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Crop Profile for Apple in Canada, 2009

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Canada

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Preface

National crop profiles are developed under the Pesticide Risk Reduction Program (PRRP), a joint program of Agriculture and Agri-Food Canada (AAFC) and the Pest Management Regulatory Agency (PMRA). The national crop profiles provide baseline information on crop production and pest management practices and document the pest management needs and issues faced by growers. This information is developed through extensive consultation with stakeholders.

Information on pest management practices and pesticides is provided for information purposes only. No endorsement of any pesticides or pest control techniques discussed, is implied. Product names may be included and are meant as an aid for the reader, to facilitate the identification of pesticides in general use. The use of product names does not imply endorsement of a particular product by the authors or any of the organizations represented in this publication.

For detailed information on growing apple, the reader is referred to provincial crop production guides and provincial ministry websites listed in the Resources Section at the end of the profile.

Every effort has been made to ensure that the information in this publication is complete and accurate. Agriculture and Agri-Food Canada does not assume liability for errors, omissions, or representations, expressed or implied, contained in any written or oral communication associated with this publication. Errors brought to the attention of the authors will be corrected in subsequent updates.

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Crop Profile for Apple in Canada

The domestic apple, *Malus domestica*, is a member of the rose family (*Rosaceae*). 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 Okanagan Valley of B.C.

Crop Production

Industry Overview

Canadian apple growers produce high quality, fresh fruit for direct consumption. 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 British Columbia, Ontario, Quebec and Nova Scotia.

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 Pesticide Risk Reduction Program currently has active risk reduction strategies for apple scab and organophosphate (OP) replacement in pome fruit.

Table 1: National apple production statistics

Canadian Production (2009)[1]	413,096 metric tonnes 20,137 hectares (cultivated area)
Farm gate value (2009)[1]	$176 million
Domestic consumption (2009)	12.08 kg/person (raw) 0.92 kg/person (processed)
Export (2009)	$24 million
Imports (2009)	$193 million
[1]Source: Statistics Canada: Catalogue no. 22-003-X; Fruit and Vegetable Production, Vol 79 #1; June 2010.	

Production Regions

Today, apples are grown in Canada in areas where warm summers are complemented by mild winters. Main production areas include British Columbia, Ontario, Quebec, Nova Scotia and New Brunswick (Table 2).

Table 2: Distribution of apple production in Canada

Production Regions	Cultivated Area 2009 (hectares)	Cultivated Area (percent national hectares)
British Columbia	3,794	19%
Ontario	7,541	37%
Quebec	6,232	31%
New Brunswick	255	1%
Nova Scotia	2,226	11%
Canada	20,137	100%

Source: Statistics Canada: Catalogue no. 22-003-X ; Fruit and Vegetable Production, Vol 79 #1; June 2010

As a reference, the Common Zone Map of field trial regions is presented in Figure1.

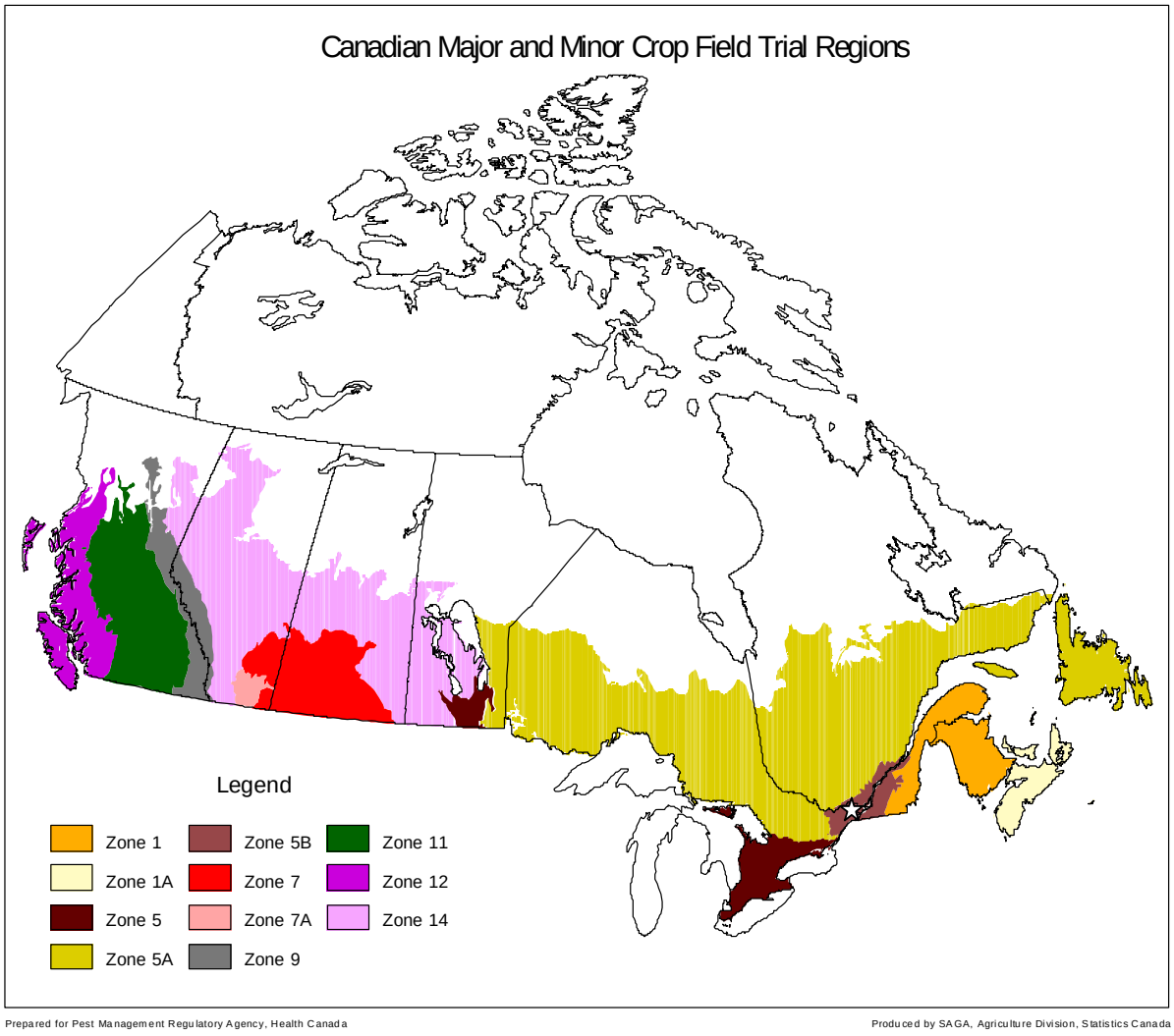

Figure 1: Common Zone Map: Canadian Major and Minor Field Trial Regions

The major and minor crop field trial regions were developed following extensive stakeholder consultation and have been harmonized between the Pest Management Regulatory Agency (PMRA) and the Environmental Protection Agency of the USA. The identified regions are used for experimental studies in support of residue chemistry data requirements for the registration of new pesticide uses. The regions are based on soil type and climate and do not correspond to plant hardiness zones. For additional information, please consult the PMRA Directive 98-02 Residue Chemistry Guidelines (www.hc-sc.gc.ca/cps-spc/pubs/pest/_pol-guide/dir98-02/index-eng.php).

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.

A schedule for cultural and pest management practices is presented in Table 3.

Table 3: General apple production and pest management schedule in Canada

Time of Year	Activity	Action
December to late April (winter dormancy)	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), cankers and fire blight cankers.
	Insect Management	Apply delayed dormant spray for aphids, scales, and mite eggs
	Other	Re-apply rodenticides, as needed
Late March to May (spring-green tip to fruit set)	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, plum curculio, mites, aphids, leafhoppers, and beneficials; apply controls as needed
	Weed Management	Monitor for weeds, and apply controls if needed
June to August (summer fruit growth)	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
September to November (fall harvest period)	Plant Care	Harvest apples; irrigate as needed after harvest; remove dead, weak or diseased trees; mow and apply urea for apple scab control
	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.

General Production 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 of the country are needed.
- There is a need for the development and testing of economically affordable hail damage prevention devices.
- There is a need to conduct crop load management studies, as climate and cultivar influence the effectiveness of thinners.
- Studies on production systems are needed to determine which systems are the most economical for the different growing regions
- Nutrient studies are required to determine the optimum nutrient levels for new cultivars, to avoid storage disorders such as those that have been an issue with Honeycrisp.
- There is a need for research on beneficial cover crops which enhance soil nutrients.

Abiotic Factors Limiting Production

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 ºC, 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 of 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 previously 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 russet and scorch

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

Excessive Rainfall

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

Diseases

Key Issues

- The development of resistance of apple scab and other diseases to commonly used fungicides is of great concern. There is a need for a pesticide resistance testing service with research support, to enable growers to use pesticides effectively, plan resistance management programs and prolong the efficacy of new chemistries.
- There is a need to develop alternatives to streptomycin, that provide effective control of fire blight, to complement the use of biological agents that only provide suppression of the disease.
- 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. There is a need to develop cultivars and rootstocks with fire blight resistance.
- There is a need to develop integrated approaches, that include biological alternatives, to diseases such as crown and root rot, canker diseases and apple replant disease.
- There is a need for the registration of additional fungicides in different chemical groups, for the control of diseases such as apple scab, powdery mildew, post harvest diseases, canker diseases and black rot, to increase the spectrum of products available and limit the development of resistance.
- Early season fungicides applied for scab also control flyspeck and sooty blotch. There is concern with the switch to newer chemistries, that the same level of control may not be achieved when these diseases pose problems.
- 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 the development of scab-resistant cultivars that are acceptable in the market-place.
- There is a need for further development of integrated pest management strategies for controlling diseases in apple.

Table 4: Occurrence of diseases in apple production in Canada

Pests	BC	ON	QC	NS
Anthracnose				
Apple scab				
Black rot				
Blister spot				
Calyx-end and dry-eye rots				
Cedar apple rust				
Crown and root rot				
Fire blight				
Gloeosporium canker[3]				
Perennial canker				
Post harvest diseases				
Powdery mildew				
Quince rust				
Replant disease complex				
Silver leaf [3]				
Sooty blotch and flyspeck				

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

[1]Source: Canadian Horticultural Council, Apple and Fruit Committee, Apple Working Group; data based on 2009 crop year.

[2]Please refer to the colour key (above) and Appendix 1, for a detailed explanation of colour coding of occurrence data.

[3]Pest write-ups not included in text.

Table 5: Adoption of disease management practices for apple in Canada

	Practice/Pest	Apple scab	Fire blight	Powdery mildew	Flyspeck	Blackrot	Sooty blotch	Summer diseases*
Avoidance	resistant varieties							
	planting / harvest date adjustment							
	crop rotation							
	choice of planting site							
	trap crops - perimeter spraying							
	use of disease-free seed or transplants							
	optimizing fertilization							
	reducing mechanical damage /insect damage							
	thinning / pruning							
Prevention	equipment sanitation							
	mowing / mulching/ flaming							
	removal of alternative or wild hosts							
	row or plant spacing (plant density)							
	seeding depth							
	water / irrigation management							
	pruning out / elimination of infected crop residues							
Monitoring	scouting / trapping							
	records to track diseases							
	soil analysis							
	weather monitoring for disease forecasting							
	grading out infected produce							
Decision Making Tools	economic threshold							
	weather/ weather based forecast/predictive model							
	recommendation from crop specialist							
	first appearance of pest or pest life stage							
	observed crop damage							
	crop stage							
	calendar spray							
Suppression	biological pesticides							
	beneficial organisms habitat management							
	environmental management (as in greenhouses)							
	pesticide rotation for resistance management							
	soil amendments							
	controlled atmosphere storage							

Information regarding the practice for this pest is unknown or not applicable.

This practice is available and used to manage this pest in at least one reporting province.

This practice is available but not used for this pest in reporting provinces.

This practice is not available for this pest

This practice is not applicable for the management of this pest.

* Includes a complex of fungi that cause sooty blotch and flyspeck diseases

Source: Canadian Horticultural Council, Apple and Fruit Committee, Apple Working Group; data based on 2009 crop year.

Apple Scab (*Venturia inaequalis*)

Pest Information

Damage: Apple scab is one of the most serious diseases of apple. Symptoms include lesions on both sides of leaves, usually developing earliest on the lower side. Severely infected leaves are shed resulting in defoliation of the tree. Lesions on fruit are characterized by small black spots that enlarge more slowly than those on leaves, eventually becoming corky and cracked. 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 infections in the spring arise from ascospores released from fruiting bodies in 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 moderate temperatures and wet conditions. It is difficult to prevent scab infections during years with high and frequent rainfalls in the spring with extended wetting periods.

Pest Management

Cultural Controls: A good orchard design that optimizes air movement through the canopy can reduce the duration 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 host trees within 100 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%. 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 delay early season sprays or relax spraying 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.

Resistant Cultivars: 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, Britegold, Macfree, Moira, Murray, Navo Easygro, Novamac, Novaspy, Primevere, Richelieu, Rouville and Trent. Other resistant varieties include Dayton, Entreprise, Liberty, Freedom, Florina and others. Resistance of these cultivars is expected to be short lived, as new races of the pathogen develop.

Chemical Controls: A number of fungicides are registered for the control of scab in commercial orchard (refer Table 6. Classification and registration status of fungicides for disease management in apple in Canada).

Issues for Apple Scab

1. The development of resistance to systemic fungicides, including the sterol inhibitors and strobilurins is of great concern. There is an urgent need for a pesticide resistance testing service with research support to interpret results.
2. There is concern about the potential loss of the registration for EBDC fungicides (mancozeb and metiram) and captan, currently under re-evaluation by the PMRA. The continued registration of broad spectrum protectants is essential for resistance management and cost effective control programs.
3. There is a need for a cost effective, non-chemical approach to scab management that includes biological controls.
4. There is a need for the development of scab resistant cultivars acceptable in the market place.
5. Growers need access to new fungicides to manage apple scab.
6. There is a need for the registration of fungicides with post infection activity.

Black Rot *(Botryosphaeria obtusa)*

Pest Information

Damage: Leaf infections result in frogeye leaf spot, with heavy infections causing leaves to yellow and drop. This may predispose the tree 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. In Ontario, black rot infections in the wood appear to be increasing, causing dead and weakened limbs and leading to tree death and orchard removal. This problem is occurring in young as well as mature orchards.

Life Cycle: In the early spring, ascospores are released from overwintering cankers and mummified fruit and are wind blown to susceptible fruit and foliage. Conidia (asexual spores) are produced throughout the growing season and also serve to spread the disease. Trees weakened by winter injury are more susceptible to black rot.

Pest Management

Cultural Controls: Affected wood should be removed and destroyed to limit the spread of the disease. Brush piles adjacent to the orchard should be removed. Fire blighted limbs can be a target for colonization by 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.

Resistant Cultivars: The most susceptible cultivars include Northern Spy, Cortland, McIntosh, Empire and Gala. There are no resistant cultivars.

Chemical Controls: Fungicides registered for black rot are listed in Table 6: "Classification and registration status of fungicides for disease management in apple in Canada".

Issues for Black Rot

1. There is a need for additional products to manage black rot.

Blister Spot *(Pseudomanas syringae)*

Pest Information

Damage: Small lesions develop around lenticels on fruit and expand during the growing season. By harvest, lesions with blistered brown centers and dark purple borders develop and can reach 5 mm in diameter and a depth of 2 mm. If numerous, the spots can reduce fruit quality.

Life Cycle: Bacterial populations build up on symptom-less plant tissues in the orchard, throughout the spring and summer and are dispersed by rain onto developing fruit. Invasion of fruit occurs through the lenticels. The bacterium overwinters in buds and infected, fallen fruit.

Pest Management

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.

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

Chemical Controls: Pesticides registered for blister spot are listed in Table 6: "Classification and registration status of fungicides for disease management in apple in Canada".

Issues for Blister Spot

1. There is a need for the registration of additional products for the management of blister spot.

Calyx End Rot (*Sclerotinia sclerotiorum*) and Dry- End Rot *(Botrytis cinerea)*

Pest Information

Damage: With calyx end rot, soft, brown rotted tissue, around the calyx end of the fruit appears about one month after bloom and over time, may expanded to cover one third or more of the apple. With dry end or dry-eye rot, the rot at the calyx end is dry and shallow and the border around the rot is often red. Infected fruit are not suitable for fresh fruit sales.

Life Cycle: Sclerotinia overwinters as sclerotia on broadleaf weeds such as dandelion and wild clover which are present in the orchard sod. Apothecia develop in early spring which release ascospores from bloom until about 3 weeks after petal fall. The spores infect the blossom and fruitlets during wet weather and suitable temperatures. The same conditions favour botrytis infections.

Pest Management

Cultural Controls: Broad leaf weeds on the orchard floor must be controlled.

Resistant Cultivars: Paula Red, MacIntosh, Cortland and Red Delicious appear to be more susceptible than other cultivars in Nova Scotia

Chemical Controls: Some fungicides for apple scab will provide control.

Issues for Calyx End Rot and Dry End Rot

1. These are sporadic diseases, the severity of which is hard to predict from year to year. Weather conditions often dictate how big a problem they will be in a particular growing season. A prediction model and fungicides to control these diseases would be of benefit.

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

Pest Information

Damage: Cedar apple rust produces yellow 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 require two different hosts. The alternate host for cedar apple rust is red cedar (*Juniperus virginianae*) while the alternate host for quince rust is red cedar and a number of other junipers. The fungi overwinter in galls on the alternate hosts. In the spring, the galls give rise to orange-yellow, gelatinous telial horns that release spores that infect apple leaves and fruit. Cedar apple rust infects both leaves and fruit of susceptible cultivars, while quince rust affects only fruit. Spores produced in lesions on the apple fruit in mid-summer are wind blown to red cedars where they cause new infections.

Pest Management

Cultural Controls: The removal of alternate hosts and wild apple trees in proximity to the orchard can reduce disease incidence. Rust resistant varieties of ornamental shrubs and trees should be planted when possible. The potential for disease development can be estimated by examination of red cedars in the proximity of orchards from May until mid June.

Resistant Cultivars: 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.

Chemical Controls: Apple scab sprays generally control rust diseases, but may not be adequate during the period from tight cluster/pink until mid June. Fungicides registered for rust diseases are listed in Table 6: "Classification and registration status of fungicides for disease management in apple in Canada".

Issues for Cedar Apple and Quince Rusts

None identified

Crown Rot and Root Rot (*Phytophthora cactorum* and other *Phytophthora* spp.)

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. Purplish cankers become evident in the crown rot phase of the disease. Trees can decline over several years before they actually die. Often, the disease will affect trees in an area of the orchard that is low lying or poorly drained.

Life Cycle: Phytophthora spp. are soilborne and are present in many orchard soils. They become a problem under conditions of prolonged soil wetness. Phytophthora diseases are spread by water movement and may be introduced into orchards on contaminated planting stock.

Pest Management

Cultural Controls: Planting sites should be well drained and soil water should be managed so that soils do not remain saturated for prolonged periods of time. Only disease free planting stock should be introduced into the orchard.

Resistant Cultivars: Resistant cultivars and seedling rootstocks do exist. The most susceptible rootstocks include M26, M7 and MM106. Rootstocks with resistance to phytophthora include CG.30, CG.6210 and G.16.

Chemical Controls: Fungicides registered for crown and root rots are listed in Table 6: "Classification and registration status of fungicides for disease management in apple in Canada".

Issues for Crown Rot and Root Rot

1. There is a need to develop biological alternatives to incorporate into an integrated approach to the management of crown and root rot.

European canker (*Neonectria ditissima*) (formerly *Nectria galligena*), anthracnose (*Pezicula malicortis, anamorph Cryptosporiopsis curvispora*) and perennial canker (*C. 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. The branch beyond the canker may die or becomes unproductive. Damage assessment is difficult, as cankers cause a general reduction in the growth and yield of individual trees.

Life Cycle: Neonectria ditissima invades pruning scars and other wounds and once established, becomes perennial. Affected limbs may be girdled. Bright orange fruiting bodies produce spores by which the disease spreads. Limb and trunk cankers due to anthracnose are initiated in the fall and remain small and oval. Infected tissues are walled-off by the host and eventually crack and slough off. Spores by which the disease spreads are produced in the cankers.

Pest Management

Cultural Controls: Pruning in the winter before sap begins to flow may minimize the chance of disease organisms being spread by pruning tools. All dead wood and mummified fruit should be removed as they serve as reservoirs for disease organisms.

Resistant Cultivars: None identified.

Chemical Controls: There are no fungicides registered for the control of canker diseases.

Issues for Cankers

1. There is a need for the development of an integrated approach to the management of canker diseases.

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 blossoms, shoots, twigs, fruit, limbs, trunk, collar and the rootstock of the tree. Affected foliage turns brown and wilts and infected shoots develop a "shepherds crook". Foliar infections can progress back into shoots and main limbs and result in sunken cankers and girdling.

Life Cycle: In the spring, bacteria "ooze" from the edges of overwintered cankers and are rain splashed or carried by insects to susceptible tissues. Infections begin in blossoms and succulent foliage and in tissues injured by wind whipping, late frosts or hail. Fireblight developing in injuries caused by environmental factors, referred to as "trauma blight" is uncommon but can be very destructive.

Pest Management

Cultural Controls: 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 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 provides good entry points for the disease and should be broken out periodically during the early growing season. 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 be infection points. Good control of plant-sucking insects such as leafhoppers, aphids and plant bugs is particularly important. Many blight forecasting programs are available, including Maryblyt and Cougar blight, to forecast when fire blight symptoms will appear, determine whether or not sprays are needed and how to best time sprays during bloom.

Resistant Cultivars: Although all apple varieties are susceptible to fire blight, some varieties are more tolerant to fire blight than others, including Red Delicious, Liberty, Enterprise and Freedom. Susceptible varieties include Gala, Idared and Jonagold. Where possible, rootstocks that are less susceptible to fire blight should be used.

Chemical Controls: Pesticides (including biopesticides), registered for fire blight, are listed in Table 6: "Classification and registration status of fungicides for disease management in apple in Canada."

Issues for Fire Blight

1. There is a need for the development of alternatives (especially for the treatment of trauma blight) to streptomycin, that provide the same level of control. The currently registered bio-pesticides provide suppression only.
2. There is a need for the development of commercial cultivars and rootstocks with fire blight resistance.

Sooty blotch and flyspeck (SBFS complex)

Pest Information

Damage: Sooty blotch and flyspeck diseases are caused by a number of saprophytic fungi that grow on the cuticle of the fruit. Dark smudges or groups of tiny black spots (fly specks) develop on the fruit. The flesh of the fruit is not damaged, however, the 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: Sooty blotch and flyspeck fungi survive the winter on dead twigs of a number of woody species. They have the ability to go dormant under unfavourable conditions, such as hot, dry weather. The diseases are spread by ascospores that are produced in infected tissues and released during rainy periods. Symptoms may only appear at harvest despite infections having occurred much earlier. Conditions are more favourable for the development of the diseases in August and September.

Pest Management

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

Resistant Cultivars: None identified.

Chemical Controls: There are a number of registered control products. However the disease is controlled by most fungicides that are applied for apple scab protection.

Issues for Flyspeck and Sooty Blotch

1. Early season fungicides applied for scab also control flyspeck and sooty blotch. There is concern with the switch to newer chemistries, that the same level of control may not be achieved in years when these diseases pose problems.

Post Harvest Diseases (*Penicillium expansum*, *Penicillium* spp. *Botrytis cinerea* and others)

Pest Information

Damage: Blue mould is the most important post harvest disease of apple. It causes a soft, watery rot, light brown in colour, on the fruit. Infected areas give rise to blue-green sporulation of the causal fungi. Grey mould results in a soft, spongy area on the fruit surface that soon fills with grey coloured sporulation.

Life Cycle: These post harvest diseases are spread by spores and invade through wounds. Blue mould spores are ubiquitous. Grey mould colonizes organic matter on the orchard floor, that liberates spores on wind currents. In storage, spores are produced in developing lesions and are capable of infecting other nearby fruit. Grey mould creates pockets of decayed fruit.

Pest Management

Cultural Controls: Careful handling and strict hygiene in the field, in transport and in storage is important for the control of post harvest diseases. Orchards should be cleared of dead material to reduce inoculum levels. Harvesting apples at optimum maturity helps prolong storage life. Controlled atmosphere (CA) storage allows the optimization of environmental conditions to prevent rot and prolong the storage life of the produce. 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.

Resistant Cultivars: None identified.

Chemical Controls: The application of fungicides during the growing season to prevent scab can reduce the occurrence of post harvest diseases.

Issues for Post Harvest Diseases

1. There is a need for the registration of additional fungicides and biological control agents for the management of post harvest diseases and for resistance management.
2. There is a need for continued research into management of post-harvest diseases in the orchard, using fungicides and the registration of fungicides for this use pattern.
3. Work needs to continue on post harvest disorders of Honeycrisp and new cultivars, as they are introduced.

Powdery Mildew *(Podosphaera leucotricha)*

Pest Information

Damage: Powdery mildew develops as a white powdery growth of mycelium and spores on the surface of foliage, buds and shoots. The disease can kill vegetative shoots and prevent fruit formation when blossoms are infected. Flower infections can also result in russeted fruit that often 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: Powdery mildew overwinters in fruit and flower buds infected the previous season. As the new growth expands in the spring, the fungus gives rise to mycelium and the asexual conidia or spores on the surface of the young tissues. Only young foliage is susceptible to attack. Spores (conidia) are dispersed by wind to nearby young tissues where they give rise to new infections. Leaf wetness is not required for infection.

Pest Management

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 onto healthy leaves, will help control the disease. Infected foliage should be cleared away. Over crowding of trees and branches should be avoided by properly spacing and trimming trees.

Resistant Cultivars: 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.

Chemical Controls: Fungicides registered for powdery mildew are listed in Table 6: "Classification and registration status of fungicides for disease management in apple in Canada".

Issues for Powdery Mildew

1. The development of resistance of powdery mildew to systemic fungicides, especially the sterol inhibiting fungicides, is of great concern to growers. There is a need for a resistance screening service for the sterol inhibitors and strobilurin fungicides.
2. There is a need for the registration of alternative chemistries for resistance management.

Replant Disease Complex

Pest Information

Damage: This disease, caused by a complex of fungal and bacterial soilborne organisms and nematodes, primarily occurs when a new planting of apple is located on sites previously planted to orchards. Affected trees may be stunted, showing little shoot growth and undersized foliage and exhibit reduced productivity and in severe cases, may die.

Life Cycle: The complex of causal agents of this disease is not well understood. Abiotic factors including soil pH, moisture stress, nutrient imbalances and compaction, among others, also contribute to this disease.

Pest Management

Cultural Controls: As the causes of replant disease vary among sites, the efficacy of the various treatments will also vary. If possible land should be rotated out of apple production for two – eight years before being re-planted to orchard. New orchards should be well maintained with proper fertilization, irrigation, pruning and weed management practices. Practices that reduce problems due to known root pathogens (such as phytophthora and root lesion nematodes) help to reduce replant disease in sites where these diseases are known to be present. Incorporating compost in the planting row will help to offset the effects of this disease. 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.

Resistant Cultivars: Some of the new Geneva rootstock are showing tolerance and resistance to replant disorder.

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

Issues for Replant Disease Complex

1. Alternatives to fumigation are needed.
2. There is a need for the development of an IPM approach to the management of replant disease complex.

Table 6: Classification and registration status of fungicides for disease management in apple in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Registration status[3]	Targeted Pests[1]
bacillus-subtilis	Bacillus subtilis and the fungicidal lipopeptides they produce	F6: lipids and membrane synthesis	microbial disrupters of pathogen cell membranes	44	R	apple scab, fireblight, powdery mildew
boscalid	pyridine carboxamides	C2. respiration	complex II: succinate-dehydro-genase	7	R	apple scab, brooks fruit spot, flyspeck, powdery mildew, sooty blotch
captan	phthalimides	Multi-site contact activity		M4	R	apple scab, bitter rot, black rot, brooks fruit spot, flyspeck, frog eye spot, perennial canker, sooty blotch,
copper (different salts)	inorganic	Multi-site contact activity		M1	R	anthracnose, blister spot, fireblight
cyprodinil	anilino-pyrimidines	D1: amino acids and protein synthesis	methionine biosynthesis (proposed) (cgs gene)	9	R	apple scab, powdery mildew
ferbam	dithio-carbamates and relatives	Multi-site contact activity		M3	R	apple scab, bitter rot, black rot, brooks fruit spot, calyx end rot, cedar apple rust, flyspeck, frog eye spot, rust, sooty blotch
fludioxonil	phenylpyrroles	E2: signal transduction	MAP/Histidine- Kinase in osmotic signal transduction (os-2, HOG1)	12	R	blue mold, grey mould
flusilazole	triazoles	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	apple scab, powdery mildew
folpet	phthalimides	Multi-site contact activity		M4	R	alternaria leaf spot, apple scab, black rot, brooks fruit spot, flyspeck, sooty blotch
fosetyl-Al	ethyl phosphonates	Unknown mode of action		33	R	blister spot, crown and root rot
kresoxim-methyl	oximino acetates	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	apple scab, powdery mildew
mancozeb	dithio-carbamates and relatives	Multi-site contact activity		M3	R	apple scab, black rot, cedar apple rust, frog eye spot, powdery mildew, quince rust, rust, sooty blotch

metalaxyl-M	acylalanines	A1: nucleic acids synthesis	RNA polymerase I	4	R	crown and root rot
metiram	dithio-carbamates and relatives	Multi-site contact activity		M3	R	apple scab, cedar apple rust, rust
myclobutanil	triazoles	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	apple scab, cedar apple rust, powdery mildew, quince rust rust
Pantoea agglomerans*	biological	unknown	unknown	N/A	R	Fireblight
propiconazole	triazoles	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	apple scab
Pseudomonas fluorescens*	biological	unknown	unknown	N/A	R	fireblight
Pseudomonas syringae*	biological	unknown	unknown	N/A	R	blue mold, grey mould
pyraclostrobin	methoxy-carbamates	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	apple scab, brooks fruit spot, flyspeck, powdery mildew, sooty blotch
pyrimethanil	anilino-pyrimidines	D1: amino acids and protein synthesis	methionine biosynthesis (proposed) (cgs gene)	9	R	apple scab, blue mold, grey mould
thiabendazole	benzimidazoles	B1: mitosis and cell division	ß-tubuline assembly in mitosis	1	RE	blue mold, grey mould
thiophanate-methyl	thiophanates	B1: mitosis and cell division	ß-tubuline assembly in mitosis	1	RE	apple scab, powdery mildew
thiram	dithio-carbamates and relatives	Multi-site contact activity		M3	RE	apple scab, bitter rot, black rot, brooks fruit, spot flyspeck, rust, sooty blotch
trifloxystrobin	oximino acetates	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	apple scab, cedar apple rust, flyspeck, powdery mildew, sooty blotch
triforine	piperazines	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	powdery mildew
ziram	dithio-carbamates and relatives	Multi-site contact activity		M3	RE	apple scab

[1]As generated through Homologa (www.homologa.com) (Nov. 18, 2010).

[2] The classification and the mode of action group are based on the classification presented by the Fungicide Resistance Action Committee, the Insecticide Resistance Action Committee and the Herbicide Resistance Action Committee on the following web sites: Fungicides: www.frac.info/frac/index.htm ; Insecticides: www.irac-online.org ; Herbicides: www.hracglobal.com

[3] R-full registration, RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of Nov. 18, 2010. 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. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: www.hc-sc.gc.ca/cps-spc/pest/index-eng.php

[4] Please consult the product label on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php) for specific listing of pests controlled by each active ingredient.

Insects and Mites

Key Issues

- Reduced risk pesticides are expensive for growers, may need more frequent applications to be effective and cannot be used as border sprays. There is a need for cost effective IPM approaches to be developed for apple maggot and other pests, that incorporate the reduced risk chemistries.
- There is a need for education of growers on integrating new chemistries into IPM programs, preventing pesticide resistance and the use of mating disruption and other reduced risk approaches to pest management in orchards.
- There is a need for the development and registration of reduced risk alternatives for apple maggot, European apple sawfly, mullein bug, plant bugs, scale insects, mites and aphids.
- There is a need for an effective approach to managing abandoned orchards and wild and abandoned host trees, on private and public properties, to eliminate sources of apple maggot, codling moth and other pests.
- There is a need to develop economic thresholds and monitoring methods and improve existing degree-day models, for predicting development stages for pests, such as the tarnished plant bug, mullein bug and plum curculio, to better time pesticide applications.
- There is a need for a pesticide resistance testing service for growers to enable them to better plan their pest management programs and enhance resistance management.
- There is concern over the repeated annual use of newer chemistries, such as neonicotinoid products, which can result in phytophagous mite population flare-ups.
- Research is required to improve the understanding of the seasonal development of natural enemies and their tolerance to pesticide residues.
- There is a need to ensure that all important pest species in a group (e.g. all pest leafroller species) are included on the label of newly registered products, to reduce the need for label expansions and delays in pesticide availability.
- There is a need for effective management strategies for lepidopteran pests, including codling moth, leafrollers, winter moth and Oriental fruit moth. The development of biological control programs is needed.
- There is a need for research on the use of nematodes and other biological options for managing dogwood borer.
- There is a need for the registration of mating disruption technology for the management of dogwood borer and apple clearwing moth.
- Additional research is needed on the selection of rootstocks to minimize the development and impact of woolly apple aphid.
- 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..
- There is a need to coordinate the registration of new products in Canada with other countries that purchase Canadian apples, ensuring there is no conflict with MRL’s

Table 7: Occurrence of insect and mite pests in apple production in Canada

Pests	BC	ON	QC	NS
codling moth				
apple maggot				
European apple sawfly				
green pug moth				
gypsy moth				
Japanese beetle				
leaf curling midge				
lesser apple worm				
Oriental fruit moth				
plum curculio				
tentiform leafminers				
western flower thrips				
winter moth				
Aphids				
green apple aphid				
rosy apple aphid				
woolly apple aphid				
Borers				
apple clearwing moth				
dogwood borer				
wood-boring beetles				
Fruitworms				
brown fruitworm				
green fruitworm				
speckled green fruitworm				
Leafrollers				
European leafroller				
fruit-tree leafroller				
obliquebanded leafroller				
pale apple leafroller				
red-banded leafroller				
threelined leafroller				
Mite pests				
apple rust mite				
European red mite				
McDaniel spider mite				
two-spotted spider mite				
Scale insects				
European fruit scale				
oyster-shell scale				
San Jose scale				
Spring-feeding caterpillar complex				
eye spotted budmoth				

Table 7: Occurrence of insect and mite pests in apple production in Canada (continued).

Pests	BC	ON	QC	NS
Stinging bug complex				
apple brown bug				
mullein plant bug				
potato leafhopper				
white apple leafhopper				
tarnished plant bug				
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				
[1]Source: Canadian Horticultural Council, Apple and Fruit Committee, Apple Working Group; data based on 2009 crop year.				
[2]Please refer to the colour key (above) and Appendix 1, for a detailed explanation of colour coding of occurrence data.				
[3]Pest write-ups not included in text.				

Table 8: Adoption of insect and mite pest management practices for apple in Canada

	Practice/Pest	Apple clearwing moth	Apple maggot	Codling moth	European red mite	Mites	Mullein bug	Obliquebanded leafroller
Avoidance	resistant varieties							
	planting / harvest date adjustment							
	optimizing fertilization							
	reducing mechanical damage							
	thinning / pruning							
	trap crops/ perimeter spraying							
	repellents							
	herbicide strip width							
Prevention	equipment sanitation							
	mowing / mulching / flaming							
	removal of alternative hosts (weeds/volunteers)							
	row or plant spacing (plant density)							
	seeding depth							
	water/ irrigation management							
	crop residue removal/ management							
	pruning out/ removal of infested material							
Monitoring	scouting / trapping							
	records to track pests							
	soil analysis							
	weather monitoring for degree day modelling							
	grading out infected produce							
Decision Making Tools	economic threshold							
	weather/weather based forecast/predictive model							
	recommendation from crop specialist							
	first appearance of pest or pest life stage							
	observed crop damage							
	crop stage							
	calendar spray							
Suppression	biological pesticides							
	environmental management (e.g as in greenhouses)							
	pesticide rotation for resistance management							
	soil amendments							
	ground cover / physical barriers							
	pheromones (e.g. mating disruption)							
	sterile mating technique							
	beneficial organisms and habitat management							
	trapping							

	Practice/Pest	Oriental fruit moth	Plum curculio	Rosy apple aphid	Summer leafroller-bud moth	Tarnished plant bug	Winter moth	Woolly apple aphid
Avoidance	resistant varieties							
	planting / harvest date adjustment							
	optimizing fertilization							
	reducing mechanical damage							
	thinning / pruning							
	trap crops/ perimeter spraying							
	repellents							
	herbicide strip width							
Prevention	equipment sanitation							
	mowing / mulching / flaming							
	removal of alternative hosts(weeds/volunteers)							
	row or plant spacing (plant density)							
	seeding depth							
	water/ irrigation management							
	crop residue removal/ management							
	pruning out/ removal of infested material							
Monitoring	Scouting / trapping							
	records to track pests							
	soil analysis							
	weather monitoring for degree day modelling							
	grading out infected produce							
Decision Making Tools	economic threshold							
	weather/weather based forecast/predictive model							
	recommendation from crop specialist							
	first appearance of pest or pest life stage							
	observed crop damage							
	crop stage							
	calendar spray							
Suppression	biological pesticides							
	environmental management (e.g# as in greenhouses)							
	pesticide rotation for resistance management							
	soil amendments							
	ground cover / physical barriers							
	pheromones (e.g. mating disruption)							
	sterile mating technique							
	beneficial organisms and habitat management							
	trapping							

Information regarding the practice for this pest is unknown or not applicable.

This practice is available and used to manage this pest in at least one reporting province.

This practice is available but not used for this pest in reporting provinces.

This practice is not available for this pest

This practice is not applicable for the management of this pest.

Source: Canadian Horticultural Council, Apple and Fruit Committee, Apple Working Group; data based on 2009 crop year.

Apple Maggot *(Rhagoletis pomonella)*

Pest Information

Damage: Apple maggot is a serious pest of apple in eastern Canada. 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 quarantine pest due to import restrictions in some countries.

Life Cycle: Apple maggot flies emerge from overwintering pupae in mid to late summer. Once mature, the adults mate on or near developing apples. Mated females puncture the apple skin with their ovipositor and deposit eggs. Larvae spend 20 to 30 days within the apple, leaving the fruit when they have reached the 3rd instar stage of development. The larvae burrow into the soil, moult to the fourth instar and soon after moult to the pupal stage. The pupae overwinter in the soil and may remain dormant for several years until appropriate conditions occur.

Pest Management

Cultural Controls: The removal of alternate hosts in the vicinity of the orchard is recommended. Adult flies can be 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. Kaolin clay has been shown to be somewhat effective.

Resistant Cultivars: None identified.

Chemical Controls: Fruit must be protected for the rest of the season, once the first flies are detected in the orchard. The timing of insecticide application depends on the pesticide mode of action and life stage against which the material is active. Active ingredients registered for apple maggot are listed in Table 9. Classification and registration status of insecticides and miticides for pest management in apple in Canada.

Issues for Apple Maggot

1. The impending loss of organo-phosphate insecticides will result in significant apple maggot management challenges for growers.
2. A greater selection of products that control apple maggot are needed for resistance management, particularly once the organophosphates are no longer available.
3. Repeat applications of neonicotinoids for apple maggot, disrupt biological control in the orchard and can result in mite flare-ups.
4. Reduced risk pesticides are expensive for growers, may need more frequent applications to be effective and cannot be used as border sprays. There is a need for a cost effective IPM approach be developed for apple maggot that incorporates the new reduced risk chemistries.
5. There is a need for an effective approach to manage wild and abandoned host trees on private and public properties, to eliminate sources of apple maggot.
6. Application methods for GF-120 need further refinement and issues with level of control (for this quarantine pest), need to be addressed.
7. As with other pests and diseases, there is a need for reduced risk, domestic products for homeowners for managing this pest on non-commercial host trees.

Codling Moth *(Cydia pomonella)*

Pest Information

Damage: Codling moth damage is apparent as "stings", caused by the first instar larvae as they enter the fruit and deeper feeding injury caused by larvae as they 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.

Life Cycle: Adult moths emerge from overwintering sites around bloom. The moths lay eggs onto fruit or leaves. Larvae enter the fruit to feed and at maturity,exit the fruit to pupate. There are 1 or 2 generations per year in Canada. Codling moths overwinter as mature larvae in cocoons that can be found on many surfaces in the orchard.

Pest Management

Cultural Controls: Alternate hosts in the vicinity of the orchard should be removed if possible. 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 been somewhat effective. 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 British Columbia, there is limited use of this technique. Sterile Insect Release (SIR) has been used in the Okanogan Valley of British Columbia to reduce codling moth in orchards to below economic thresholds. The SIR program is moving into a long-term program to apply an integrated area-wide approach to managing codling moth using mating disruption and strategic release of sterile moths, supported by reduced-risk sprays based, on pest monitoring. The SIR program is also investigating the possibility of expanding its mandate to include other pest species such as apple clearwing moth

Resistant Cultivars: There are no resistant cultivars.

Chemical Controls: Refer Table 9. "Classification and registration status of insecticides and miticides for pest management in apple in Canada". Organophosphate insecticides have been the main chemicals used in the past but growers have been shifting to newer chemistries as they become available.

Issues for Codling Moth

1. There is a need for education of growers on integrating new chemistries into an IPM program and preventing the development of pesticide resistance.
2. There is concern that codling moth may be developing tolerance or resistance to insecticides such as the neonicotinoids and organophosphates.
3. There is a need for an effective approach to manage wild and abandoned host trees on private and public properties, to eliminate sources of codling moth.
4. There is the need for tools for the domestic control of codling moth.

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 leaving 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: There is one generation per year. The adult insect deposits eggs at the calyx end of the king flower of a blossom cluster. After hatching, larvae feed just under the skin of the fruit, gradually tunnelling towards the seed cavity as it matures. At maturity, the larvae move into the soil where they form a cocoon to spend the winter. Pupation occurs in the spring. Adult moths may emerge as much as three years later.

Pest Management

Cultural Controls: Monitoring is done using white sticky traps. A parasitic wasp has been released in a limited number of orchards in Quebec and Ontario and has been shown to reduce sawfly numbers.

Resistant Cultivars: There are no resistant cultivars available.

Chemical Controls: Insecticides registered for European apple sawfly are listed in Table 9. "Classification and registration status of insecticides and miticides for pest management in apple in Canada"

Issues for European Apple Sawfly

1. This pest is becoming more widespread in Ontario and Nova Scotia and there is concern that there are no registered alternatives to azinphos-methyl, an organophosphate insecticide scheduled for de-registration in 2012.
2. There is a need for more work on the distribution and impact of the biological control agent (*Lathrolestes ensator*) in orchards.

Green pug moth (*Chloroclystis rectangulata*)

Pest Information

Damage: The green pug moth is an introduced species originally found in Europe and Asia and first detected in Nova Scotia in 1970. The larvae feed on many species of trees including apple and pear. In the spring, larvae feed on buds, flowers and sometimes developing leaves. Severe infestations can result in defoliation.

Life Cycle: There is one generation per year. The insect overwinters as an egg on twigs. The eggs hatch in early spring and the larvae web tender tissues together on which they feed. Pupation occurs under bark or in soil. Adults emerge in late spring to early summer and lay the overwintering eggs.

Pest Management

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

Resistant Cultivars: None identified.

Chemical Controls: A number of insecticides are registered for control of this pest (refer Table 9: "Classification and registration status of insecticides and miticides for pest management in apple in Canada."

Issues for Green Pug Moth

None identified.

Leafcurling midge (*Dasineura mali*)

Pest Information

Damage: Feeding by the midge larvae cause marginal rolling of the leaves. Severely damaged leaves eventually become purple, brittle and drop from the tree. Mature trees usually do not sustain economic damage. However high populations can result in stunting of shoot growth of young trees.

Life Cycle: The adult midge lays eggs in partially expanded leaves in young shoots. After hatching, the larvae feed on the upper surface of leaves causing the margins of the leaves to roll inwards. After feeding for 2 to 3 weeks, the larvae pupate. Second generation adult midges are present in late summer. The insect overwinters in soil or rolled leaves as pre-pupae or pupae.

Pest Management

Cultural Controls: The pest can be monitored by checking trees for the presence of rolled leaves containing the tiny, orange midge larvae. Management of this pest is usually not necessary.

Resistant Cultivars: All cultivars are susceptible.

Chemical Controls: Insecticidal control of this insect is difficult as the larvae are protected within leaf rolls.

Issues for Leafcurling Midge

1. There is a need for greater understanding of the biology of the leafcurling midge, impact on the trees and damage thresholds.
2. There is a need for registered products for the management of leafcurling midge.

Oriental Fruit Moth *(Grapholitha molesta)*

Pest Information

Damage: Larvae tunnel into both branch terminals and fruit. Terminal infestations are detectable to the experienced eye. Late season fruit injury is particularly important, as the small stings and larvae 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. Adults emerge in early spring . Early generation larvae attack shoots and developing fruitlets, while later generations attack fruit. The overwintering stage is as a late instar larva.

Pest Management

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

Resistant Cultivars: There are no resistant cultivars available.

Chemical Controls: Insecticides registered for Oriental fruit moth are listed in Table 9. "Classification and registration status of insecticides and miticides for pest management in apple in Canada".

Issues for Oriental Fruit Moth

None Identified

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 also provide 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 mature following spring. Females lay eggs in the developing fruit. Larvae feed inside the fruit and can cause premature fruit drop. At maturity, the larvae leave the fruit and enter the soil to pupate. Adults continue to feed on fruit after emergence and move to overwintering sites in early fall.

Pest Management

Cultural Controls: Monitoring is difficult and requires visual observation of fruit damage along orchard perimeters and on nearby alternate hosts. Border spraying, to prevent movement of the pest into orchards, from surrounding hedgerows and woodlots, has been used successfully in Ontario. In Ontario and Nova Scotia, kaolin clay has worked well when used from petal fall until late June, to limit fruit injury from the pest.

Resistant Cultivars: There have been no resistant cultivars identified.

Chemical Controls: Insecticides registered for plum curculio are listed in Table 9. "Classification and registration status of insecticides and miticides for pest management in apple in Canada".

Issues for Plum Curculio

1. Neonicotinoids are the only registered alternatives to organophosphate insecticides. There is concern that these products may not provide adequate control when populations are high.
2. Improved monitoring tools are needed to more accurately determine first spring activity and the need for additional treatments.
3. There are few effective options for monitoring and timing of sprays for plum curculio.

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

Pest Information

Damage: Larvae mine between the leaf layers causing visible holes on the surface. Severe infestations will result in reduced vegetative and fruit growth.

Life Cycle: There are two to three generations per year. The insects overwinter in fallen leaves in the orchard and adult moths emerge in the early spring and lay eggs on the developing foliage.

Pest Management

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

Resistant Cultivars: The cultivar McIntosh is particularly susceptible.

Chemical Controls: Pesticides registered for tentiform leafminer are listed in Table 9. "Classification and registration status of insecticides and miticides for pest management in apple in Canada".

Issues for Spotted Tentiform Leafminer

None identified.

Western Flower Thrips (*Frankliniella occidentalis*)

Pest Information

Damage: White to pink irregular areas ('pansy spots') appear on surface of the fruit resulting from egg-laying . This injury results in downgrading of the value of fruit.

Life Cycle: The thrips overwinter as adults in the soil, emerging in the spring to feed and reproduce on spring flowering plants. The next generation feeds in apple blossoms and lay eggs in developing fruitlets. Several overlapping generations are produced each year.

Pest Management

Cultural Controls: The presence of thrips can be detected during early bloom with the use of a beating tray. The movement of thrips from other flowering hosts into apple can be prevented by avoiding mowing of ground cover for the period from 1 week before bloom until after petal fall.

Resistant Cultivars: Most varieties are tolerant except McIntosh, Spartan and Newtown apples.

Chemical Controls: Insecticides applied at petal fall for leafroller control will help to control leafrollers.

Issues for Western Flower Thrips

1. The registration of reduced-risk products that suppress thrips but do not harm pollinators, is required.
2. Tolerance to thrips feeding must be incorporated into new varieties.

Winter Moth (*Operophtera brumata*)

Pest Information

Damage: Larvae feed on bud clusters, leaves and fruit. In high infestations, trees can be severely defoliated, resulting in weakened trees and increased susceptibility to winter injury.

Life Cycle: There is 1 generation per year. Eggs are laid in the spring in crevices in the bark. After hatching the young larvae are dispersed by hanging from silken threads and being blown by wind to host trees. Feeding is generally completed by mid-June when the larvae drop to the soil to pupate. Adults emerge in the spring and the wingless females crawl up the tree trunk to lay eggs.

Pest Management

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

Resistant Cultivars: There are no resistant cultivars available.

Chemical Controls: A number of insecticides are registered for control of this pest (refer Table 9: "Classification and registration status of insecticides and miticides for pest management in apple in Canada.").

Issues for Winter Moth

None identified.

Green Apple Aphid (*Aphis pomi*)

Pest Information

Damage: Green apple aphids 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 and causing blemishes on fruit. Heavy infestations can result in feeding on immature fruit, causing russeting.

Life Cycle: Overwintered eggs hatch as leaves begin to expand in the spring. The nymphs feed on expanding leaves and develop into wingless adults in about two weeks. Adults reproduce without mating and bear live young. Thus populations can build up quickly. There are many generations per year.

Pest Management

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 re-growth. 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.

Resistant Cultivars: There are no resistant cultivars available.

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.

Issues for Green Apple Aphid

1. There is a need for the registration of alternative chemistries for resistance management.

Rosy Apple Aphid (*Dysaphis plantaginea*)

Pest Information

Damage: This pest is one of the most economically important aphid pests 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: This aphid overwinters as eggs laid on bark at the base of buds. Egg hatch occurs in spring. Nymphs feed on buds, expanding leaves and young fruitlets.

Pest Management

Cultural Controls: Practices used for the management of the green apple aphid are also used for the rosy apple aphid.

Resistant Cultivars: There are no resistant cultivars available.

Chemical Controls: Pesticides registered for rosy apple aphid control are listed in Table 9. "Classification and registration status of insecticides and miticides for pest management in apple in Canada".

Issues for Rosy Apple Aphid

1. There is a need for a greater selection of reduced risk active ingredients to reduce reliance on neonicotinoids.

Woolly Apple Aphid (*Eriosoma lanigerum*)

Pest Information

Damage: Feeding by the pest results in knots and galls on twigs and roots. Damaged areas are more prone to frost and winter injury. Root injury is found mainly in the warmer climate of British Columbia. Honeydew, excreted by the aphids, drips onto leaves and fruit causing russet spots and promoting the establishment of sooty fungi. This can result in downgrading of fruit quality. The honeydew and sooty mold fungi are nuisances at harvest as the fruit becomes sticky and clothing can be stained on contact with sooty molds.

Life Cycle: The life cycle of the woolly apple aphid is not completely understood and may involve more than one host. Aerial colonies are commonly observed on apple around pruning wounds and at the base of succulent shoots. Infestations increase as the growing season progresses. Both winged aphids and crawlers can move from tree to tree.

Pest Management

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. 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. Economic thresholds have not been established.

Resistant Cultivars: There are no resistant cultivars available.

Chemical Controls: Sprays of a number of pesticides can help control populations. Later summer pesticide use is discouraged, as treatments are ineffective due to the waxy covering of this species.

Issues for Woolly Apple Aphid

1. Additional research is needed on the selection of rootstocks to prevent or minimize the development and impact of woolly apple aphid infestations.
2. There is a need for the registration of new products, including systemic products to control root populations, for the management of woolly apple aphid.
3. Further research is needed on biological control opportunities with introduced and native natural enemies.
4. Further research is required on the tolerance of woolly apple aphid to reduced risk products.

Clearwing borers (Dogwood borer (*Synanthedon scitula*) and apple clearwing moth (*Synanthedon myopaeformis*)

Pest Information

Damage Caused: Dogwood borer is present in eastern Canada. The apple clearwing moth is a new pest in British Columbia (2005) and in Ontario (2006). Both species cause similar damage. Larvae bore into burr knots 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: Eggs are laid in wounds or burr knots produced at the root-scion interface. Larvae tunnel under the bark feeding on bark and cambium tissues. Larvae overwinter in hibernaculae under the bark and pupate in the spring. Adult moths emerge over several months. The life cycle of the dogwood borer takes 1 year and that of the clearwing moth 1-2 years.

Pest Management

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. There are no established monitoring methods, but visual observation of trunk areas can reveal cast pupal skins.

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

Chemical Controls: Chemical controls for clearwing moth species are listed in Table 9. "Classification and registration status of insecticides and miticides for pest management in apple in Canada".

Issues for Dogwood Borer

1. There is a need for the registration of additional products for the management of this insect.
2. There is a need for research on the use of nematodes and other biological options for managing dogwood borer.
3. There is a need for the registration of mating disruption technology for the management of dogwood borer.

Issues for Apple Clearwing Moth

4. The development of reduced risk, non-neonicotinoid ovicides and larvicides and an improved mating disruption product, is needed.
5. The development of degree day models for insect development, to better time sprays, is needed.
6. Research on the impact of borer on tree productivity and longevity, is required to develop an economic basis for management decisions.

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

Pest Information

Damage: 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 life cycle of the mites varies with the mite species, with some overwintering as eggs and others as adults. Mites develop from egg, through nymphal stages to adults. There are several generations per year.

Pest Management

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. 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.

Resistant Cultivars: There are no resistant cultivars available.

Chemical Controls: Dormant oil is used as a first strategy for controlling the European red mite. Spray coverage is very important and increased water volumes are usually used for miticide applications. It is recommended that the miticides listed be applied only once per year.

Issues for Mites

1. Grower education is required on the prevention of miticide resistance.
2. Grower education is required to improve understanding of the causes of mite problems and how to promote biological control through preserving predators.
3. The increasing cost of oils has resulted in their decreased use, contributing to more mite (and scale) problems.

Scale Insects: European fruit scale (*Quadraspidotus ostreaeformis*) oystershell scale (*Lepidosaphes ulmi)* and San Jose scale (*Quadraspidotus perniciosus*)

Pest Information

Damage: Scale insects feed by sucking plant juices. 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: The life cycle of scale insects is complex and varies with the species. Scale insects overwinter under rough bark. Female scales lay eggs or give birth to live young (crawlers) beneath the scale covering. The crawlers disperse on plant surfaces and eventually settle down to feed, at which time they begin to produce the protective, waxy scale covering. Winged males are produced at certain times of the life cycle.

Pest Management

Cultural Controls: New orchards should be planted away from hardwood stands and from older plantings where scale has been a problem. Nursery stock should be free from scale infestations. Infested fruit and limbs should be removed and destroyed. Trees should be pruned to open canopies to improve spray penetration and coverage. Monitoring, other than simple visual observation, is rarely done.

Resistant Cultivars: The introduction of dwarfing rootstocks has reduced the seriousness of these pests.

Chemical Controls: The spring application of dormant oil, prior to bud break is effective and reduces the need for post-bloom sprays against the subsequent crawler stages. High water volumes are needed to achieve thorough coverage to reach insects overwintering in bark crevices. It is difficult to control these insects later in the season due to the formation of their impervious, waxy shell.

Issues for Scale Insects

1. The application of dormant sprays, which are very effective in preventing scale infestations, needs to be promoted to growers. The efficacy of chemical pesticides is variable during the growing season once scale shells have hardened.
2. There is a need for effective, alternative insecticides for the control of occasional scale flare-ups.
3. San Jose scale seems to be increasing as we are moving towards more reduced risk pesticide programs and away from the organophosphates.
4. There is little information available on the use of traps to time sprays for scale in orchards.

Spring-Feeding Caterpillar Complex (Includes: green fruitworm (*Lithophane georgii*), speckled green fruitworm (*Orthosia hibisci*), brown fruitworm (*Eupsilia tristigmata*), eye spotted budmoth (*Spilonota ocellana*), fruit-tree leafroller (*Archips argyrospilus*) pale apple leafroller *(Pseudexentera mali)* and red-banded leafroller*(Argyrotaenia velutinana) and others)*

Pest Information

Damage: Caterpillars feed on young developing leaves and bore into buds early in the spring. Larvae of some 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 among species.

Pest Management

Cultural 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.

Resistant Cultivars: There are no resistant cultivars.

Chemical Controls: Insecticides registered for the control of the various caterpillar species are listed in Table 9. "Classification and registration status of insecticides and miticides for pest management in apple in Canada".

Issues for Spring-Feeding Caterpillar Complex

1. There is a need for the development of monitoring tools to accurately detect changes in pest populations in order to make sound pest management decisions.
2. There is a need to ensure that all important pest species in a group (eg. all pest leafroller species) are included on the label of newly registered products, to reduce the need and delays of pesticide availability, due to label expansion.
3. Growers need access to a pesticide resistance testing service to allow the design of resistance management programs and help prevent field failures and reduce crop losses.

Obliquebanded Leafroller *(Choristoneura rosaceana)*

Pest Information

Damage: The obliquebanded leafroller feeds on buds, leaves , flowers and fruitlets. Feeding damage to fruitlets, resulting in deep gouges in the small apples, is of greatest concern. Damaged fruit that does not drop develops 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. First summer generation fruit damage includes tiny circular excavations on the fruit surface and more extensive shallow feeding resembling railroading. The second summer generation larvae create small feeding holes that allow entry of rot pathogens, resulting in the downgrading of fruit during long-term storage.

Life Cycle: Immature larvae overwinter in hibernacula. In the spring, larvae move to terminals, complete their development and pupate within protective, rolled leaves. Adult moths emerge in late June through July and lay eggs in the canopy of the tree. Following hatch, young larvae disperse by crawling or on silken threads and feed on leaves and fruit clusters, before pupating. Second generation adults emerge in late summer and the subsequent second larval generation feeds briefly before seeking overwintering sites on host trees. In BC, the threelined leafroller (*Pandemis limitata*) occurs in association with OBLR. It has the same life cycle (two generations/year) and causes similar damage.

Pest Management

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. 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.

Resistant Cultivars: The pest seems to have a preference to feed on certain cultivars.
Chemical Controls: Insecticides registered for oblique banded leafrollers are listed in Table 9. "Classification and registration status of insecticides and miticides for pest management in apple in Canada".

Issues for Obliquebanded (and Threelined) Leafrollers

1. There is a need to educate growers on the proper use of new products that require more precise timing, rates and application and for resistance management.
2. Research is required to improve the understanding of the seasonal development of natural enemies and their tolerance to pesticide residues, to minimize the impact of pesticides on beneficial insects.

Stinging Bug Complex (includes tarnished plant bug (*Lygus lineolaris*), apple brown bug (*Atractotomus mali*), green apple bug (*Lygocoris cummunis*) and apple red bug (*Lygidea mendax*)

Pest Information

Damage: Stinging bugs suck juices from plant tissue. Toxins are released into the fruit, blossom and leaf axils 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: The life cycles vary with the species of bug. Some overwinter as eggs inserted into young bark of apple trees and others overwinter as adults under plant debris. The tarnished plant bug has a broad host range and readily moves between hosts.

Pest Management

Cultural 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.
Resistant Cultivars: There are no resistant cultivars.
Chemical Controls: Insecticides registered for control of the various stinging bugs are listed in Table 9. "Classification and registration status of insecticides and miticides for pest management in apple in Canada".

Issues for Stinging Bug Complex

1. There is a need for the registration of reduced risk products for the management of plant bugs.
2. There is a need for improved monitoring approaches and economic thresholds for tarnished plant bugs and stink bugs.
3. There is a need for improved understanding of the ecology and behaviour of stink and lygus bugs in order to design reliable monitoring methods and effective management tactics.
4. There is a need for research on pest prevention tactics and economic impact.

Mullein Bug (*Campylomma verbasci*)

Pest Information

Damage: Feeding in blossoms during bloom to petal fall and on developing fruitlets 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

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

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

Chemical Controls: Refer to Table 9 for pesticides registered for the control of mullein bug.

Issues for Mullein Bug

1. There is a lack of effective, IPM compatible alternatives to diazinon. Neonicotinoids are the only alternative chemistry which already has many registered uses in tree fruit, creating resistance development issues.
2. There is a need for research into factors in organic apple production that currently keep mullein bug populations in check.

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. The pest can cause significant damage to nursery trees and young, non-bearing trees in a short period of time.

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

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

Resistant Cultivars: There are no resistant cultivars.

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

Issues for Potato Leafhopper

1. There is concern that this insect is a vector of fireblight.

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 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: This leafhopper overwinters as eggs under the bark of apple tree branches where they cause blisters. The eggs hatch throughout the flowering period and the young nymphs move to the underside of foliage where they feed and complete their development. There are two generations per year. Eggs of the second generation are laid in petioles and midribs of leaves.

Pest Management

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

Resistant Cultivars: There are no resistant cultivars

Chemical Controls: Pesticides registered for the management of white apple leafhopper are listed in Table 9.

Issues for White Apple Leafhopper

1. There is concern of the potential for this insect to be a vector of fire blight.
2. The use of neonicotinoid products that replaced carbaryl (and soon endosulfan), is associated with increased mite problems.
3. The increased risk of resistance to neonicotinoid insecticides is an issue as no alternative chemistries are available.

Table 9: Classification and registration status of insecticides and miticides for pest management in apple in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Registration status[3]	Targeted Pests[1]
abamectin	Avermectins, Milbemycins	Chloride channel activators	6	R	european red mite, leafminers, McDaniel spider mite, two-spotted spider mite
acetamiprid	Neonicotinoids	Nicotinic acetylcholine receptor (nAChR) agonists	4A	R	aphid (general), caterpillars, leafhoppers, leafminers, psyllids
azinphos-methyl	Organophosphates	Acetylcholinesterase inhibitors	1B	PO	apple maggot, codling moth, european apple sawfly, fruit-tree leafroller, green fruitworm, leafhoppers, mullein plant bug, obliquebanded leafroller, pear psylla, plum curculio, red-banded leafroller, san jose scale, scale insects, spring-feeding caterpillar complex, stinging bug complex, tarnished plant bug, winter moth
Bacillus thuringiensis subsp. kurstaki	Bacillus thuringiensis or Bacillus sphaericus and the insecticidal proteins they produce	Microbial disruptors of insect midgut membranes	11	R	green fruitworm, spring-feeding caterpillar comple, winter moth
carbaryl	Carbamates	Acetylcholinesterase inhibitors	1A	R	aphid (general), apple maggot, apple rust mite, codling moth, fruit-tree leafroller, green fruitworm, leafhoppers, leafminers, mite pests, oriental fruit moth, pear psylla, pear slug, plum curculio, red-banded leafroller, scale insects, spring-feeding caterpillar complex, tarnished plant bug, tent caterpillars
clothianidin	Neonicotinoids	Nicotinic acetylcholine receptor (nAChR) agonists	4A	R	aphid (general), caterpillars, codling moth, leafhoppers, pear psylla, plum curculio
cydia pomonella granulosis virus*	Biological	unknown	N/A	R	codling moth
cypermethrin	Pyrethroids, Pyrethrins	Sodium channel modulators	3A	R	apple brown bug, codling moth, green fruitworm, leafhoppers, leafminers, midges, mullein plant bug, plum curculio, spring-feeding caterpillar complex, stinging bug complex, winter moth
deltamethrin	Pyrethroids, Pyrethrins	Sodium channel modulators	3A	R	apple brown bug, codling moth, fruit-tree leafroller, green apple aphid, leafminers, mullein plant bug, obliquebanded leafroller, oriental fruit moth, spring-feeding caterpillar complex, stinging bug complex, white apple leafhopper, winter moth

diazinon	Organophosphates	Acetylcholinesterase inhibitors	1B	R	aphid (general), apple maggot, codling moth, european red mite, fruit-tree leafroller, green apple aphid, green fruitworm, leafhoppers, leafminers, mite pests, mullein plant bug, pear psylla, rosy apple aphid, san jose scale, scale insects, spring-feeding caterpillar complex, stinging bug complex
dodecyl-alcohol (lauryl-lcohol)(dodecanol)(dodeca*	Biological (mating disrupter)	unknown	N/A	R	codling moth, european leafroller, fruit-tree leafroller, obliquebanded leafroller, spring-feeding caterpillar complex, threelined leafroller
imidacloprid	Neonicotinoids	Nicotinic acetylcholine receptor (nAChR) agonists	4A	R	aphid (general), green apple aphid, leafhoppers, leafminers, mullein plant bug, rosy apple aphid, white apple leafhopper
lambda-cyhalothrin	Pyrethroids, Pyrethrins	Sodium channel modulators	3A	R	aphid (general), apple brown bug, codling moth, fruit-tree leafroller, green apple aphid, leafminers, obliquebanded leafroller, plum curculio, spring-feeding caterpillar complex, stinging bug complex, tarnished plant bug, winter moth
malathion	Organophosphates	Acetylcholinesterase inhibitors	1B	R	aphid (general), codling moth, leafhoppers, mite pests, plum curculio, psyllids, red-banded leafroller,scale insects spring-feeding caterpillar complex, tarnished plant bug, tent caterpillars, thrips, two-spotted spider mite,
methoxyfenozide	Diacylhydrazines	Ecdysone receptor agonists	18	R	codling moth, leafminers, obliquebanded leafroller, oriental fruit moth, spring-feeding caterpillar complex, threelined leafroller, winter moth
novaluron	Benzoylureas	Inhibitors of chitin biosynthesis, type 0	15	R	caterpillars, codling moth
n-tetradecanol (myristyl-alc)(tetradecyl-alc)(tetr*	Biological (mating disrupter)	unknown	N/A	R	codling moth, european leafroller, fruit-tree leafroller, obliquebanded leafroller, spring-feeding caterpillar complex, threelined leafroller
permethrin	Pyrethroids, Pyrethrins	Sodium channel modulators	3A	R	apple maggot, borers, codling moth, green fruitworm, leafminers, lesser apple worm, mullein plant bug, obliquebanded leafroller, plum curculio, red-banded leafroller, spring-feeding caterpillar complex, tarnished plant bug, tent caterpillars, white apple leafhopper, winter moth
pirimicarb	Carbamates	Acetylcholinesterase inhibitors	1A	DI	aphid (general), white apple leafhopper

spinetoram	Spinosyns	Nicotinic acetylcholine receptor (nAChR) allosteric activators	5	R	apple maggot, codling moth, leafminers, obliquebanded leafroller, oriental fruit moth, plum curculio, spring-feeding caterpillar complex, threelined leafroller
spinosad	Spinosyns	Nicotinic acetylcholine receptor (nAChR) allosteric activators	5	R	apple clearwing moth, apple maggot, codling moth, european leafroller, fruit-tree leafroller, obliquebanded leafroller, spring-feeding caterpillar complex, threelined leafroller
spirotetramat	Tetronic and Tetramic acid derivatives	Inhibitors of acetyl CoA carboxylase.	23	R	aphid (general), green apple aphid, pear psylla, psyllids, rosy apple aphid, san jose scale, scale insects
tebufenozide	Diacylhydrazines	Ecdysone receptor agonists	18	R	codling moth, leafminers, obliquebanded leafroller, winter moth
thiacloprid	Neonicotinoids	Nicotinic acetylcholine receptor (nAChR) agonists	4A	R	apple maggot, codling moth, leafhoppers, leafminers, mullein plant bug, oriental fruit moth, plum curcilio
thiamethoxam	Neonicotinoids	Nicotinic acetylcholine receptor (nAChR) agonists	4A	R	leafminers, mullein plant bug, plum curculio, rosy apple aphid

[1]As generated through Homologa (www.homologa.com) (Nov. 18, 2010).

[2] The classification and the mode of action group are based on the classification presented by the Fungicide Resistance Action Committee, the Insecticide Resistance Action Committee and the Herbicide Resistance Action Committee on the following web sites: Fungicides: www.frac.info/frac/index.htm ; Insecticides: www.irac-online.org ; Herbicides: www.hracglobal.com

[3] R-full registration RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of Nov. 18, 2010. 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. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: www.hc-sc.gc.ca/cps-spc/pest/index-eng.php

[4] Please consult the product label on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php) for specific listing of pests controlled by each active ingredient.

Table 10. Pheromone products registered on apple in Canada

Product Name[1]	Targeted Pests[2]
3M Sprayable Pheromone For Mating Disruption Of Oriental fruit moth	oriental fruit moth
Isomate-C Plus Codling Moth Pheromone	codling moth
Isomate-Cm/Lr Pheromone	codling moth, fruit-tree leafroller, obliquebanded leafroller, spring-feeding caterpillar complex, threelined leafroller
Isomate-Cm/Lr Tt	codling moth, european leafroller, fruit-tree leafroller, obliquebanded leafroller, spring-feeding caterpillar complex, threelined leafroller
Isomate-Cm/Ofm Tt	codling moth, lesser apple worm, oriental fruit moth
Isomate-M Rosso Oriental Fruit Moth Pheromone	oriental fruit moth
Isomate-M100 Oriental Fruit Moth Pheromone	oriental fruit moth
Isomate-P Pheromone	apple clearwing moth

[1] Please consult the product label on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php) for specific listing of pests controlled by each active ingredient.

[2]As generated through Homologa (www.homologa.com) (Nov. 18, 2010).

Weeds

Key Issues

- There are concerns about the development of resistance in weeds such as Canada fleabane, giant ragweed and common ragweed, to glyphosate. Some weeds are resistant to linuron, which is used as a resistance management tool, where two treatments are needed. 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.
- Further research is required to support the development of integrated weed management in apple, including testing of new methods, 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 need for technical expertise to assist growers with integrated, non-chemical methods of weed control.
- 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 11: Occurrence of weeds in apple production in Canada

Pests	BC	ON	QC	NS
Annual broadleaf weeds				
Cleavers				
Common mallow				
Common chickweed				
Hemp nettle				
Common lamb's quarters				
Redroot pigweed				
Wild buckwheat				
Annual grass weeds				
Barnyard grass				
Crabgrass				
Foxtail				
Perennial broadleaf weeds				
Canada thistle				
Dandelion				
Bindweed				
Perennial grass weeds				
Woody plants				
Raspberry				
Wild grape				

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

[1]Source: Canadian Horticultural Council, Apple and Fruit Committee, Apple Working Group; data based on 2009 crop year.

[2]Please refer to the colour key (above) and Appendix 1, for a detailed explanation of colour coding of occurrence data.

Table 12: Adoption of weed management practices for apple in Canada

	Practice/Pest	Annual grass weeds	Annual broadleaf weeds	Perennial grass weeds	Perennial broadleaf weeds
Avoidance	planting / harvest date adjustment				
	crop rotation				
	choice of planting site				
	use of weed-free seed				
	optimizing fertilization				
Prevention	equipment sanitation				
	mowing / mulching / flaming				
	row or plant spacing (plant density)				
	seeding depth				
	water/ irrigation management				
	weed management in non-croplands				
	weed management in non-crop years				
	tillage/ cultivation				
Monitoring	scouting - field inspection				
	field mapping of weeds/ record of resistant weeds				
	soil analysis				
	grading of grain/ produce for weed contamination				
Decision Making Tools	economic threshold				
	weather/ weather based forecast/predictive model				
	recommendation from crop specialist				
	first appearance of weed or weed growth stage				
	observed crop damage				
	crop stage				
	calendar spray				
Suppression	biological pesticides				
	habitat / environment management				
	pesticide rotation for resistance management				
	soil amendments				
	ground cover / physical barriers				
	inter-row cultivation				
	mechanical weed control				
	spot treatments				

Information regarding the practice for this pest is unknown or not applicable.

This practice is available and used to manage this pest in at least one reporting province.

This practice is available but not used for this pest in reporting provinces.

This practice is not available for this pest

This practice is not applicable for the management of this pest.

Source: Canadian Horticultural Council, Apple and Fruit Committee, Apple Working Group; data based on 2009 crop year.

All weeds

Pest Information

Damage: Weeds compete with tree roots for moisture and nutrients and may harbour disease and insect pests, as well as increase rodent problems. In the year of planting, the growth of young trees can be significantly reduced by competition from weeds, between May and July, the critical weed-free period. For bearing trees, the critical weed free period is from bud break to early July. Weed competition during this time can significantly affect the current year's yield and affect fruit bud set for the next growing season.

Life Cycle: ***Annual weeds:*** Annual weeds complete their life cycle, from seed germination, through vegetative growth and flowering, to seed production, in one year. Many weeds in fruit crops are winter annuals, plants that begin their growth and produce a rosette of leaves in the fall and flower and set seed the second year. Annual weeds produce large numbers of seeds and some weed seeds remain viable in the soil for many years, germinating when conditions are suitable.

Biennial weeds: Biennial weeds germinate in the spring and remain vegetative during the first summer. They over-winter as rosettes and in the second growing season, produce a flower stock on which seeds are produced. The original plants die at the end of the second growing season. Biennial weeds reproduce only through seeds produced every other year.

Perennial weeds: Perennials are plants that live for many years. They spread through seeds, the expansion of various types of root systems and other vegetative means.

Pest Management

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 and mowing.

Chemical Controls:. There are many herbicides registered for use on apple, including burn-off, residual and selective types (Refer Table 13. Classification and Registration status of herbicides for weed management in apple in Canada).

Issues for Weeds

1. See "Key issues", above.

Table 13: Classification and registration status of herbicides for weed management in apple in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Registration status[3]	Targeted Pests[1]
2,4-D	Phenoxy-carboxylic-acids	Action like indole acetic acid (synthetic	O	R	annual and perennial weeds
bentazon (bendioxide)	Benzothiadiazinone	Inhibition of photosynthesis at photosystem	C3	R	annual and perennial weeds
carfentrazone-ethyl	Triazolinones	Inhibition of protoporphyrinogen oxidase	E	R	annual and perennial weeds
clopyralid	Pyridine carboxylic acids	Action like indole acetic acid (synthetic	O	R	vetch
fluazifop-P-butyl	Aryloxyphenoxy-propionates	Inhibition of acetyl CoA carboxylase	A	DI	grass weeds
flumioxazin	N-phenylphthalimides	Inhibition of protoporphyrinogen oxidase	E	R	annual and perennial weeds
linuron	Ureas	Inhibition of photosynthesis at photosystem	C2	R	annual and perennial weeds
metribuzin	Triazinones	Inhibition of photosynthesis at photosystem	C1	R	annual and perennial weeds
napropamide	Acetamides	Inhibition of cell division (Inhibition of	K3	R	annual and perennial weeds
pendimethalin	Dinitroanilines	Microtubule assembly inhibition	K1	R	annual and perennial weeds
propyzamide (pronamide)	Benzamides	Microtubule assembly inhibition	K1	R	grass weeds
sethoxydim	Cyclohexanediones 'DIMs'	Inhibition of acetyl CoA carboxylase	A	R	annual and perennial weeds
simazine	Triazines	Inhibition of photosynthesis at photosystem	C1	R	annual and perennial weeds
terbacil	Uracils	Inhibition of photosynthesis at photosystem	C1	R	annual and perennial weeds
trifluralin	Dinitroanilines	Microtubule assembly inhibition	K1	R	annual and perennial weeds

[1]As generated through Homologa (www.homologa.com) (Nov. 18, 2010).

[2] The classification and the mode of action group are based on the classification presented by the Fungicide Resistance Action Committee, the Insecticide Resistance Action Committee and the Herbicide Resistance Action Committee on the following web sites: Fungicides: www.frac.info/frac/index.htm Insecticides: www.irac-online.org ; Herbicides: www.hracglobal.com

[3] R-full registration RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of Nov. 18, 2010. 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. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: www.hc-sc.gc.ca/cps-spc/pest/index-eng.php

[4] Please consult the product label on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php) for specific listing of pests controlled by each active ingredient.

Vertebrate Pests

Birds

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. There is concern that birds are becoming accustomed to feeding in orchards with the newer cultivars, that are often later maturing.

Pest Management

Cultural Controls: Planting of orchards away from pine plantations can help. 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.

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

Chemical Controls: None available.

Issues for Birds

1. There is a need for the development of protocols for the determination of crop damage levels.

Rodents

Pest Information

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

Pest Management

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/ mouse guards around trees, are all good management techniques. Predators, such as shrews, skunks, weasels, dogs, foxes, coyotes, owls, hawks and snakes will help keep rodents away.

Resistant Cultivars: None identified.

Chemical Controls: Rodenticides can be used to kill rodents.

Issues for Rodents

None identified

Rabbit

Pest Information

Damage: Rabbits feed on terminal growth and fruit buds. Jackrabbits can damage limbs.

Pest Management

Cultural Controls: Orchards should be planted away from natural meadows. Latex paint with thiram can be used on trunks. Predators, such as dogs, foxes, owls and hawks will deter rabbits.

Resistant Cultivars: None identified.

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. This is more critical on newer high density orchards, where browsing can ruin the fruiting area. Rubbing of antlers may damage smaller trees. Deer are also a major problem in tree fruit nurseries.

Pest Management

Cultural Controls: Fencing has been effective at excluding deer from orchards in British Columbia. Electrical fencing has been successful in Nova Scotia. 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.

Issues for Deer

1. There is a need for an economical approach to preventing deer feeding in orchards, given the high cost of fencing.

Resources

IPM / ICM resources for production of apple in Canada

Organic Apple Production Guide for Atlantic Canada, 2008: 31 p. Ed. G. Braun and B, Craig
http://www.organicagcentre.ca/DOCS/Organicappleprod08_e.pdf

Integrated Fruit Production Guidelines for Apple Orchards in Canada, Canada Horticultural Council, 2003 : 51 p. http://www.hortcouncil.ca/en/resources/chc-publications.aspx

Guide de gestion intégrée des ennemis du pommier Centre de Référence en Agriculture et Agroailmentaire du Québec, 2001: 234 pp.
http://www.craaq.qc.ca/Publications?p=32&l=fr&IdDoc=1000

Integrated Pest Management for Ontario Apple Orchards, Publication 310 Ontario Ministry of Agriculture, Food and Rural Affairs, 2009: 244 p.
http://www.omafra.gov.on.ca/english/crops/pub310/p310order.htm

Fruit Production Recommendations 2010-11, Ontario Ministry of Agriculture, Food and Rural Affairs
http://www.omafra.gov.on.ca/english/crops/pub360/p360toc.htm

Ontario Crop IPM, Ontario Ministry of Agriculture, Food and Rural Affairs
http://www.omafra.gov.on.ca/IPM/english/index.html

2010 Integrated Fruit Production Guide for Commercial Tree Fruit Growers – Interior BC
B.C. Fruit Growers Association (http://www.bcfga.com)

Field Guide to Harmful and Beneficial Insects and Mites of Tree Fruits (3rd ed.)
Hugh Philip & Linda Edwards/ B.C. Fruit Growers Association (http://www.bcfga.com)

Harmful and Beneficial Insects and Mites of Tree Fruits
Hugh Philip & Linda Edwards / B.C. Ministry of Agriculture and Lands
http://www.agf.gov.bc.ca/cropprot/fieldguide/main.htm

Tree Fruit Insect Pests and Diseases
B.C. Ministry of Agriculture and Lands
http://www.agf.gov.bc.ca/cropprot/tfipm/treefruitipm.htm

Production fruitière intégrée 2009-2010
Institut de recherche et de développement en agroenvironnement
http://www.agrireseau.qc.ca/reseaupommier/documents/Affiche%20PFI_2009_finale.pdf

Guide d'identification des ravageurs du pommier et de leurs ennemis naturels
Centre de référence en agriculture et agroalimentaire du Québec

http://www.craaq.qc.ca/Publications?p=32&l=fr&IdDoc=897

Le Réseau-pommier du Québec
Centre de référence en agriculture et agroalimentaire du Québec
http://www.agrireseau.qc.ca/reseaupommier

Tree Fruit Field Guide to Insect, Mite, and Disease Pests and Natural Enemies of Eastern North America
NRAES
http://www.craaq.qc.ca/Publications?p=32&l=fr&IdDoc=1807

Orchard Management Schedule for Nova Scotia Apples and Pears. Bill Craig, AgraPoint
http://www.extensioncentral.com/eng/index.php?option=com_docman&task=cat_view&gid=113&Itemid=32

Best Management Practices for Nova Scotia Apple Production
Bill Craig, AgraPoint

http://www.extensioncentral.com/eng/index.php?option=com_docman&task=doc_view&gid=589&tmpl=component&format=raw&Itemid=32

Guide to Weed Management in Nova Scotia Orchards, Bill Craig, AgraPoint
http://www.extensioncentral.com/eng/index.php?option=com_docman&task=cat_view&gid=113&Itemid=32

Provincial Apple Crop Specialists and Minor Use Coordinators

Province	Ministry	Crop Specialist	Minor Use Coordinator
British Columbia	British Columbia Ministry of Agriculture and Lands (www.infobasket.gov.bc.ca/portal/server.pt)	Jim Campbell, Industry Specialist - Tree Fruit and Grapes, jim.g.campbell@gov.bc.ca	Caroline Bédard (caroline.bedard@gov.bc.ca)
Ontario	Ontario Ministry of Agriculture and Food (www.omafra.gov.on.ca)	Leslie Huffman, Apple Specialist, Leslie.huffman@ontario.ca Kathryn Carter, Pome Fruit IPM Specialist, Kathryn.carter@ontario.ca	Jim Chaput (jim.chaput@ontario.ca)
Quebec	Ministére d'Agriculture, Pêcheries et Alimentation du Québec (www.mapaq.gouv.qc.ca)	N/A	Marie Garon (marie.garon@mapaq.gouv.qc.ca)
New Brunswick	New Brunswick Department of Agriculture and Aquaculture (www.gnb.ca/0027/index-e.asp)	Garth Nickerson, Nursery / Tree fruit Specialist, garth.nickerson@gnb.ca	Kelvin Lynch (kelvin.lynch@gnb.ca)
Nova Scotia	Nova Scotia Department of Agriculture and Fisheries (www.gov.ns.ca/nsaf.ca)	N/A	Lorne Crozier (crozielm@gov.ns.ca)
	AgraPoint International (www.agrapoint.ca)	Bill Craig Horticultural Specialist b.craig@agrapoint.ca	

National and Provincial Apple Grower Organizations

Canadian Horticultural Council; www.hortcouncil.ca

British Columbia Fruit Growers Association; www.bcfga.com

Saskatchewan Fruit Growers Association; www.saskfruit.com

Ontario Apple Growers; www.onapples.com

Ontario Fruit & Vegetable Growers Association; www.ofvga.com

Norfolk Fruit Growers Association; www.nfga.ca

Nova Scotia Fruit Growers Association; www.nsapples.com

L'Union des producteurs agricoles; www.upa.qc.ca/fra/index_flash.asp

Conseil québécois de l'horticulture; www.cqh.ca

Association des emballeurs de pommes du Québec; www.pommes-quebec.com

Apple Grower's of New Brunswick

Fédération des producteurs de pommes du Québec
www.lapommeduquebec.ca/

Appendix 1: Explanation of colour coding of disease, insect and mite and weed occurrence tables (Tables 4, 7 and 11)

Information on the occurrence of disease, insect and mite and weed pests in each province is provided in the Tables 4, 7 and 11, respectively of the crop profile. The colour coding in the cells in these tables is based on three pieces of information, namely pest distribution, frequency and importance in each province as presented in the following chart. (Definitions of terms is provided at the bottom of the table):

Pest Frequency	Distribution	Pest Importance	Colour Code
If the pest is present 7 or more years out of 10 (yearly)	widespread	high	Red
		moderate	Orange
		low	Yellow
	localized	high	Orange
		moderate	White
		low	White
If the pest is present 6 years or less out of 10 (sporadic)	widespread	high	Orange
		moderate	yellow
		low	white
	localized	high	yellow
		moderate	White
		low	White
Pest not present			black
Data not reported			grey

Definition of terms describing pest distribution, frequency and importance:

Distribution: Localized: Present only in limited areas of the province

Widespread: Present throughout the province

Frequency (number of years the pest is present at levels requiring controls)

Sporadic: Present 6 years or less/ 10

Yearly: Present 7 years or more /10

Pest importance (based on crop impact and the need for controls when present)

Low: If present, potential for spread and crop loss is low and controls must be implemented only under specific conditions.

Moderate: If present, potential for spread and crop loss is moderate; pest situation must be monitored and controls may be implemented.

High: If present, potential for spread and crop loss is high and controls must be implemented even for small populations.

References

Nova Scotia Orchard Pest Management Fact Sheets
Nova Scotia Dept. of Agriculture and Marketing, 1993

Guide de Gestion Intégrée des Ennemis du Pommier
Centre de Référence en Agriculture et Agroailmentaire du Québec, 2000: 226 pp.

Integrated Pest Management for Ontario Apple Orchards, Publication 310
Ontario Ministry of Agriculture, Food and Rural Affairs, 2009: 244 pp.

Fruit Production Recommendations, 2002-2003, Publication 360
Ontario Ministry of Agriculture and Food, 2003: 294 pp.

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

Food and Agriculture Organization of the United Nations
http://apps.fao.org/page/collections?subset=agriculture
http://www.ipgri.cgiar.org/index.htm

Statistics Canada
http://dsp-psd.pwgsc.gc.ca/Collection-R/Statcan/21-001-XIB/21-001-XIB-e.html

Agriculture and Agri-Food Canada
www.agr.gc.ca/misb/hort/trends-tendances/pdf/fru_02_03_e.pdf
http://pgrc3.agr.gc.ca

Communications Canada
http://dsp-psd.communication.gc.ca/Collection-R/Statcan/32-229-XIB/32-229-XIB-e.html

Integrated Pest Management for Ontario Apple Orchards, Publication 310 Ontario Ministry of Agriculture, Food and Rural Affairs, 2009: 244 p.
http://www.omafra.gov.on.ca/english/crops/pub310/p310order.htm