Pest Management

Chemical Controls: The only registered chemical is deltamethrin, used as a trunk spray.

Cultural Controls: Weeds should be controlled around the trunk and mulching should not be done around the base of the tree. Wire mesh mouse guards can be used around tree trunks.

Brushing on undiluted white latex paint to the trunk area each year deters female moths from laying eggs. Thick paint layers may suffocate borers already in the wood. The removal of adjacent wild hosts may be required if borers are a problem near established orchards.

Alternative Controls: There are no established monitoring methods, but visual observation of trunk areas can reveal cast pupal skins. In Ontario, demonstrations of pheromone disruption technologies have been successful, but no product has been registered.

Cultivar Susceptibility: Rootstocks particularly susceptible to burr knot formation include M.9, M.26 and Mark.

Issues for Dogwood Borer

1. There is a lack of registered materials for control.
2. Although mating disruption has been effective in Ontario, there is still no Canadian registration for the technology.

Table 6. Insect control products, classification and performance for Canadian apple production

Control product (active ingredient / organism) ¹	Classification ²	Mode of action – resistance group ³	PMRA status of active ingredient ⁴	Pests or group of pests targeted	Performance of product according to recommended use ⁵	Notes
abamectin (Agri-Mek)	Avermectin insecticide (antibiotic)	6		Mites	A	Concerns over resistance developing.
				Tentiform leafminer	A	
acetamiprid (Assail)	Pyridylmethylamine insecticide	4A	RR/OP	Codling moth	A	
				Oriental fruit moth	A	
				Aphids	A	
				Leafhoppers	A	
azinphos-methyl (Guthion, APM, Sniper)	Benzotriazine organothio-phosphate insecticide	1B	RE	Codling moth	A ^P	Product exhibits high human toxicity.
				Plum curculio	A ^P	
				Apple maggot	A ^P	
				Spring-feeding caterpillars/leafrollers	A ^P	Leafroller resistance documented in B.C. and Ontario
<i>Bacillus thuringiensis</i> var. <i>kurstaki</i> (Dipel, Foray)	Microbial insecticide	11	BI	Spring-feeding caterpillars	A	Application timing and spray water pH extremely important to get good control.
				Leafrollers	A	
				Obliquebanded leafroller	A	
carbaryl (Sevin)	Carbamate insecticide	1A	RE	Leafhoppers	A ^P	Product harsh on beneficials, disruptive to IPM programs. Important chemical thinner.
clofentezine (Apollo)	Mite growth regulator	10	R	Mites	A	Concerns over resistance developing.
cyhalothrin lambda (Matador)	Pyrethroid ester insecticide	3	R	Tentiform leafminer	A ^P	Pyrethroids harsh on beneficials and flare phytophagous mite populations.
				Stinging bugs	A ^P	
				Leafrollers	A ^P	
cypermethrin (Cymbush, Ripcord)	Pyrethroid ester insecticide	3	R	Tentiform leafminer	A ^P	Pyrethroids harsh on beneficials and flare phytophagous mite populations.
				Stinging bugs	A ^P	

Control product (active ingredient / organism) ¹	Classification ²	Mode of action – resistance group ³	PMRA status of active ingredient ⁴	Pests or group of pests targeted	Performance of product according to recommended use ⁵	Notes
deltamethrin (Decis)	Pyrethroid ester insecticide	3	R	Tentiform leafminer	A ^P	Pyrethroids harsh on beneficials and flare phytophagous mite populations.
				Stinging bugs	A ^P	
				Oriental fruit moth	A ^P	
				Dogwood borer	A ^P	Applied as trunk spray with oil. No alternatives registered.
diazinon	Pyrimidine organothio-phosphate insecticide	1B	RE	Mullein bug	A	Primary material to control this pest.
				Scale insects	A ^P	Short-lasting.
				Aphids	I	Aphids are resistant to OP's.
dimethoate (Cygon, Lagon)	Aliphatic amide organothio-phosphate insecticide	1B	R	Aphids	A ^P	Product harsh on beneficials, disruptive to IPM programs.
				Leafhoppers	A ^P	
				Apple maggot	A ^P	
endosulfan (Thiodan)	Cyclodiene insecticide	2A	RE	Aphids	A ^P	Harsh on beneficials. Export restrictions.
				Leafhoppers	A ^P	
formetanate HCL (Carzol)	Formamidine insecticide	1A	RE	Mites	A ^P	Harsh on beneficials, short lasting effect, disruptive to IPM programs.
imidacloprid (Admire)	Nitroguanidine insecticide	4A	R	Tentiform leafminer	A	Most effective with low to moderate pressure.
				Aphids	A	
				Mullein bug	A ^P	Variable performance on this pest.
				Leafhoppers	A	
Isomate M-100/Isomate Rosso (pheromone dispensers)	Pheromone	N/A		Oriental fruit moth	A	Requires minimum 10 acre, square or rectangular orchards to be effective.

Control product (active ingredient / organism) ¹	Classification ²	Mode of action – resistance group ³	PMRA status of active ingredient ⁴	Pests or group of pests targeted	Performance of product according to recommended use ⁵	Notes
Isomate-C-Plus (pheromone dispensers)	Pheromone	N/A	RE	Codling moth	A ^P	Minimum 2 ha block, best under area-wide program. May require 1-2 cover sprays if pressure moderate to high.
Kaolin clay (Surround)	Inorganic insecticide	N/A	R	Plum curculio	A	Excellent control and also useful for organic programs
				Apple maggot	A	Excellent control and also useful for organic programs
				White apple leafhopper	A	Excellent control and also useful for organic programs
malathion	Aliphatic organothio-phosphate insecticide	1B	RE	Aphids	A ^P	
				Codling moth	A ^P	
				Apple maggot	A ^P	
Petroleum oil (Dormant oil)	Inorganic insecticide	N/A	R	Scale insects	A	#1 line of defence
				European red mite	A	#1 line of defence against phytophagous mites.
phosalone (Zolone)	Heterocyclic organothio-phosphate insecticide	1B	RE	Codling moth	A	Product may be harmful to some predatory mite species.
				Plum curculio	A	
				Apple maggot	A	
				Woolly apple aphid	A	
phosmet (Imidan)	Isoindole organothio-phosphate insecticide	1B	RE	Codling moth	A	Product may be harmful to some predatory mite species.
				Plum curculio	A	
				Apple maggot	A	
				Spring-feeding caterpillars	A	
pirimicarb (Pirimor)	Dimethyl-carbamate insecticide	1A	R	Aphids	A ^P	Export restrictions on product, not much used.
				Leafhoppers	A ^P	

Control product (active ingredient / organism) ¹	Classification ²	Mode of action – resistance group ³	PMRA status of active ingredient ⁴	Pests or group of pests targeted	Performance of product according to recommended use ⁵	Notes
pyridaben (Pyramite)	Pyridazinone insecticide / acaricide	21	R	Mites	A	Only summer miticide. Concerns over resistance developing.
spinosad (Success)	Macrocyclic lactone insecticide	5	RR/OP	Obliquebanded leafroller	A	useful for organic programs
				Eye-spotted budmoth	A	useful for organic programs
				Other leafroller spp.	A	useful for organic programs
tebufenozide (Confirm)	Moulting hormone agonist	18	RR	Codling moth	A ^P	During summer months in E. Canada must still apply OP for apple maggot.
				Tentiform leafminer	A	
				Leafrollers	A ^P	Cross-resistance with OP's has been documented in Ontario & B.C.

¹ Common trade name(s), if provided in brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.

² Chemical classification according to “The Compendium of Pesticide Common Names”, see http://www.hclrss.demon.co.uk/class_pesticides.html

³ The mode of action group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action

⁴ R-full registration (non-reduced risk), RE-under re-evaluation (coloured in yellow), DI-discontinued (coloured in red), BI-biological, RR-reduced risk (coloured in green), OP-organophosphate replacement, NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: <http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp>

⁵ A – Adequate (coloured in green) (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^P – Provisionally Adequate (coloured in yellow) (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (coloured in red) (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control)

Source(s): Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec; NB Department of Agriculture, Fisheries and Aquaculture; BC Ministry of Agriculture, Food & Fisheries; AgraPoint International Inc.; Ontario Ministry of Agriculture and Food; Pest Management Regulatory Agency

Table 7. Availability and use of insect pest management approaches for Canadian apple production

	Practice \ Pest	codling moth	apple maggot	plum curculio	obliquebanded leafroller	oriental fruit moth
Prevention	tillage					
	residue removal / management					
	water management					
	equipment sanitation					
	row spacing / seeding depth					
	removal of alternative hosts (weeds/volunteers)					
	mowing / mulching / flaming					
Avoidance	resistant varieties					
	planting / harvest date adjustment					
	crop rotation					
	trap crops - perimeter spraying					
	use of disease-free seed					
	optimizing fertilization					
	reducing mechanical damage / insect damage					
	thinning / pruning					
Monitoring	scouting - trapping					
	records to track pests					
	field mapping of weeds					
	soil analysis					
	weather monitoring for disease forecasting					
	grading out infected produce					
Suppression	use of thresholds for application decisions					
	biological pesticides					
	pheromones					
	sterile mating technique					
	beneficial organisms & habitat management					
	pesticide rotation for resistance management					
	ground cover / physical barriers					
	controlled atmosphere storage					
	forecasting for applications					

no information regarding the practice is available
available/used
available/not used
not available
Source(s): Information in the crop profile for individual pests

Weeds

Key Issues

- There is concern over the development of resistance in some weeds, such as lamb's quarters and pigweed. Resistance monitoring tools are needed.
- Research is required on the critical periods of weed control in apples.
- There is a need for the registration of reduced risk herbicides, especially residual types, that will provide extended control of emerging weeds.
- More research is required to support the development of integrated weed management in apple, including weed surveys, integrated management method testing, long term rotations and predictive models. Innovative methods, such as flaming, mulch applicators, low cost production of mulches and testing of cultivators, need to be investigated further.
- There is a strong need for technical expertise and extension specialists to assist growers with integrated non-herbicidal methods.
- Scouting should focus on identifying when weeds escape.
- Demonstration sites are needed for non-herbicidal weed management practices.
- There is a need for a weed survey to identify a baseline of weeds present, the occurrence of resistance and to monitor changes, as growing technology evolves.

Table 8. Degree of occurrence of weed pests in Canadian apple production

Weed	Degree of occurrence					
	BC	ON	QC	NB	PE	NS
Annual grasses	E	E	E	E	E	E
Annual broadleaf weeds	E	E	E	E	E	E
Perennial grasses	E	E	E	E	E	E
Perennial broadleaf weeds	E	E	E	E	E	E

Widespread yearly occurrence with high pest pressure
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure
Widespread yearly occurrence with low to moderate pest pressure
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure
Pest not present
E – established
D – invasion expected or dispersing

Source(s): Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec; NB Department of Agriculture, Fisheries and Aquaculture; BC Ministry of Agriculture, Food & Fisheries; AgraPoint International Inc.; Ontario Ministry of Agriculture and Food

Major and Minor Weeds

Annual and Perennial Broadleaves and Grasses

Pest Information

Damage: Weeds compete with tree roots for moisture and nutrients and may harbour pests, as well as increase rodent problems.

Life Cycle:

Pest Management

Chemical Controls: There are five critical periods of apple development during which time weeds should be controlled to maximize yields; flowering, fruit set, fruit enlargement, flower bud initiation and hardening off. There are many herbicides registered for use on apple, including burn-off, residual and selective types. A good strategy to manage weed resistance involves rotating herbicides with different modes of action.

Cultural Controls: When irrigation is used and nutrient levels are high, trees will tolerate a higher level of weed competition. Cultural controls include cultivation, mulching, mowing, flaming.

Alternative Controls:

Issues for Weeds

None identified

Table 9. Weed control products, classification and performance for Canadian apple production

Control product (active ingredient / organism) ¹	Classification ²	Mode of action – resistance group ³	PMRA status of active ingredient ⁴	Pests or group of pests targeted	Performance of product according to recommended use ⁵	Notes
2,4-D	Phenoxyacetic herbicide	4	R	Broadleaf weeds	A ^P	Post-emergent only. Regrowth expected. Good clean up in Fall, weather permitting. Risk of drift.
Amitrole (Amitrol)	Triazole herbicide	11	R	All weeds	A ^P	Post-emergent only. Regrowth expected.
Bentazon (Basagran)	Benzothiadiazinone herbicide	6	R	Annual broadleaf weeds	A ^P	Post-emergent only. Weeds must be very small to be controlled. Regrowth expected.
Clopyralid (Lontrel)	Picolinic acid herbicide	4	R	Broadleaf weeds	A ^P	Post-emergent only. Regrowth expected, frequent escapes.
Dichlobenil (Casoron)	Nitrile herbicide	20	R	Most weeds	I	Expensive. Used for spot-treatment or alternate year treatments. Weak on annuals, escapes common.
			R			
Fluazifop-p-butyl (Venture L)	Aryloxyphenoxy-propionic herbicide	1	R	Annual grasses	A ^P	Burn-off. Regrowth expected. Limited to 1 application per year.
Glufosinate (Ignite)	Organo-phosphorous herbicide	10	R	All weeds	A ^P	Burn-off. Repeated applications necessary.
Glyphosate (Roundup, Touchdown)	Organo-phosphorous herbicide	9	R	All weeds	A ^P	Post-emergent only. Repeated applications necessary. Young trees may be harmed.
Metolachlor (Dual Magnum)	Chloro-acetanilide herbicide	15	R	Annual grasses	A ^P	Requires moisture to activate.
			R	Nutsedge	A ^P	
			R	Nightshades	A ^P	

Control product (active ingredient / organism) ¹	Classification ²	Mode of action – resistance group ³	PMRA status of active ingredient ⁴	Pests or group of pests targeted	Performance of product according to recommended use ⁵	Notes
Metribuzin (Sencor)	Triazinone herbicide	5	R	Many weeds	A ^P	Requires moisture to activate. Some resistant weeds in Quebec.
Napropamide (Devrinol)	Amide herbicide	15	R	Annual weeds	A ^P	Expensive. Requires irrigation/moisture for activation.
Paraquat (Gramoxone)	Quaternary ammonium herbicide	22	RE	All weeds	A ^P	Burn-off. Repeated applications necessary. Young trees may be harmed.
Pendimethalin (Prowl)	Dinitroaniline herbicide	3	R	Annual grasses	A ^P	Registered in BC only. Allows lowering of simazine rates. Requires irrigation for activation.
				Annual broadleaf	A ^P	
Propyzamide (Kerb)	Amide herbicide	3	R	Annual grasses	A ^P	Expensive.
				Perennial grasses	A ^P	
				Chickweed	A ^P	
Sethoxydim (Poast Ultra)	Cyclohexene oxime herbicide	1	R	Annual grasses	A ^P	Post-emergent only. Regrowth expected. Limited to 1 application per year.
				Quack grass	A ^P	
Simazine (Princep, Simadex)	Chlorotriazine herbicide	5	R	Grasses	A ^P	Perennials require high rate. Some resistant weeds in Quebec.
				Broadleaf weeds	A ^P	

Control product (active ingredient / organism) ¹	Classification ²	Mode of action – resistance group ³	PMRA status of active ingredient ⁴	Pests or group of pests targeted	Performance of product according to recommended use ⁵	Notes
Terbacil (Sinbar)	Uracil herbicide	5	R	Annual grasses	I	Risk of crop injury, poor control if washed below soil surface.
				Annual broadleaf weeds	A	
Trifluralin (Treflan, Bonanza)	Dinitroaniline herbicide	3	R	Annual grasses	A ^P	Non-bearing only. Requires irrigation for activation.
				Pigweed/lamb's quarters	A ^P	

¹ Common trade name(s), if provided in brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.

² Chemical classification according to “The Compendium of Pesticide Common Names”, see http://www.hclrss.demon.co.uk/class_pesticides.html

³ The mode of action group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action

⁴ R-full registration (non-reduced risk), RE-under re-evaluation (coloured in yellow), DI-discontinued (coloured in red), BI-biological, RR-reduced risk (coloured in green), OP-organophosphate replacement, NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: <http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp>

⁵ A – Adequate (coloured in green) (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^P – Provisionally Adequate (coloured in yellow) (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (coloured in red) (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control)

Source(s): Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec; NB Department of Agriculture, Fisheries and Aquaculture; BC Ministry of Agriculture, Food & Fisheries; AgraPoint International Inc.; Ontario Ministry of Agriculture and Food; Pest Management Regulatory Agency

Table 10. Availability and use of weed pest management approaches for Canadian apple production

	Practice \ Pest	annual grass	annual broadleaf	perennial grass	perennial broadleaf
Prevention	tillage				
	residue removal / management				
	water management				
	equipment sanitation				
	row spacing / seeding depth				
	removal of alternative hosts (weeds/volunteers)				
	mowing / mulching / flaming				
Avoidance	resistant varieties				
	planting / harvest date adjustment				
	crop rotation				
	trap crops - perimeter spraying				
	use of disease-free seed				
	optimizing fertilization				
	reducing mechanical damage / insect damage				
	thinning / pruning				
Monitoring	scouting - trapping				
	records to track pests				
	field mapping of weeds				
	soil analysis				
	weather monitoring for disease forecasting				
	grading out infected produce				
Suppression	use of thresholds for application decisions				
	biological pesticides				
	pheromones				
	sterile mating technique				
	beneficial organisms & habitat management				
	pesticide rotation for resistance management				
	ground cover / physical barriers				
	controlled atmosphere storage				
	forecasting for applications				

no information regarding the practice is available
available/used
available/not used
not available
Source(s): Information in the crop profile for individual pests

Vertebrate Pests

Vertebrate pests can cause economic damage in apple orchards. Common pests include birds, rodents, rabbits and deer.

Bird

Pest Information

Damage: Pecking apples often causes injury to exposed fruit at the tops of trees. Stripping of bark from newly planted trees can also be a problem.

Life Cycle:

Pest Management

Chemical Controls: None

Cultural Controls: Planting of orchards away from pine plantations can help. Trials are being conducted in B.C. using baited cages for mass-trapping of starlings. Netting has been used for other crops (cherries, blueberries) but is not currently considered to be cost effective for apples.

Alternative Controls: The use of automatic exploders or electronic sound devices, plastic tape, streamers and bird eye balloons can keep birds away from orchards. The presence of predators, such as hawks, kestrels and weasels will discourage birds from being in the orchard.

Cultivar Susceptibility: Early cultivars (Melba, Jersey Mac, Vista Bella) are often pecked by birds as they ripen in Eastern Canada. In B.C., Fiji tends to be susceptible, as it matures very late.

Issues for Birds

1. There is concern that birds are becoming accustomed to feeding in orchards on the newer cultivars being used that are often later maturing.
2. There is a need to model populations to determine the effectiveness of mass-trapping trials being done in B.C.
3. There is a need for the development of protocols for the determination of crop damage levels.

Rodent

Pest Information

Damage: Injury to bark of apple trees, particularly in winter, results in tree stress or death. Voles and mice feed on and injure bark, particularly in winter. Pocket gophers feed on tree roots causing severe damage. Woodchuck damage ranges from bark injury to root damage caused by burrowing. Other pests include porcupines and beavers.

Life Cycle:

Pest Management

Chemical Controls: Rodenticides can be used to kill rodents.

Cultural Control: Removing straw, weeds and sod from a 60 cm area around the base of tree trunks, regularly mowing sod, removing dropped apples, using white latex paint and thiram mixture on trunks and using wire mesh around trees are all good management techniques.
Alternative Controls: Predators, such as shrews, skunks, weasels, dogs, foxes, coyotes, owls, hawks and snakes will help keep rodents away.

Cultivar Susceptibility:

Issues for Rodents

None identified

Rabbit

Pest Information

Damage: Feed on terminal growth and fruit buds. Jackrabbits can do damage to limbs within 1 meter of the ground.

Life Cycle:

Pest Management

Chemical Controls:

Cultural Controls: Orchards should be planted away from natural meadows.

Alternative Controls: Latex paint with thiram can be used on trunks. Predators, such as dogs, foxes, owls and hawks will deter rabbits.

Cultivar Susceptibility:

Issues for Rabbits

None identified

Deer

Pest Information

Damage: Deer feed on soft tender tips and terminal growth of apple trees. This results in loss of fruit buds, and more importantly, tree shape. Rubbing of antlers may damage smaller trees.

Life Cycle:

Pest Management

Chemical Controls:

Cultural Controls: Fencing has been effective at excluding deer from orchards in B.C.

Alternative Controls: Hanging small soap bars in young trees can help repel deer. Odour repellents, such as blood meal, hair, or soap give limited protection as they must be replaced frequently. Commercial deer fencing can be successful, but is costly. Trained patrol dogs are the only predator deterrent in populated rural areas. Shooting to reduce populations is also effective.

Issues for Deer

None identified

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Nova Scotia Dept. of Agriculture and Marketing, 1993

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Centre de Référence en Agriculture et Agroalimentaire du Québec, 2000: 226 pp.

Integrated Pest Management for Ontario Apple Orchards, Publication 310
Ontario Ministry of Agriculture, Food and Rural Affairs, 1999: 230 pp.

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B.C. Ministry of Agriculture, Fisheries and Food, 2001.

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IPM / ICM resources for production of apple in Canada

Integrated Fruit Production Guidelines for Apple Orchards in Canada
Canadian Horticultural Council, 2003: 51 pp.
Nova Scotia Orchard Pest Management Fact Sheets
Nova Scotia Dept. of Agriculture and Marketing, 1993

Integrated Fruit Production Guide (for the apple growers of Atlantic Canada)
Agriculture and Agri-Food Canada, Kentville, NS, 2001: 93 pp.

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Centre de Référence en Agriculture et Agroalimentaire du Québec, 2000: 226 pp.

Integrated Pest Management for Ontario Apple Orchards, Publication 310
Ontario Ministry of Agriculture, Food and Rural Affairs, 1999: 230 pp.

Tree Fruit Production Guide
B.C. Ministry of Agriculture, Fisheries and Food, 2001.

Table 11. Research contacts related to pest management in Canadian apple production

Name	Organization	Pest type	Specific pests	Type of research
Antonet Svircev	AAFC, SCPFRC, Vineland, ON	diseases	Fire blight, scab	Fungicide efficacy, resistance testing, field assays of pesticide resistance
Bernt Solymár	EarthTramper Consulting Inc., Simcoe, ON	insects, mites, diseases, weeds	Apple pest complex	Development and implementation of advanced IPM, integrated fruit production, pheromone mating disruption and reduced risk pesticide strategies
Charles Vincent	AAFC, HRDC, St-Jean-sur-Richelieu, QC	insects	Various	Behaviour, ecology and integrated management of apple pests
Daniel Cormier	IRDA, St-Hyacinthe, QC	insects	Plum curculio	Development of monitoring and management strategies for plum curculio
David Pree	AAFC, SCPFRC, Vineland, ON	insects, mites	Various	Insect and mite toxicology and pesticide resistance
Deena Errampalli	AAFC, SCPFRC, Vineland, ON	diseases	Various	Development of DNA-based rapid and sensitive methods for the detection of fungicide resistant fungi
Dick Rogers	Wildwood Labs, Kentville, NS	insects	Various	Pesticide efficacy testing; sprayer technology
Erika Bent	Agricultural Pest Monitoring, Wolfvill, NS	insects, mites, diseases	Various	Pesticide efficacy testing, IPM development
Fred Vaughn	Vaughn Agr. Research Services, Branchton, ON	insects, mites, diseases	Various	Efficacy testing of new pesticides
Gaeten Bourgeois	AAFC, HRDC, St-Jean-sur-Richelieu, QC	insects	Various	Development of CIPRA software to predict insect development and spray timings
Gary Judd	AAFC, PARC, Summerland, BC	insects	Lepidoptera	Insect behavioural ecology, pheromone technology.
Gérald Chouinard	IRDA, St-Hyacinthe, QC	insects	Various	Development of monitoring techniques, biological control, integrated fruit production
Gerhard Gries	Simon Fraser University, BC	insects	Lepidoptera	Pheromone/kairomone research
Gordon Braun	AAFC, AFHRC, Kentville, NS	diseases	Anthrachnose, replant disease, apple scab	Epidemiology, etiology, and management of diseases
Howard Thistlewood	AAFC, PARC, Summerland, BC	insects, mites	Various	Insect population and landscape ecology, biological control, integrated fruit production and organic pest management.

Name	Organization	Pest type	Specific pests	Type of research
J. Cossentine	AAFC, PARC, Summerland, BC	insects	Various	Biological control; potential of parasitoids, predators and pathogens to control fruit insect pests
Michael Smirle	AAFC, PARC, Summerland, BC	insects	Obliquebanded leafroller, various	Host plant chemistry, pesticide resistance; bio-insecticides,
Mike Hardman	AAFC, AFHRC, Kentville, NS	insects, mites	Spider mites, insect pests, predatory mites	Biological control of spider mites, selective pesticide efficacy on insect and mite pests
Mitch Trimble	AAFC, SCPFRC, Vineland, ON	insects	Oriental fruit moth, obliquebanded leafroller	Management of pest insects using semiochemicals.
Murray Isman	University of British Columbia	insects	Codling moth	Assessment of azadirachtin for leafroller control
Noubar Bostanian	AAFC, HRDC, St-Jean-sur-Richelieu, QC	mites	Spider mites, predatory mites	Development of natural or synthetic insecticides and acaricides, biological control
Odile Carisse	AAFC, HRDC, St-Jean-sur-Richelieu, QC	diseases	Apple scab	Biological control and development of biofungicides
P.D.Jensen	AAFC, AFHRC, Kentville, NS	weeds	Roundleaf mallow, weed pests	Biological control of weeds; vegetation management
Peter Sholberg	AAFC, PARC, Summerland, BC	diseases	various	disease detection, forecasting and control
Parmajit Gill	Okanagan University College, Kelowna, BC	insects	Codling moth	Statistical analysis of codling moth damage and population sampling in SIR program
Rob Smith	AAFC, AFHRC, Kentville, NS	insects	All insect pests	Orchard pest management ecology; integrated fruit production
S. Gaul	AAFC, AFHRC, Kentville, NS	insects, mites	Various	Characterization of insect pheromones and plant volatiles; insecticide toxicity and mechanisms of resistance
Vincent Phillion	IRDA, St-Hyacinthe, QC	diseases		Integrated management of diseases, fungicide efficacy testing
Wendy McFadden-Smith	McSmith Agricultural Research Services, Vineland, ON	diseases	Apple scab	Fungicide efficacy testing, sprayer technology