Crop Profile for Field Cucurbits in Canada, 2021

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Preface

National crop profiles are developed by the Pest Management Program of Agriculture and Agri-Food Canada (AAFC). The crop profiles provide baseline information on production and pest management practices and document growers' needs to address pest management gaps and issues for specific crops grown in Canada. This information is developed through extensive consultation with stakeholders and data collected from reporting provinces. Reporting provinces are selected based on their acreage of the target crop (>3% of the national production) and provide qualitative data on pest occurrence and integrated pest management practices used by growers in those provinces. This crop profile covers field cucurbit crops, providing detailed information on pumpkin, squash and zucchini, as well as cucumber and gherkin. For cucurbit production, the reporting provinces are British Columbia, Ontario and Quebec.

Information on pest issues and management practices is provided for information purposes only. For detailed information on growing cucurbits, the reader is referred to provincial crop production guides and provincial ministry websites listed in the Resources Section at the end of the profile. For guidance about crop protection products registered for pests on cucurbits, the reader is referred to provincial crop production guides and Health Canada's Pesticide label database.

Agriculture and Agri-Food Canada gratefully acknowledges the contributions of provincial crop specialists, industry specialists and growers in the gathering of information for this publication.

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Crop Profile for Field Cucurbits in Canada

Plant species that belong to the *Cucurbitaceae* or gourd family are collectively known as cucurbits. Cucurbits are annual, herbaceous, frost-sensitive, tendril-bearing vines or bushes with palmate leaves. They are monoecious with separate male and female flowers on the same plant. The large orange-yellow flowers produce nectar and are visited by bees. Cucurbits include edible crops such as pumpkins, zucchini, melons, squash and cucumbers. They provide fibre, minerals, vitamins and carotenes to human diets. Cucurbits also include nonedible gourds which are cultivated for ornamental purposes. Cucurbits are grown world-wide under temperate, sub-tropical and tropical conditions.

Cucurbits of the genus *Cucurbita* are native to the Americas. They were domesticated about 7,000 to 9,000 years ago, during the Neolithic era, and were a staple food of many pre-Columbian cultures and civilizations. *Cucurbita* have a very high diversity of fruit colours, shapes and sizes, especially *C. pepo*. Various parts of the plant are eaten including mature and immature fruits, seeds and flowers.

Pumpkins are edible *Cucurbita* that are globe-shaped or almost globe-shaped. They are used when they are fully enlarged and mature. In Canada, the majority of pumpkins are carved into Jack-O-Lanterns for Halloween. A small amount of pumpkin is also processed for the pie market.

Squashes are also edible *Cucurbita*, but are non-globe shaped. Most squash are used when immature and are referred to as "summer squash". Zucchini is a type of summer squash. Other types of squash are used when mature and are referred to as "winter squash". Acorn, butternut and spaghetti are examples of winter squashes. Squashes are grown for fresh market sale.

Cucurbits of the genus *Cucumeris* are native to Africa, Asia and Australia. The cucumber, *Cucumeris sativus*, is native to India, where it was domesticated about 3,000 years ago. Cucumbers were introduced to China about 2,000 years ago and to Europe about 700 to 1,500 years ago. Approximately 500 years ago Europeans transported cucumbers to Canada.

Cucumbers are better adapted to low temperatures than most other cucurbits. They are early bearing and easy to grow. There are two main types of field cucumber grown for the Canadian market: pickling and slicing cucumbers. Pickling cucumbers are sold to the processing market and are often once-over machine picked. Slicing cucumbers are grown for fresh market sale and are hand picked, with multiple harvests throughout the cropping cycle.

Crop Production

Industry Overview

Cucurbits are an important component of Canada's overall field vegetable production. Pumpkins; squash and zucchini; and cucumber and gherkins have the 10^{th}, 11^{th} and 12^{th} largest growing areas respectively out of the 32 field vegetables grown in Canada, with a combined growing area of 9,535 ha (Table 1). Pumpkins; cucumber and gherkins; and squash and zucchini have the 7^{th}, 10^{th} and 11^{th} highest yields respectively, with a combined production of 173,673 metric tonnes (Table 1). Lastly, squash and zucchini; cucumber and gherkins; and pumpkins have the 10^{th}, 13^{th}

and 15th highest farm gate values respectively, worth a combined value of $130.7 million (Table 1).

Between 1986 and 2001 the area planted with pumpkins, squash and zucchini increased more than two-fold. The fast growth during this time period was related to the increased popularity with consumers for pumpkin use at Thanksgiving and Halloween. The advent of on-farm Halloween themed events also helped to boost pumpkin sales.

Since 2015 to the present, there has been little change in pumpkin growing area, yields and farm gate value. This more-or-less stable state from 2015 to the present also holds for squash and zucchini, as well as cucumbers and gherkins.

Canada is a net importer of fresh or chilled pumpkins, squashes and gourds (Table 1). By contrast, Canada is a net exporter of fresh or chilled cucumbers and gherkins (Table 1). Almost all exports of Canadian cucurbits are to the United States. The majority of Canada's imported cucurbits come from Mexico. Mexico accounts for approximately 72 percent of fresh or chilled pumpkins, squashes and gourds and approximately 76 percent of fresh or chilled cucumbers and gherkins imports into Canada.

Table 1. General production information for field cucurbit, 2021

	Cucumber and Gherkin	Pumpkin	Squash and Zucchini
Canadian Marketed Production[1]	56,497 metric tonnes	73,579 metric tonnes	43,597 metric tonnes
	2,420 hectares	4,003 hectares	3,112 hectares
Total Farm Gate Value[1]	$46.4 million	$33.3 million	$51.0 million
	Cucumber (Fresh)	**Pumpkin and Squash (Fresh)**	
Food Available[2]	2.87 kg/person/year	2.99 kg/person/year	
	Cucumber and Gherkin (Fresh or Chilled)	**Pumpkin, Squash and Gourds (Fresh or Chilled)**	
Domestic Exports[3,4]	$20.2 million 25,941 metric tonnes	$27.5 million 37,873 metric tonnes	
Imports[3,5]	$6.3 million 7,292 metric tonnes	$73.9 million 59,562 metric tonnes	

[1]Statistics Canada. Table 32-10-0365-01 - Area, production and farm gate value of marketed vegetables (accessed June 13, 2022).
[2]Statistics Canada. Table 32-10-0054-01 - Food available in Canada (accessed June 13, 2022).
[3]Statistics Canada. Canadian International Merchandise Trade Web Application (accessed June 13, 2022).
[4]Domestic Exports: 0707.00.90 - Cucumbers and gherkins, other than greenhouse, fresh or chilled; and 0709.93.00 - Pumpkins, squash and gourds, fresh or chilled.
[5]Imports: 0707.00.10.00 - Cucumbers and gherkins, for processing, fresh or chilled; and 0709.93.00.00 - Pumpkins, squash and gourds, fresh or chilled.

Production Regions

Ontario is the largest producer of cucurbits in Canada followed by Quebec and British Columbia (Table 2). The main cucurbit growing areas are near major urban centres and include southern Ontario, the Montérégie region of Quebec and the lower Fraser Valley of British Columbia.

Table 2. Distribution of cucurbit production in Canada, 2021[1]

Production Regions	Area Planted (hectares)	Total Production (metric tonnes)	Farm Gate Value ($)
Cucumber and Gherkin			
British Columbia	89 (4%)	1,578	$2.9 million[2]
Ontario	17,00 (68%)	36,540	$26.5 million
Quebec	614 (24%)	14,415	$14.0 million
Canada	**2,518**	**57,720**	**$46.4 million**
Pumpkin			
British Columbia	384 (8%)	7,252	$4.5 million
Ontario	3,248 (69%)	58,554	$21.2 million
Quebec	609 (13%)	10,801	$3.9 million
Canada	**4714**	**84,458**	**$33.3 million**
Squash and Zucchini			
British Columbia	401 (12%)	4,782	$7.7 million
Ontario	1,352 (40%)	19,400	$17.4 million
Quebec	1,331 (39%)	17,993	$21.2 million
Canada	**3,377**	**45,035**	**$51.0 million**

[1]Statistics Canada. Table 32-10-0365-01 - Area, production and farm gate value of marketed vegetables (accessed June 13, 2022). (CDN production, Total Farm Gate Value)
[2]Data is for 2019. Data for 2020 and 2021 was deemed unreliable by Statistics Canada.

Cultural Practices

Cucurbits do best on well-drained, fertile, compact-free, neutral to slightly alkaline soils. Sandy loam soils are ideal. Clay soils are adequate, but fruit can become dirty and is then difficult to clean. Soil samples are collected before the growing season and are used to determine the types and amounts of fertilizers to apply. There are generally two times that the crop is fertilized. First, a broadcast treatment before planting and, second, a banded treatment after planting. In the case of cucumbers, post-planting fertilizer treatments can also be delivered to the crop through drip irrigation systems.

Cucurbits are deep rooted and tolerant of dry conditions. However, if the soil is too dry then fruit set and size will be reduced. A reduction in fruit quality under dry conditions is especially noticeable with cucumbers and zucchini because the fruit is harvested within a weeks of pollination. Cucurbits also tolerate wet conditions. However, wet conditions can result in an increased incidence of foliar diseases and fruit rots. While cucurbits can be grown without irrigation, they do benefit greatly when irrigated during flowering and fruit development.

Cucurbits are sub-tropical, warm season crops that grow best during hot weather. They do not tolerate frost or low temperatures. Frosts can heavily damage or kill plants while temperatures below 10 °C reduce both crop growth and fruit quality. Low lying areas, where cold air can pool, are avoided due to the risk of frost damage.

Cucurbit crops can be direct seeded into the field. Sowing occurs only when the soil temperatures are warm enough to permit germination. Seeds can germinate at 15 °C, but germinate best at 29 °C to 35 °C. Plastic mulch and/or row covers can raise the temperature of the soil and provide some frost protection.

Cucurbits can also be started in a greenhouse and then transplanted into the field. Ideally seedlings are two to four weeks old when they are transplanted. At this age, the plant roots are the least susceptible to transplant injury. Any root injury stops or slows plant growth and sets the plant back.

Cucurbits are monoecious with separate male and female flowers on the same plant. Male flowers provide pollen but do not produce fruit. Female flowers produce fruit. Some processing cucumber hybrids produce only female flowers. The seeds of these hybrids also contain 10 percent to 15 percent monoecious cucumber seeds to ensure that some male flowers are present to provide pollen for fruit set. Female flowers are pollinated by bees. About 15 to 20 bee visits per flower are needed for proper fruit set otherwise the fruit will be small and misshapen. While native bees can pollinate cucurbit crops, honey bee hives are used to ensure adequate fertilization. Poor weather reduces bee visits, thereby causing a reduction in fruit set and quality.

Cucumbers are harvested soon after pollination at four to five days for pickling cucumbers and 15 to 18 days for slicing cucumbers. Pickling cucumbers are often machine picked, while sliced cucumbers are hand harvested. Zucchini fruits are hand harvested when immature before their skins harden. They must be handled carefully to ensure that the tender fruit is not bruised. Pumpkins are not harvested until they are fully ripe and the rinds have hardened. The pumpkins are either cut or pulled from the vine so a part of the stem remains attached to the fruit. Careful handling is also needed to avoid bruising the pumpkin fruit.

After harvesting, pumpkins are ripened or cured. Curing allows the shell to harden, small wounds to heal, water content to be reduced and eating quality to improve. When the weather is warm and dry, pumpkin fruit can be cured by leaving them in the field for 10 to 14 days. Alternatively, the fruits can be kept in a room held at 26 °C to 29 °C and a relative humidity of 80 percent for a month.

Storage of cucumbers and zucchini is short term, for one to two weeks only. Fruits are kept at a temperature of 5 °C to 12 °C and a relative humidity of 95 percent. Pumpkins can be stored for longer, until the end of December. However, pumpkins usually do not need to be stored because the marketing season is short, confined to Halloween and the pie trade. If stored, pumpkin fruits are kept at a temperature 10 °C and a relative humidity of 70 percent to 75 percent.

Table 3. Cucurbit production and pest management schedule in Canada

Time of Year	Activity	Action
May	Plant care	Transplants[1] started in greenhouses or mini hoop houses (in some growing areas). Transplanting or direct sowing of seeds[2] begins when soil and air temperatures are warm enough to facilitate crop growth and seed germination[3].
	Soil care	If needed, testing is conducted to determine soil fertility levels. Pre-plant fertilizers are applied and incorporated into the soil.
	Disease management	Disease monitoring begins; pesticides applied, if necessary.
	Insect and mite management	Pest monitoring begins; pesticides applied, if necessary.
	Weed management	Stale seedbed technique used. Mulches might be used. Pre-plant and post-emergent herbicides are applied, if necessary.
June	Plant care	Transplanting and sowing continue. Possible irrigation (weather dependant). Pollinators provided when crop starts to flower.
	Soil care	Just before vine spread, if applicable, fertilizers are side-dressed. Alternatively, if using mulch and trickle irrigation, crops are fertigated.
	Disease management	Disease monitoring continues; pesticides applied, if necessary.
	Insect and mite management	Pest monitoring continues; pesticides applied, if necessary.
	Weed management	Post-emergent herbicides are applied or inter-row cultivation carried out, if necessary.
July	Plant care	Pollinators provided while crop is flowering. Possible trickle irrigation, if needed and available. Harvesting begins.
	Soil care	Fertigation, if applicable and necessary.
	Disease management	Disease monitoring continues; pesticides applied, if necessary.
	Insect and mite management	Pest monitoring continues; pesticides applied, if necessary.
August	Plant care	Harvesting continues.
	Disease management	Disease monitoring continues; pesticides applied, if necessary.
	Insect and mite management	Pest monitoring continues; pesticides applied, if necessary.
September	Plant care	Harvesting continues.
	Disease management	Crop debris are plowed under as soon as possible after harvest, if applicable.
	Weed management	Late season weeds are hand pulled, if necessary.
October	Plant care	Harvesting continues. Pumpkins left in field to cure.
	Disease management	Crop debris are plowed under as soon as possible after harvest, if applicable.

[1] Early pickling cucumbers, slicing cucumbers and zucchini.
[2] Pumpkin, squash and non-early pickling cucumbers.
[3] Ontario: late May to early June.

Abiotic Factors Limiting Production

Blossom-End Rot

A lack of calcium causes blossom-end rot in cucumbers and squash. Affected plants have small, light brown spots at the blossom end of immature fruit. As the fruit ripens the affected area gradually expands into a sunken, leathery, brown or black lesion. Hard, brown areas may also develop inside the fruit.

Blossom-end rot often occurs in the summer when fluctuations in soil moisture hinder plant root uptake of calcium. Less frequently, it occurs when there is not enough calcium present in the soil to meet the plant’s nutritional needs.

Misshapen Fruit

Problems with pollination and proper water management result in deformed cucumbers. About 15 to 20 bee visits per flower are needed for proper fruit set otherwise the fruit will be small and misshapen. Inadequate or inconsistent watering during hot weather also results in misshapen fruit.

Oedema

Oedema is a physiological problem that occurs when the epidermal cells of leaves or fruit die. The dead cells discolour and give leaves and fruit a warty appearance.

Conditions that favour oedema are high soil moisture, high relative humidity and an air temperature that is colder than the soil temperature. These conditions result in a low plant transpiration rate combined with an increase in water absorption by roots from the soil. This causes an increase in cell turgor pressure and the bursting of the epidermal cells.

Oedema is also associated with dry conditions during fruit sizing and maturity. The lesions commonly appear where the fruit rests on the soil surface.

Cold Injury

Frosts can heavily damage or kill plants and temperatures below 10 °C reduce both crop growth and fruit quality. Damage includes dead spots on leaves and brownish tan areas on the skin of the fruits. Fruit cracking can also occur.

Diseases

Key issues

- There is a gap between the knowledge currently held by the cucurbit industry and new information and disease management approaches under development.
- Recommendations on fungicide use need to be strengthened by improving scouting methods, action thresholds and timing of fungicide applications.
- Alternative management tools for crop protection need to be identified and best management practices need to be developed to reduce the occurrence and spread of resistant diseases.
- Recently developed technologies that would aid with spraying, scouting and disease identification need to be evaluated to determine if they would work in a Canadian context and where they would fit within current IPM recommendations.
- Easy, rapid, farm level disease diagnostics which incorporate new technologies such as LAMP-based on farm disease assays, qPCR-based spore trapping networks and microclimate disease forecasting systems need to be identified for more efficient diagnosis of diseases (e.g., angular leaf spot, Alternaria, downy mildew) and fungicide resistance.
- New resistant cultivars need to be developed for many cucurbit diseases to minimize disease incidence and reduce reliance on conventional fungicides.
- Cultivars of early-maturing winter squashes, such as *C. pepo*, *C. maxima*, *C. moschata*, that exhibit some resistance to common cucurbit diseases, such as powdery mildew need to be developed for organic production.

Table 4. 2022 Canadian Pest Management Top Priority Rankings of cucurbit diseases in relative order of importance by province[1]

Pest	Provincial Rankings								
	Cucumber			Pumpkin			Summer Squash		
	QC	ON	BC	QC	ON	BC	QC	ON	BC
Conventional Production									
Angular leaf spot	Yellow		Blue						Blue
Bacterial leaf spot		Blue			Blue			Blue	
Anthracnose		Blue			Blue			Blue	
Downy mildew	Orange	Orange			Orange			Orange	
Belly rot and Pythium rot[3]	Blue	Blue	Blue		Blue	Red		Blue	Red
Gummy stem blight		Blue	Yellow		Blue	Blue	Yellow	Blue	Blue
Phytophthora	Red	Red		Red	Red		Orange	Red	
Powdery mildew		Blue	Blue		Blue	Blue		Blue	Blue
Scab		Blue	Orange		Blue		Red	Blue	Yellow
Fusarium root rot		Yellow	Red		Yellow	Orange		Yellow	Orange
Fusarium wilt			Red	Orange		Orange			Orange
Septoria				Yellow					
Plectosporium blight		Blue			Blue			Blue	
White rot									Blue
Organic Production									
Downy mildew	Red	Red							
Powdery mildew		Orange							

[1]Provinces provide rankings of their top pest priorities for the annual Canadian Pest Management Priority Setting Workshops. This table provides rankings for the key diseases of cucurbit crops published in 2022 (BC rankings were updated in August 2022). Rankings are colour coded in order of highest to lowest relative importance where red indicates a first highest priority, orange indicates a second highest priority, yellow indicates a third highest priority and blue indicates a priority of four and below. A blank does not mean that the disease does not occur in a province, it could be that it was not ranked in the top pests for 2022.

Table 5. Adoption of integrated disease management practices in cucurbit production in Canada[1]

Practice	Bacterial leaf spot	Downy mildew	Gummy stem blight	Phytophthora	Powdery mildew	Fusarium
Avoidance:						
Varietal selection / use of resistant or tolerant varieties						
Planting / harvest data adjustment						
Rotation with non-host crops						
Choice of planting site						
Optimizing fertilization for balanced growth and to minimize stress						
Minimizing wounding and insect damage to limit infection sites						
Use of disease-free propagative materials (seed, cuttings, transplants)						
Cucurbit propagation facilities are separate from greenhouse cucumber facilities						
Water sources that receive run-off water from disease infested fields are avoided						
Prevention:						
Workers wash hands and wear laundered clothing						
Equipment sanitation						
Canopy management (thinning, pruning, row or plant spacing)						
Manipulating seeding / planting depth						

…continued

Table 5. Adoption of integrated disease management practices in cucurbit production in Canada[1] (continued)

Practice	Bacterial leaf spot	Downy mildew	Gummy stem blight	Phytophthora	Powdery mildew	Fusarium
Irrigation type (trickle) and management (timing, duration, amount) are used to minimize disease infection periods and manage plant growth						
Management of soil moisture (e.g., improvements in drainage, use of raised beds, hilling, mounds)						
End of season or pre-planting crop residue removal / management						
Prune out / removal of infected material throughout the growing season						
Removal of other hosts (weeds / volunteers / wild plants) in field and vicinity						
Diseased fields are worked at the end of the day						
Water sources are tested for the presence of the pathogen						
Monitoring:						
Scouting / spore trapping						
Maintaining records to track diseases						
Soil analysis for the presence of pathogens						
Weather monitoring for disease forecasting						
Use of precision agriculture technology (GPS, GIS) for data collection and mapping of diseases						

…continued

Table 5. Adoption of integrated disease management practices in cucurbit production in Canada[1] (continued)

Practice	Bacterial leaf spot	Downy mildew	Gummy stem blight	Phytophthora	Powdery mildew	Fusarium
Decision making tools:						
Economic threshold						
Use of predictive model for management decisions						
Crop specialist recommendation or advisory bulletin						
Decision to treat based on observed disease symptoms						
Use of portable electronic devices in the field to access pathogen / disease identification / management information						
Suppression:						
Use of diverse product modes of action for resistance management						
Cover crops and mulches are used to manage pathogen dispersal						
Use of non-conventional pesticides (e.g., biopesticides)						
Controlled atmosphere storage						
Targeted pesticide applications (e.g., banding, spot treatments, use of variable rate sprayers)						
Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms						
Avoid fields that tend to have heavy dews and prolonged morning mists (BC)						

This practice is used to manage this pest by at least some growers in the province.

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

Information regarding this practice for this pest is unknown.

This practice is not used by growers in the province to manage this pest.

[1]Source: Stakeholders in reporting provinces (British Columbia and Quebec); the data reflect the 2019, 2020 and 2021 production.

Angular Leaf Spot and Fruit Blotch (*Pseudomonas syringae*)

Pest Information

Damage: Angular leaf spot affects cucumbers and zucchini. It infects both leaves and fruits. Cucumber leaf symptoms start as small, round to irregularly shaped, water-soaked lesions. The lesions expand until they are limited by larger leaf veins. This gives the lesions an angular appearance. Under humid conditions, the water-soaked lesions become covered by a white exudate. Eventually the exudate dries, forming a thin, white crust on or adjacent to the lesion on the underside of the leaf. Lesions eventually dry, shrinking and tearing away from the healthy tissue. The result is irregular holes that give the leaf a ragged and yellowish appearance. Zucchini leaf lesions are more variable in size and are surrounded by yellow halos. Fruit symptoms start with much smaller, nearly circular, water-soaked lesions on ripening fruit. These lesions eventually become chalky white and may crack open. The fruit wounds allow secondary fungi and bacteria to invade and cause a slimy, foul-smelling fruit rot. On cucumber, angular leaf spot can reduce fruit number by 37 percent and fruit mass by 40 percent, in addition to turning some fruits into unmarketable culls.

Life cycle: Angular leaf spot is seed-borne and long-distance dispersal may occur via contaminated seeds. The bacteria overwinter in soil containing infected crop residues. *Pseudomonas syringae* is able to survive in the soil for two to three years. In the spring, the bacteria enter the leaf through openings, such as wounds and stomata. Infections are spread by splashing rain and insects as well as by routine farm operations such as tillage, hoeing and picking. Infections are accelerated by extended periods of leaf and fruit wetness due to rain, high humidity and heavy dews.

Pest Management

Cultural controls: Certified, disease-free seeds are used. Rotation with non-cucurbit crops is practiced. Soil drainage is improved to prevent development and spread of the disease. When possible, trickle irrigation is used to stop splashing water amongst crop plants. Fields are worked when the crop foliage is dry, especially early in the growing season. Sanitized tools are used to reduce the chance of bacterial spread while working with the crop. Plants are inspected for signs of the disease and infected plants are removed to prevent disease expansion.

Resistant cultivars: There are many angular leaf spot resistant cucumber cultivars available. No angular leaf spot resistant zucchini cultivars are available.

Issues for Angular Leaf Spot and Fruit Blotch

1. Improved disease control strategies including preventative measures are needed.

Bacterial Leaf Spot (*Xanthomonas cucurbitae*)

Pest Information

Damage: Bacterial leaf spot infects cucumbers and zucchini, but is of greatest importance on pumpkins. It infects both cucurbit leaves and fruits. Leaf symptoms start as small, dark lesions, with indefinite yellow margins. The lesions may merge to form larger necrotic areas, usually on leaf margins. Lesions vary in color and size. Fruit symptoms start as small, slightly sunken, circular spots with a beige center and a dark-brown halo. Later the cuticle and epidermis crack and the lesions enlarge. The large lesions may have a scab-like appearance and give rise to tan, raised blisters. Overall, lesions vary in size and appearance depending on rind maturity and the presence of moisture. Penetration of the bacteria into the fruit flesh can lead to significant fruit rot in the field or later in storage. Saprophytic fungi often colonize the dead, tan tissue at the center of lesions found on mature fruit. Under moist, field conditions, yield losses caused by bacterial spot can exceed 50 percent.

Life cycle: The bacterium is reported to be seed-borne and long-distance dispersal is thought to occur via contaminated seeds. The bacteria can overwinter on crop residues. Bacterial leaf spot first appears during the summer months when temperatures are high and often after heavy rain, dew or overhead irrigation. Fruit infection occurs through natural openings or wounds in young, rapidly expanding fruit prior to the development of a thick, waxy cuticle. The bacteria are splash-spread in the field. Spread of the bacteria within fields can be very rapid.

Pest Management

Cultural controls: Certified, disease-free seeds are used. Rotation with non-cucurbit crops is practiced. Soil drainage is improved to prevent development and spread of the disease. When possible, trickle irrigation is used to stop splashing water amongst crop plants. Plants are spaced properly to reduce the amount of water splashing from plant-to-plant. Sanitized tools are used to reduce the chance of bacterial spread while working with the crop. Plants are inspected for signs of the disease and infected plants are removed to prevent disease expansion.

Resistant cultivars: There are no bacterial leaf spot resistant cucumber, pumpkin or zucchini cultivars available, except for *Gateway F1*, a sliced cucumber cultivar.

Issues for Bacterial Leaf Spot

1. Research into the disease biology including conditions that favour disease infection is needed.
2. Improved preventative disease control strategies are needed.
3. Conventional and non-conventional bactericides, including pest control products for organic production are needed for the management of bacterial leaf spot.

Anthracnose (*Colletotrichum orbiculare*)

Pest Information

Damage: Anthracnose impacts seedlings, leaves, vines and fruit of cucurbits. In seedlings, *Colletotrichum orbiculare* causes stem lesions at the soil line and cotyledon wilt. Anthracnose leaf lesions start as yellowish, water-soaked areas on or near leaf veins. Later, the lesions enlarge, become brittle and turn tan to dark brown. Overtime, lesions may drop out, giving leaves a ragged appearance. Lesions on leaf stems and vines are elongated and dark with a light center and can result in vine defoliation. Fruits tend to become infected at the time of ripening. Fruit cankers are circular, black, sunken lesions that expand quickly to merge into larger lesions. Under moist conditions, the center of the fruit lesions fill with a gelatinous mass of pink spores. The lesions do not penetrate the flesh of the fruit, but are points of entry for soft rot organisms. Anthracnose can appear anytime during the growing season, but the most damage occurs after fruit set. In addition, when epidemics of anthracnose are severe, they can reduce yield, especially when they occur early in the growing season.

Life cycle: Colletotrichum orbiculare overwinters as mycelia on infected cucurbit residues, as well, it is seed-borne. Spores are produced in the spring and are spread plant-to-plant by water, cultivation equipment and cucumber beetles. The most favorable conditions for disease development are wet weather and moderately warm temperatures. The pathogen can survive for up to two years without a host.

Pest Management

Cultural controls: Certified, disease-free seeds are used. Rotation with non-cucurbit crops is practiced. Soil drainage is improved to prevent development and spread of the disease. When possible, trickle irrigation is used to stop splashing water amongst crop plants. Fields are worked when the crop foliage is dry. Sanitized tools are used to reduce the chance of fungal spread while working with the crop. Plants are inspected for signs of the disease. To encourage decay, crop debris are plowed under as soon as possible after harvest.

Resistant cultivars: There are many anthracnose resistant cucumber cultivars available, but no pumpkin and zucchini resistant cultivars.

Issues for Anthracnose

None.

Downy Mildew (*Pseudoperonospora cubensis*)

Pest Information

Damage: Downy mildew symptoms first appear as small yellow spots or water-soaked lesions on the top surface of older leaves. In cucumbers, the lesions are often confined by leaf veins and appear angular in shape. The centre of the spot eventually turns tan or brown and dies. The yellow spots have no distinct borders and sometimes take on a "greasy" appearance. Under humid conditions, a downy growth develops on the underside of the lesions. The downy growth is frequently speckled with dark purple to black sporangia. As the disease progresses, the lesions expand and multiply. Eventually the crop takes on a brown and "crispy" appearance. Lesions are sometimes invaded by secondary pathogens such as soft rot bacteria or other fungi. During prolonged wet periods, the disease may move from the older leaves onto the upper crop canopy. Downy mildew can cause severe to complete crop losses.

Life cycle: Pseudoperonospora cubensis requires living, green plant tissue to survive. Killing frosts and cold winters prevent spores from overwintering in Canada. Instead, the pathogen primarily overwinters in Mexico and the southern U.S. where cucurbits are grown year-round. In these areas, the sporangia levels build-up on cucurbit crops in early spring. Sporangia are then carried long distances by storms to Canada. Once sporangia land on the crop, they germinate and directly infect the leaf. Sporangia are spread locally by air currents, splashing rains, overhead irrigation, insects, tools, farm equipment, the clothing of workers and through the handling of infected plants. During prolonged cool wet periods, the sporangia burst open and release many zoospores. The zoospores swim through the film of water along the leaf surfaces and into leaf stomata, infecting the plant.

Pest Management

Cultural controls: Propagation of field cucurbit transplants is kept separate from greenhouse cucumber production facilities. Transplants are inspected to make sure they are free of the disease before they are planted into the field. The crop is managed to promote air movement and reduce humidity levels inside the crop canopy. When possible, trickle irrigation is used. Alternate weed hosts such as wild cucumber, goldencreeper (*Thladiantha dubia*) and volunteer cucumbers are controlled. Equipment and tools are washed before moving from one field to another. Field workers wash their hands before moving from one field to another and, if possible, wear freshly laundered clothing each day. When possible, diseased fields are worked at the end of the day. The *Cucurbit Downy Mildew Forecast* website is used to follow the movement of the disease throughout the growing season. When the disease arrives, fields are scouted for disease symptoms.

Resistant cultivars: There are many downy mildew resistant cucumber cultivars available, but the pathogen is highly variable and dynamic. Resistant cucumber cultivars do not remain resistant indefinitely and can be overcome by new virulent isolates of downy mildew. There are only a few resistant pumpkin cultivars and no resistant zucchini cultivars.

Issues for Downy Mildew

1. Improved disease control strategies including preventative measures are needed.

2. Action thresholds based on forecasting models and crop stage are needed, including alternative and more accurate ways to determine when crops are at high risk of infection and when growers should apply fungicides.
3. The genetic diversity within the airborne spore populations of downy mildew, especially with regards to virulence and fungicide resistance need to be determined for proper monitoring and forecasting.
4. How downy mildew overcomes plant cultivar resistance and a greater understanding of the complex interactions between downy mildew and cucurbit hosts needs to be determined.

Belly Rot and Pythium Rot (*Rhizoctonia solani* and *Pythium* sp.)

Pest Information

Damage: Belly rot primarily affects cucumbers. Pythium rot affects most cucurbits, but is most common on cucumbers. Both rots cause damping-off as well as fruit rot. With damping-off, seedling stems collapse and turn tan to brown. Seedling roots die and cotyledons and leaves wilt. With fruit rot, both pathogens infect those portions of the fruit that are in contact with the soil. With belly rot, immature fruit develop a yellowish brown, superficial discoloration. Mature fruit develop large water-soaked, decayed lesions. Lesions eventually turn into sunken, dried, irregular spots on fruit undersides. Fruit remains firm, seldom succumbing to a soft rot. Under humid conditions, a dense brown mold covers the rotted area. With Pythium rot, symptoms start as small, water-soaked spots that expand rapidly until large portions of fruit are necrotic and soft. Under humid conditions, a profuse, white fungal growth is found on the rotted areas.

Life cycle: Rhizoctonia solani overwinters on crop residues as mycelium and in the soil as firm, hardy sclerotia. In the spring, excessive moisture, warm temperatures and high humidity favors disease infection and development. Under favorable conditions, symptoms and signs can become evident within one day of infection and subsequently fruits decay quickly. *Pythium* sp. overwinters as oospores in crop and weed residues. In the spring, infections occur through plant wounds. Later, *Pythium* sp. infects fruits that are in contact with the wet ground.

Pest Management

Cultural controls: Certified, disease-free seeds are used. Rotation with non-cucurbit crops is practiced. Seeding and transplanting occur when temperatures are warmer to encourage quick stand establishment. Soil drainage is improved to prevent development of the disease. For example, crops are planted on raised beds. Plastic mulch or dry, rolled straw are used to minimize fruit contact with the soil. When possible, trickle irrigation is used to prevent excessive moisture on crop plants. Plants are inspected for signs of the disease and infected plants are removed to prevent disease expansion. To encourage decay, crop debris are plowed under as soon as possible after harvest.

Resistant cultivars: There are no belly rot or Pythium rot resistant cucumber, pumpkin or zucchini cultivars available.

Issues for Belly Rot

1. Conventional and non-conventional pest control products, including products for organic production are needed for the management of belly and Pythium rots.

Gummy Stem Blight (*Stagonosporopsis cucurbitacearum*[1])

Pest Information

Damage: Gummy stem blight can infect cucurbit leaves, stems and fruits. Foliar symptoms on pumpkin start with tan to brown spots on the leaf margins that later become large, wedge-shaped necrotic areas on the entire leaf. The primary veins remain dark green. Pycnidia, the asexual fruiting bodies, appear as small black specks on affected leaves. Leaf symptoms on cucumber and zucchini are infrequent, but are similar in appearance to those on pumpkin. Infected stems first show water-soaked lesions and later develop into tan cankers. Older stems, particularly of cucumber, show pycnidia within the cankers. Stem lesions often have bead-shaped, gummy, reddish-brown or black exudates. With sever infections cankers girdle the stem and kill the plant. Infected fruits first develop water-soaked lesions on the fruit surface, eventually turning into a black rot. Many spores are produced which give the fruit surface a sooty, black appearance. The disease often occurs in "hot spots", spreading out from a single infected seed or plant. Severity of gummy stem blight varies from year-to-year, but fruit production can be reduced by up to 80 percent.

Life cycle: Stagonosporopsis cucurbitacearum is seed-borne. It also overwinters on infected crop debris as dormant mycelium and thick-walled chlamydospores. In the spring, pycnidia are produced, giving rise to spores, which are the primary inoculum. Peak spore dispersal occurs after rain and during dew periods at night. Moderate temperatures and free moisture on leaves optimizes infection and further continuous leaf wetness is needed for lesion expansion. Leaves are penetrated either directly through the cuticle or through intercellular spaces around the bases of trichomes. Stems are penetrated through wounds or by the extension of leaf lesions. Fruits are penetrated either through wounds or through flower scars at the time of pollination. Striped cucumber beetles and aphid feeding, along with powdery mildew infection, predispose plants to infection. Closed crop canopies with restricted air-movement also predispose plants to infection.

Pest Management

Cultural controls: Certified, disease-free seeds are used. Crop rotation with non-cucurbit crops is practiced. When possible, powdery mildew-resistant varieties are grown to reduce the opportunity for gummy stem blight infections. The crop is managed to promote air movement and reduce humidity levels inside the crop canopy. Cucumber beetles and aphids are managed to reduce disease incidence. The crop is visually inspected for signs of the disease. Pumpkin fruits are harvested as soon as they are mature and are stored in a cool, dry location with adequate airflow. To encourage decay, crop debris are plowed under as soon as possible after harvest.

Resistant cultivars: There are no resistant gummy stem blight resistant cucumber, pumpkin or zucchini cultivars.

Issues for Gummy Stem Blight

1. Improved disease control strategies including preventative measures are needed.

[1] Formerly *Didymella bryonie*

2. A factsheet should be developed to reinforce the importance of preventative cultural practices as a key component of a grower's disease management strategy.

Phytophthora (*Phytophthora capsici*)

Pest Information

Damage: Phytophthora can infect cucurbit seeds, seedlings, vines, leaves and fruit. Symptoms include damping off, crown rot, vine blight, foliar blight and fruit rot. Damping off starts as a watery rot on the stem at or near the soil line that eventually results in seedling death. Crown rot often starts at the growing point. Dark green-to-brown lesions form on the crown, eventually girdling the crown and causing the entire plant to collapse and die. With vine blight, water-soaked lesions develop on vines. The lesions are dark olive and then become dark brown in a few days. Lesions girdle the stem, resulting in the rapid collapse and death of foliage above the lesion. With foliar blight, both leaf stems and leaf blades are infected. Dark brown, water-soaked lesions develop on leaf stems, resulting in rapid collapse of the leaf stem and leaf death. Infected leaf blades develop spots which are chlorotic at first, but within a few days are necrotic with chlorotic to olive-green borders. Foliar blight is uncommon on cucumbers, instead *Phytophthora capsici* usually targets the fruit. Fruit rot typically begins as a water-soaked lesion that often occurs where the fruit is in contact with the ground. Lesions expand and become covered with white mold. The fruit infection progresses rapidly, resulting in complete collapse of the fruit. Infection by *P. capsici* may result in the total loss of the crop.

Life cycle: Phytophthora capsica overwinters as thick-walled oospores in soil or mycelium in plant debris. Oospores can survive in the soil for many years. Oospores germinate and produce sporangia, which are spread long distances by air and splashing water. Sporangia may either germinate directly and infect the host plant or germinate and give rise to zoospores that are released in water and infect the plant. The zoospores swim towards the root exudates of host crops, allowing the infection to spread from plant-to-plant and from field-to-field. Irrigation water may also be an additional source of zoospores. Once inside the plant, the pathogen grows within the host and produces sporangia on the surface of the infected tissues. The disease is usually associated with heavy rainfall, excessive-irrigation or poorly drained soil. Frequent irrigation increases the incidence of the disease. Warm conditions are favorable for disease development.

Pest Management

Cultural controls: The most effective method of control for Phytophthora is to prevent the pathogen from moving into a non-infested field. All farm equipment used in an infested field is thoroughly cleaned before moving it to another field. Water sources that receive run-off water from an infested field are avoided. Water sources are tested for the presence of the pathogen. Excessive irrigation is avoided. Well-drained fields without a history of Phytophthora are selected for planting. Non-vining cucurbit crops such as zucchini is planted on dome-shaped, raised beds. Fields are scouted regularly for Phytophthora symptoms. When symptoms are localized in a small area of the field, the infected plants are plowed into the soil. Healthy fruit is removed from the infested area as soon as possible, and is routinely checked for disease development. Growing cover crops and/or mulching with plant materials including straw and rye vetch are used to manage Phytophthora dispersal.

Resistant cultivars: Two resistant pumpkin cultivars, “Apprentice” and “Iron Man”, are commercially available. There are no resistant or tolerant cucumber and zucchini cultivars available.

Issues for Phytophthora

1. An integrated approach of chemical, biological and cultural control strategies to be used in the crop, in the soil and in irrigation water, is needed in order to control Phytophthora in cucurbits.
2. A system to treat surface irrigation water as it is pumped from the source to the crop needs to be developed. The system should be fast acting, have minimal effects on the crop itself and be economical for growers.

Powdery Mildew (*Podosphaera xanthii*[2] and *Erysiphe cichoracearum*)

Pest Information

Damage: Powdery mildew impacts cucurbit leaves and fruits. Infections usually start on crown leaves, on shaded lower leaves and on the undersides of leaves. A dense, white, powdery fungal growth develops on infected plant tissues. Yellow spots may form on the upper leaf surfaces above the powdery mildew colonies established on the underside of the leaves. The fungal growth eventually spreads to the upper leaf surface and down the leaf stem. Infected leaves turn brown, shrivel and die prematurely. Leaf senescence impacts fruit quality, causing sunburning as well as incomplete or premature ripening. Yield is reduced due to reduced fruit numbers and size. With infected pumpkins, the fruit rinds have imperfections such as speckling, raised indentations, oedema and poor colour. The fruit handles are shriveled and discoloured, breaking apart and crumbling when picked. This makes the pumpkin fruits unmarketable. Powdery mildew infections also predispose cucurbits to other diseases such as gummy stem blight.

Life cycle: The pathogens responsible for powdery mildew require living, green plant tissue to survive. Sources of initial spring inoculum have not been definitively determined. The fungi can produce a sexual spore in the fall that enables it to overwinter; however, they also produce an abundance of asexual spores that are easily and widely dispersed by wind. Therefore, the initial inoculum source is likely airborne spores originating from Mexico and the southern US where cucurbits are grown year-round. High relative humidity is favorable for infection and spore survival. However, infection can also take place at low relative humidity and dryness is favorable for colonization, sporulation and dispersal. Rain and free moisture on the plant surface are unfavorable for disease development. Infection rates increase with a low intensity light and a dense plant canopy. Infections develop more quickly when there are wide fluctuations in day and night temperatures.

Pest Management

Cultural controls: Weeds that serve as alternative powdery mildew hosts are controlled. Sunny field sites with good air movement are used. Plants are fertilized in such a way as to avoid unnecessarily dense canopies. Successive cucurbit plantings are physically separated or planted up-wind of older plantings to prevent older plants from serving as an inoculum source for the new crop.

Resistant cultivars: There are many commercial powdery mildew resistant cucumber, pumpkin or zucchini cultivars available.

Issues for Powdery Mildew

1. There is a need for new conventional and non-conventional pest control products including organic options and improved disease control strategies for powdery mildew management.
2. Resistant varieties are needed.

[2] Formerly *Sphaerotheca fuliginea*

Scab (*Cladosporium cucumerinum*)

Pest Information

Damage: Scab affects pumpkins, zucchini and non-resistant cucumber cultivars. It infects leaves, vines and fruits. Foliar and vine infections start as pale-green, water-soaked lesions that gradually turn gray to white and become angular shaped. A chlorotic halo may appear around the lesion. The center of each lesion may deteriorate, giving the leaf a shot-hole appearance. Severe scab infections deform young leaves, shorten internodes and kill the apical vines of young plants. Fruit infections start as small, sunken lesions that look similar to insect stings. A sticky substance may ooze from the infected area. The lesions become darker with age and the margins are often coated with a dried corky layer. The cavities may also be lined with a dark olive green, velvety layer of spores. Secondary soft rotting bacteria can invade the cavities and lead to a foul-smelling decay. Fruits that are green and rapidly expanding, before the rind starts to harden, are the most prone to scab infection. Pumpkin fruits will continue to expand around the lesions, resulting in bumpy and misshapen fruits. Scab is present at low levels every year. Under certain environmental conditions, scab can have a devastating effect on both yield and marketability.

Life cycle: Cladosporium cucumerinum overwinters in the soil on infected cucurbit residues. The pathogen may also be seed-borne. Spores are produced in the spring and can travel for long distances on moist air currents. Wide-spread infections are occasionally traced back to specific storm fronts. The most favorable conditions for disease development are wet weather and moderately warm temperatures.

Pest Management

Cultural controls: Certified, disease-free seeds are used. Rotation with non-cucurbit crops is practiced. Sites with good drainage are used to grow the crop. When possible, trickle irrigation is used to reduce moisture on the crop plants. Crop plant densities are used which permit good air movement for rapid drying of leaves, vines and fruits. Plants are inspected for signs of the disease.

Resistant cultivars: There are many *C. cucumerinum*-resistant cucumber cultivars available. There are no scab resistant pumpkin and zucchini cultivars available.

Issues for Scab

1. Improved disease control strategies including identification of effective fungicides and timing of fungicide applications are needed.
2. Additional conventional and non-conventional pest control products for scab management are required as regulatory re-evaluations continue with possible losses of registered fungicides.

Fusarium Root Rot (*Fusarium solani* f. sp. *cucurbitae*)

Pest Information

Damage: Fusarium root rot is primarily a problem on pumpkin and zucchini, but can also infect cucumber seedlings. Crown and root tissues of seedlings and older plants are infected, causing water-soaked lesions near or below the soil line on crowns and upper roots. As the disease progresses, the lesions darken and leaves and shoots may wilt. The plants are stunted and suffer from poor growth. Leaves eventually become necrotic and dry up. Vines collapse and plants die. Plants showing symptoms develop numerous spores, giving the stem near the ground surface a white to pink color. When fruits are in contact with the soil, they may become infected. Fusarium root rot occurs sporadically in most areas and disease severity depends on soil moisture and inoculum density.

Life cycle: The Fusarium root rot pathogen overwinters as chlamydospores and mycelium in infected or dead plant tissue and seed. It can survive for only two to three years in soil. The pathogen infects plants through wounds. It often attacks plants weakened by poor growing conditions, nematodes or other diseases. The disease is spread by splashing rain and in irrigation water.

Pest Management

Cultural controls: Certified, disease-free seeds are used. Fields with a history of Fusarium root rot are avoided. Fields are rotated with non-cucurbits for four years. Farm equipment is cleaned when moving between fields. When possible, drip irrigation is used to maintain adequate soil moisture. Plants are monitored for signs of wilting.

Resistant cultivars: There are no Fusarium root rot resistant cucurbit cultivars available.

Issues for Fusarium Root Rot

1. There is a need for new conventional and non-conventional pest control products for the management of Fusarium root rot.
2. Research into whether the fungus survives in water (i.e., irrigation ponds). If so, a system to treat surface irrigation water as it is pumped to the crop needs to be developed.

Fusarium Wilt (*Fusarium oxysporum* f. sp. *curcurbitacearum*)

Pest Information

Damage: Fusarium wilt is primarily a problem on muskmelons and an occasional problem on cucumbers. Early-season infections result in damping-off of seedlings and transplants. Later infections occur as either a slow wilt with progressive yellowing of the foliage or as a sudden wilt without any yellowing. Symptoms first appear on the crown leaves, progressing outwards along the vines. Generally, the veins of some leaves turn yellow on one side. On stems, long brown streaks appear, often exuding gum. The vascular tissue of infected stems is orange-red to brown. This discoloration is sometimes on the side of the stem corresponding to wilted leaves. Fruit does not develop properly and remains flaccid. In the final stages of the disease, the fungus forms pinkish spores. When initial stages of infections are mistaken for water stress, the disease can remain unidentified until large portions of the field collapse and die. When epidemics of Fusarium wilt occur, they can cause cucumber yield losses of 10 to 30 percent.

Life cycle: The Fusarium wilt pathogen overwinters saprophytically on plant debris and in the soil as chlamydospores. The spores survive in the soil for several years. However, some soil types are less conducive to disease infection than others. Disease suppressiveness is associated with soils high in montmorillonite clay and microorganisms antagonistic to Fusarium wilt. The disease may infect the plant at any stage, although outbreaks often follow periods of crop stress such as hot, dry weather conditions. Fusarium wilt is primarily spread via infested soil.

Pest Management

Cultural controls: Certified, disease-free seeds are used. Fields with a history of Fusarium wilt are avoided. Steps are taken to prevent the movement of contaminated soil between fields. For example, farm equipment is cleaned when moving between fields. Plants are monitored for signs of wilting.

Resistant cultivars: There are Fusarium wilt resistant cucurbit cultivars available.

Issues for Fusarium Wilt

1. There is a need for new conventional and non-conventional pest control products for the management of Fusarium wilt.
2. Research into whether the fungus survives in water (i.e., irrigation ponds). If so, a system to treat surface irrigation water as it is pumped to the crop needs to be developed.

Septoria (*Septoria cucurbitacearum*)

Pest Information

Damage: Septoria affects pumpkin leaves and fruits and zucchini leaves. Septoria leaf lesions are very small, circular and white-to-beige in colour with a brown border. Later, the lesions may crack and small black pycnidia develop within the lesions. Septoria fruit lesions are small, pimple-like and pale yellow in colour. The lesions are usually superficial and generally do not develop into rots. However, damaged fruit may be rejected due to these cosmetic blemishes. Septoria occurs sporadically, but is more common when conditions are unusually cool and moist.

Life cycle: Septoria cucurbitacearum overwinters as dormant mycelia on infected cucurbit residues. In the spring the mycelia produce spores that act as the primary inoculum. High humidity and moderate temperatures favour disease development. Rain and splashed soils spread the spores from plant-to-plant. Disease spread may be halted during hot, dry summer conditions, to start again in the fall once temperatures become more moderate.

Pest Management

Cultural controls: Rotation with non-cucurbit crops is practiced. Plants are inspected for signs of the disease. To encourage decay, crop debris are plowed under as soon as possible after harvest.

Resistant cultivars: There are no resistant pumpkin and zucchini cultivars available.

Issues for Septoria

1. Improved disease control strategies are needed for the management of *S. cucurbitacearum*.
2. An understanding of the pathogen's biology and what factors lead to the disease spreading to the fruit is needed.

Plectosporium Blight (*Plectosphaerella* spp.)

Pest Information

Damage: Plectosporium blight affects cucurbit leaves, leaf petioles, vines and fruits. Initially, small, white, diamond-shaped lesions form on the leaf veins on the underside of leaves, on leaf petioles and on vines. Under favorable environmental conditions, the lesions can coalesce and affected tissues appear white and become brittle. Heavily infected leaves and leaf petioles may die, leading to premature defoliation and subsequent sunscald on fruit. Vines may prematurely brown and dry up, reducing vine longevity. Spores produced on the undersides of leaves fall and infect the topsides of fruit lying beneath the canopy. The lesions that develop on the fruit are small, white and generally round. Mostly fruit infection is cosmetic but it can reduce fruit quality and predispose fruit to other opportunistic fruit rots.

Life cycle*: Plectosporium* spp. overwinter in the soil on crop debris and other organic matter. Spores are produced in the spring when there is prolonged warm, rainy weather resulting in the soil staying wet for extended periods. Disease hot spots appear in fields and the disease is spread further by driving rains and wind. Plectosporium blight can survive for several years in the soil on organic matter.

Pest Management

Cultural controls: Fields with a history of Plectosporium blight, poor drainage or shade are avoided. Fields are rotated with non-cucurbits for three years. Plants are fertilized in such a way as to avoid unnecessarily dense canopies. The crop is managed to promote air movement through the crop canopy. When possible, trickle irrigation is used. Plants are monitored for signs of the disease. To encourage decay, crop debris are plowed under as soon as possible after harvest.

Resistant cultivars: Cucurbit varieties vary somewhat in susceptibility to Plectosporium blight, but none are resistant.

Issues for Plectosporium Blight

1. There is a need for new conventional and non-conventional pest control products, including biopesticides, for the management of Plectosporium blight.
2. Research is needed to identify Plectosporium blight resistant cucurbit cultivars.

Insects and Mites

Key issues

- Recommendations on insecticide and miticide use need to be strengthened by improving scouting methods, action thresholds and timing of pest control product applications.

- Alternative management tools for crop protection need to be identified and best management practices need to be developed to reduce the occurrence and spread of insecticide/miticide resistant pests.

- New technologies focused on pest control product application, scouting and pest identification need to be evaluated to determine their effectiveness in Canadian production systems and how they can be incorporated into current integrated pest management recommendations.

- Research into new resistant cultivars is needed to minimize insect and mite incidence and damage and to reduce the reliance on pest control products.

- Cultivars of early-maturing winter squashes, such as *C. pepo*, *C. maxima*, *C. moschata*, that exhibit some resistance to common cucurbit pests, such as squash borer and cucumber beetle, need to be developed for organic production.

Table 6. 2022 Canadian Pest Management Top Priority Rankings of cucurbit insect and mite pests in relative order of importance by province[1]

Pest	Provincial Rankings								
	Cucumber			Pumpkin			Summer Squash		
	QC	ON	BC	QC	ON	BC	QC	ON	BC
Conventional Production									
Green peach aphid		Blue	Yellow		Blue	Yellow		Blue	Yellow
Melon aphid								Blue	
Plant bugs including Lygus and brown marmorated stink bug		Blue			Blue			Blue	
Striped and spotted cucumber beetles	Red	Yellow		Red	Yellow		Red	Yellow	
Spider mites including two-spotted spider mite	Orange	Orange	Orange		Orange	Orange		Orange	Orange
Flea Beetles including red-headed flea beetle	Yellow								
Squash bug				Orange			Orange		
Wireworm		Red	Red		Red	Red		Red	Red
Seed corn maggot		Red	Red		Red	Red		Red	Red
White grubs		Red			Red			Red	
Squash vine borer				Yellow			Yellow		
Organic Production									
Striped and spotted cucumber beetles	Red				Orange				
Squash bug	Orange	Red			Red		Orange	Red	
Squash vine borer				Red			Red		

[1]Provinces provide rankings of their top pest priorities for the annual Canadian Pest Management Priority Setting Workshops. This table provides rankings for the key insects/mites for cucurbit crops published in 2022 (BC rankings were updated in August 2022). Rankings are colour coded in order of highest to lowest relative importance where red indicates a first highest priority, orange indicates a second highest priority, yellow indicates a third highest priority and blue indicates a priority of four and below. A blank does not mean that the insect/mite does not occur in a province, it could be that it was not ranked in the top pests for 2022.

Table 7. Adoption of integrated insect and mite management practices in cucurbit production in Canada[1]

Practice	Aphids	Cucumber beetle	Mites	Squash Bug	Wireworms	Maggots	Squash Vine Borer
Avoidance:							
Varietal selection / use of resistant or tolerant varieties	[green]						
Planting / harvest date adjustment					[green]	[green]	
Rotation with non-host crops						[green]	
Choice of planting site		[green]		[green]	[green]	[green]	
Optimizing fertilization for balanced growth	[green]						
Minimize wounding to reduce attractiveness to pests							
Reducing pest populations at field perimeters		[green]		[grey]			[grey]
Use of physical barriers (e.g., mulches, netting, floating row covers)	[green]	[green]	[grey]	[green]	[grey]	[grey]	[green]
Use of pest-free propagative materials (seeds, cuttings, transplants)	[green]						
Use of trap crops	[grey]	[green]	[grey]	[red]	[grey]	[grey]	[red]
Intercrop with non-cucurbits	[grey]	[grey]	[grey]	[grey]	[grey]	[grey]	[grey]
Soil analysis for pests before planting the crop to determine site selection					[green]	[green]	
Prevention:							
Equipment sanitation	[green]		[green]		[green]		
Canopy management (e.g., thinning, pruning, row or plant spacing, etc.)							
Manipulating seeding / planting depth					[red]	[green]	
Irrigation management (timing, duration, amount) to manage plant growth	[green]		[grey]				

…continued

Table 7. Adoption of integrated insect and mite management practices in cucurbit production in Canada[1] (continued)

Practice	Aphids	Cucumber beetle	Mites	Squash Bug	Wireworms	Maggots	Squash Vine Borer
Management of soil moisture (e.g., improvements to drainage, use of raised beds, hilling, mounds)							
End of season or pre-planting crop residue removal / management							
Pruning out / removal of infested material throughout the growing season							
Tillage / cultivation to expose soil insects							
Removal of other hosts (weeds / wild plants / volunteers) in the field and vicinity							
Monitoring:							
Scouting / trapping							
Maintaining records to track pests							
Soil analysis for the presence of pest							
Weather monitoring for degree day modelling							
Use of precision agriculture technology (GPS, GIS) for data collection and mapping of pests							
Decision making tools:							
Economic threshold							
Use of predictive model for management decisions							
Crop specialist recommendation or advisory bulletin							
Decision to treat based on observed presence of pest at susceptible stage of life cycle							
Use of portable electronic devices in the field to access pest identification / management information							

…continued

Table 7. Adoption of integrated insect and mite management practices in cucurbit production in Canada[1] (continued)

Practice	Aphids	Cucumber beetle	Mites	Squash Bug	Wireworms	Maggots	Squash Vine Borer
Suppression:							
Use of diverse pesticide modes of action for resistance management							
Soil amendments and green manure involving soil incorporation as biofumigants to reduce pest populations							
Use of non-conventional pest control products (e.g., biopesticides)							
Release of arthropod biological control agents							
Preservation or development of habitat to conserve or augment natural controls (e.g., preserve natural areas and hedgerows, adjust crop swathing height)							
Mating disruption through the use of pheromones							
Mating disruption through the release of sterile insects							
Trapping							
Targeted pesticide applications (e.g., banding, spot treatments, use of variable rate sprayers)							
Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms							

…continued

Table 7. Adoption of integrated insect and mite management practices in cucurbit production in Canada[1] (continued)

Practice	Aphids	Cucumber beetle	Mites	Squash Bug	Wireworms	Maggots	Squash Vine Borer
Crop Specific practices:							
Use of overhead watering to reduce pest populations							
Use of green organic matter and manures at least 4 weeks before planting crops							
Soil hilled at stem joints							
This practice is used to manage this pest by at least some growers in the province.							
This practice is not applicable for the management of this pest.							
Information regarding this practice for this pest is unknown.							
This practice is not used by growers in the province to manage this pest.							

[1]Source: Stakeholders in reporting provinces (British Columbia and Quebec); the data reflect the 2019, 2020 and 2021 production.

Green Peach Aphid (*Myzus persicae*) and Melon Aphid (*Aphis gossypi*)

Pest Information

Damage: Aphids favour the growing tip of vines, the undersides of leaves and new, sheltered growth. Nymphs and adults feed on plant sap by piercing plant tissues. Initial symptoms from aphid feeding are yellow spots near leaf veins. In the case of melon aphids, later, leaves become curled, puckered and distorted. Growth of heavily infested plants slows and the plant eventually wilts and dies. The green peach aphid does not usually produce high volumes of honeydew but the melon aphid secretes a great deal. Any honeydew excreted can lead to sooty mould and ants. The sooty mould grows on the honeydew, reducing plant photosynthesis and transpiration. Ants eat the honeydew and attack arthropods that feed on aphids. It is also important to note that winged aphids of both species transmit serious cucurbit viral diseases such as cucumber mosaic virus (CMV), watermelon mosaic virus (WMV), zucchini yellow mosaic virus (ZYMV), and papaya ringspot virus (PRSV). Winged green peach aphids often deposit only a few young and then take flight again. This highly dispersive behavior contributes to their effectiveness as vectors of plant viruses.

Life cycle: Aphids overwinter as eggs with green peach aphid laying eggs on *Prunus* species and melon aphid laying eggs on woody shrubs, such as the rose of Sharon. Eggs hatch in the spring into wingless females who give live birth to immature females through asexual reproduction. During asexual reproduction aphid colonies grow quickly. When conditions become crowded or food becomes scarce, winged females are produced. The winged females fly to cucurbit crops, with melon aphids preferring cucumber over squash and pumpkin. Once on the cucurbit crop, the winged aphids establish a new colony and the cycle is repeated. Besides cucurbits, both green peach and melon aphids have hundreds of other secondary plant hosts. Asexual reproduction continues throughout the growing season. In the fall, male and female aphids are produced and they mate. The mated females lay the overwintering eggs. It is noteworthy that the melon aphid, unlike many other aphid species, is not adversely affected by hot weather and can multiple quickly under such conditions.

Pest Management

Cultural controls: Vigorous, healthy plants are more resistant to aphid attack and are grown by using proper nutrient and water management. Excessive nitrogen, which favors aphid reproduction, is avoided. Yellow sticky traps are placed at field edges to detect winged aphids migrating into the crop and plants are inspected for signs and symptoms of an aphid infestation. Reflective, light-coloured mulches can be used to repel flying aphids. Floating mulches, which act as a physical barrier, are used to keep aphids off crop plants. Perennial broadleaf weeds that act as reservoirs for CMV and WMV are eliminated. Fields infested with aphids are disked or plowed under as soon as harvest is complete. Ants that might protect aphids are managed. There are numerous natural enemies of aphids. Some common aphid predators include lady beetles and their larvae; minute pirate bugs; syrphid fly larvae; green and brown lacewing larvae; and larvae of the aphid midge, *Aphidoletes aphidimyza*. Some common aphid parasitoids (parasitic wasps) include *Aphidius, Lysiphlebus* and *Aphelinus* species.

Resistant cultivars: There are no aphid resistant or tolerant cucurbit cultivars available but there are varieties that are resistance to certain viral diseases.

Issues for Green Peach and Melon Aphids

None.

Plant Bugs (Lygus and Brown Marmorated Stink Bug)

Pest Information

Damage: Nymphs and adults consume plant sap by using piercing, sucking mouthparts. Plant bugs preferentially feed on the tender parts of plants. This includes young leaves, stems, flowers and immature fruit. Feeding injury includes destruction of the growing point of young seedlings, the stunting of shoot growth and the reduction of flower set. Damaged buds produce leaves that may have several holes and appear discolored, ragged and crinkled. Plant bugs can transmit serious plant diseases such as aster yellows.

Life cycle: Plant bugs overwinter as adults in sheltered spots in the soil, on weeds and in plant debris. In the spring, females emerge and lay eggs. Lygus species lay eggs into plant stems. Stink bugs lay eggs in masses on the surface of plant leaves. Eggs hatch and nymphs emerge to feed on the tender, new growth of the host plant. Plant bugs undergo five molts before emerging as adults. Plant bug species produce one to five generations per year, with fewer generations produced in the northern range of the insects. Plant bugs infest at least 385 plant species, with the majority of host plants belonging to the Rose and Aster plant families. Plant bugs are very mobile and often move onto cucurbits after other nearby crops mature and dry down or are harvested. Adults continue to feed until early fall before moving to sheltered sites to overwinter.

Pest Management

Cultural controls: Crop residues that might shelter overwintering adults are destroyed after harvest. Deep plowing kills any overwintering adult hiding in the soil. Alternative food sources such as weeds are controlled. Growing cucurbits close to other susceptible crops is avoided. Yellow or white sticky traps and visual inspection of cucurbit plants are used to monitor for the presence of plant bugs. In the case of brown marmorated stink bug, an aggregation pheromone lure is combined with either black pyramid traps or sticky traps to determine pest population levels. Various generalist predators such as damsel bug, lacewings and crab spiders, are known to feed on plant bugs. In addition, plant bug eggs are parasitized by wasps including those of the genus *Anaphes*, *Telenonus* and *Polynema*. Other wasps such as the genus *Leiophron* and *Peristenus* attack nymphs. Trachinid flies target adult plant bugs. Lastly, the samurai wasp, *Trissolcus japonica*, parasitizes brown marmorated stink bug eggs.

Resistant cultivars: There are no plant bug resistant or tolerant cucurbits cultivars available.

Issues for Plant Bugs

1. Improved management strategies and novel control products are needed to give growers more tools to control plant bugs including the brown marmorated stink bug and squash bug.

Striped Cucumber Beetle (*Acalymma vittatum*) and Spotted Cucumber Beetle[3] (*Diabrotica undecimpunctata*)

Pest Information

Damage: Adult cucumber beetles feed on plant leaves and stems, giving leaves a shot-hole appearance and sometimes resulting in broken stems. Young seedlings are killed and older plants are weakened. Adults also feed on flowers, reducing pollination and fruit set. During warm weather adults feed on the underside of developing fruit, impacting fruit quality. Larvae feed on and tunnel into plant roots, impeding root development and sometimes causing plant wilting. Through their feeding activities, cucumber beetles vector plant diseases. The most serious disease spread by adult beetles is bacterial wilt. The bacteria overwinter in the beetle gut and are transmitted when the beetle defecates onto feeding wounds. Bacterial wilt is impossible to stop once a plant is infected. Black rot and various viral diseases are also spread by adult beetles. Fusarium wilt is spread by the root feeding larvae. Yield losses due to direct feeding by the cucumber beetle are estimated at 15 percent. Bacterial wilt and other diseases reduce yields even further.

Life cycle: Unmated adult beetles overwinter in or near cucurbit fields in leaf litter or the soil. Adults emerge in the spring and feed on the foliage, pollen and petals of various non-cucurbit plant species. Adults move onto cucurbit plants when the plants first emerge or are transplanted into the field. In the spring, adults form large congregations on individual plants in order to mate. Mated females lay eggs just below the surface in moist soil and within 15 cm of the base of the plant. Eggs hatch and the larvae feed on roots, pupate in the soil and emerge as adults. In Canada there is one generation per year. However, beetle development is staggered, resulting in several flushes of beetle activity throughout the growing season. Cucumber beetles are found in the southern parts of Canada east of the Rocky Mountains.

Pest Management

Cultural controls: Because adult beetles overwinter near last year's crop, new cucurbit crops are planted as far from these locations as possible. Weeds and volunteer cucurbits that act as alternative food sources are controlled. Cucurbit seedlings at the one to three leaf-stage are the most vulnerable to cucumber beetle attack. Therefore, transplants are used instead of direct seeding to reduce the exposure time of the seedlings to the beetles. Cucurbit cultivars with high levels of cucurbitacins, compounds that attract cucumber beetles, are planted at the boarder of the main crop. Cucumber beetles preferentially colonize the trap crop reducing the need for insecticidal sprays on the main crop. Intercropping with non-cucurbits also reduces the ability of the cucumber beetle to find the main crop. Natural mulches of straw or vermicompost, that support beneficial insect communities, are used. Floating row covers act as physical barriers to prevent adult beetles from accessing plants. The covers are removed before flowering to allow for pollination. Monitoring involves closely inspecting numerous small groups of crop plants to determine the number of cucumber beetles per plant. Cucumber beetles have numerous natural enemies. The trachinid flies, *Celatoria setosa* and *C. compressa*, and the wasp, *Centistes diabroticae*, parasitize adult cucumber beetles. Generalist predators such as carabid beetles, lycosid spiders and coccinellid beetles also reduce beetle populations. Various nematode species attack the larvae and some reduce the fecundity and lifespans of adult females.

[3] Also known as southern corn rootworm

Resistant cultivars: Cucurbit cultivars that produce low levels of cucurbitacins attract fewer adult beetles and have less feeding damage. In general, cucumber beetle prefers cucumber and zucchini over pumpkin.

Issues for Cucumber Beetles

1. There is a need for new conventional and non-conventional pest control products for the control of cucumber beetles for cucurbit crops.
2. The biology of the cucumber beetle needs to be better understood including factors that influence infestation and overwinter locations.
3. Mating disruption strategies such as management puffer systems and sterile insect release specific to cucumber beetles need to be developed.

Spider Mites including Two-Spotted Spider Mites (*Tetranychus urticae*)

Pest Information

Damage: Spider mites have needle-like, sucking mouthparts used to pierce plant tissues in order to feed. Feeding destroys chlorophyll, resulting in pale stippling of the leaves. Since mites are located mostly on the underside of leaves, the loss of color is pronounced on the lower leaf surface before it becomes apparent on the upper leaf surface. In the later stages of a mite infestation, the leaves become bronzed, then dry up and die. Mite damage to open flowers causes petals to turn brown and wither. Cucurbits tolerate light mite infestations, but heavy infestations reduce yield and fruit quality.

Life cycle: Spider mite development differs somewhat between species. Typically, spider mites overwinter as adult females in plant debris or under the bark of trees and shrubs. In early spring, females lay eggs on grassy plant species. Spider mites spin fine strands of webbing on host plants and the eggs are attached to the webbing. Under optimum conditions, spider mites move through the egg, larva and two nymphal life stages to become adults in five to 20 days. There are numerous, overlapping generations per growing season. Spider mites prefer hot, dry weather and often move into cucurbits after wheat and other crops are harvested. The two-spotted spider mite is known to infest over 200 different plant species.

Pest Management

Cultural controls: Weeds that serve as spider mite overwintering sites are controlled. Areas next to wheat and bean crops are avoided. Overhead watering is used to reduce spider mite populations to tolerable levels. Crop plants are monitored for stippled, bronzed leaves. A magnifying glass is used to look for spider mite webbing, cast skins, eggs and adults on the underside of leaves. Alternatively, a sheet of white paper is placed beneath the leaves and the leaves are sharply struck. The mites fall onto the paper and are more easily observed and identified. Predators are very important in regulating spider mite populations and, whenever possible, are protected. Predator mites that feed on spider mites include A*mblyseius*, *Galendromus*, *Mesoseiulus*, *Neoseiulus* and *Phytoseiulus* species. Other predators include *Chrysoperla* (lacewing larva), *Stethorus* (lady beetle), *Orius* (minute pirate bug), *Leptothrips* (thrip) and *Scolothrips* (thrip) species.

Resistant cultivars: Cucurbit cultivars that produce higher levels of cucurbitacins are more resistant to two-spotted spider mites.

Issues for Spider Mites

1. There is a need for new conventional and non-conventional pest control products for the control of spider mites and mitigation of resistance development.
2. Additional scouting and monitoring tools are needed to detect spider mite infestations and identify resistant populations.

Flea Beetles including the Red-Headed Flea Beetle (*Systena frontalis*)

Pest Information

Damage: Adult flea beetles chew rounded areas on the top or bottom of leaves and also make small holes (shot holes). With numerous shot holes, the leaves become discoloured and dry out. Photosynthesis is impaired and plant growth is slowed. The leaf injuries allow diseases to infect the plant more easily. Early cucurbit seedlings are the most vulnerable to leaf damage by flea-beetles.

Life cycle: Most flea beetle species including red-headed flea beetle overwinters as eggs laid in the soil at the base of the host plant. The larvae emerge in late May. They are likely root feeders, but cause little damage and are rarely observed. After pupation, adults emerge from early July onwards. Flea beetle populations increase quickly during hot, dry weather. Adults are strong flyers and jumpers, able to move into crops from neighboring fields and weedy borders. They are less mobile during cool weather. Using olfactory cues, adults tend to congregate in areas where plant damage has started. Flea beetle species found on cucurbits are polyphagous. For example, red-headed flea beetles have more than 40 known hosts including cucumber.

Pest Management

Cultural controls: Alternate hosts including annual and perennial weeds found along field margins are controlled. Crop rotation is practiced so that susceptible crops are not grown in the same area every year. Planting dates are adjusted to avoid times when the adult populations are at their peak. Trap and companion crops are planted next to cucurbit fields. When possible, floating row covers are used for several weeks to protect young crops. White or yellow sticky cards are used to monitor field edges. Sticky cards are also placed in hot spots to trap adult beetles. Wetting the crop leaves or soil causes flea beetle adults to leave the crop fields but this practice needs to be weighted against the risk of increased plant diseases. Generalist predators such as lacewing larvae (*Chrysopa* spp.), adult big-eyed bugs (*Geocoris* spp.) and damsel bugs (*Nabis* spp.) feed on adult flea beetles.

Resistant cultivars: There are no flea beetle resistant or tolerant cucurbit cultivars available.

Issues for Flea Beetles

1. There is a need for research into the biology of the pest. For example, what are the key host plants, how far are adult beetles able to travel, what is the role of annual and perennial weeds in the survival of eggs and larvae, and what olfactory chemical(s) cause flea beetles to aggregate?
2. There is a need for new conventional and non-conventional pest control products for the control of flea beetles on cucurbit crops.
3. There is a need to develop biological, cultural or mechanical controls.
4. There is a need for the development of flea beetle resistant cucurbit cultivars.

Squash Bug (*Anasa tristis*)

Pest Information

Damage: Adults and nymphs pierce cucurbit leaves, vines and fruits with their needle-like mouthparts to feed on plant sap. When feeding, squash bugs secrete a toxic saliva into the plants that cause leaves to wilt, blacken and eventually die. These symptoms are sometimes called "anasa wilt". Squash bug fruit damage is characterized by white discoloration. With very heavy feeding the fruit will not form. The squash bug is a vector of *Serratia marcescens*, a bacterium that causes cucurbit yellow vine disease (CYVD).

Life cycle: Unmated adults overwinter in cucurbit fields and adjacent areas under crop debris and other suitable shelter. When cucurbits start to grow in the spring, adults fly into the crop and mate. Eggs are mostly laid on the undersides of leaves and occasionally on the upper surface or on leaf petioles. There are five nymphal instars. Young nymphs are strongly gregarious, and tend to feed in groups. This behavior dissipates slightly as the nymphs mature. The period of egg laying is prolonged, resulting in nymphs and adults being present throughout the summer. Feeding continues until frost triggers the adults to hibernate. In Canada, there is one generation of squash bugs per year. The squash bug is reported to attack nearly all cucurbits, but it prefers squash and pumpkin.

Pest Management

Cultural controls: Crop debris and weeds are removed and destroyed after harvest to eliminate food sources and overwintering sites. Adult squash bugs preferentially colonize larger, more mature plants, so early planting of crops is avoided. Squash or pumpkin are used as trap crops to protect less preferred host plants such as cucumbers. Row covers and netting are used to delay squash bug colonization. However, squash bugs quickly invade protected plantings when covers are removed to allow pollination. Monitoring is done by visually inspecting crop plants and field margins for squash bugs. Wasp egg parasitoids such as Encyrtidae and Scelionidae are natural enemies of squash bug. The fly, *Trichopoda pennipes*, is a common parasitoid of squash bugs.

Resistant cultivars: Resistant squash varieties such as Butternut, Royal Acorn and Sweet Cheese are planted to reduce problems with squash bugs. However, there is evidence that over time squash bugs can feed on varieties that formerly were resistant to attack.

Issues for Squash Bugs

1. There is a need for pest control products to manage squash bugs in cucurbit production.
2. Biological, cultural and/or mechanical controls need to be evaluated for their effectiveness in controlling squash bugs.
3. A greater understanding of the complex interactions between squash bug and its cucurbit hosts including the transmission of the yellow vine disease is needed.

Wireworm (*Agriotes* spp., *Limonius* spp., and other species)

Pest Information

Damage: Wireworms are the larval stage of click beetles. The click beetles (adult stage) do little or no damage because they only feed on flowers and pollen. By contrast, the wireworm larvae cause severe damage because they feed on cucurbit seeds, resulting in stand loss. Wireworms also bore into the roots and crowns of seedlings. In some instances, the larvae even tunnel up the stems of seedlings. This feeding damage results in the wilting, stunting and distorted growth of the seedlings and often kills the plants. Wireworm damage can result in 50 percent crop losses for watermelon.

Life cycle: Both larvae and adults overwinter in the soil. Overwintering adults mate the following spring. Mating occurs in or on the soil, usually in the same area where the pest developed as a larva. Females prefer to lay eggs deep in moist soil on the roots of grassy plants. However, females also lay eggs on over 40 plant species including cucurbits. After laying most of their eggs, females of some species emerge from the soil and make short flights to nearby fields, where they continue egg laying. Depending on the species, larvae live from two to 10 years in the soil before pupating. Wireworms move vertically through the soil profile, going downwards to avoid hot and cold temperatures and moving upwards to feed on seeds and plants. In Canada, there is one generation per year. However, because the period of egg-laying is prolonged, larvae and adults are both present throughout the summer.

Pest Management

Cultural controls: Consistent scouting before planting is used to assess the potential risk of wireworm infestations. Soil samples and bait traps are used to determine larvae numbers and pheromone traps are used to monitor adult males of some species. The history of wireworm damage in a field is also taken into consideration. A field formerly used for grass or seed production is an indicator that wireworm damage may be worse in that particular field. Areas with high risk of wireworm damage are avoided. Crops are planted in warm soils to speed growth and shorten the time spent in the vulnerable seed and seedling growth stages.

Resistant cultivars: There are no wireworm resistant or tolerant cucurbit cultivars.

Issues for Wireworms

1. There is a need for pest control products to manage wireworms in cucurbit production.
2. Biological, cultural and mechanical controls need to be evaluated for their effectiveness in controlling wireworms.

Seedcorn Maggot (*Delia platura*)

Pest Information

Damage: Seedcorn maggot is the larval stage of the bean seed fly. The maggots preferentially feed on the cotyledons of germinating seeds, resulting in stand loss. Damaged seedlings are spindly, with few leaves and die before they mature. Occasionally, seedcorn maggots also tunnel into seeds and seedling stems. Areas of plant damage act as entry sites for disease and the maggots help spread bacterial soft rot. Once the cucurbit plants are past the seedling stage, they become resistant to seedcorn maggot damage.

Life cycle: Seedcorn maggot overwinters as pupae in the soil. Adults emerge in early spring and lay eggs singly or in clusters in the soil near plant stems. Eggs hatch, larvae feed and then burrow into the soil to pupate and emerge as adults. Adults lay eggs as before and larvae again feed to maturity and pupate. There are three to five generations of seed corn maggots each year before the overwintering pupal stage is reached. The host range of seedcorn maggot includes approximately 50 plant species including cucurbits. However, seedcorn maggots can also develop in organic matter in humid soils, where the organic matter acts as the main larval food when no seeds are available.

Pest Management

Cultural controls: The incorporation of live, green organic matter or animal manure into the soil in the spring is done more than four weeks before the crop is planted. Otherwise, the organic matter and manure attract egg-laying flies to the crop. Early planting dates and cool-wet weather that favour seedcorn maggot-numbers are avoided. Instead, crops are planted in warm soils to speed growth and shorten the time spent in the vulnerable seed and seedling growth stages. A chain is dragged behind the planter to remove any seed row moisture gradient which would otherwise attract adult flies. Food sources like flowering weeds are removed from field margins. Potential infestation levels prior to planting are assessed using bait traps. Areas with high risk of seedcorn maggot damage are avoided. Crop is monitored during seedling emergence for wilted plants and gaps in the plant stand. Examine seeds and seedlings for the seed corn maggot.

Resistant cultivars: There are no seedcorn maggot resistant or tolerant cucurbit cultivars.

Issues for Seedcorn Maggots

1. There is a need for pest control products to manage seedcorn maggot in cucurbit production.
2. Research to determine peak populations is needed, as well as the development of management strategies, including biological, cultural and mechanical controls to protect the crop at vulnerable stages.

White Grubs (*Phyllophaga* spp.)

Pest Information

Damage: White grubs are the larval stage of May/June beetles. White grubs feed on cucurbit roots, thereby disrupting the uptake and transport of water and nutrients. Initial symptoms include yellowing and wilting of foliage, as well as stunting of plants. White grubs kill seedlings but have less impact on plants with larger, more robust root systems.

Life cycle: The life cycle of white grubs varies depending on the species. Some complete their growth in one year, while others require as many as four years. Adults emerge in late May and early June and mate in the evening. At dawn, females burrow into the soil to lay eggs. After hatching from eggs, white grubs feed on plant roots. In autumn, larvae migrate downward into the soil profile and remain inactive until spring, when they migrate towards the soil surface to again feed on plant roots. Over the course of the next few years, larvae pass through three instars, becoming larger and more destructive with each stage. Eventually, in their last year, larvae pupate before emerging as adults in May or June. White grubs are polyphagous, with more than 44 known host plant species including cucurbits.

Pest Management

Cultural controls: Fields with a history of white grub damage are avoided. Fields are plowed in late spring or early autumn, killing many larvae, pupae and adults in the soil and exposing the insects to predators, such as birds. For this cultural practice to be effective, plowing must occur before the white grubs migrate below the plow depth. Proper irrigation and fertilization are used to maintain plant health and vigour, which helps minimize the impacts of feeding damage. Unwanted grasses that act as alternate hosts are removed from fields and field borders. Blacklight traps are used at night to monitor for adult beetles. Natural enemies that control white grubs include *Tiphia* species, *Myzinum* species, *Pelecinus polyturator* and *Pyrgota undata*.

Resistant cultivars: There are no white grub resistant or tolerant cucurbit cultivars.

Issues for White Grubs

1. There is a need for pest control products to manage white grubs in cucurbit production, as well as biological, cultural and mechanical controls.

Squash Vine Borer (*Melitta cucurbitae*)

Pest Information

Damage: Squash vine borer is a day-flying, clearwing moth. The larvae cause severe damage because they tunnel into cucurbit vines to feed. Larval feeding destroys vascular tissues, stopping the flow of water and nutrients from the roots to developing fruit. This causes sudden localized wilting of damaged plants, usually seen during the hottest part of the day. There are reports of squash vine borer on pumpkin and squash causing yield losses of more than 25 percent.

Life cycle: Squash vine borers overwinter as pupae in the soil. Females emerge in early summer. They mate and lay a single egg on the lower part of the main stem of the host plant, as well as on the leaf stalks, leaves and fruit buds. Some eggs are laid in the cracks in the soil near the base of the host plant. Eggs hatch and the larvae burrow into vines. The larvae develop through four instars. The late instar larvae drop to the ground and burrow into the soil to pupate. Squash vine borer is native to North America and is distributed throughout southeastern Canada. In Canada, there is one generation per year. The host range of the squash vine borer is restricted to the genus *Cucurbita*. It prefers host plants with softer, wider stems such as summer squash and pumpkin compared to those with woodier, narrower stems such as cucumber.

Pest Management

Cultural controls: In fields with known squash vine borer infestations, as soon as the crop is harvested, vines are either collected and discarded or plowed under. Plowing after harvest will also destroy the overwintering pupae in the soil. Planting dates are staggered to allow some crops to escape periods of heavy egg laying. Row covers are used to stop adults from laying their eggs on the crop. However, row covers must be removed at crop flowering to permit pollination. When the main crop is a less-preferred cucurbit cultivar, a more-preferred cultivar trap crop is planted next to the main crop to divert insects from the main crop. When feasible, plants killed by squash vine borer are rogued out. Moist soil is heaped over stem joints to promote root development, so in the event squash vine borer damages the main stem base new roots will continue to feed the plant. The squash vine borer population is monitored by field scouting and pheromone trapping of adult moths. Parasitic wasps of the family Scelionidae parasitize squash vine borer eggs. Several species of ground beetle attack larvae and robber flies occasionally attack adults. However, none of these natural biological control agents significantly reduce pest populations.

Resistant cultivars: The most tolerant cultivars belong to *Cucurbita moschata* and *Cucurbita argyrosperma,* probably due to their tougher, woodier stems.

Issues for Squash Vine Borer

1. There is a need for pest control products to manage squash vine borer in cucurbit production, in addition to biological, cultural and mechanical controls.

Weeds

Key Issues

- New and improved integrated weed management solutions for cucurbit cropping systems are needed. Priority weed species include common ragweed (*Ambrosia artemisiifolia),* glyphosate resistant Canada fleabane (*Erigeron canadensis*), water hemp (*Amaranthus tuberculatus*), Palmer amaranth (*Amaranthus palmeri*) and redroot pigweed (*Amaranthus* retroflexus), as well as group 2 resistant weeds.

- Recommendations on herbicide use need to be strengthened by improving scouting methods, action thresholds and timing of herbicide applications.

Table 8. 2022 Canadian Pest Management Top Priority Rankings of weeds in cucurbit crops in relative order of importance by province[1]

Pest	Provincial Rankings								
	Cucumber			Pumpkin			Summer Squash		
	QC	ON	BC	QC	ON	BC	QC	ON	BC
Conventional Production									
Annual broadleaf weeds (e.g., *Ambrosia artemisiifolia*, *Amaranthus retroflexus*)	red	red	red	red	red	red	red	red	red
Perennial broadleaf weeds	red	red	red	red	red	red	red	red	red
Annual grassy weeds			red			red	red	red	red
Perennial grassy weeds			red			red	red	red	red
Canada fleabane (glyphosate resistant)		orange	orange		orange	orange		orange	orange
Group 2 resistant weeds (e.g., *Erigeron canadensis*)		blue			blue			blue	
Waterhemp		blue			blue			blue	
Weeds (plastic mulch)		yellow	yellow		yellow	yellow		yellow	yellow

[1]Provinces provide rankings of their top pest priorities for the annual Canadian Pest Management Priority Setting Workshops. This table provides rankings for the key weeds for cucurbits published in 2022 (BC rankings were updated in August 2022). Rankings are colour coded in order of highest to lowest relative importance where red indicates a first highest priority, orange indicates a second highest priority, yellow indicates a third highest priority and blue indicates a priority of four and below. A blank does not mean that the weed does not occur in a province, it could be that it was not ranked in the top pests for 2022.

Table 9. Adoption of integrated weed management practices in cucurbit production in Canada[1]

Practice	Annual Broadleaf	Annual Grass	Perennial Broadleaf	Perennial Grass
Avoidance:				
Varietal selection / use of competitive varieties				
Planting / harvest date adjustment				
Crop rotation				
Choice of planting site				
Optimizing fertilization for balanced growth and to minimize stress				
Use of weed-free propagative materials (seed, cuttings, transplants)				
No till or low disturbance seeding to minimize weed seed germination				
Use of physical barriers (e.g., mulches)				
Prevention:				
Equipment sanitation				
Canopy management (e.g., thinning, pruning, row or plant spacing)				
Manipulating seeding / planting depth				
Irrigation management (timing, duration, amount) to minimize disease infection periods and manage plant growth				
Management of soil moisture (e.g., improvements in drainage, use of raised beds, hilling, mounds)				
Weed management in non-crop lands				
Monitoring:				
Scouting / field inspection				
Maintaining records of weed incidence including herbicide resistant weeds				
Use of precision agriculture technology (GPS, GIS) for data collection and mapping of weeds				

…continued

Table 9. Adoption of integrated weed management practices in cucurbit production in Canada[1] (continued)

Practice	Annual Broadleaf	Annual Grass	Perennial Broadleaf	Perennial Grass
Decision making tools:				
Economic threshold				
Crop specialist recommendation or advisory bulletin				
Decision to treat based on observed presence of weed at susceptible stage of development				
Decision to treat based on observed crop damage				
Use of portable electronic devices in the field to access weed identification / management information				
Suppression:				
Use of diverse herbicide modes of action for resistance management				
Soil amendments and green manure soil incorporation as biofumigants to reduce weed populations				
Use of non-conventional pesticides (e.g., biopesticides)				
Release of arthropod biological control agents				
Mechanical weed control (cultivation / tillage)				
Manual weed control (e.g., hand pulling, hoeing, flaming)				
Use of stale seedbed approach				
Targeted pesticide applications (e.g., banding, spot treatments, use of variable rate sprayers)				
Selection of herbicides that are soft on beneficial insects, pollinators and other non-target organisms				
This practice is used to manage this pest by at least some growers in the province.				
This practice is not applicable for the management of this pest.				
Information regarding this practice for this pest is unknown.				
This practice is not used by growers in the province to manage this pest.				

[1]Source: Stakeholders in reporting provinces (British Columbia and Quebec); the data reflect the 2019, 2020 and 2021 production.

Annual Broadleaf and Grassy Weeds

Pest Information

Damage: Annual weeds compete with cucurbits for light, water and nutrients, reducing crop yield and vigour. Early crop stages are the most vulnerable to weed competition. Cucumbers and pumpkins grow as spreading vines and zucchini as compact bushes. Under ideal growing conditions, all are able to quickly form weed-suppressive canopies. Once the crop canopy is established, weed competition is minimized. However, any gaps in the canopy caused by pests and diseases or pre-mature leaf senescence allow weeds to establish. Weeds conceal fruit, hamper manual picking, promote diseases by limiting air circulation and propagate themselves. Weeds also serve as alternate hosts for insect pests and cucurbit diseases. Weed interference is estimated to cause annual average yield losses of 10 to 15 percent for cucumbers and 5 percent for pumpkin and squash.

Life Cycle: Annual weeds complete their life cycles in one year starting with seed germination in the spring, followed by vegetative growth, flowering and seed production. By contrast, winter annuals germinate in the fall and overwinter as plants. In the spring they start to grow again, eventually flowering and setting seed. The main source of annual weeds in any cropping system are the numerous, dormant seeds found in the soil. The seeds remain viable for many years, germinating when environmental conditions favour weed growth. Annual weeds are spread when farm equipment, farmers' boots, etc. move soil containing weed seeds from one field to another.

Pest Management

Cultural Controls: Fields with a history of problematic weeds are avoided. Cucurbits are rotated with crops whose planting dates, emergence, height, and nutrient requirements differ from that of cucurbits, disrupting weed life cycles. Certified seed, free of weed seeds is used. Stale seedbeds or cultivated fallows are prepared to stimulate weed seeds to germinate. The weeds are then killed before the crop is planted. Mulches are laid out before the crop is planted. In the row, weeds are managed with timely cultivation or mowing as well as organic mulches and cover crops. Competitive cultivars are planted at appropriate plant densities and row spacing. They are planted in warm soil with adequate moisture and nutrients which promotes rapid crop emergence, establishment and canopy closure. Equipment and footwear are cleaned when moving between fields to reduce the spread of weed seeds. Fields are monitored and records of the weed species that occur are kept to determine what weeds escape preplant treatment. These records help to plan weed management strategies and track the occurrence of hard-to-control weeds. Just before harvest, weeds are surveyed and their locations are recorded for future management. Late season weeds are hand pulled to help facilitate harvest and reduce the number of weeds seeds produced.

Issues for Annual Broadleaf and Grassy Weeds

1. The biology and distribution of the invasive weed, Palmer amaranth, needs to be determined.

Perennial Broadleaf and Grassy Weeds

Pest Information

Damage: Perennial weeds, especially those that are well established, compete with cucurbits for light, water and nutrients, reducing crop yield and vigour. Fast growing cucurbit cultivars with quick canopy closure are most vulnerable to perennial weed competition as seedlings. Once the crop canopy is established, weed competition is minimized. For slower growing cucurbit cultivars with poor canopy cover, potential weed impact on yield and crop vigour occurs throughout the cropping cycle.

Life Cycle: Perennial weeds are long lived, completing their life cycles over many years. Perennial weeds propagate through seeds and vegetative parts such as roots, rhizomes and corms. Cultivation, tillage and plowing cut roots, rhizomes and corms into pieces and spreads them around the field. Each piece has the potential to grow into a new perennial weed. Farm equipment and farmers' boots that are not cleaned can move soil containing vegetative parts and seeds from one field to another.

Pest Management

Cultural Controls: Most of the cultural control practices used to control annual weeds can also be used to control perennial weeds. Exceptions are cultivation, tillage and plowing, which can spread vegetative weed parts around the field. Instead, minimum tillage is used to prevent the multiplication of perennial weeds.

Issues for Perennial Broadleaf and Grassy Weeds

1. No-till cover crops need to be identified for perennial weed control.

Resources

Integrated Pest Management and Integrated Crop Management Resources for Production of Field Cucurbits in Canada

British Columbia Ministry of Agriculture. *Cucurbits*.
https://www2.gov.bc.ca/gov/content/industry/agriservice-bc/production-guides/vegetables/cucurbits

Ontario Ministry of Agriculture, Food and Rural Affairs. *Cucumber Production*.
http://www.omafra.gov.on.ca/english/crops/facts/cucumber_production.htm

Ontario Ministry of Agriculture, Food and Rural Affairs. *Pumpkin and Squash Production*.
http://www.omafra.gov.on.ca/english/crops/facts/00-031.htm

Ontario Ministry of Agriculture, Food and Rural Affairs. *Ontario Crop Protection Hub.*
https://cropprotectionhub.omafra.gov.on.ca/

Provincial Contacts

Province	Ministry	Crop Specialist	Minor Use Coordinator
British Columbia	British Columbia_Ministry of Agriculture and Food www2.gov.bc.ca/gov/content/industry/agriservice-bc	Susan Smith susan.l.smith@gov.bc.ca	Caroline Bédard caroline.bedard@gov.bc.ca
Ontario	Ontario Ministry of Agriculture, Food and Rural Affairs www.omafra.gov.on.ca	Elaine Roddy elaine.roddy@ontario.ca	Joshua Mosiondz joshua.mosiondz@ontario.ca
Quebec	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (French only) www.mapaq.gouv.qc.ca	Isabelle Couture isabelle.couture@mapaq.gouv.qc.ca	Mathieu Coté mathieu.cote@mapaq.gouv.qc.ca

Provincial and National Vegetable Grower Organizations

British Columbia BCFresh: https://bcfresh.ca/

Canadian Organic Growers: https://www.cog.ca/

Ontario Fruit and Vegetable Growers' Association: http://www.ofvga.org

Ontario Processing Vegetable Growers: https://www.opvg.org/

Fruit and Vegetable Growers of Canada: https://fvgc.ca

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