Crop Profile for Strawberry in Canada

Prepared by:

Pesticide Risk Reduction Program

Pest Management Centre

Agriculture and Agri-Food Canada

April 2005

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada | Canada

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The authors recognize the efforts of the Pest Management Regulatory Agency (PMRA), provincial pest management representatives, industry specialists and growers in the gathering of information that was required, and the review and validation of the content of this publication.

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The cultivated strawberry, genus *Fragaria, i*s a member of the Rosaceae (rose) family. Modern cultivated varieties for fruit production are usually crosses between species such as *Fragaria vesca* (the wood strawberry), *F. virginiana* (the meadow or wild strawberry), *F. chiloensis* (the beach strawberry) and *F. moschata*. Other genome sources include *F. x ananassa* (*F. virginiana* and *F. chiloensis* crosses) and *F. x bringhurstii*. *Fragaria vesca* was first cultivated by the Romans in 200 BC. Today, strawberries grow in temperate regions throughout the world. In North America, strawberries have been grown for fruit production since about 1835.

General Production Information

Canadian Production (2003)	24,521 metric tonnes 5,593 hectares
Farm gate value (2003)	$53 million
Domestic consumption (2001)	42,000 metric tonnes (raw) 16,490 metric tonnes (processed)
Export (2002)	$3.7 million
Imports (2002)	$177 million

Source(s): Statistics Canada

Production Regions

Strawberries are grown in all provinces of Canada. Quebec (36%), Ontario (32%), British Columbia (15%) and Nova Scotia (7.9%) have the largest total productions. New Brunswick (2.8%), Manitoba (2.7%), Alberta (1%), Prince Edward Island (0.9%), Newfoundland (0.9%) and Saskatchewan (0.5%) also produce strawberries.

Cultural Practices

Strawberry plants are shallow rooted, with most of the roots in the top 15 cm of soil, and require a well-drained soil at least 20 cm deep. Heavy clay soils that are slow to drain should be avoided. Strawberries can be grown in coarse, sandy soils, but fertilization and irrigation must be managed carefully for successful yields. Raised beds are often used for sites with poor soil drainage. A moderately high (7 to 30%) organic matter content is desirable and optimum soil pH is between 6.0 and 6.5. Adequate preparation of the site, including weed and nematode management, before new plantings can be established is very important.

Strawberries cannot tolerate drought and often require irrigation. June-bearing fields are often irrigated with overhead equipment. In June-bearing crops in BC coastal areas irrigation is often not necessary as the berries are harvested before the hot, dry summer season. However, after field renovation in July, irrigation is often necessary to encourage good re-growth. Day-neutral crops are often grown on raised beds with trickle or drip irrigation and plastic mulch. Strawberry cultivars vary widely in their cold hardiness, from 4 to 10 °C. The most popular commercial cultivars for northern climates are June-bearing types, which produce a single crop of berries during the spring or early summer, beginning one year after planting. Day-neutral or

long-day (ever-bearing) cultivars flower and bear fruit throughout the growing season and bear a light crop the year of planting. Double-cropping or traditional ever-bearing cultivars begin bearing one year after planting, but most are more suitable for home gardens. June-bearing varieties are the source of the main summer harvest, while day-neutral (ever-bearing) varieties produce fruit from June to the first frost. Production of day-neutral strawberries in BC is limited to local fresh markets (accounting for about 1% of total BC strawberry production), and requires more intensive management than June-bearing strawberry production. Peak yields for all cultivars in cold climate are normally obtained during the year after planting.

Growers in Canada can choose from a variety of strawberry cultivars,based on fruit quality, disease (e.g. cultivars resistant to red stele or black root rot) or insect resistance, harvest time, and suitability for fresh and frozen markets. Strawberry planting stock is sold as one-year-old, bare-root plants. The Ontario Strawberry Plant Propagation Program provides the Ontario growers with a reliable supply of high-quality, virus-free planting stock that optimizes the control to a number of pests such as red stele, *Verticillium* wilt, black root rot, cyclamen mites and nematodes. Nova Scotia nurseries also produce and ship certified virus-free planting stock to most Canadian provinces. British Columbia growers import most strawberry planting stock from nurseries in central California through distributors in Oregon and Washington State.

Production Issues

Strawberry plantings produce well for several years, but fruit size tends to decline over time. Fresh-market crops may be ploughed under after the second harvest to maintain fruit size and reduce pest impact. Processing crops may be harvested for three or occasionally four years. Most strawberries in Canada are June-bearing varieties picked in June and July, but there is some production of day-neutral varieties, which have a longer harvest season. Commercial growers tend to harvest fruit before they become over-ripe and try to properly cool and store them to reduce fruit rot incidence. Strawberries are hand-harvested and a shortage of labourers during the picking season is a common problem for growers.

Low temperature (winter) injury is the main abiotic factor affecting strawberries in Canada. In British-Columbia, waterlogged soils during winter combined with fluctuating, mostly warm temperatures in coastal regions, are the most important factors that kill or injure plants.

The most important pest issues of strawberries include fungal diseases and insect damage. Field sanitation (weed management), proper site selection and adequate post-harvest renovation of the crop can reduce the impact of pests. Growing on raised beds and/or under mulches can also reduce pest pressure. Straw mulch is often used in eastern Canada but not in the British-Columbia Lower Mainland (coastal areas including the Fraser Valley) because of winter rains.

Many strawberry varieties depend upon pollinators to produce high yields and well-developed, full-fleshed berries. Poor pollination can result from lack of pollinators (e.g. honey bees), cold and wet conditions, or blossoms coverage by large leaves and may lead to misshapen berries and low marketable yield.

Table 1. Canadian strawberry production and pest management schedule

Time of Year	Activity	Action
January and February	Soil Care	Take soil samples for new plantings, if not done previously
March (early growth begins)	Plant Care	Remove old leaves before new growth begins, narrow rows and incorporate leaves into soil
	Soil Care	Incorporate winter cover crop, apply and incorporate lime, compost, and manure for new plantings, (if used)
	Disease Management	Remove and destroy old leaves to control fruit rot, powdery mildew, and leaf spot diseases
	Insect Management	Monitor for two-spotted spider mites and predators, apply acaricide if needed, monitor areas of poor growth for root weevil larvae, wireworms and leatherjackets, apply control if needed
	Weed Management	Begin hand weeding winter weeds and apply an herbicide for residual weed control
April (early growth continues)	Plant Care	Plant new plantings, irrigate new plantings as necessary
	Soil Care	Apply complete fertilizer in bands, apply first fertilizer to new plantings when new leaves appear
	Disease Management	Monitor for leaf spot, examine roots for signs of red stele, apply controls if necessary
	Insect Management	Monitor for mites, predators, root weevil larvae, wireworms and leatherjackets, examine new leaves for aphids, apply controls if necessary
	Weed Management	Hand weed and hoe in rows and cultivate between rows, as needed; apply herbicide for residual weed control in new plantings
May (flower buds appear and open)	Plant Care	Apply foliar fertilizer sprays if plant growth is weak, irrigate as necessary
	Disease Management	Start Botrytis fruit rot control when first flowers open, monitor for powdery mildew and leaf spot, apply controls if necessary
	Insect Management	Monitor for mites, predators, root weevils, wireworms, leatherjackets and aphids, apply control if needed, begin monitoring for lygus bugs and apply control immediately at first flowering
	Weed Management	Hand weed weeds not controlled by herbicides
June (flowering, fruit development, ripening and harvest)	Plant Care	Continue foliar fertilizer sprays, if necessary, irrigate as needed, harvest and market fruit, set runners in rows of new plants, remove flower buds in less vigorous new plantings
	Disease Management	Continue Botrytis fruit rot control, monitor for powdery mildew and leaf spot, apply controls if necessary
	Insect Management	Monitor for mites, predators, root weevils, wireworms, leatherjackets, aphids and lygus bugs, begin monitoring for spittlebugs
	Weed Management	Complete hand weeding before harvest

Time of Year	Activity	Action
July and August (post harvest)	Plant Care	Take leaf samples immediately after harvest, if needed, begin renovation, mow tops of plants, narrow rows and bury plant debris, irrigate as needed
	Soil Care	Take soil samples immediately after harvest, apply fertilizer in bands along rows if necessary, seed cover crop between rows and on the site of future plantings, apply fertilizer in bands along new plantings, install drainage for future plantings
	Disease Management	Perform post-harvest cultivation to reduce fungal inoculum, apply control if needed, examine areas of poor growth for root and crown diseases
	Insect Management	Continue monitoring for mites, predators, root weevils and aphids, check sites of future plantings for wireworm and control if needed
	Weed Management	Apply herbicide before mowing to control established weeds, hand-weed or hoe if needed
September (post harvest)	Plant Care	Irrigate as needed
	Soil Care	Cultivate soil to break soil compaction and improve winter drainage
	Disease Management	Continue monitoring for diseases, apply controls if needed
	Insect Management	Continue monitoring for mites, predators, root weevils and aphids, apply controls if needed
	Weed Management	Monitor fields for weeds, hand-weed if needed, apply residual herbicide for seedling weed control during fall and winter
October and November (post harvest)	Disease management	Apply control to suppress red stele
	Insect Management	Monitor for leatherjackets, apply controls if necessary
	Weed management	Apply residual herbicide for winter, if not already completed, mow grass and tall weeds that could shelter mice for winter
November and December (post harvest)	Disease management	Apply controls for red stele up to Nov. 30th if not already completed
	Insect Management	Monitor fields for mice and deer and control if needed

Adapted from the Strawberry Crop Profile, BC Crop Profiles 2002-2004, BC Ministry of Agriculture, Food and Fisheries, March 2003.

Source(s): Tracy Hueppelsheuser, BC Ministry of Agriculture, Food and Fisheries.

Abiotic Factors Limiting Production

Key Issues

- There is a need to develop new strawberry cultivars resistant to frost and temporary flooding.
- Regional work on soil issues, such as micronutrient requirements of strawberries is needed.

Cold Injury

Strawberry buds, blossoms, and immature fruit can be damaged by cold temperatures. Frost injury is more common in low lying areas of the field. Straw mulch between the rows may contribute to lower field temperatures, preventing the soil from warming up during the day. The critical temperature for injury depends on the variety, the stage of development, and the duration of adverse conditions. Freezing damage to crowns is common and can kill plants. Frost-damaged blossoms may dry-up or drop before forming fruit or misshapen fruit may be produced. Damage can be reduced by using sprinkler irrigation during low temperature periods, and row covers. Late blooming or frost-resistant varieties are less prone to blossom frost injury.

Herbicide Injury

Herbicide injury is sometimes confused with disease symptoms or insect damage. Drift or contamination with 2,4-D herbicide may cause deformed fruit. Symptoms of terbacil, simazine or other herbicide injury may resemble fungal or viral diseases.

Misshapen Berries

Berry size and shape is largely due to the number of seeds that develop on the surface of the berry. If a group of seeds does not develop, the portion of the berry under the seed will not enlarge or ripen. This results in a misshapen berry that is either pinched-in ("monkey faced" or "cat faced"), multiple-tipped, or fan-shaped (fasciated). Anything that prevents seed development can result in misshapen berries, including poor pollination,frost or hail injury to blossoms or fruit, high temperatures and drying winds during bloom, disease, insect feeding on flowers or fruits, short day length in the fall, herbicide injury, genetic factors (varieties) and nutrient imbalances.

Soil Quality

Poor soil conditions can cause poor growth and plant death during the establishment year. Very high soil acidity levels can contribute to poor growth. Strawberries are shallow rooted, and have a low tolerance to salts. Winter drainage will help leach salts from the soil. Irrigation water should be tested for dissolved salts, and plants should be irrigated during the summer months to keep the salts below the root zone. Salt injury can occur in south-western BC but is very site-specific and is not a problem in most of Canada.

Nutrient Balance

A balance of nutrients is required for optimal growth of strawberry plants. Nutrients may be present in soil, but depending on conditions they may be unavailable for uptake, or in concentrations that are toxic to plants. Soil pH can affect the availability of nutrients, and lime is usually applied to raise pH levels in acidic soils. Leaf and soil analyses are useful to determine

fertilizer requirements. Foliar sprays of micronutrients are generally recommended during the growing season if nutrient deficiency is observed.

Diseases

Key Issues

- The product registration system should be harmonized with the United States to alleviate the increasing domestic competition with berries imported from countries where more fungicides are available (e.g. United States and Mexico).
- There is concern over the heavy reliance on captan for the control of Botrytis fruit rot and new replacement fungicides, already available in other countries, are needed to be registered.
- There is a need to develop IPM programs for Botrytis fruit rot. Programs are effective in some regions, but resources are limited.
- Label expansion is necessary for some products. Products labelled for use against Botrytis fruit rot are also effective to control other foliar diseases.
- There is concern over the apparent stall in the development of biopesticides. Biological control products are currently registered in the United States and previously researched in Canada (e.g. *Trichoderma* spp.).
- There is a need for tools to accurately assess the level of pesticide resistance.
- New products need to be registered for the control of red stele root rot to add to the rotation with existing products.
- Soil fumigation options are needed for nematode and Verticillium wilt control, particularly in Atlantic Canada.
- There is a need to register new products for the control of powdery mildew as there are no effective fungicides available.
- Additional research is needed to study the physiology of the powdery mildew fungus so that fungicides can be better timed and IPM programs can be developed.
- There is a need to register new products for the control of anthracnose, common leaf spot and other foliar spot, scorch and blight diseases which are an increasing problem with some newer cultivars.
- There is a need to develop IPM programs for the control of angular leaf spot and Anthracnose.
- Aphid borne viruses are an increasing problem, mainly in nursery stock. There is a need for research into the identification of viruses and management strategies for vectors.
- Improved screening and assessment methods for both viruses and other pathogens are required for stock plants sold nationally and internationally.
- There is a need for the development of new strawberry cultivars with resistance to Botrytis fruit rot, red stele root rot, powdery mildew, common leaf spot and viruses.
- There is a continual concern over the lack of availability of qualified scouting services.
- There is concern over growers' reluctance to pursue more intensive IPM practices when costs are prohibitive or when risks are unacceptable.

Table 2. Degree of occurrence of diseases n Canadian strawberry production

	Degree of occurrence									
Major Diseases	**BC**	**AB**	**SK**	**MB**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Botrytis grey mould	E			E		E	E		E	
Red stele root rot	E					E	E		E	
Common leaf spot	E			E	E	E	E		E	
Powdery mildew	D			E		E	E		E	
Leather rot				E		E	E	D	E	
Minor Diseases	**BC**	**AB**	**SK**	**MB**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Angular leaf spot				E		E	E		E	
Anthracnose				E		E			E	
Cladosporium fruit rot	E			E			E			
Penicillium fruit rot	E			E			E			DNR
Rhizopus fruit rot (leak)	E			E		E	E		E	
Leaf blight					E	E			E	DNR
Leaf scorch				E	E	E	E		E	DNR
Phytophthora crown rot	E	DNR	DNR	DNR	DNR	DNR	DNR	DNR	E	DNR
Black root rot	E			E		E	E		E	DNR
Verticillium wilt	E			E		E	E		E	DNR
Viruses	D			E			E		E	
Aster-yellows type diseases	DNR	DNR	DNR	DNR	DNR	E	DNR	DNR	DNR	DNR
Widespread yearly occurrence with high pest pressure										
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure										
Widespread yearly occurrence with low to moderate pest pressure										
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure										
Pest not present										
DNR - Data not received for this pest from this province										
E – established										
D – invasion expected or dispersing										
Source(s): Provincial government specialists.										

Major diseases

Botrytis Grey Mould (*Botrytis cinerea*)

Pest Information

Damage: Botrytis cinerea is the main cause of strawberry fruit rot. If not controlled by a spray program, serious losses of fruit can occur yearly, especially in wet seasons. The disease affects all stages of fruit development, from blossoming through post-harvest marketing. Rot can occur on blossoms, blossom stems, and on green and rip berries. Infected plant parts develop a fuzzy, grey growth consisting of spores which are easily spread to other berries and blossoms. After harvest, the disease can spread rapidly from rotted to healthy berries, causing whole loads to be unmarketable.

Life Cycle: The pathogen over-winters in old leaves and fruit on the ground. In the spring, the fungus produces spores that infect blossoms. The fungus grows down through the flower parts into the young green berries as they develop.

Pest Management

Chemical Controls: Sprays must be applied regularly to prevent the disease from becoming established in the blossoms and developing fruit. First sprays are applied when blossoms open, and are repeated every 7 days. Spray rotations (among the different chemical groups) are used to reduce disease resistance. In drier areas, chlorothalonil applied as an early spring or post-harvest fall treatment can be effective in reducing Botrytis fruit rot. Control products include boscalid, captan, chlorothalonil, fenhexamid, folpet, iprodione, lime sulphur, thiophanate-methyl, thiram and vinclozolin.

Cultural Controls: Renovating and rotovating in early spring can remove and destroy leaves and fruit debris carrying the pathogen. Over-fertilization with nitrogen before harvest can cause excessive growth and increased fruit rot. Managing row spacing and row width allows for adequate air movement and rapid drying of leaves. Irrigation should be timed so that flowers and leaves dry off quickly. Weed control reduces humidity around the plants and carry-over of disease. Fields should be picked clean and rotten berries discarded away from the field. Harvested berries should remain in the shade until they are removed from the field. Covering flats with a reflective tarp will help reduce heating. Fruit should be cooled (to 1ºC) as soon as possible after harvest to slow disease development.

Alternative Controls: In Nova Scotia, sprays are applied based on weather conditions. Sprays start at 10% bloom and continue as required relative to product labels and weather.

Cultivar Resistance: Some varieties are moderately resistant, most are susceptible in wetter years; Redcoat is highly susceptible.

Issues for Botrytis Grey Mould

1. Management of Botrytis fruit rot is a high priority for the industry and pathogen resistance is already present to many of the products available. The application timing with respect to harvest and infection periods is not appropriate for some of these products. Although several products are available, current disease management relies heavily on the use of captan.
2. There is a need for education for growers so that proper disease control measure are implemented at the proper time.

3. Continued research is required in eastern Canada to develop a weather-based disease prediction and treatment model.

Red Stele Root Rot (*Phytophthora fragaria* f. sp. *fragaria*)

Pest Information

Damage: The disease can cause serious plant losses and poor yields. Severely infected plants are undernourished and stunted, with the plants eventually wilting and dying.

Life Cycle: The disease is caused by a soil borne fungus-like organism (*Phytophthora fragariae* var. *fragariae*) which attacks the roots. It attacks only strawberries, but can remain in the soil for many years without strawberries being present. Infection occurs in cool, wet soil at temperatures from 1-10ºC. The most damaging periods for infection are during the formation of new adventitious roots in the fall and new feeder roots in early spring. The disease is much more severe under conditions of poor drainage and will often appear in low spots in the field.

Pest Management

Chemical Controls: Metalaxyl-m is registered for fall application only. Pathogen resistance to metalaxyl has been found in BC. Fosetyl-Al is applied as a spray in the spring or fall and is mainly taken up by the leaves and then translocated to the roots. Pre-plant soil fumigants, such as metam-sodium applied for nematodes, helps to suppress red stele as well.

Cultural Controls: The use of certified disease-free planting stock is the most important means to control this disease. Plant only on well-drained sites as light soils are less prone to the disease. Strawberries should not be grown repeatedly in the same field. Fields where the disease has been severe in the past should be avoided. Where the disease is present, winter and subsoil drainage between the rows should be improved.

Alternative Controls: Monitoring for disease in the wet areas of fields is important.

Cultivar Resistance: Some varieties show resistance or tolerance to red stele. These may become infected if certain races of the fungus are present. The cultivars Annapolis, Cavendish, Sparkle, Puget Reliance, Rainier and Bountiful are considered resistant or tolerant to most races of the pathogen.

Issues for Red Stele Root Rot

1. There is concern over the high cost of Aliette® (fosetyl-Al) and Ridomil® (metalaxyl) and the resistance of pathogen to metalaxyl recorded in some fields.
2. There is a need to register new and effective products for the control of red stele (e.g., fenamidone and fluazinam).
3. Effective biorational products (e.g., phosphoric acid fertilizer) should be registered and made available to Canadian growers.
4. Additional research is necessary to develop effective biological and cultural control methods.
5. There is a need to develop new strawberry cultivars with resistance to current races of the pathogen.

Common Leaf Spot (*Mycosphaerella fragariae*)

Pest Information

Damage: Common leaf spot can reduce plant vigour, yield and fruit quality when spots are numerous. Minor infections do not cause significant damage. Flower stem infection can cause blossom drop on very susceptible varieties.

Life Cycle: The fungus can survive on infected transplants in cold storage, and on plant debris in the soil. The disease develops and spreads during wet weather when temperatures are from 7 to 25ºC. The spores are moved by splashing rain or irrigation. Infection occurs on leaves or stems that are wet for at least 12 hours.

Pest Management

Chemical Controls: Sprays for Botrytis fruit rot usually control this disease as well, but a fungicide application may be necessary in early spring on highly susceptible varieties. In susceptible varieties, sprays should be applied 7 to 14 days before blossoms start to open. Fall infections generally do not need to be controlled with fungicides. Registered products include captan, tribasic copper sulphate and thiophanate-methyl.

Cultural Controls: Certified disease free planting stock should be used. Mowing and rotovating old leaf debris in the spring, or renovating after harvest can reduce disease.

Alternative Controls: Regular scouting for symptoms, especially for more susceptible varieties, helps determine is fungicide treatments are needed to avoid crop loss.

Cultivar Resistance: Most varieties show some resistance but may develop the disease during long wet periods. Chambly, Jewel and Vantage are highly resistant, while Puget Reliance, Shuksan and Kent are very susceptible.

Issues for Common Leaf Spot

1. There is concern over some newer varieties being more susceptible to the disease.
2. There is a need to register propiconazole in Canada, as it is an effective control.

Powdery Mildew (*Sphaerotheca macularis* f. sp. *fragariae*)

Pest Information

Damage: Powdery mildew attacks flowers, leaves and fruit and can cause heavy crop losses during warm, humid conditions. Infected flowers are covered with white mycelium and may be deformed or killed, leading to poor pollination and poor fruit set. Diseased leaves turn reddish purple or have small purple flecks or spots. Infections on green fruit can stop ripening, leaving hard, russetted and cracked fruit. Infected ripe berries may be firm, or soft and pulpy, and usually have a somewhat flat or bitter taste which makes the fruit unmarketable.

Life Cycle: The pathogen overwinters as mycelium on plant debris, but may also survive in the crowns of infected transplants. Spores are wind disseminated and short-lived, and require living plant tissue to survive. Ideal conditions for infection to occur are dry leaf surfaces, high relative humidity, and cool to warm air temperatures. On ripening fruit, the fungus first grows under individual seeds, raising them from the fruit surface. The white, powdery fungus then spreads over the surface of the fruit.

Pest Management

Chemical Controls: Fungicides should be applied when the disease is first observed, especially during warm, humid conditions. If the disease was a problem the previous year, sprays are applied before symptoms appear. It is usually not necessary to spray after harvest in August or September, except for very susceptible and day-neutral varieties. Registered products include sulphur, lime sulphur and thiophanate-methyl.

Cultural Controls: Plantings should be renovated soon after harvest to destroy old, infected foliage.

Alternative Controls: Monitoring for the first signs of the disease is done in spring and fall when days are warm with heavy evening dews.

Cultivar Resistance: Hood, Totem, and Benton have some tolerance to powdery mildew, while Redcrest, Independence, Firecracker and Puget Summer are very susceptible.

Issues for Powdery Mildew

1. There is a need for new fungicide management tools that are available but either not registered for control of powdery mildew or are not registered in Canada.
2. Additional research is necessary to study the timing of sprays for improving the efficacy of chemicals.

Leather Rot (*Phytophthora cactorum*)

Pest Information

Damage: The disease is often misdiagnosed as grey mould and can cause up to 30% yield loss. Lesions on green fruit are brown. On ripe fruit lesions appear bleached and may be light pink to purplish in colour with the discolouration extending into the fruit. Lesion tissue is tough, and often tastes bitter. The disease can taint the flavour of processed products with only a few infected berries.

Life Cycle: Leather rot is favoured by wet weather and may appear on fruit at any stage of development.

Pest Management

Chemical Controls: None available.

Cultural Controls: Planting sites should have good soil and drainage. In waterlogged areas drainage should be improved. The most effective control in eastern Canada is a thick straw mulch between the rows that prevents water from splashing and moving spores from the soil to developing fruit. Mulch should be applied during the winter or at first bloom to protect developing fruit. During fruit-bearing stages, irrigation should be done between 11am and 3pm and only for short two-hour periods to allow plants to dry out by nightfall. Surface soil water should not be splashed onto the fruit. Fruit should be picked early in the day, as soon as plants are dry, handled with care, and cooled to at least 4°C immediately after harvest. Diseased fruit should be culled and removed from fields, especially if leather rot is a serious problem. If puddles or soil compaction occurs, the planting should be sub soiled at least once per year, ideally between August and early September.

Alternative Controls: None identified.

Cultivar Resistance: None available.

Issues for Leather Rot

1. In Ontario, leather rot is the second most important strawberry disease.

Minor Diseases

Angular Leaf Spot (*Xanthomonas fragariae*)

Pest Information

Damage: The bacterium that causes angular leaf spot, *Xanthomonas fragariae*, infects stems, leaves, and crowns of wild and cultivated strawberries. It also infects the calyx leading to unmarketable fruit. The disease occasionally becomes a problem during cool and wet seasons. It occurs in nurseries of fruit production areas in eastern Canada and the Prairies.

Life Cycle: The pathogen survives in dried infected leaves, leaf tissue buried in the soil, or the crowns of infected transplants. During rain or sprinkler irrigation, bacteria in dried leaf tissue become active and are spread to healthy plants in water droplets. Development and spread of angular leaf spot are favoured by prolonged wet conditions and cool weather. Maximum disease development occurs when daily high temperatures are about 15 to 20ºC and lows are near or below freezing.

Pest Management

Chemical Controls: The only registered product is tribasic copper sulphate, but is not very effective.

Cultural Controls: Dry leaves should be removed from the field. In new plantings, the primary source of disease is infected planting stock, making the use of disease free plants important. Bacteria in infected transplants can survive cold storage for at least one year.

Alternative Controls: Scouting should be done to detect the presence of the disease.

Cultivar Resistance: A couple of varieties are moderately resistant, such as Redcoat and Veestar, however most varieties are quite susceptible.

Issues for Angular Leaf Spot

1. There is a need for effective control products and the development of a management program.

Anthracnose (*Colletotrichum acutatum*)

Pest Information

Damage: Anthracnose causes lesions on petioles and trusses, fruit rot and occasionally crown rot. The disease is often seen in crops grown under plastic mulch where the soil and microclimate around the plants is warmer. Damage from anthracnose can result in plant death.

Life Cycle: Infection requires warm and wet conditions. Anthracnose fruit infections may occur in nurseries, where the use of overhead sprinklers favours the disease. If warm, rainy weather occurs during fruit production, anthracnose symptoms may appear on fruit. Fruit at any stage of ripeness can be affected. The disease is not known to occur in British Columbia.

Pest Management

Chemical Controls: There are no control products registered in Canada for this disease. For infested fields, fumigation at higher rates can help.

Cultural Controls: Plastic mulch used in annual systems actually increases water splashing and spreads the disease more rapidly. Crop rotations should be planned so that fields are out of strawberry production for several years before strawberries are replanted. Plants should be mulched to prevent rain splash dispersal of the spores and remove debris from the field after renovation.

Alternative Controls: Scouting for symptoms should be practiced.

Cultivar Resistance: Anthracnose resistance has been incorporated into some newer varieties, but all varieties used in Ontario are susceptible.

Issues for Anthracnose

1. New, effective control products need to be registered for this disease, as there are currently no registered chemicals in Canada.

Rhizopus Fruit Rot (*Rhizopus* spp.)

Pest Information

Damage: This pest usually occurs after harvest, but may develop on ripe fruit in the field in warm weather. Infected fruit soften rapidly and collapse, leaking their contents. This feature distinguishes Rhizopus rot from grey mould.

Life Cycle: Rhizopus spp. survive on crop debris in the soil when host plants are not present. Spores are spread by wind and insects, and infection occurs only through wounds in ripe fruit. Tiny but conspicuous, spherical spore-forming structures called sporangia are present, each one on the end of a hair-like stalk about 2 mm long. Sporangia are white when first formed and turn black as they mature. *Botrytis* does not form sporangia, although masses of spores resembling tiny clusters of grapes may sometimes be seen. Both *Botrytis* and *Rhizopus* can be present on the same fruit.

Pest Management

Chemical Controls: The only registered product is lime sulphur. Captan, used to control Botrytis fruit rot also helps control Rhizopus rot.

Cultural Controls: Weed control can help reduce losses to this pathogen by decreasing humidity around the plants and carry-over of disease. Renovating and rotovating in early spring will remove and destroy old leaves and fruit. Fertilizing can lead to optimal leaf growth. Over-fertilization with nitrogen before harvest can cause excessive growth and increased fruit rot. Managing row spacing and row widths will allow adequate air movement and rapid drying of leaves. Irrigation should be timed so that flowers and leaves dry off quickly. Fields should be picked clean and rotten berries discarded away from the field. Harvested berries should remain in the shade until they are removed from the field. Covering flats with a reflective tarp will help reduce heating. Fruit should be cooled to 4ºC as soon as possible after harvest to slow down disease development. Early picking before fruit is over-ripe can reduce losses.

Alternative Controls: None identified.

Cultivar Resistance: Differences in susceptibility between cultivars exist but are not well documented.

Issues for Rhizopus Rot

None identified

Leaf Blight (*Phomopsis obscurans*)

Pest Information

Damage: The pathogen causes circular, reddish purple spots on a leaflet that when expand develop into dark brown v-shaped lesions in the leaf edge. The disease can weaken strawberry plants through the destruction of older foliage. Weakened plants can result in reduced yields the following year. In years highly favorable for disease development, leaf blight can cause defoliation and, in some cases, death of plants. In warmer climates, the fungus that causes leaf blight can also cause fruit soft rot.

Life Cycle: The pathogen, *Phomopsis obscurans*, survives in lesions on old leaves. Spores produced in these lesions are spread to healthy leaves by splashing rain. Disease usually develops in late summer or fall and is favoured by wet weather. Spore-forming structures appear as black dots in the dark centre of blight spots. Symptoms resembling anthracnose may develop on runners and stems.

Pest Management

Chemical Controls: There are no registered chemicals in Canada. Control measures used for leaf spot and leaf scorch will also control leaf blight.

Cultural Controls: Control measures for leaf spot and leaf scorch will also control leaf blight.

Alternative Controls: None identified.

Cultivar Resistance: None available.

Issues for Leaf Blight

None identified

Leaf Scorch (*Diplocarpon earliana*)

Pest Information

Damage: Plants affected by leaf scorch do not overwinter well, and yields the following year may be reduced. Infected leaves have many irregular purplish blotches which coalesce and cause the leaves to dry up. The disease is most significant in eastern Canada.

Life Cycle: Spores of the pathogen travel in air currents and are also spread by splashing rain. All green parts of the strawberry plant are susceptible to infection from the pathogen, although it is most visible on older leaves and calyces. Leaf tissue is destroyed and photosynthetic capacity is reduced, thus slowing down plant growth and development. Infected calyces are further susceptible to grey mould, which renders fruit unmarketable.

Pest Management

Chemical Controls: The only registered product is dodine.

Cultural Controls: Row width should be narrowed to 30 cm in order to encourage aeration and quick drying of foliage. Irrigation should be performed in the morning or early afternoon to allow sufficient time for the crop canopy to dry before sunset.

Alternative Controls: Monitoring should be practiced throughout the season for leaf lesions.
Cultivar Resistance: Resistant varieties include Cavendish, Honeoye, Scotland, Vantage and Vibrant.

Issues for Leaf Scorch

None identified

Black Root Rot (*Pythium, Rhizoctonia, Fusarium* spp.)

Pest Information

Damage: The disease causes poor yields and serious plant losses, with infected plants failing to produce new roots. Roots of severely infected plants turn black and rot.
Life Cycle: The cause of the disease is complex, with several pathogenic fungi being implicated along with certain environmental stresses, such as cold injury, excessive water near roots and soil compaction. In some cases, the disease has been associated with interaction between lesion nematode and particular soil borne fungi.

Pest Management

Chemical Controls: No practical chemical treatment is available. Soil fumigation before planting may reduce the problem in the short term, by minimizing populations of nematodes.
Cultural Controls: Black root rot is best controlled by promoting optimal and healthy growth in the field. Only certified stock should be planted on well-drained fertile soils. Soils with high fluctuating water tables should be avoided. A long rotation of at least 2-3 years between strawberry crops should be used. Improving winter drainage by sub-soiling between the rows, or planting on raised beds can be beneficial. Plants should be mulched during the growing season between the rows to reduce soil compaction, and to prevent winter injury to crown and roots. Mulching also adds organic matter to the soil. Irrigation should only be done when needed, however conditions of drought in the field should be avoided. Nitrogen should be applied moderately (for root growth) and herbicides, if used, should be rotated. Minimizing herbicide residuals in the soil will allow more vigorous root growth.
Alternative Controls: None identified.
Cultivar Resistance: Varieties react inconsistently to the disease because black root rot can be caused by several different organisms.

Issues for Black Root Rot

None identified

Verticillium Wilt (*Verticillium dahliae* and *V. albo-atrum*)

Pest Information

Damage: The disease may cause individual plants or small patches of plants in the field to wilt and die during the summer following planting. Plants are commonly stunted due to the disease.
Life Cycle: The pathogen enters the plant through the roots and moves up through the vascular system inhibiting the movement of water and nutrients to the leaves. The disease is more severe on light, sandy soils where root lesion nematodes are present and in strawberry

plantings that follow potatoes or raspberries. This disease is more common in the southern Interior of B.C. and less common in the Fraser Valley. Two different species are present in Ontario, one more prevalent in northern Ontario, the other in the south; there are also several different races. In the Atlantic provinces, the principal species is *V. albo-atrum*. *V. dahliae* will survive in fields for several years. *V. albo-atrum* does not carry over more than one or two years, so can be controlled with crop rotation.

Pest Management

Chemical Controls: Pre-plant soil fumigation for nematodes reduces the disease temporarily but does not eliminate it.

Cultural Controls: Soil should be fumigated one year prior to planting,. Strawberries should not be grown in fields planted to potatoes, raspberries or alfalfa the previous year. Some cover crops, such as marigolds, oilseed radish and ryegrasses may reduce inoculum of Verticillium spp. or nematodes in the soil, but require a high level of management and are not always practical. Crop rotation can help avoid the disease where *V. albo-atrum* is the primary pathogen.

Alternative Controls: None identified.

Cultivar Resistance: Susceptible varieties, especially Shuksan or Honeoye, should not be planted where the disease is likely to cause losses. Tribute, Tristar, and Vantage offer some resistance.

Issues for Verticillium Wilt

None identified

Viruses and Phytoplasmas

Pest Information

Damage: Viruses can be a serious problem, reducing vigour and yield of strawberry plants. The most significant losses occur when transplants become infected in nurseries. Once infected, plants pass the viruses on to their runner plants. For the last four years, B.C. has experienced increasing incidence and severity of viral symptoms in the first planting year, in several varieties such as ‘Totem’ and ‘Rainier’ that were previously asymptomatic. Recent tests have confirmed strawberry mottle, strawberry crinkle and strawberry yellow leaf edge viruses in the affected plants. “Aster-yellows”-type symptoms affect certain varieties in eastern Canada.

Life Cycle: Most strawberry viruses are transmitted by aphids and to a lesser extent by nematodes, whiteflies and other sucking insects. However, there is relatively little impact from secondary spread in the field. Strawberry aphids develop wings and can fly before new strawberry fields are planted and can infect new plants with viruses as soon as the first leaves emerge from the crown. The viruses are then passed to other plants by either winged or wingless aphids as they move about in search of young leaves. Although all plants are grown under virus-free certification programs, occasional problems can occur when viruses are present but asymptomatic in young plants. Viruses cause different symptoms depending on the type of virus and the strawberry variety. Susceptible varieties, like Hood, may show dwarfing plus yellowing, mottling or leaf curling. More tolerant varieties may show few symptoms except for dwarfing, declining fruit size and yield. Phytoplasmas that cause aster-yellows-type diseases are spread by leafhoppers.

Pest Management

Chemical Controls: A residual, systemic aphicide should be applied when aphids are observed in new plantings. Aphids should subsequently be controlled whenever they reappear. In addition, aphids should be controlled in established fields close to new plantings.

Cultural Controls: New plantings should be planted with certified stock, produced especially to minimize infection. Fields should be kept free of weeds, as they harbour several kinds of aphids that can spread viral diseases as well as leafhoppers.

Alternative Controls: None identified.

Cultivar Resistance: Susceptible varieties, such as Hood, should be avoided and should not be planted near established plantings of tolerant varieties.

Issues for Viruses and Phytoplasmas

None identified

Phytophthora Crown Rot (*Phytophthora cactorum* and other species)

Pest Information

Damage: Phytophthora crown rot causes strawberry plants to stunt and produce small leaves. As the season progresses, plant collapse may occur rapidly or slowly. When infected plants are cut open, a brown discoloration can be seen in the crown vascular tissue or throughout the crown tissue. The same Phytophthora spp. also attack roots, causing a brown to black root rot.

Life Cycle: Phytopthora spp. produce resilient spores that enable the pathogen to survive in soil for long periods without a host or under adverse conditions. Infections can occur during cool to moderate temperatures. Crown rot can be a problem in eastern Canada in areas or sections of the field where drainage is poor. Wounding or frost damage to the crown increases the risk of crown rot disease.

Pest Management

Chemical Controls: There are no registered control products. Pre-plant soil fumigants for nematode control can help suppress the disease.

Cultural Controls: Sites should be selected with good soil drainage or raised beds should be used. Plants should be protected from frost injury to crowns. Cultural controls used for black rot can also effective.

Alternative Controls: None identified.

Cultivar Resistance: None available.

Issues for Phytophthora Crown Rot

1. Metalaxyl-m and fosetyl-Al are registered for Phytophthora red stele, but also provide some control of Phytophthora crown rot. There is a need for label expansion so that these products can be registered for this disease.

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

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Disease, pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Boscalid	anilide fungicide	7	R	Botrytis grey mold	New	Max. of 5 applications per season; potential risk for resistance.
Captan	phthalamide fungicide	M[2]	RE	Botrytis grey mold	A - A[P]	Used in all provinces
				Common leaf spot	A	
Chlorothalonil	aromatic fungicide	M[2]	R	Botrytis grey mold	I - A[P]	Fall or early spring application only.
Dodine	aliphatic nitrogen fungicide	M[2]	R	Leaf scorch	A[P]	Used in eastern Canada only.
				Leaf blight		
				Common leaf spot	A[P]	
Fenhexamid	anilide fungicide	17	R	Botrytis grey mold	A[P]	Max. of 4 applications per season; high cost and risk for resistance; most growers apply 1-2 times per season.
Folpet/folpan	Phthalamide fungicide	M[2]	RE	Botrytis grey mold	I - A[P]	Used mainly in eastern Canada only.
				Common leaf spot		
Fosetyl-aluminium	organo-tins		R	Red stele fruit rot	A[P]	Max. 2 spring + 2 fall applications; most gorwers apply only once or twice a year.
Iprodione	imidazole fungicide	2	R	Botrytis grey mold	A-A[P]	Potential risk resistance moderate to high; supresses also Penicillium fruit rot.
				Penicillium fruit rot	A[P]	

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Disease, pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Lime-sulphur	Inorganic	M^2	RE	Botrytis grey mold	I	Early spring or post-harvest only; mainly used for supressing powdery mildew
				Powdery mildew	I	
				Cladosporium fruit rot	I	
				Rhizopus fruit rot	I	
Metalaxyl-m	anilide fungicide	4	R	Red stele fruit rot	I - A^P	Max. of 2 applications in fall; most apply only once; resistance in some fields and to some races of *Phytophtora* spp.
Metam sodium	dithiocarbamate fungicide	M2	R	Nematodes	A^P	Pre-plant only; limited use; sandy soils only; temporary supression only.
				Root rots	A^P	
				Verticillium wilt	A^P	
Methyl bromide	fumigant	8^A	RE	Nematodes	A^P	Pre-plant only; very limited use in propagation nurseries only.
				Root rots	A^P	
				Verticillium wilt	A^P	
Pyraclostrobin	strobilurin fungicide	11	R	Anthracnose	A (new)	Max. of 5 application per season; high risk of resistance.
Sulphur	inorganic	M2	RE	Powdery mildew	I	Only domestic product registered on strawberry but a few growers apply pre-bloom and/or post-harvest for disease supression.
Thiophanate-methyl	benzimidazole fungicide	1	R	Botrytis grey mold	I-A^P	Potential risk for resistance to the causal agents of botrytis grey mold and powdery mildew is high. Not used for botrytis grey mold and common leaf spot; one application only for powdery mildew.
				Powdery mildew	I-A^P	
				Common leaf spot	I-A^P	

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Disease, pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Thiram	dithiocarbamate fungicide	M[2]	RE	Botrytis grey mold	I-A[P]	Very little use.
Tribasic copper	inorganic	M[2]	R	Common leaf spot	I	Some use in eastern Canada only; some possible use for Botrytis gray mold in organic production.
				Angular leaf spot	I	
Vinclozolin	dicarboximide	2	R	Botrytis grey mold	A[P]	Potential risk for resistance moderate to high.
1,3-dichloropropene	fumigant		RE	Nematodes	A	Used in NS, ON, QU only, mainly in propagation nurseries.
1,3 - dichloropropene+chloropicrin	Fumigant		RE	Nematodes	A	Used in NS, ON, QU only, mainly in propagation nurseries.

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

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

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

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

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

Source(s): Provincial government specialists; PMRA EDDENet database.

Table 4. Availability and use of disease pest management practices for Canadian strawberry production

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

no indication that the practice is available/used

available/used

available/not used

not available

Source(s): Information in the crop profile for individual pests

Insects and Mites

Key Issues

- There is concern over the limited availability of insecticides and pest resistance or tolerance to many of the products that are currently registered.
- New, IPM compatible, safer, and reduced risk products are needed to control pests on strawberries at reasonable prices. Currently, growers must rely on OP's, endosulfan and pyrethroids, which can be harmful to beneficials.
- New, biological control products need to be developed and registered (e.g, parasitic fungi).
- There is concern that the competitiveness of the Canadian industry is threatened by the wider range of pest control products available to growers in the United States.
- There is concern over the limited availability of effective products, monitoring, thresholds and management strategies for many strawberry pests, such as root weevils, wireworms, white grubs and thrips.
- There is a need for an insecticide for day-neutral strawberries, as there is a short day-to-harvest interval with these plants. The problem is a limiting factor for production in Ontario.
- There is concern over newer products registered for mites, such as abamectin, that are labelled for post-harvest application only and are therefore not very useful.
- Improved methods of pest identification need to be developed and more training for growers and scouts should be provided

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

Major Insects	BC	AB	SK	MB	ON	QC	NB	PE	NS	NF
Lygus bugs (Tarnished plant bug)	E			E		E	E			4
Two-spotted mite	E			E		E	E			
Strawberry mite	E			E		E	E			DNR
Aphids	E			E		E	E			
Root weevils	E			E		E	E			
Wireworms	E			E		E	E	D		
Strawberry clipper (bud) weevil				E		E	E			DNR
Minor Insects	**BC**	**AB**	**SK**	**MB**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Leafrollers	E			E		E	E			
Potato leafhopper				E		E	E		E	DNR
Slugs	E			E			E			
Spittlebugs	E			E		E	E			
White grubs	E			E		E	E			DNR
Strawberry cutworm (crown borer)			D	E		E	E		E	
Flower thrips				E		E	E			DNR
Leatherjackets and crane flies	E			E						DNR
Omnivorous Leaf tier	E			D			E		E	
Grey moth		DNR	DNR	DNR	DNR	DNR	E	DNR	DNR	DNR
Flea beetles		DNR	DNR	DNR	DNR	DNR	E	DNR	DNR	DNR
Strawberry seed beetle		DNR	DNR	DNR	DNR	DNR	E	DNR	DNR	DNR
Nematodes	E					E	E		E	DNR

Widespread yearly occurrence with high pest pressure

Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure

Widespread yearly occurrence with low to moderate pest pressure

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure

Pest not present

DNR - Data not received for this pest from this province

E – established

D – invasion expected or dispersing

Source(s): Provincial government specialists

Major Insects and Mites

Black Vine Weevil (*Otiorynchus sulcatus*)

Pest Information

Damage: Larvae cause the most extensive damage feeding on the roots. Plants attacked by larvae are stunted, have weak root systems and die. Adults, when present in large numbers can seriously damage foliage while feeding. Other weevil species include the obscure weevil (*Sciopithes obscurus),* the rough strawberry root weevil (*Otiorynchus rugosostriatus),* the strawberry root weevil *(Otiorynchus ovatus),* and the clay coloured weevil (*Otiorynchus singularis*), but none are as destructive as the black vine weevil.

Life Cycle: Black vine weevils overwinter as grubs in the top 5-20 cm of soil. They pupate in May and emerge from the soil as adults during May and early June. These adults are active on foliage at night during June and July, feeding on above-ground plant parts. Newly emerged adults begin laying eggs in late June prior to the onset of harvest. Larvae are present from August until April.

Pest Management

Chemical Controls: Control is directed against the adult beetles which must be killed before they lay eggs. Unlike the sprays targeted at larval stage, sprays directed towards the adults are foliar. Sprays should be applied only to areas where fresh leaf notches are seen. Registered products include cyhalothrin-lambda, cypermethrin and carbofuran.

Cultural Controls: Fields should be monitored for fresh leaf notches especially before blossoming and during harvest. Plants close to old berry plantings, pastures or wooded areas are usually the first attacked, and therefore close attention should be paid.

Alternative Controls: Pheromone trapping methods are being researched, but are not yet ready for commercial use. Biological (fungal) insecticides are also being tested and may be available in the future. Proper identification is important to achieve proper spray timings. The life stage and population size of the weevils can be estimated by monitoring with evening sweep-netting, when the adults would normally be feeding, or by digging up roots and looking for larvae and pupae in the spring.

Cultivar Resistance: None available.

Issues for Black Vine Weevil

1. There is a need to register thiamethoxam, imidacloprid, and clothianidin for the control of root weevils, as currently registered products are very damaging to natural predators.
2. Continued research is needed on trapping methods and biological control.

Strawberry Clipper "Bud" Weevil (*Anthonomus signatus*)

Pest Information

Damage: The strawberry clipper weevil is the most damaging weevil pest in eastern Canada. It is not a pest in British Columbia and rarely on the prairies. The insect causes economic damage

to the blossoms and buds which can reduce fruit production. Injury usually increases in older strawberry fields, where resident populations can develop.

Life Cycle: There is one generation per year, with the adult overwintering in protected areas, such as fence lines and hedgerows, and under mulch. Damage takes place during egg laying, as female clipper weevils lay single eggs inside flower buds and partially cut off the blossom stalk a few centimetres below the bud, causing the damaged bud to wilt and dry up. The larvae develop inside the bud for four weeks, pupate, and emerge in mid-summer, and adults feed on pollen.

Pest Management

Chemical Controls: Registered products include carbofuran, cyhalothrin-lambda, cypermethrin and methoxychlor.

Cultural Controls: Clipper weevil activity should be monitored. Good weed management, especially of broadleaf weeds, is essential to control strawberry clipper weevils. Renovation should take place promptly after harvest. Long crop rotations (2-3 years) are favourable.

Alternative Controls: None identified.

Cultivar Resistance: None available.

Issues for Strawberry Clipper Weevil

None identified

Lygus Bug "Tarnished Plant Bug" (*Lygus lineolaris* and other *L.* spp.)

Pest Information

Damage: The pest is a major concern in production areas across Canada. The pest causes economic damage to fruit. Adults and nymphs feed on all parts of the plant by sucking sap, destroying embryos within seeds and preventing fruit tissue growth beneath the seed. The resulting misshapen berries are known as "monkey faced" or "cat faced" and are unmarketable.

Life Cycle: Adults overwinter in vegetation and stubble and emerge in the spring. Emerging adults start feeding on flower buds and shoot tips of strawberry plants which results in blossom losses. The females lay eggs in April and early May in the plant tissue. The nymphs emerge in one week and feed on developing seed during and after bloom or on the receptacle of developing fruit. At the same time, their feeding kills surrounding tissue which leads to small seedy strawberries with a woody texture that fails to mature properly. Lygus bug has a wide host range, including strawberry, raspberry, weeds, clover and some vegetable crops.

Pest Management

Chemical Controls: Fruit can be misshapen by other injuries, so the cause of the damage should be correctly identified before spray is applied. Sprays should be timed to kill the earliest stages of nymphs. Chemicals should be applied as soon as nymphs become active in the strawberries. The number of treatments should be limited, and sprays selected carefully. Registered products include cypermethrin, endosulfan, cyhalothrin-lambda and deltamethrin.

Cultural Controls: Good weed control within and beside strawberry plantings helps keep lygus bugs at low levels. Weeds should be destroyed when lygus are still in the nymph stage and cannot fly. If the weeds are not destroyed, lygus adults will move into the crop when the weeds dry up.

Alternative Controls: Natural predators include big-eyed bugs, damsel bugs, and lacewings. The pest is parasitized by a number of braconid wasps and several tachinid flies. None of these insects will prevent the pest from causing economic damage when numbers are high. In California and on one farm in BC, a tractor-mounted vacuum has been shown to remove up to 60% of the lygus bug population in one run.

Cultivar Resistance: Some strawberry varieties may be more resistant to the feeding damage and show less apical seediness from it. Later-flowering varieties tend to have higher pest populations at the critical stage of flower development.

Issues for Lygus Bug

1. Registration of acetamiprid for the control of the lygus bug is needed.
2. There is concern over the use of cypermethrin and endosulfan, which are toxic to bees and natural predators of two-spotted mites. Their use can lead to an increase in mite populations.

Strawberry Mite "Cyclamen Mite" (*Phytonemus pallidus*)

Pest Information

Damage: The pest attacks young folded leaflets at the centre of the plant first. Later, the pest attacks older leaves, stems and runners, causing them to be shortened and rough. With severe infestation, plants are stunted, yields are reduced and plant vigour is drastically diminished. Injury is often confused with herbicide or winter injury.

Life Cycle: Hot and dry weather favours cyclamen mite development. Tools, clothes and other materials easily spread mites from infested to clean plants.

Pest Management

Chemical Controls: High pressure and high volume spray to reach the well-hidden mites is important. If mite damage is noticed before or during harvest, a spray after renovation when plants start re-growth may be required, with another spray in two weeks. Registered products include endosulfan, dicofol and diazinon. If endosulfan is applied for lygus or spittlebug control, separate sprays may not be necessary for cyclamen mite. When sprays are necessary, applications should be done as soon as possible after growth starts in the spring.

Cultural Controls: New plantings should be isolated as much as possible from older infested fields or wild strawberry patches. Only clean planting stock should be used.

Alternative Controls: Usually these mites are kept in control by naturally-occurring predatory mites. If the predatory mites are killed by insecticides, the cyclamen mites can become a problem. Regular field scouting can detect problems before they cause significant damage.

Cultivar Resistance: None available.

Issues for Strawberry Mite

1. Registration of abamectin, acramite and bifenazate is needed**. A**bamectin has recently been registered (2003), but only as a post-harvest treatment, limiting it's effectiveness.
2. There is concern over the use of dicofol, as it is more effective on two-spotted spider mite and resistance is frequent.
3. There is concern over the harmful effects of diazinon to beneficial organisms.

Two-spotted Spider Mite (*Tetranychus urticae*)

Pest Information

Damage: The mites feed on the underside of leaves, sucking plant juices and causing whitish flecking of the upper surface. Large populations can cause leaves to dry up and turn brown. Yields can be reduced, especially if populations are large in the early parts of the season. Populations increase rapidly and severe crop damage may occur during hot and dry weather, when plants become dusty. Yield reductions of 10-15% can be expected when populations sizes reach 30-60 mites per leaflet during harvest.

Life Cycle: Two-spotted mite overwinters as adult females in the plant debris Adults start feeding late spring and summer and lay eggs. Both fertilized and unfertilized females can produce and lay eggs. The average fecundity of females is 90-110 eggs, but it can reach 200 eggs. If females are fertilized, they give rise to a mix of males and females. Unfertilized give rise to only males. Such reproduction without mating is partly responsible for the rapid rate of population increase. Females attract males by a pheromone released shortly before the female deutonymphs emerge as adults.

Pest Management

Chemical Controls: Registered miticides should be rotated to reduce the development of resistance. Registered products include abamectin, clofentezine, pyridaben and dicofol.

Cultural Controls: Excess nitrogen fertilizer can increase populations of spider mites. Mowing and renovation can reduce spider mite populations by reducing their food supply. Dust barrier crops, such as corn, can keep dust off the field.

Alternative Controls: As an alternative to spraying, predator mites can be released in newly planted fields, about ten days after sprays for aphids. This can establish predator mites in the field. These mites feed on two-spotted spider mites, but require time to reduce pest numbers. If sprays are applied for other pests, chemicals should be chosen so that they do not affect the predator mites. Some predators usually survive dimethoate and diazinon sprays. It should be assumed that no predators will survive after cypermethrin or carbofuran sprays. The predatory mite *Amblyseius fallacis* is used by about 25% of growers in B.C.

Cultivar Resistance: Some varieties, such as Annapolis, Bounty, Glooscap, Governor Simcoe and Kent, appear to be more resistant than other varieties to spider mites.

Issues for Two-spotted Spider Mite

1. There is a need for the registration of abamectin, acramite and bifenazate for the control of this pest. Abamectin was registered in 2003 for post-harvest application only, limiting its effectiveness.

Shallot Aphid (*Myzus ascalonicus*) and Strawberry Aphid (*Chaetosiphon fragaefolii*)

Pest Information

Damage: The shallot aphid damage causes flower stalks to be short and thick, resulting in misshapen blossoms and failure to fruit. The entire plant can be stunted with twisted yellow leaves. Only small populations of aphids are required to cause damage, with plants being

affected in spotty areas in the field. In addition to direct damage, the shallot aphids can be vectors for viruses. Strawberry aphids rarely cause direct damage, but are vectors for viruses.

Life Cycle: Hosts of these pests include many weeds (chickweed and wild rose). The nymphs of the shallot aphid overwinter in strawberry crowns or weeds. Aphids move from weeds to strawberries very early in the spring when the weeds are removed. Winged aphids leave planting in June and reappear in mid-August. The nymphs of the strawberry aphid overwinter in strawberry crowns or as black eggs on older leaves. Aphids are most abundant in the spring, when plants are growing quickly. There are many generations each year.

Pest Management

Chemical Controls: Registered products include dimethoate, primicarb, diazinon and malathion.

Cultural Controls: Control of viruses depends on the cooperation of neighbouring farms, as all growers must control aphids together. Weeds should be controlled, especially chickweed. Only certified virus-free plants should be used.

Alternative Controls: A number of beneficial insects help to control and reduce aphids to non-damaging levels, but control is not effective enough for viruses in all cases and it may be necessary to apply an insecticide. Beneficial organisms include lady beetles (*Hippodamia convergens*), lacewings (*Neuroptera*), syrphid flies (*Episyrphus balteatus*) and parasitic wasps (*Aphelinus mali*). Monitoring for aphids should be done.

Cultivar Resistance: None available.

Issues for Shallot Aphid and Strawberry Aphid

1. There is a need for the registration of actamiprid, imidacloprid, and pyrmetrozine for the control of aphids.
2. There is concern over the increasing incidence of viruses in B.C.

Wireworm (*Agriotes obscurus* and *A. lineatus*)

Pest Information

Damage: Plants can be killed and yields can be reduced by the boring actions of wireworms. Wireworms can also enter fruit that are in contact with the soil, making them unmarketable. Once inside the fruit, wireworms are impossible to detect or remove.

Life Cycle: Wireworms can build up to high levels in pasture fields with longstanding established grass or sod. When ploughed, wireworms can live for 3-4 years, boring into newly planted strawberry crowns and roots.

Pest Management

Chemical Controls: Registered products for seed treatments of trap crops include carbathiin, thiram and lindane. There are no products registered for use on strawberries for the control of this pest.

Cultural Controls: Trap crops, such as wheat, can reduce wireworm populations somewhat. Trap crops attract wireworms and kill them if the seed is treated with an insecticide. For new strawberry plantings, trap crops should be planted in the spring, when most wireworms are near the soil surface. Trap crops are sown 10 days before the berry crop and should remain in the ground until the berry crop is well established. Harvesting should be done on time so that over-ripe fruit, that are attractive to larvae, are not present.

Alternative Controls: Wireworms are often brought to the surface when fields are ploughed or disked, and thus eaten by birds, such as crows and seagulls. This alone does not provide enough control. Trapping and monitoring can be used.
Cultivar Resistance: None available.

Issues for Wireworm

1. The wireworm is a serious threat to the industry and no effective control products are registered for this pest. New, effective chemicals are critically needed for wireworm control, such as fipronil and clothianidin.

Minor Insect and Mite Pests

European Chafer (*Rhizotrogus majalis*), Japanese Beetle (*Popillia japonica*) *and* June Beetle (*Phyllophaga* sp.)

Pest Information

Damage: The larvae feed on roots, causing the most severe damage during the second year of growth. Plants wilt and lose vigour, and eventually collapse and die. Plantings are most susceptible in their first year.
Life Cycle: The June beetle has a 3 year life cycle, while the Japanese beetle and European chafer have 1 year life cycles. Larvae overwinter in the soil and feed on roots in the top 10-12 cm.

Pest Management

Chemical Controls: None
Cultural Controls: Strawberries should not be planted following sod, corn, potato, strawberry, or cereal-grass species, all of which are hosts for June beetles. Forage legumes and horticultural row crops should be included in rotation with strawberry plantings, or before plantings, to break up sod and pasture. Strawberry fields and surrounding areas should be kept weed-free during the period of peak flight (May and June). Summer fallowing and frequent cultivation can also reduce grub populations by physically destroying larvae and pupae, or exposing them to predators such as birds.
Alternative Controls: None identified.
Cultivar Resistance: None available.

Issues for European Chafer, Japanese Beetle and June Beetle

None identified

Strawberry Fruitworm (*Clepsis* sp.), Omnivorous Leaf Tier (*Cnephasia longana*) and other species

Pest Information

Damage: The most damage to the plant and yield reduction is caused by larvae. Early spring larvae feed on young unopened leaves and on green berries immediately after the blossom period. Caterpillars are periodic pests and often do not require control.

Life Cycle: Hosts of these pests include strawberry, thistle, vetch, clover and a wide range of other plants. Moths begin to fly towards the end of the strawberry harvest.

Pest Management

Chemical Controls: If spraying is required to prevent fruit injury, it should be applied when young leaves are tied together by webbing, at the first sign of blooms. Registered products include diazinon, malathion and carbaryl.

Cultural Controls: None identified.

Alternative Controls: Monitoring for the pests should be done weekly. A spray treatment is usually prompted at a threshold of 10% of plants having caterpillar infestation. There are several natural predators that prey upon the caterpillars, such as parasitic wasps. However, additional research is needed to evaluate the efficacy of a planned release and introduction of these natural enemies.

Cultivar Resistance: None available.

Issues for Strawberry Fruitworm and Omnivorous Leaf Tier

None identified

Leatherjackets "European Marsh Crane Fly" (*Tipula paludosa*)

Pest Information

Damage: Larvae feed on the roots, crowns and leaves of plants. In new plantings, transplants can be cut at the soil level. Damage is most severe in the spring.

Life Cycle: Hosts of leatherjackets include strawberry and grasses, with populations being highest in damp and heavy soils. The pest is normally not a problem in new plantings following grass the previous fall.

Pest Management

Chemical Controls: Products registered for control of this pest in strawberries include parathion and diazinon. Chemical control should be applied before establishing new plantings (e.g., during October or in the early spring). The treated field should sit for at least 1-2 weeks before cultivating, in order to allow the spray to take effect.

Cultural Controls: Weeds should be controlled, especially in the fall, winter and early spring.

Alternative Controls: Monitoring for damage signs should be conducted frequently after new plantings. Beneficial nematodes (*Sterinernema feltiae*) have shown promising results in controlling leatherjackets when properly applied.

Cultivar Resistance: None available.

Issues for Leatherjackets

1. More research is required on the use of beneficial nematodes for the control of this pest.

Potato Leafhopper (*Empoasca fabae*)

Pest Information

Damage: Potato leafhopper is not a significant pest of strawberries in most provinces, but it can cause significant damage in Ontario in some years. Nymphs and adults feed on the underside

of leaves, sucking sap and causing whitish spots on the upper surface. Heavy infestation can result in mottled leaves that can wither and curl in hot weather. Plants lack vigour and berries are often small and sticky from the honeydew secreted by the pest. The leafhopper can also vector the pathogens causing aster yellows and green petal diseases.

Life Cycle: The pest migrates each year from the United States on wind current. The pest first establishes in alfalfa fields, later dispersing to strawberries and other host crops. The pest develops several generations per year.

Pest Management

Chemical Controls: More than one treatment may be necessary to control multiple leafhopper generations. The registered product used for control is malathion.

Cultural Controls: None identified.

Alternative Controls: Monitoring of crops should be done weekly.

Cultivar Resistance: None available.

Issues for Potato Leafhopper

None identified

Spittlebug (*Philaenus spumarius* and *P. leucophthalmus*)

Pest Information

Damage: Spittlebug nymphs suck on plant sap, causing leaves and stems to become twisted and thickened, and fruit stems to become shortened. Yield can be reduced if spittlebug populations are large, and the frothy spittle is a nuisance to pickers.

Life Cycle: Hosts of this pest include strawberry, clover and a number of weeds and ornamental plants. The pest creates a frothy spittle as it feeds on the plant. Plants can recover after the spittlebug leaves the plant. Populations can be higher near grassy areas or where broadleaf weeds are found adjacent to vegetation.

Pest Management

Chemical Controls: Chemical controls can be applied if the pest was a problem in the previous year of if they are observed. Sprays that are applied for the lygus bug or for aphids usually also control spittlebug. Spraying for this pest can be harmful to bees. Registered products include cyhalothrin-lambda, endosulfa, naled and azinphos-methyl.

Cultural Controls: Good weed management, especially of grasses, is key to the control of this pest. In the fall, adults are less likely to return to planting that are free of weeds.

Alternative Controls: None identified.

Cultivar Resistance: None available.

Issues for Spittlebug

None identified

Strawberry Cutworm

Pest Information

Damage: Strawberry cutworm is not very common in strawberries, but it has been responsible for extensive damage in the past. Larvae feed on the crown of the plant, boring into the base of the leaf petioles and destroying new growth. Eventually, most of the crown is consumed and stalks are damaged. Older strawberry plantings are more susceptible to this pest than newer ones.

Life Cycle: The pest lays eggs on straw, plants and in plant debris in the field. There is no infestation in the first year of the crop, as eggs are laid in the fall. In second-year plantings, localized areas of damage can occur and wilting may be observed. During the third and fourth years, populations are higher and larger areas of the field can be damaged.

Pest Management

Chemical Controls: Insecticides can be applied at the end of May, when larvae are feeding on leaf stalks. Registered products include diazinon and chlorpyrifos.

Cultural Controls: Old infested plantings should be destroyed in mid-September so that most eggs will have already been laid and therefore destroyed when fields are ploughed under.

Alternative Controls: Monitoring for the pest should be done once a week from May to July.

Cultivar Resistance: None available.

Issues for Strawberry Cutworm

None identified

Strawberry Flower Thrips (*Frankliniella tritici*)

Pest Information

Damage: Thrips are an occasional pest of strawberry, but can cause significant damage to fruit. Affected fruit is cracked, bronzed and unacceptable for marketing. Large infestations can injure nearly all the fruit in a field.

Life Cycle: Adult thrips are carried by air currents from the south in the spring. The migration sometimes coincides with strawberry bloom, which the thrips are attracted to. Both adult and immature thrips hide in protected places and are more active at night. The pest sucks on the fruit, especially in protected areas, such as the hull and in depressions around the seeds.

Pest Management

Chemical Controls: There are no registered products for the control of thrips on strawberries. Controls for the lygus bug will also suppress thrips. Good control requires high volumes of spray at high pressure because thrips are located in protected areas of the hull.

Cultural Controls: None identified.

Alternative Controls: Monitoring should be done weekly.

Cultivar Resistance: None available.

Issues for Strawberry Flower Thrips

None identified

Slug (*Deroceras* and *Arion* spp.)

Pest Information

Damage: Slugs feed on ripening berries boring holes and making them unmarketable. Damage to leaves is usually insignificant, unless the growing points of young plants are destroyed. The pest is normally only a problem in wet seasons or when strawberry plantings are adjacent to high grass, bush or other damp areas. The pest and its slime trail can be a nuisance to pickers and 'pick your own' customers.

Life Cycle: Most species are only active at night, or in the shade of thick foliage. The pest finds shelter under straw mulch in the field and can overwinter there.

Pest Management

Chemical Controls: If the pest is present in large numbers, control should be done before they climb into the plants. Application should be done in the evening at the base of plants or to the headlands when the pests are active and conditions dry. During the flowering and fruiting period, application should be between rows only. Most insecticides are toxic to slugs, therefore sprays targeting other pests such as lygus bugs or weevils will also suppress slugs, provided the foliage is not too dense and the straw mulch not too thick. Registered products include ferric phosphate, metaldehyde and methomyl.

Cultural Controls: Straw mulch and plant debris should be cultivated into the soil at renovation. Weeds should be controlled and cover crops mowed. Tall grasses and weeds provide protection for slugs, and may attract them. Cultivating twice throughout the season will reduce populations. Irrigation should be done early in the day to allow plants to dry by sunset. Good soil drainage and planting rows further apart, promoting air movement, helps in the control of the pest.

Alternative Controls: None identified.

Cultivar Resistance: None available.

Issues for Slug

None identified

Nematodes (*Pratylenchus, Meloidogyne, Xiphinema and Paratylenchus* spp.)

Pest Information

Damage: Pathogenic nematodes feed on the strawberry roots and decrease feeder-root production causing stunting and reduced vigour of plants. Damage is usually patchy in fields and can be serious if nematodes are present in large numbers. Root-knot nematodes cause galls on roots. *Xiphinema* (dagger) nematodes also transmit some viral diseases of strawberry. The most serious impact on strawberry crops is the combination of root lesion (*Pratylenchus* spp.) nematodes and Verticillium wilt in eastern Canada. Verticillium wilt is more severe where *Pratylenchus* spp. are in high numbers, and vice-versa.

Life Cycle: In most species sexual reproduction by adult nematodes is the norm and occurs within an infected host. Eggs are laid by the female and pass from the host into the external environment. Eggs pass through the three juvenile developmental stages before the nematode is again infective for another host. Root-knot nematodes stay alive when plants are dug and shipped, and consequently are readily spread in nursery stocks. Other nematodes, feed on the

surface of roots and are usually dislodged when the plants are dug. Most root nematodes are more destructive in sandy than in clay soils.

Pest Management

Chemical Controls: Fumigants can be applied before planting. Registered products include metam sodium, methyl bromide, 1,3-dichloropropene and chloropicrin.

Cultural Controls: New fields should be sampled for nematodes in the late spring before the year of planting so fumigation can be done in late summer or early fall, if necessary. Compost or manure should always be applied the following spring after fumigation treatment. Only certified planting stock free of nematodes should be used. Keeping land bare of weeds and vegetation between crops is essential to reduce nematode populations; however soils subject to wind or water erosion should have an over-winter cover crop. Cover crops such as clovers and buckwheat should be excluded from strawberry rotations, because they are preferred hosts of root-lesion nematode. Wheat or barley is the best choices from the group of cereal grains. Another strategy to reduce nematode populations is to manipulate the soil carbon: nitrogen ratio to between 11:1 and 20:1. Balanced combinations of chicken manure (for nitrogen) and straw (for carbon) will allow such C:N ratios to be achieved.

Alternative Controls: Some suppression has been achieved using cover crops such as marigolds, oilseed radish, sorghum Sudan grass, etc. but requires a high level of management and is often impractical.

Cultivar Resistance: Some varieties show resistance to the root-lesion nematode.

Issues for Nematodes

1. There is a need for research on varietal resistance and tolerance to root-knot, pin and dagger nematodes.
2. There is concern over the lack of new effective soil fumigants and other management techniques.

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

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Abamectin	avermectin	6	R	Two-spotted mite	A^P	Post-harvest application only for this pest. Harmful to beneficials. New label for this crop; resistance potential high; some use reported in ON.
Amblyseius fallacis	biological			Two-spotted mite	$I\text{-}A^P$	About 25% of area treated in BC. Less effective for strawberry mite. Can be affected by some insecticides used for other pests.
Azinphos-methyl	benzotriazine organothiophosphate insecticide	1B	RE	Aphids	A	Rarely used; MB only for this pest.
				Spittlebugs	$A\text{-}A^P$	
				Leafrollers	A	
				Root weevils	I-AP-A	PE mentions “restricted” use only; used in MB (A).
Bacillus thuringiensis **var. *kurstaki***	biological	11	R	Leafrollers	A	Reported used in MB only.
Carbaryl	carbamate insecticide	1A	RE	Leafrollers	$A\text{-}A^P$	Performance varies.
				Leaf tier	$A\text{-}A^P$	
				Spittlebugs	A	Reported use in MB only for this pest.

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Carbofuran	benzofuranyl methylcarbamate insecticide	1A	RE	Strawberry clipper (bud) weevil	A-A^{P}	Registered only as a pre-harvest treatment in Eastern Canada only. Kills beneficial mite predators. Phytotoxic to some varieties.
				Tarnished plant bug	NU	Eastern Canada registration only; not used for this pest. Phytotoxic.
				Root weevils	I-A^{P}	BC post-harvest only; rarely used.
				Spittlebugs	NU	
Chlorpyrifos	pyrimidine organothiophosphate insecticide	1B	RE	Strawberry cutworm (crown borer)	A-A^{P}	Eastern Canada only; also used in MB for this pest.
Clofentezine	mite growth regulator	10	R	Two-spotted mite	A-A^{P}	Performance varies; timing not suitable for strawberries in ON and some other provinces.
Cyhalothrin-lambda	pyrethroid ester insecticide	3	R	Strawberry clipper (bud) weevil	A-A^{P}	Harmful to beneficials. Used in Eastern Canada and MB only for this pest.
				Lygus bugs	A^{P}	Performance varies. Harmful to beneficials.
				Spittlebugs	A^{P}	Performance varies. Harmful to beneficials. Rarely used for this pest.
				Root weevils	A^{P}	BC only for root weevils. Performance varies. Controls adults only.

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Cypermethrin	pyrethroid ester insecticide	3	R	Lygus bugs	A-A^{P}	Performance varies. Harmful to beneficials.
				Strawberry clipper (bud) weevil	A-A^{P}	Reported use in MB and ON only. Harmful to beneficials.
				Root weevils	I-A^{P}	Performance varies. Harmful to beneficials. Controls adults only.
Deltamethrin	pyrethroid ester insecticide	3	R	Lygus bugs	A^{P}	Harmful to beneficials.
				Strawberry clipper (bud) weevil	A^{P}	Used in ON for this pest. Harmful to beneficials.
Diazinon	pyrimidine organothiophosphate insecticide	1B	RE	Aphids	A^{P}	Performance varies; pest resistance.
				Spittlebugs	A	Reported use in MB only for this pest.
				Strawberry mite (cyclamen mite)	I-A^{P}	Ineffective, resistance; rarely used.
				Leafrollers & leaf tier	A-A^{P}	Performance varies in some regions; used in MB for these pests (A).
				Leatherjackets & crane flies	A^{P}	Used in BC only; performance varies.
				Strawberry cutworm (crown borer)	A	Eastern Canada only.
Dicofol	diphenylethanes	3	R	Two-spotted mite	A-A^{P}	Performance varies. Pest resistance common in many areas.
				Strawberry mite (cyclamen mite)	I-A^{P}-A	Performance varies. Pest resistance common in many areas.

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
dimethoate	aliphatic amide organothiophosphate insecticide	1B	RE	Aphids	A-A^{P}	Performance varies. Pest resistance but acceptable control in some regions. Harmful to beneficials.
				Lygus bugs	I-A^{P}	Pest resistance. Little used for this pest.
				Potato leafhopper	A	Some use reported in PE only.
Endosulfan	cyclodiene insecticide	2A	R	Aphids	A	Some use reported in PE only.
				Lygus bugs	A-A^{P}	Widely used for this pest. Generally effective although performance varies in BC. Harmful to beneficials.
				Spittlebugs	A-A^{P}	Used occasionally in ON and QU.
				Strawberry mite	I-A	Performance varies; pest resistance.
Malathion	aliphatic organothiophosphate insecticide	1B	RE	Aphids	I-A^{P}	Performance varies; pest resistance. Limited or restricted use.
				Leafrollers & leaf tier	A-A^{P}	Performance varies. Limited use.
				Root weevils	I	Registered but not used for this pest; not effective.
				Potato leafhopper	A	Reported use in MB and ON only for this pest. Short residual; harmful to beneficials.
				Two-spotted spider mite	I	Reported use in MB only for this pest.
Methomyl	oxime carbamate insecticide	1A	RE	Slugs	A	Very limited use reported in NB and MB only.
Methoxychlor	organochlorine insecticide	3	R	Strawberry clipper (bud) weevil	A	Reported use in NB only for this pest.

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
M-P 4% metaldehyde pellets	molluscicide		R	Slugs	A-A^P	Performance varies in BC. Applied in early spring as surface broadcast or between rows during bloom or harvest.
Naled	organophosphate insecticide	1B	R	Spittlebugs	A^P-NU	BC only. Performance varies; not used.
				Red spider mite	NU	BC only – not used; poor control of two-spotted and strawberry mite.
				Aphids	I-A^P	BC only – rarely used for this pest.
Parathion	phenyl organothiophosphate insecticide	1B	RE	Leatherjackets and marsh crane flies	A-A^P; NU	Performance varied in BC. Also used in SK (A). No longer registered (2003).
Pirimicarb	dimethylcarbamate insecticide	1A	RE	Aphids	A-A^P	Not for use on any crop exported to U.S. Pest resistance limits effectiveness.

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Pyridaben	pyridazinone	21	R	Two-spotted mite	A-A^{P}	Performance can vary in BC; new registration.

[1] Common trade name(s), if provided brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.
[2] Chemical classification according to "The Compendium of Pesticide Common Names", see http://www.hclrss.demon.co.uk/class_pesticides.html
[3] The mode of action group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, *Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action*
[4] R-full registration (non-reduced risk), RE-under re-evaluation, DI-discontinued, BI-full registration (biological), RR- full registration (reduced risk), OP-full registration (organophosphate replacement), NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. The following website can be consulted for more information on pesticide registrations: http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp
[5] A – Adequate (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^{P} – Provisionally adequate (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control). NU- Not used.
Source(s): Provincial government specialists; PMRA EDDENet database.

Table 7. Availability and use of insect pest management practices for Canadian strawberry production

	Practice \ Pest	Black vine weevil	Strawberry clipper (bud) weevil	Two-spotted mite	Strawberry mite	Aphids	Lygus bug	Wireworm
Prevention	tillage							
	residue removal / management							
	water management							
	equipment sanitation							
	row spacing / seeding depth							
	removal of alternative hosts (weeds/volunteers)							
	mowing / mulching / flaming							
Avoidance	resistant varieties							
	planting / harvest date adjustment							
	crop rotation							
	trap crops - perimeter spraying							
	use of disease-free seed							
	optimizing fertilization							
	reducing mechanical damage / insect damage							
	thinning / pruning							
	choice of planting site							
Monitoring	scouting - trapping							
	records to track pests							
	field mapping of weeds							
	soil analysis							
	weather monitoring for disease forecasting							
	grading out infected produce							
Suppression	use of thresholds for application decisions							
	biological pesticides							
	pheromones							
	sterile mating technique							
	beneficial organisms & habitat management							
	pesticide rotation for resistance management							
	ground cover / physical barriers							
	controlled atmosphere storage							
	forecasting for applications							
	innovative techniques							
	pest specific pesticides / consideration of beneficials							

no indication that the practice is available/used

available/used

available/not used

not available

Source(s): Information in the crop profile for individual pests

Weeds

Key Issues

- There is a need for herbicide labels to include reduced rates or combination options.
- In Ontario, there is concern over the labelling of products, as labels do not have a complete list of weeds for which they are effective.
- There is a concern over the lack of post-emergence products for broadleaf weed control, especially in the establishment year.
- There is a need for a specialist to conduct research on weed management options for strawberries and help promote new product registrations.
- New and effective pesticide-free methods need to be developed for weed control, including testing of practices such as flaming, hot water and steam between rows.
- There is concern over the lack of available qualified scouting services.
- New post-emergence, non-residual herbicides are needed for perennial broadleaf weed control in strawberries. This would be an important tool for promoting strawberry IPM.
- There is a need for products to control brome grasses, groundsel, round-leafed mallow and horsetail. Registration of clethodim for control of annual bluegrass is needed.
- Improved tools and methods are needed to manage dandelion, Canada thistle and quackgrass.
- The development of new, selective chemicals and biopesticides for weed control are required.
- There is a need to improve the spot-application technology.
- In Saskatchewan, there is a need for the registration of 2,4-D, which is currently registered only in eastern Canada.
- In Prince Edward Island, there is difficultly with the control of mustards.
- In New Brunswick, there is a need to improve perennial broadleaf weed control. Clopyralid is registered, but the weed spectrum that it controls and its timing are very limited. The registration of sulfentrazone is needed.
- There is concern in Ontario that growers in United States and other parts of Canada have products that are not labelled in Ontario (simazine, propyzamide).
- Some registered products can be phytotoxic to strawberries.
- There is a need for companies to express a willingness to expand labels.

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

	Degree of occurrence									
Major Annual Grasses	**BC**	**AB**	**SK**	**MB**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Annual bluegrass	E			E			E			
Barnyard grass	E			E		E	E			
Bromegrass				E					E	
Crabgrass						E	E			
Crabgrass, large										
Fall panicum					4		E			
Foxtail, green	E	E		E		E	E			
Foxtail, yellow				E		E	E			
Volunteer cereals										
Wild oats				E						
Witchgrass				E		E	E			
Major Perennial Grass and Sedge	**BC**	**AB**	**SK**	**MB**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Fescue, creeping red				E			E		E	
Foxtail barley				E						
Nutsedge, yellow	E			E		E			E	
Quackgrass	E			E		E	E			
Red top				E			E			
Major Broadleaf	**BC**	**AB**	**SK**	**MB**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Bindweed, field (morning glory)	E			E						
Buckwheat, Tartary		E		E			E			
Buckwheat, wild				E		E	E			
Buttercup, creeping	E			E		E	E			
Buttercup, tall				E			E			
Camomile, scentless			D	E		E	E			
Chickweed, common	E			E		E	E			
Chickweed, mouse-eared				E		E	E			
Cleavers (*Galium*)				E			E			
Clover, alsike				E			E			
Clover, white	E			E			E			
Corn spurry	E			E		E	E			
Cudweed, low	E						E			
Daisy, oxeye				E		E	E			

	Degree of occurrence									
Major Annual Grasses (cont.)	**BC**	**AB**	**SK**	**MB**	**ON**	**QC**	**NB**	**PE**	**NS**	**NF**
Dandelion	E			E		E	E			
Fleabane, Canada				E						
Goldenrod				E			E			
Groundsel	E			E		E	E			
Hemp-nettle (*Galeopsis*)				E			E			
Hawkweed, orange							E			
Hawkweed, yellow							E			
Horsetail, field	E			E		E	E			
Kochia				E						
Lady's- thumb (smartweed)	E			E		E	E			
Lamb's-quarters	E			E		E	E			
Mallow, common	E			E			E			
Mallow, round-leaved			E	E			E			
Milkweed, common				E						
Mustard, wild	E			E		E				
Mustard, tall hedge				E						
Mustard, tumbling				E						
Mustard, wormseed				E			E			
Nightshade, black	E			D						
Nightshade, hairy	E			D						
Oxalis (wood sorrel)	E			E		D	E			
Pansy, field (*Viola arvensis)*						E				
Pigweed, redroot	E			E		E	E			
Pineappleweed				E		E	E			
Plantain, broad-leafed	E			E		E	E			
Prickly lettuce				E					E	
Purslane				E		E	E			
Radish, wild				E			E			
Sheep sorrel	E			E		E	E			
Shepherd's purse	E			E		E	E			
Snapdragon, dwarf										
Sowthistle, annual	E			E		E	E			
Sowthistle, perennial	E			E		E	E			

Major Annual Grasses (cont.)	Degree of occurrence									
	BC	AB	SK	MB	ON	QC	NB	PE	NS	NF
St. John's wort				E			E			
Stinkweed				E	4		E			
Tansy, common				E					E	
Thistle, Canada	E			E		E	E			
Thistle, Russian				E						
Thistle, Scotch				E						
Toadflax, yellow				E		E	E			
Toadflax, dalmation										
Vetch, common				E		E	E			
Vetch, hairy				E						

Widespread yearly occurrence with high pest pressure
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure
Widespread yearly occurrence with low to moderate pest pressure
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure
Pest not present
E – established
D – invasion expected or dispersing
Source(s): Provincial government specialists

Annual Weeds

Pest Information

Damage: Annual weeds are normally the most important weeds in strawberry production as they reduce growth and yield of strawberry plants. Annual grass weeds that occur in strawberries include annual bluegrass, wild oats, barnyard grass, and volunteer grains from crops grown in rotation with strawberries.

Life Cycle: Winter annuals are weeds that germinate in the fall and overwinter in a vegetative state, flower in the spring, form seeds and then die. Summer annual weeds germinate in the spring, flower and fruit in the summer or fall and die before the onset of winter. Annual broadleaf weeds are usually the most common weeds found in strawberry fields. The most important are the species whose seeds are not killed by soil fumigation, such as sweet clover. Other weeds, such as sow thistle or groundsel, produce large quantities of windblown seed that can invade the fields after fumigation. Some weeds, such as purslane, can re-grow if their roots remain in contact with moist soil.

Pest Management

Chemical Controls: Once plants are well set, herbicides can be applied in two ways: as an overall spray, or as a band applied over the row combined with cultivation between the rows. Applying a pre-plant herbicide in the spring does help reduce labour requirements for weed control in the first year. Pre-plant soil fumigants applied for nematode control also help to suppress weeds.

Cultural Controls: Growers can gradually decrease the reservoir of weed seeds in their fields by managing weeds in headlands and other non-productive areas, and preventing them from setting seed on crop land. Mechanical or hand weeding can be used if weed populations are manageable. Cover cropping and mulching (using sawdust, wood shavings, grass clippings, weed-free hay, clean or fumigated straw, black plastic) are techniques used to help control weeds. Planting should be done into soil that is as weed free as possible. Crop rotations help break the growth cycle of weeds.

Alternative Controls: None identified.

Issues for Annual Weeds

See "key issues" at the start of the weed section.

Perennial Weeds

Pest Information

Damage: Perennial weeds will shade out strawberries and will affect plant growth if not controlled.

Life Cycle: Perennial weeds form rhizomes, rootstocks, or tubers that survive when aboveground parts of the plant are killed. This makes them difficult to control, especially when the perennial structures are able to escape soil fumigation. Simple perennials regenerate each year from a root or crown structure and reproduce by sexual means only. Creeping perennials regenerate from roots, shoots and other structures and can reproduce both asexually (vegetatively) and sexually. Broken root pieces can result in the formation of a new plant. This group of weeds is usually the most difficult to control.

Pest Management

Chemical Controls: There are a number of products registered for the control of perennial weeds. Pre-plant soil fumigants applied for nematode control also help suppress weeds.

Cultural Controls: Avoiding infested fields and preventing infestations from becoming established are the most important control strategies. A rotation cycle should be used to control perennials when strawberries are not planted. Weed seedlings should be removed during hand weeding operations, which is practical for localized infestations. Strict sanitation procedures should be followed to avoid the spread of roots, tubers or rhizomes to other fields. Weeds should be controlled before land preparation to prevent spreading them throughout the field. Deep ploughing to thoroughly invert the soil is an effective cultural control for nutsedge.

Alternative Controls: None identified.

Issues for Perennial Weeds

See "key issues" at the start of the weed section.

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

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Clopyralid	pyridine herbicide	4	CR	Annual broadleaf	A[p]	Established, mature plantings only; post-harvest only. Resistant and tolerant species, e.g., groundsel. Weak on many broadleaf weeds in strawberries.
				Perennial broadleaf	A[p]	
Chlorthal	phthalic acid herbicide	3	CR	Annual broadleaf	A	Reported use in MB and PE only.
Fluazifop-p-butyl	aryloxyphenoxypropionic herbicide	1	CR	Annual grass	A[p]	Not effective on annual bluegrass or bromegrass.
				Perennial grass	A[p]	Not very effective on quackgrass.
Glyphosate	organophosphorus herbicide	9	CR	Annual grass	A	Pre-plant or year prior to planting only. Some cultivars sensitive to higher rates and lower rates not very effective.
				Annual broadleaf	A	
				Perennial broadleaf	A	
				Perennial grass	A	
Napropamide	amide herbicide	15	CR	Annual grass	I - A	Does not control annual bluegrass. Many annual grasses escape and re-grow.
				Annual broadleaf	I - A	Does not control chickweed or groundsel.
Oxyfluorfen	nitrophenyl ether herbicide	14	CR	Annual broadleaf	A	Reported use in Quebec only; primarily to control field pansy and wood sorrel; new registration in BC for control of annual winter broadleaves as a dormant spray.
				Wood sorrel	A	
				Field pansy	A	
Paraquat	quaternary ammonium herbicide	22	RE	Annual grass	A	Reported use in Saskatchewan for spot sprays only.
				Annual broadleaf	A	
Propyzamide	chloroacetaminde herbicide	15	CR	Annual grass	A - A[p]	Does not control annual bluegrass.
				Perennial grasses	A - A[p]	Control is inconsistent; many weeds tolerant and suppressed only.
Sethoxydim	cyclohexene oxime herbicide	1	CR	Annual grass	A - A[p]	Only one application per season. Does not control annual bluegrass.
				Quackgrass	A - A[p]	Not effective on brome or quackgrass. Suppression of many weeds only.

Control product (active ingredient / organism)[1]	Classification[2]	Mode of action – resistance group[3]	PMRA status of active ingredient[4]	Pests or group of pests targeted	Performance of product according to recommended use[5]	Notes
Simazine	chlorotriazine herbicides	5	CR	Annual grass	I - A	Does not control annual bluegrass. Many grasses escape and re-grow. Can only be used where soil pH is <5.6 (NS). In BC can only be used in coastal areas.
				Annual broadleaf	I - A	Does not control mustards, chickweed, redroot pigweed, lambs'quarters, groundsel.
S-metalochlor	chloroacetamides	15	CR	Annual grass	I - A	Can be applied only in planting year. Does not control annual bluegrass.
Terbacil	uracil herbicides	5	CR	Annual grass	I - A^p	Does not control annual bluegrass or bromegrass.
				Annual broadleaf	I - A^p	Performance varies according to species. Poor control of groundsel and chickweed.
Trifluralin	dinitroaniline herbicide	3	CR	Annual grass	A - A^p	Planting year application only. Does not control annual bluegrass.
				Annual broadleaf	I - A^p	Does not control groundsel, nightshade, pigweed, lamb'squarters. Many escapes.
2,4-D isomer as dimethylamine	phenoxys	4	RE	Annual broadleaf	A	Eastern Canada only. Only controls some weeds; phytotoxic to some cultivars.
				Perennial broadleaf	I - A^p	

[1] Common trade name(s), if provided brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.
[2] Chemical classification according to "The Compendium of Pesticide Common Names", see http://www.hclrss.demon.co.uk/class_pesticides.html
[3] The mode of action group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, *Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action*
[4] R-full registration (non-reduced risk), RE-under re-evaluation, DI-discontinued, BI-full registration (biological), RR- full registration (reduced risk), OP-full registration (organophosphate replacement), NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. The following website can be consulted for more information on pesticide registrations: http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp
[5] A – Adequate (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^p – Provisionally adequate (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control). NU- Not used.

Source(s): Provincial government specialists; PMRA EDDENet database.

Table 10. Availability and use of weed pest management practices for Canadian strawberry production.

	Practice \ Pest	Annual	Perennial
Prevention	tillage		
	residue removal / management		
	water management		
	equipment sanitation		
	row spacing / seeding depth		
	removal of alternative hosts (weeds/volunteers)		
	mowing / mulching / flaming		
Avoidance	resistant varieties		
	planting / harvest date adjustment		
	crop rotation		
	trap crops - perimeter spraying		
	use of disease/weed-free seed		
	optimizing fertilization		
	reducing mechanical damage / insect damage		
	thinning / pruning		
	choice of planting site		
Monitoring	scouting - trapping		
	records to track pests		
	field mapping of weeds		
	soil analysis		
	weather monitoring for disease forecasting		
	grading out infected produce		
Suppression	use of thresholds for application decisions		
	biological pesticides		
	pheromones		
	sterile mating technique		
	beneficial organisms & habitat management		
	pesticide rotation for resistance management		
	ground cover / physical barriers		
	controlled atmosphere storage		
	forecasting for applications		
	innovative techniques		
	pest specific pesticides / consideration of beneficials		
no indication that the practice is available/used			
available/used			
available/not used			
not available			
Source(s): Information in the crop profile for individual pests			

Vertebrate Pests

Birds

Birds, such as starlings, crows, robins, sparrows, finches and Canada geese may occasionally damage strawberry crops. The berries are eaten whole or “pecked” and left on the plants. Several types of control are available, such as netting and visual and noise scaring devices.

Deer

Deer can cause serious damage to strawberry plantings. They eat the leaves and new growth, weakening plants and reducing yields. In most provinces prevention of damage is based on the use of repellents and fencing. Preferential feeding on some varieties has been observed in trials.

Mice

Field Mice (Voles) can cause severe damage when numerous, but damage can be variable. Injury usually occurs in the winter under a protective snow cover. Below the ground, injury may be extensive, but not visible from the surface until the plants fall-over or fail to leaf-out normally. Mice injury is usually associated with high grass and weed growth within or beside strawberry plantings, as these provide protection and are breeding sites for mice. Therefore, weed control is an important part of vole control. Herbicides and/or frequent close mowing will do as much or more to keep mice under control as poison baits. Trapping of field mice is seldom effective.

Moles

Moles burrow underground and leave hills of dirt. Mole activity in strawberry fields may indicate the presence of root weevils. Trapping with scissor traps is the most effective control method.

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

Name	Organization	Pest type	Specific pests	Type of research
A. Dale	University of Guelph, Ontario Agricultural College	breeding		New varieties; resistance to tarnished plant bug
A. Jamieson	AAFC, Atlantic Food and Horticulture Research Centre	cultivars		Improved technology for the production and distribution of high quality strawberries
A.C. Kushalappa	Research and Development Institute for the Agri-Environment (Quebec)	disease	Botrytis grey mould	Development of pre and post harvest disease warning systems for strawberry grey mould management
B. Hughes	University of Guelph, Ontario Agricultural College	disease, cultivars		Selection and management studies to improve strawberry production in Ontario and horticultural crop production in the north. selection of winter-hardy cultivars with improved quality and yield
B. Martin	Corvallis, OSU, USA	disease	virus	Virus identification
B. Strik	Corvallis, OSU, USA			Crop management
B. Vernon	AAFC- PARC, Agassiz, BC	insect	wireworms	Tap crops and insecticides
C. Kempler	AAFC- PARC, Agassiz, BC	breeding		New varieties
C. Mouritzen	Southwest Crop Consulting, Chilliwack, BC	weed	weed	Applied weed management
C. Neeser	Alberta Department of Agriculture, Food & Rural Development, Crop Diversification Centre South	cultivars		Evaluation of new cultivars and advanced selections for agronomic and quality characteristics under Alberta conditions
C. Vincent	AAFC, Horticulture Research and Development Centre	insect		Ecology, habits and control of some important insects in horticultural crops
D. Benoit	AAFC, Horticulture Research and Development Centre	weed		Impact du désherbage mécanique sur les patrons d'émergence des mauvaises herbes
D. Henderson	ES Crop Consult Ltd., Vancouver, BC	insect and disease	aphids, mites, caterpillars, lygus bugs, Botrytis, etc.	Insecticides, biocontrols, field scouting and pest thresholds; IPM
J. Elmhirst	Elmhirst Diagnostics & Research, Abbotsford, BC	disease	red stele	Fungicides for management, disease resistance

Name	Organization	Pest type	Specific pests	Type of research
J. Madill	University of Guelph, Ontario Agricultural College	weed		To provide sustainable management techniques suited to eastern Ontario through mulching and support of the herbicide minor use program.
J. Potter	AAFC, Southern Crop Protection and Food Research Centre	nematode	Lesion nematode	Strawberry plant resistance for nematode control
K. Jensen	AAFC, Atlantic Food and Horticulture Research Centre	cultivars		
K. Mackenzie	AAFC, Atlantic Food and Horticulture Research Centre	cultivars		
K. Mcrae	AAFC, Atlantic Food and Horticulture Research Centre	cultivars		
M. Hardman	AAFC, Atlantic Food and Horticulture Research Centre	cultivars		
M.T. Charles	AAFC, Horticulture Research and Development Centre	diseases		
N. Nickerson	AAFC, Atlantic Food and Horticulture Research Centre	cultivars		
O. Carisse	AAFC, Horticulture Research and Development Centre	diseases		
P. Braun	AAFC, Atlantic Food and Horticulture Research Centre	cultivars		
P. Bristow	Puyallup,WSU, USA	disease	red stele, Botrytis	Cultural management; non-chemical controls
P. Fisher	OMAF, Simcoe, ON	IPM	general	Applied IPM methods
P. Hicklenton	AAFC, Atlantic Food and Horticulture Research Centre	cultivars		
P. Hildebrand	AAFC, Atlantic Food and Horticulture Research Centre	cultivars		

Name	Organization	Pest type	Specific pests	Type of research
P.O Thibodeau	Research and Development Institute for the Agri-Environment (Quebec)	disease	Botrytis grey mould	Development of pre and post harvest disease warning systems for strawberry grey mould management
R. Hallett	University of Guelph, Ontario Agricultural College	insect	Tarnished plant bug	To identify sources of resistance to tarnished plant bug in strawberry, study the inheritance in day neutral populations and to estimate threshold values for the cultivar 'Seascape'
S. Fitzpatrick	AAFC- PARC, Agassiz, BC	insect & mite		
S. Khanizadeh	AAFC, Horticulture Research and Development Centre	disease, insect		Development and evaluations of winter hardy, disease resistant day-neutral and June bearing strawberry cultivars with high fruit quality (e.g. high antioxidant) and long shelf life resistant to pest and diseases
T. Baumann	UCFV, Abbotsford, BC			Crop management, yield estimation and variety trials
T. Kanagara	AAFC- PARC, Agassiz, BC	disease	red stele	
V. Brookes	AAFC, PARC, Agassiz, BC	all	all	Minor use pesticide efficacy and residue trials